Material Flow Cost Accounting

MFCA Case Examples 2011

Ministry of Economy, Trade and Industry

Introduction

Material Flow Cost Accounting (MFCA) is a method of Environmental Management Accounting that simultaneously realizes “reduced environmental impacts” and “improved business efficiency.” The method was originally developed in Germany and has been further developed in Japan. Currently, the inclusion of MFCA into the International Organization for Standardization (ISO) is in progress under the initiative of Japan in ISO/TC207/WG8 (MFCA). MFCA will be issued as ISO14051 in 2011, and attracts attention in recent years.

The approach and effectiveness of MFCA have been studied after its introduction in Japan in 2000. The MFCA introduction to companies is in progress, and the approach is making further progress. Initially, MFCA was introduced mainly to a single process or product, but as the method was developed and its effect was recognized, companies began promoting environmental management, making both the environment and economies compatible by integrating MFCA into their business management mechanism. Moreover, the MFCA idea is expanding from a single company to the upstream and downstream of a supply chain. In this way, many advanced and easy-to-understand MFCA case examples have been achieved in Japan.

The Ministry of Economy, Trade and Industry aims to advance ISO standardization and promote environmental management utilizing MFCA by sharing such case examples among the industry. Therefore, this booklet of MFCA Case Examples contains specially selected advanced and easy-to-understand cases.

The first edition of the MFCA Case Examples appeared in fiscal year 2009 and was distributed widely to countries the world over, including WG8 and TC207 participating countries. This new edition of MFCA Case Examples 2011 includes nine new cases. We would be highly pleased if this book would be used for further dissemination of MFCA.

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Recycling Promotion Division,
Industrial Science and Technology Policy and Environment Bureau,
Ministry of Economy, Trade and Industry, Japan

In producing this booklet, the committee members of the "FY 2010 International Standardization of Low-Carbon Environmental Management Accounting (Material Flow Cost Accounting introduction and verification, domestic countermeasures etc.)" provided guidance and advice, which the Japanese Ministry of Economy, Trade and Industry of Japan commissioned. The committee is comprised of the following members (member names are listed in alphabetical order):

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I. How to read this case example

1. Objective of this booklet

The Ministry of Economy, Trade and Industry of Japan has been promoting ISO-standardization of MFCA in order to globally disseminate Material Flow Cost Accounting (MFCA), one of the environmental management accounting tools, which contributes to making both the environment and economies compatible. Japan proposed the inclusion of Material Flow Cost Accounting (hereafter referred to as "MFCA") in the ISO to ISO/TC207[1]. As a result, ISO/TC207/WG8 (MFCA)[2] was established in 2008, making efforts toward international standardization of MFCA (ISO14051) in 2011.

During the course of developing the standard, it was considered necessary to produce a booklet that collates the MFCA case examples. Consequently, this booklet was produced in order to disseminate MFCA on a global scale.

Additionally, this booklet includes annex on overview of MFCA. The annex is based on the first chapter of "Guidance on Introduction of Material Flow Cost Accounting (Third version)", including explanation on the basic approach of MFCA. See the annex if you are a beginner in MFCA.

2. Case examples selected for this booklet

MFCA was developed as a tool to enhance material productivity in manufacturing operations. Hence, there have been a number of examples in manufacturing industries. In addition to examples in the manufacturing industry, MFCA case examples in the supply chain that involve multiple organizations are also selected. Furthermore, MFCA application to industries other than the manufacturing industry has started recently, and characteristic examples such as logistics, construction, and recycling are also included in this booklet.

In order to familiarize MFCA with various types of manufacturing industries, easy-to-understand cases were selected from wide varieties of industries and fields such as those from manufacturing activity, supply chain, logistics, construction and distribution service.

Characteristics of these examples are summarized in "4. List of companies that applied MFCA" and "5. Characteristics of case examples." Refer to these sections when considering type of industries and processes for MFCA application.

3. Structure of case examples

Each case example consists of (1) "Organizational profile," (2) "Material flow model of Main Target Process (es)," (3) "Description of material losses," (4) "Findings through MFCA analysis," (5) "Targeted points to be improved or improvements based on MFCA analysis," and (6) "Results and future issues (Conclusion)." Given below are brief explanations on each of these sections:

(1) Organizational profile

This section includes the overview of corporate information such as the type of products

[1] TC 207 is one of the technical committees in International Organization for Standardization (ISO) under which the ISO 14000 series of environmental management standards are developed.

[2] WG 8 is one of the working groups under the TC 207. This working group is engaged in international standardization of MFCA.

manufactured, number of employees, sales, and capital.

(2) Material flow model of Main Target Process (es)
This section introduces products subjected to the MFCA analysis and the characteristics of manufacturing processes. Besides this information, this section provides a guide for establishing a quantity centre and for applying MFCA.
In the case of nonmanufacturing industries, no manufacturing processes are present. Therefore, this section notes only the scope for MFCA analysis and its characteristics.

(3) Description of material losses
This section describes the materials used and material losses generated in the process. Further, it introduces the approach for calculating energy and system costs.

(4) Findings through MFCA analysis
This section states the MFCA calculation result and the findings based on the result.

(5) Targeted points to be improved or improvements based on MFCA analysis
This section states the targeted points for improvement and the improvement measures, as identified on the basis of the MFCA analysis result.

(6) Results and future issues (Conclusion)
This section describes results from the MFCA introduction and implementation, future implementation plan, and other related issues.

4. List of companies that applied MFCA and were included in this booklet

Table 1 organizes the 32 companies or Supply chain teams included in this booklet by the type of industry, and scale in terms of the number of employees. The type of industry is generally based on the categories defined by the Tokyo Stock Exchange. In order to understand the scale of each company, categories based on the number of employees are defined and included in the list. The scale for the number of employees is divided into three categories comprising “Less than 100,” “100 to 999,” and “more than 1,000.” Further, the “Remarks” lists the important points to be noted in the MFCA application and record of MFCA awards presented.

- Type of MFCA case examples
  MFCA case examples are divided into three categories comprising “Manufacturing,” “Nonmanufacturing,” and “Supply chain.”

  - Examples in manufacturing sector are those of a single MFCA-applied company/factory.
  - Examples in nonmanufacturing sector includes those of companies generally known as manufacturing companies and those who have applied MFCA to their nonmanufacturing activities such as service, construction, and logistics.
  - Examples in Supply chain sector are based on the examples of multiple companies that concurrently applied MFCA and were cooperatively engaged in associated improvement activities.

Table 1 List of companies that applied MFCA and are included in this booklet

Type of MFCA case examples	Name of company	Type of industry	Classification based on number of employees	Remarks
Manufacturing	NITTO DENKO CORPORATION	Chemicals	More than 1,000	Special award for Material Flow Cost Accounting, Eco-efficiency Award 2007*
	SEKISUI CHEMICAL CO., LTD.	Chemicals	More than 1,000	Special award for Material Flow Cost Accounting, Eco-efficiency Award 2008*
	SUMIRON CO.,LTD.	Chemicals	100～999	
	TOYO INK MFG. CO., LTD.	Chemicals	More than 1,000	
	Sumitomo Chemical Co., Ltd.	Chemicals	More than 1,000	
	Mitsubishi Tanabe Pharma Corporation	Pharmaceutical	More than 1,000	・Special award for Material Flow Cost Accounting, Eco-efficiency Award 2006* ・Mitsubishi Tanabe Pharma Corporation was created through the merger of Tanabe Seiyaku Co., Ltd. and Mitsubishi Pharma Corporation on 1st October 2007 (Tanabe Seiyaku Co., Ltd. at the time of the production of the MFCA case example and the award presentation).
	Canon Inc.	Electric Appliances	More than 1,000	Special award for Material Flow Cost Accounting, Eco-efficiency Award 2006*
	Nagahama Canon Inc.	Electric Appliances	More than 1,000	Special award for Material Flow Cost Accounting, Eco-efficiency Award 2009*
	OMRON Corporation	Electric Appliances	More than 1,000	Special award for Material Flow Cost Accounting, Eco-efficiency Award 2008*
	TS Corporation	Electric Appliances	Less than 100	
	Press Manufacturer A	Electric Appliances	100～999	
	Katagiri Seisakusho Co., Ltd.	Transportation equipment	100～999	
	GUNMA GOHKIN Co., Ltd.	Transportation equipment	Less than 100	
	Mitsuya Co., Ltd.	Metal Products	100～999	
	KOSEI ALUMINUM CO., LTD.	Metal Products	100～999	
	MIWA LOCK Co., Ltd.	Metal Products	More than 1,000	Special award for Material Flow Cost Accounting, Eco-efficiency Award 2010*
	NIPPON FILCON CO., LTD.	Metal Products	100～999	
	Shimizu Printing Inc.	Pulp & Paper	Less than 100	
	THE REBIRTH CO., LTD.	Pulp & Paper	100～999	
	GUNZE Limited	Textiles & Apparels	More than 1,000	
	Kohshin Rubber Co., Ltd.	Rubber Products	100～999	
	Shinryo Co., Ltd.	Foods	Less than 100	
	KODAI SANGYO CO., LTD.	Other Products	Less than 100	Special award for Material Flow Cost Accounting, Eco-efficiency Award 2009*
Nonmanufacturing	JFE group	Construction	More than 1,000	
	GUNZE Limited	Textiles & Apparels	More than 1,000	
	OHMI BUSSAN, Inc.	Other Services	Less than 100	
	Sanden Corporation	Machinery	More than 1,000	Special award for Material Flow Cost Accounting, Eco-efficiency Award 2009*
	Convenience store A	Retail Trade	Less than 100	

*Eco-efficiency Award
This award was established in 2005 with the support of the Ministry of Economy, Trade and Industry of Japan. In 2006, a special award for Material Flow Cost Accounting was established. Since then, this award has been given annually to companies that are considered to especially achieve successful results in MFCA application, development, and dissemination.

Type of MFCA case examples	Name of company	Type of industry	Classification based on number of employees	Remarks
Supply chain	Sanden Corporation SC team			
	Sanden Corporation	Machinery	More than 1,000	
	Sanwa Altech	Machinery	Less than 100	
	Panasonic Ecology Systems Co., Ltd. SC team			Grand Prize for Supply-Chain Model for Resource Conservation 2008**
	Panasonic Ecology Systems Co., Ltd.	Electric Appliances	More than 1,000	
	Nippon Sangyo Shizai Co., Ltd.	Chemicals	-	
	OMRON RELAY & DEVICES Corporation SC team			Grand Prize for Supply-Chain Model for Resource Conservation 2009**
	OMRON RELAY & DEVICES Corporation	Electric Appliances	More than 1,000	
	Press processing manufacturer	Metal Products		
	Heat treatment manufacturer	Metal Products		
	Plate processing manufacturer	Metal Products		
	Ohu Wood Works Co., Ltd. SC team			・Green Supply-Chain Award 2008*** ・Special award for Material Flow Cost Accounting, Eco-efficiency Award 2009*
	Ohu Woods Works Co., Ltd.	Other Products	100～999	
	Miyoshi Industry	Metal Products	Less than 100	

*Eco-efficiency Award
This award was established in 2005 with the support of the Ministry of Economy, Trade and Industry of Japan. In 2006, a special award for Material Flow Cost Accounting was established. Since then, this award has been given annually to companies that are considered to especially achieve successful results in MFCA application, development, and dissemination.

**Grand Prize for Supply-Chain Model for Resource Conservation and ***Green Supply-Chain Award
These awards are presented to companies that participated in the supply-chain cooperation promotion project for resource conservation and achieved successful results. In the Grand Prize for Supply-Chain Model for Resource Conservation, the awards are presented to MFCA-applied supply chain which is most likely to be a model for others in its MFCA approach and the associated improvement plan. The Green Supply-Chain Award is awarded to the supply chain that newly shaped a cooperative formation and achieved successful results next to those awarded the Grand prize for Supply-Chain Model for Resource Conservation.

5. Characteristics of case examples

Below is the description on characteristics the field subjected for MFCA analysis in this booklet. Those companies noted after the description are included in this booklet.

Forming process

After forming process of raw materials (e.g., resin and metals) and materials left-over such as runners often become material losses. Separate material losses are generated at the switching-phase of production types. Material losses are frequently increased through manufacturing of wide varieties of products in small quantities. The companies with the case example on the forming process are NITTO DENKO CORPORATION, SEKISUI CHEMICAL CO., LTD., SUMIRON CO., LTD., TOYO INK MFG. CO., LTD., GUNMA GOHKIN Co., Ltd., NIPPON FILCON CO., LTD., Kohshin Rubber Co., Ltd., Shinryo Co., Ltd., and Panasonic Ecology Systems Co., Ltd. Supply chain team.

Machining process

Machining of various materials such as metals, resins, glass, and wood materials become material losses through various processes including pressing, cutting, lathe-processing, milling, and polishing. The companies with the case example on the machining process are Canon Inc., Nagahama Canon Inc., OMRON Corporation, TS Corporation, Press Manufacturer A, Katagiri Seisakusho Co., Ltd., KOSEI ALUMINUM CO., LTD., MIWA LOCK Co., Ltd., KODAI SANGYO

CO., LTD., Sanden Corporation Supply chain team, OMRON RELAY & DEVICES Corporation Supply chain team, and Ohu Wood Works Co., Ltd. Supply chain team.

Chemical reaction process

Material losses are frequently generated due to impurities and yield loss in reactions and refining processes. The company with the case example on the chemical reaction process is Mitsubishi Tanabe Pharma Corporation and Sumitomo Chemical Co., Ltd.

Surface treating process

Surface treating includes plating, heat treatment, coating, and rinsing etc. Small amount of material losses are generated from the materials to be treated. However, significant amounts of material losses are generated from operating materials (plating solution, paint, rinsing liquid etc.). The company with the case example on the surface treating process is Mitsuya Co., Ltd.

Manufacturing process of textile products

The subject processes consists of a wide variety of product types differentiated by brand, design, color, and size etc. A significant amount of waste textile materials are produced in cutting process. Likewise, there are also cases when raw materials and products become material losses due to changes in trends that result in clearance of inventory. The company with the case example on the textile products is GUNZE Limited.

Paper processing

The subject process consists of printing, processing of pre-printing paper, and cutting after printing etc. Material losses are frequently generated in the process that involves manufacturing of a wide variety of products in small quantities; material losses are generated at the time of switching of product types. The company with the case example on the paper processing is Shimizu Printing Inc.

Paper manufacturing

Processes are divided into two: paper-making process where a jumbo roll is made and product-processing process where the jumbo roll is cut in order to produce the end-product. A large volume of water and energy such as steam are consumed in the paper-making process. Packing material loss is considered to be typically generated in the product-processing process. The company with the MFCA case example on the paper manufacturing is THE REBIRTH CO., LTD.

Logistics

Product logistics concerns two types of material flows: one is toward the customers, while the other is related to returned products, which is considered as loss. It is necessary to identify environmental impacts and losses in business resources (i.e., cost) that are associated with both flows. The company with the MFCA case example on the logistics is GUNZE Limited.

Construction activity

In addition to materials and costs classifying concepts as defined under MFCA, material losses are identified based on the newly-defined classification of intended construction and unintended construction. The company with the MFCA case example on the construction activities is JFE group.

Recycling activity

Characteristics of the recycle business are that available amount of raw material, its price and amount of intermediate product fluctuate, and that disposal of stocked materials occasionally takes place. The business status can be revealed through MFCA application, which enables accurate understanding of process-oriented losses in physical and monetary units. The company with the MFCA case example on the recycling activities is OHMI BUSSAN, Inc.

Cleaning service

MFCA can be applied to the cleaning service in two ways: one is from the viewpoint of those who provide services and the other, from those who are served. The Company with the MFCA case example on the cleaning service is Sanden Corporation.

Distribution service

In the distribution service, remained items are disposed once they expire, becoming material losses. Further, there is an opportunity loss due to sold-out. MFCA especially increase transparency of loss related to remained items in physical and monetary units. The company with the MFCA case example on the distribution service is the convenience store A.

6. Abbreviations/terms used in this booklet

Abbreviated terms used in this booklet are explained based on the terms and definition given in the draft International Standard of ISO 14051 as shown in the followings:

- QC: quantity centre
  Selected part or parts of a process for which inputs and outputs are quantified in physical and monetary units
- MC: material cost
  Expense for the materials that are used and/or consumed in a quantity centre
- EC: energy cost
  Expense for the energy used to enable operations
- SC: system cost
  All expenses incurred in the course of in-house handling of the material flows except for material costs, energy costs and waste management costs

II. Case Examples in the Manufacturing Industry

Case 1 NITTO DENKO CORPORATION
Production characteristics: Manufacturing line for adhesive tapes for electronics

(1) Organizational profile

One of the products manufactured by NITTO DENKO CORPORATION (hereafter referred to as "Nitto Denko") is adhesive tapes for electronics. One of the company's facilities is located in Toyohashi, Japan. The company is the Japan's first model company that introduced MFCA in 2000 in order to verify effectiveness of the method.

The company employees numbered 28,640 on a consolidated basis at the time of the project. The company's sales were 577.9 billion yen on a consolidated basis. The capital was 26.7 billion yen (FY 2009).

The selected process for the subject project was the manufacturing process of adhesive tapes for electronics.

(2) Material flow model of main target process/es

Material flow model for the selected process (MFCA boundary) is shown in Figure 1.1:

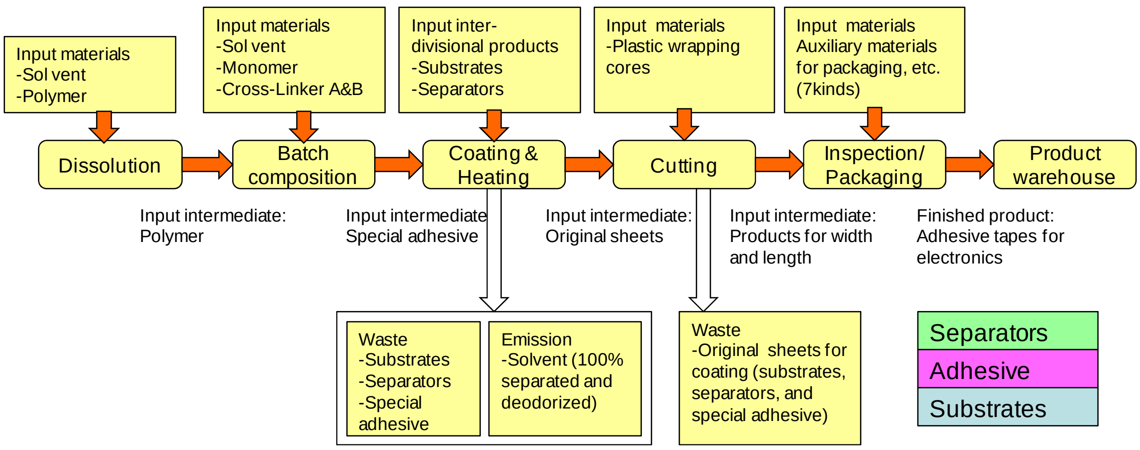


Figure 1.1 Material flow model for the selected process

As illustrated in Figure 1.1, the process consists of five processes that are dissolution, batch composition, coating and heating, cutting, and inspection/packaging.

Nitto Denko independently developed the "Daily Transaction Control System" to completely control items and information from reception of orders to delivery of products. This system is applied for production control and monthly closing. Material flows (e.g., input, output and yield rate) were managed through the main production/control process unit of this system. Therefore, this system's control unit was selected and defined as a quantity centre for the purpose of MFCA data collection.

(3) Description of material losses

Material losses in each step of the manufacturing process included the followings:

- Coating and heating process: substrates, separators and specialized adhesive, and
- Cutting process: cut ends of the intermediate product.

The percentage of the above material losses per initial input materials by weight was identified to be approximately 32.83 %.

(4) Findings through MFCA analysis

Based on the MFCA calculation, the data collected within the boundary are summarized in monetary units as shown in the following:

Table 1.1 Material flow cost matrix

Cost Classification	Material	Energy	System	Waste Management	Total
Product	¥2,499,944 (68.29%)	¥57,354 (68.29%)	¥480,200 (68.29%)	-	¥3,037,498 (67.17%)
Material Loss	¥1,160,830 (31.71%)	¥26,632 (31.71%)	¥222,978 (31.71%)	¥74,030 (100%)	¥1,484,470 (32.83%)
Total	¥3,660,774 (100%)	¥83,986 (100%)	¥703,178 (100%)	¥74,030 (100%)	¥4,521,968 (100%)

Table 1.2 Comparison between conventional and MFCA-based profit and loss (P/L) statement

MFCA-based P/L (Unit: Yen)		Conventional P/L (Unit: Yen)	
Sales*	15,000,000	Sales*	15,000,000
Product costs	3,037,498	Cost of sales	4,521,968
Material losses	1,484,470	N/A	N/A
Gross profit	10,478,032	Gross profit	10,478,032
Sales and general administrative expenses*	8,000,000	Sales and general administrative expenses*	8,000,000
Operating profit	2,478,032	Operating profit	2,478,032

(The values with an asterisk "*" mark were modified to be fictitious for disclosure)

The MFCA-based P/L statement revealed that sales costs (= product costs) were 3,037,498 yen and waste costs (= material losses) were 1,484,470 yen. The conventional P/L statement indicates sales cost of 4,521,968 yen, which included hidden material loss-related costs. MFCA highlighted such hidden cost.

(5) Targeted points to be improved or improvements based on MFCA analysis

Nitto Denko implemented “waste/loss analysis” and “improvement measures” based on the MFCA results and achieved improvement by approximately 10%. However, further rooms for improvement still remained and a wider scale of improvement measures (a capital investment) were considered along with implementation of the other existing improvement measures. As a result, the production processes were fundamentally reviewed and the full-scale capital investment to advance further improvement/reform was decided. The company’s MFCA implementation results and target were indicated in Table 1.3.

Table 1.3 MFCA implementation results and target

Cost Classification	FY2001	FY2004	FY2010(Target)
Products	68%	78%	90%
Material Losses	32%	22%	10%
Total	100%	100%	100%

(6) Conclusion

The Nitto Denko's case proved that MFCA could serve as a management effective tool for business decisions in the following aspects:

- MFCA clarifies issues and potential solution for these issues; and
- MFCA enables appropriate capital investment and secures a budget for such investment.

Especially, in this project, MFCA was employed as a company decision-making tool, which led to 700 million yen of improvement measures and capital investments.

Case 2 SEKISUI CHEMICAL CO., LTD.
Production characteristics: Company-wide MFCA implementation for 34 sites with individually different production characteristics

(1) Organizational profile

In SEKISUI CHEMICAL CO., LTD. (hereafter referred to as “Sekisui Chemical”), MFCA has been conducted at their 34 sites in Japan. The subject sites manufacture a variety of products including unit houses and chemical products (raw materials of resin and resin-processed products). The company’s total employees numbered 19,742 on a consolidated basis. The company’s sales were 932.4 billion yen (FY 2009) with a capital of 100.002 billion yen on a consolidation-basis.

In Sekisui Chemical, MFCA is considered as a monitoring tool for manufacturing-related innovation activities that aim to realize “no waste,” “no defective products,” “no complaints” and “N-multiplication of productivity”. MFCA has been implemented company-wide as shown in Figure 2.1.

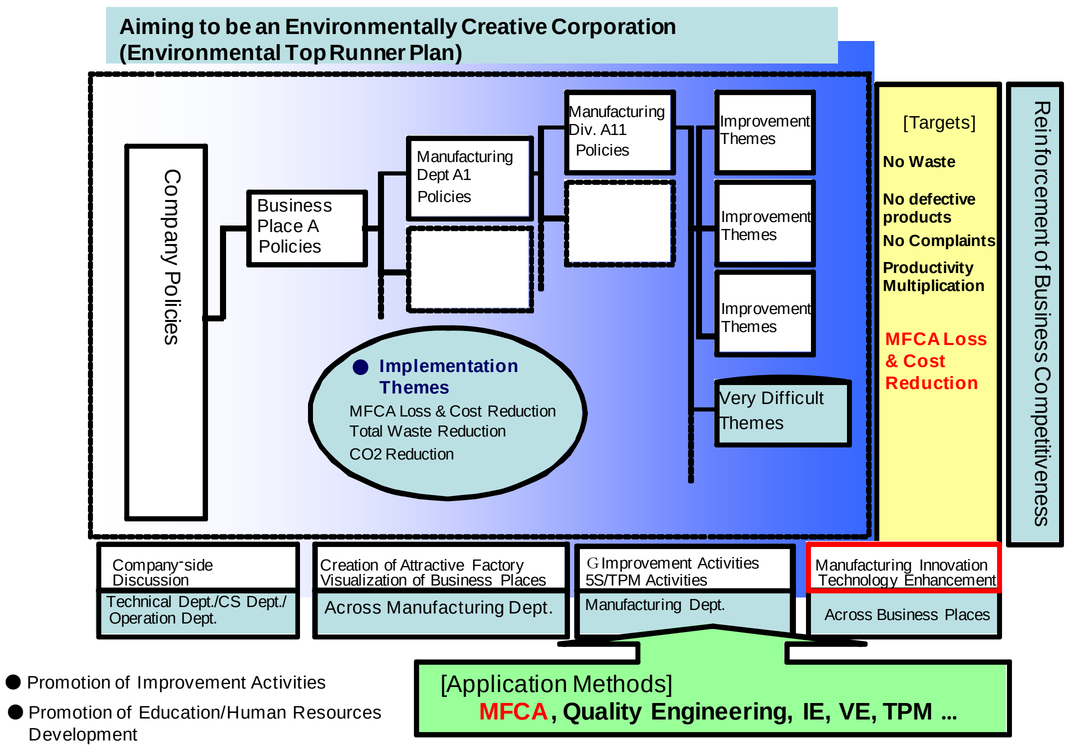


Figure 2.1 Illustration of company-wide MFCA implementation

(2) Material flow model of main target process/es

MFCA calculation and analysis were conducted for each process, which also incorporated losses at the inventory phase as shown in Figure 2.2.

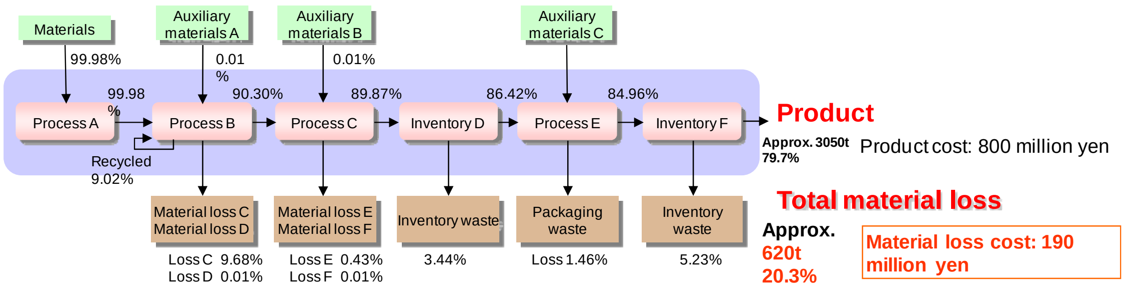


Figure 2.2 Material flow model of the main target process (MFCA boundary)

(3) Conclusion

The company's group-wide target was set to reduce loss costs by 5 billion yen within three years, from 2006 to 2008. The performance up to FY2007 revealed that the target was achieved one year earlier than forecasted; the loss costs were reduced by 5.3 billion yen. Simultaneously, the total amount of waste was reduced by 11%. Further MFCA deployments at household construction sites and overseas branches are the company's future subject.

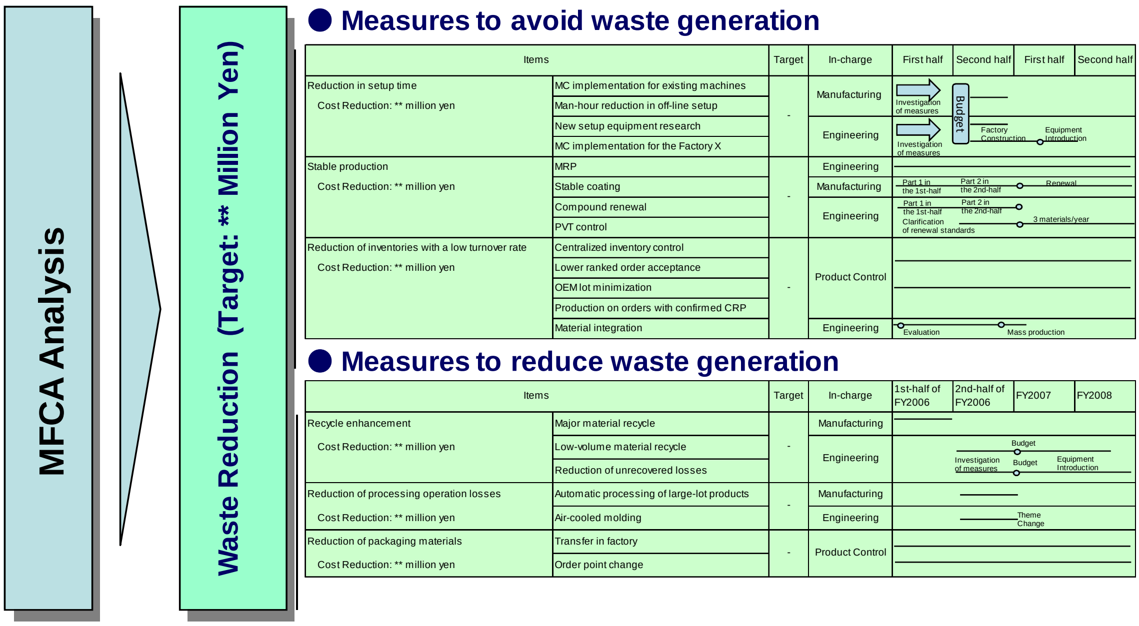


Figure 2.3 Material flow cost-related activities (a case of the Manufacturing Dept.)

Case 3 SUMIRON CO., LTD.
Production characteristics: Small-to-medium business and mass production

(1) Organizational profile

SUMIRON CO., LTD. manufactures industrial adhesive tapes. The facility is located in Iga-shi, Mie, Japan. The total factory employees numbered 140. The company's sales were 6.1 billion yen (FY 2007). The company's capital was 96 million yen at the time of the project.

The selected process was the manufacturing processes of adhesive tapes used as a surface protection film for construction materials and metal plates, protection films for automotive coating, optical members, functional protection films; adhesive mats, and cleaning tapes for electronic parts.

(2) Material flow model of main target process/es

Operations were divided into five quantity centres (QC). QC was defined based on their internal data collection process, and operational units. The five QCs consisted of "Adhesive Compound," "Coating and Aging," "Inspection," "Semi-finished Product Warehouse" and "Stacking, "Laminating and Cutting." Material flow model for the selected process is illustrated in Figure 3.1 below:

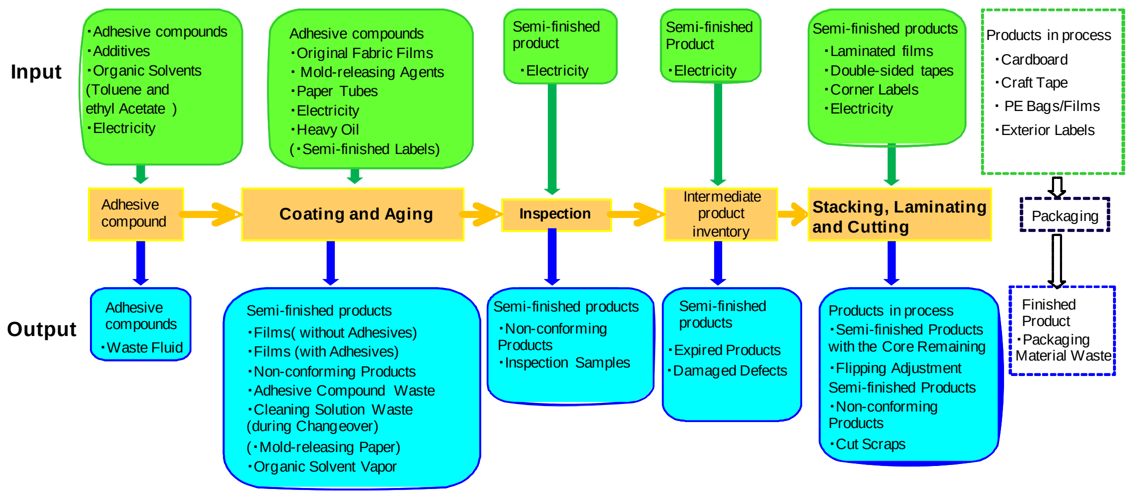


Figure 3.1 Material flow model for the main target process (MFCA boundary)

Adhesive compound was processed for PE film coating. Subsequently, the adhesive compound was coated on the PE film substrates in the coating process and fixed on PE films in the aging process. The films coated and fixed with the adhesive compound were stored once in the semi-finished product warehouse before the stacking process where the coated films were stacked and cut in appropriate sizes. Subsequently, the films flowed to the laminating process where they were combined with protection films and double-sided tapes and re-cut in product sizes in the cutting process. Finally, the products were packaged and delivered.

The materials, auxiliary materials and operating materials in the target process were shown in the followings:

- Materials: adhesive compounds, original fabric films and semi-finished products;
- Auxiliary materials: additives, laminate films, double-sided films and corner labels; and
- Operating material: organic solvents, releasing agents and paper tubes.

(3) Description of material losses

The material flow cost matrix for the subject process is shown in Table 3.1.

Table 3.1 Material flow cost matrix

	Material cost	Energy cost	System cost	Waste management cost	Total
Product	40,300,000	2,700,000	8,900,000		51,900,000
	53.3%	3.6%	11.8%		68.7%
Material loss	16,600,000	1,600,000	5,400,000		23,600,000
	22.0%	2.1%	7.1%		31.2%
Disposed/recycled				90,000	90,000
				0.1%	0.1%
Subtotal	56,900,000	4,300,000	14,300,000	90,000	75,590,000
	75.3%	5.7%	18.9%	0.1%	100.0%

As indicated in Table 3.1, the percentage of the material loss per the initial input by cost ratio is 31.2%.

(4) Findings through MFCA analysis

Adhesive compounds consisted of adhesives, solvent, and additive, and antibacterial agent. Among all these materials, only 22% of the solvent flowed to a next process; remaining 78% of the solvent became material loss. On the other hand, original fabric film in the painting and edging processes represented the most significant ratio of the input material cost or 30 million yen (approximately 9% of the material loss). In the stacking, laminating and cutting processes, cut-loss represented approximately 5 million yen/year or 18% of the input materials became material losses.

(5) Targeted points to be improved or improvements based on MFCA analysis

Based on the MFCA analysis, 11 improvement measures were raised. Through the MFCA-based simulation, material-loss costs were expected to decrease from 31.2% to 27.5% through the following improvement measures:

- Reduction of organic solvent gas through rectification of solvent blending volume; and
- Reduction of material losses by replacing two types of coating cloth with one type; and
- Use of the thinner film in the coating and aging processes.

(6) Conclusion

Cost-effectiveness analysis was conducted for the three measures noted in Clause 5. This revealed that the amount of material losses could be reduced from 31.3% to 27.5%. Through implementation of MFCA, all material losses in the process were clarified. Especially, it was very meaningful to identify hidden cost related not only to materials but also to system and energy. Moreover, the product costs per square meter of products were clarified, which enabled simulation of the investment impacts. In this project, the scope was limited to a single site. The company intends to expand MFCA company-wide to further promote environmentally-friendly management.

Case 4 TOYO INK MFG. CO., LTD.
Production characteristics: MFCA implementation in production of coloring pellets for plastic

(1) Organizational profile

TOYO INK MFG. CO., LTD. (hereafter referred to as "Toyo Ink") was involved in development, manufacturing, and sale of the various products including the followings:

- Printing ink and related equipment;
- Can coating;
- Resins;
- Adhesives;
- Adhesive tape;
- Colorants;
- Colouring pellets for plastic; and
- Ink jet ink.

Toyo Ink positions safety management and environmental conservation as its most important themes. MFCA was implemented as the aforementioned themes are consistent with their activities to thoroughly eliminate losses at a manufacturing stage to promote energy-saving and resource-saving policies. The company's employees numbered 2,123 on a non-consolidated basis and 6,860 on a consolidated basis. The company's sales were 239.814 billion yen on a consolidated basis (FY 2008). The capital was 317.33 million yen.

(2) Products and processes subject to MFCA implementation and their characteristics (material flow model of main target processes)

Coloring pellets and large manufacturing lines that produce lot sizes greater than 500kg were selected for MFCA analysis. The extrusion molding process (OC1) consisted of mixing of colorants, extrusion molding, inspection, and filling processes, and switching process (OC2) which involved cleaning activity for an extruder at the end of each production as shown in Figure 4.1. As the four production processes in the extrusion-molding process were implemented successively, they were grouped together as a single quantity centre (QC1).

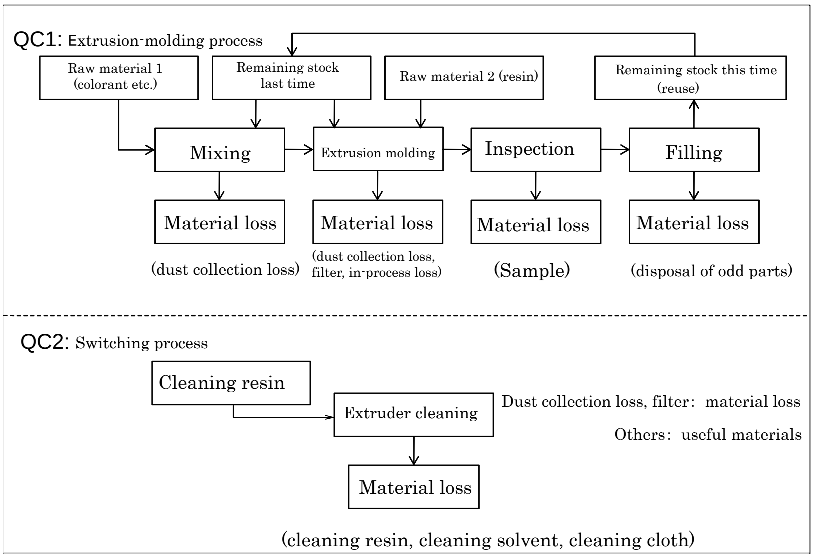


Figure 4.1 Input/output per quantity centre

(3) Description of material losses

The following losses were identified from each process:

- Mixing process: dust collection loss;
- Extrusion-molding process: dust collection loss, filter, and in-process loss;
- Inspection process: sample products;
- Filling process: disposal of odd parts; and
- Switching process: cleaning resin, cleaning solvent, cleaning cloth.

MFCA data were defined in the following way:

- Actual values collected from on-site activities were used with regard to raw material blending ratio, raw material unit price, total amount of processed materials (remaining added from the previous process), total amount of materials added (including remaining materials), total amount of finished materials (including remaining materials), amount of remaining materials, amount of mill end waste, amount of samples, processing time, and switching time;

- Allocated data of total values from a company-wide operation were used with regard to amount of collected dust, in-process loss, cleaning resin, cleaning materials, and cleaning cloth;

- System costs (SC) included labor costs, depreciation costs, other expenses, and allocation-related operational costs. The product-related SC costs were the allocated cost out of 95% of the costs related to the extrusion molding process. The SC costs for material losses were the allocated costs out of 95% of the costs related to the extrusion molding process plus the costs related to switching-process; and

- Energy costs (EC): Electricity costs represented energy costs in the process. 95% of the electricity costs were assigned to the extrusion molding process and 5% of the costs were assigned to switching process.

(4) Findings through MFCA analysis

Material loss was found to be only 2.2% of the direct materials in the extrusion molding process, being increased to only 2.7% even with incorporation of material losses related to indirect materials and those generated in the switching process.

- QC1: extrusion-molding process
  - 97.8%i of raw materials and remaining materials from the previous process became product, and 2.2% became material losses (i.e., remaining materials, dust, sample, disposal of edged parts, and in-process loss); and
  - All of filters input to the process as indirect materials became material losses.

- QC2: Switching process
  All of the input cleaning resin, cleaning solvent, and cleaning cloth became material losses.

The ratio of the material loss cost was 7.2%. This consisted of material costs (MC) that accounted for 2.0% and SC that accounted for 5.1% of its cost, indicating that the loss cost ratio of SC was more significant.

Table 4.1 Material flow cost matrix

	Material cost	Energy cost	System cost	Waste Manage-ment cost	Selling price for recycled materials	Total
Product	77.4%	1.7%	13.7%			92.8%
Material loss	2.0%	0.1%	5.1%			7.2%
Waste/Recycle				0.1%	0.0%	0.0%
Total	79.3%	1.8%	18.8%	0.1%		100.0%

(5) Targeted points to be improved or improvements based on MFCA analysis

In order to improve switching time, yield ratio, and manufacturing time (processing speed), MFCA data per lot was collected for a further analysis. A study of ten products that takes more than nine-hour for switching process revealed that all parts were disassembled and rinsed as switching was conducted from a darker color to a lighter color. This process can be improved through preparation of spare parts and planning for lump production. For products with lot sizes of less than approximately one-ton, the yield ratio was identified to be particularly low where frequent replacement of the extruder filter occurred for two of these products. Such process can be improved through planning of lump production and coloring inspection by preceding samples. The reason for low processing speed was resin viscosity and coloring density. Increasing processing speed made stable production difficult, leading to an increase in material loss. Therefore Toyo Ink will consider alternative measures from an equipment perspective.

(6) Conclusion

It had been considered that the production line selected for this project did not generate excessive material losses. However, through the MFCA analysis, rooms for improvement were revealed in switching time, yield ratio, and processing speed. MC from cleaning resin etc. and SC and EC for the material losses were highlighted.

In the future, Toyo Ink will utilize MFCA to conduct assessment of impact and profit related to improvements, to raise loss awareness, to unify various management activities, to respond to process abnormalities, to clarify and prioritize issues for improvement, to cost each product, and to conduct LCA analysis for an operational line.

Expanded application of MFCA in an internal production line will be also considered. As a future issue, innovation will be necessary in ensuring that the data input activities for the MFCA analysis will not be overlapped with existing management activities. Also, specific attention should be paid to SC for the material losses, as improvement measures will not immediately lead to reduction in SC.

Case 5 Sumitomo Chemical Co., Ltd.
Production characteristics: MFCA introduction case in chemical works

(1) Organizational profile

Sumitomo Chemical Co., Ltd. constitutes a comprehensive chemical company that consists of six group companies in the basic chemicals, petrochemicals & plastics, fine chemicals, IT-related chemicals, agricultural chemicals, and pharmaceutical sectors.

In this MFCA introduction, the target was the manufacturing of fine chemical products. In order to manufacture high quality chemical products, ingredients of high purity are needed, and a large amount of solvent waste and waste fluid are generated to prevent and dispose impure substances, e.g., non- and partially-reacted substances. The company introduced MFCA, aiming to reduce amount of the solvent waste and waste fluid which contributes to increased negative environmental impacts, while ensuring the quality. It is necessary to widely analyze the process considering the environment, the processing technology, accounting, and production management, etc. Led by an executive officer, the project was conducted by the team consisting of production planning (in charge for accounting), the manufacturing department, the environmental safety department, and the responsible care office of the headquarters.

As of March 31, 2010, the whole company employed 5,954 people, and had sales of 719.1 billion yen (FY 2009 results) and a capital of 89.699 billion yen on a non-consolidated basis.

(2) Material flow model of main target process/es

(i) Target product and scope of process

The subject product was a pharmaceutical intermediate in the field of fine chemicals, and the target was the manufacturing process associated with the subject product.

(ii) Manufacturing process and quantity centre

− Manufacturing processes consist of the following operations:

i) The catalyst is added and heated for reaction after the solvent, raw materials A and B, and the collected solvent are all put in a reaction vessel.
ii) The catalyst is collected upon termination of the reaction.
iii) Product C is extracted, and then filtered for extraction of the product.
iv) The solvent is collected by distillation. At this point, the residue and the waste fluid in the distillation boiler needs to be processed as waste.
v) After manufacturing several batches of the pharmaceutical intermediate product, the tools associated with the process, such as the container and other equipments, are all rinsed with solvent and water.

− Definition of quantity centre

Manufacturing of the target products are conducted in a series of processes that include reaction, catalyst collection, and filtration. This series of processes are defined as one quantity center "Reactive process (QC1)."

In switching between types of products, reaction containers and process facilities are washed. During the washing process, a large amount of waste fluid is generated. As a consequence, the necessity for improvement is high.

Therefore, to evaluate material loss during washing associated with switching, a quantity center named "Switch-cleaning process (QC2)" was established.

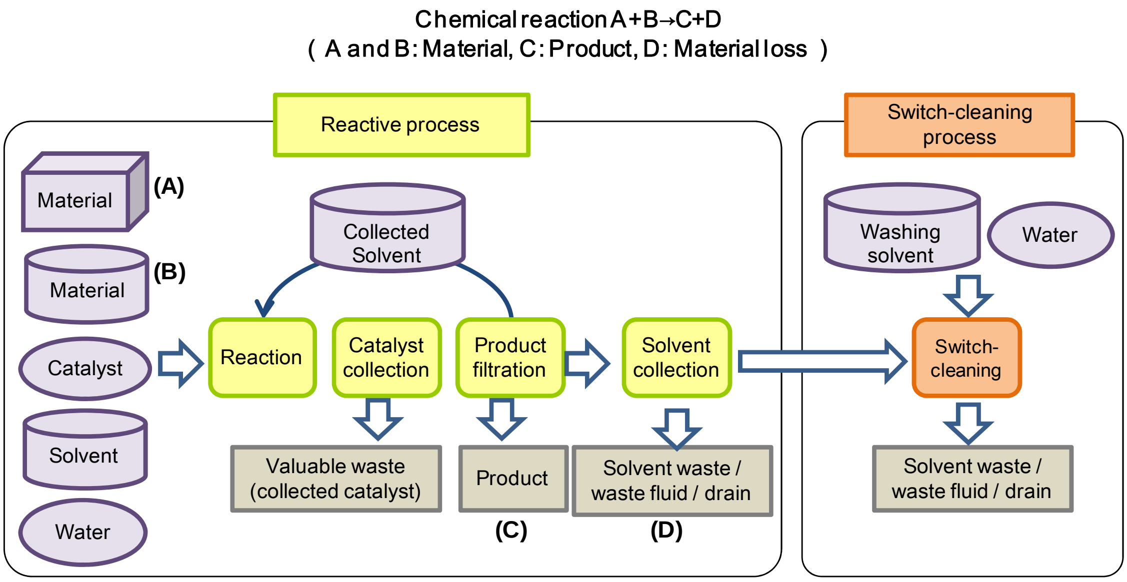


Figure 5.1 Input/output of each quantity centre

(3) Description of material losses

(i) Material loss at each quantity centre

- Reactive process (QC1): Solvent waste, solvent collection, waste fluid, drainage, and catalyst residue, etc.
- Switch-cleaning process (QC2): The whole quantity of washing solvent and water used

(ii) Definition of MFCA data

- Material: the products from raw materials A and B and material loss are calculated based on the reaction yield. All indirectly used materials such as solvents and catalysts, solvents for washing, and water are defined to be material losses. The water supply used includes the process water and municipal water which are defined to be one of the materials.
- System cost: A total fixed cost for product C is calculated, taking into account the portion of equipment used in producing C.
- Energy cost: A gross volume is calculated by the numerical value of the energy intensity for each product, and the allocation of the energy costs to QC1 and QC2 is made by the number of the days that are necessary for each production series.

(4) Findings through MFCA analysis

(i) Table of material losses and its explanation

As shown in Table 5.1, the reactive process (QC1) and the switch-cleaning process (QC2) generate substantial material losses. Especially, in QC2, all input materials become material losses.

In addition, the difference between the input and output of the raw materials (A) and (B) and the solvent (new) is the drainage and a waste fluid.

Table 5.1 Input/output of material

	Input	Quantity (kg)	Output	Category	Quantity (kg)
QC1: Reactive process	Material (A)	780	Product (C)	Product	1,250
	Material (B)	650			
	Solvent (new)	1,200	Solvent waste	Material loss	500
	Collected solvent	8,200	Collected solvent	Material loss	8,200
	Process water	7,300	Waste Water	Material loss	7,380
			Waste solution	Material loss	800
	Catalyst	20	Collected catalyst	Valuable waste	15
			Catalyst residue	Material loss	5
	Total input	18,150	Total output		18,150
QC2: Switch-cleaning process	Washing solvent	900	Solvent waste	Material loss	1,700
	Process water	1,300	Drainage	Material loss	500
	Total input	2,200	Total output		2,200

(ii) MFCA Cost Evaluation

The cost of the material loss in the reactive process (QC1) accounts for 13.8% of the total cost, the highest portion of the total cost.

The cost of the material losses in the switch-cleaning process (QC2) accounts for as much as 87.1% of the total cost.

Table 5.2 Material flow cost matrix
(Figure is in the unit of JPY 1,000/batch.
Profits from sale of the waste and waste fluid are excluded)

	Reactive process (QC1)					Switch-cleaning process (QC2)				
	Material cost	Energy cost	System cost	Waste management cost	Total	Material cost	Energy cost	System cost	Waste management cost	Total
Product	5,610	130	2,600		8,340	0	0	0		0
	54.2%	1.3%	25.1%		80.6%	0.0%	0.0%	0.0%		0.0%
Material loss	1,430	30	520	30	2,010	90	70	1,350	40	1,550
	13.8%	0.3%	5.0%	0.3%	19.4%	5.8%	4.5%	87.1%	2.6%	100%
Subtotal	7,040	160	3,120	30	10,350	90	70	1,350	40	1,550
	68.0%	1.5%	30.1%	0.3%	100%	5.8%	4.5%	87.1%	2.6%	100%

(5) Targeted points to be improved or improvements based on MFCA analysis

With respect to loss reduction, it is probably effective to minimize material loss by improving the yield ratio and reducing waste generation during the reactive process, and to lower the system costs by shortening the washing time and decreasing manual operations in the switch-cleaning process.

(6) Conclusion

In the manufacturing process of the fine chemical products, the production management during washing and the refinement process is especially important in maintaining high quality, and a lot of waste fluids and waste are consequently generated. As a “more effective evaluation approach” for the subject business characteristics, it is considered that MFCA has the potential for conserving energy and resources, and reducing the negative environmental impact.

As the next step, the inventiveness and collective experience of the company’s personnel will be sought for the easy and frequent use of the MFCA approach within the company.

At this project, the application of MFCA was attempted to a pharmaceutical intermediate. In the future, the company would like to conduct the same evaluation to other products and perform a detailed analysis of the cost composition and a comparative study among products to clarify the product characteristics and issues inherent in the products, and to achieve a concrete loss reduction.

Case 6 Mitsubishi Tanabe Pharma Corporation
Production characteristics: Low-volume production of various medical products

(1) Organizational profile

Mitsubishi Tanabe Pharma Corporation manufactures medical products. The facility is located in Sanyo Onoda-shi, Yamaguchi, Japan. The total factory employees numbered 10,330 on a consolidated basis as of the end of March. The company's sales were 414.752 billion yen with a capital of 50 billion yen. The selected process for this project was a production line of a medical product.

(2) Material flow model of main target process/es

Material flow model of the selected process is shown in Figure 6.1 below:

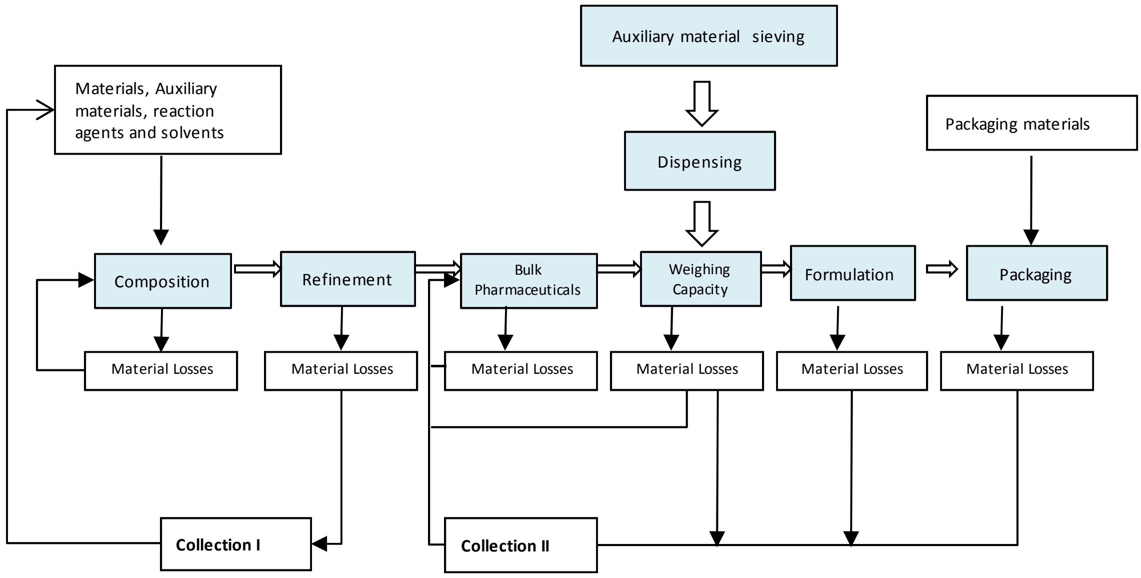


Figure 6.1 Material flow model for the main target process (MFCA boundary)

Main materials, auxiliary materials, operating materials, solvents and packaging materials were involved in the subject process. Wastes, waste fluid and solvents-sourced air emissions were generated as material losses from the process. Each phase of operations shown in Figure 6.1 was defined as quantity centre (QC).

Characteristics of the manufacturing process included the followings:

- Manufacturing of various medical products in small volumes;
- Mixed use of common equipments and specific equipments for a certain medical product; and
- Presence of recycling process.

(3) Description of material losses

Material loss costs, energy costs, system costs and waste management costs were calculated in the following way:

- Material costs: Gaps between theoretical value and actual value based on the molecular-weight calculation were considered to be material losses. For those materials that only became material losses, their calculations were separately made;

- Energy costs: Energy consumption by each department was allocated to each QC by machine-hour. Subsequently, the losses were calculated and understood based on the material distribution percentage;

- System cost:

  - Labor costs: Labor costs were calculated in man-hour by each QC. Subsequently, the losses were calculated based on the material distribution percentage;

  - Equipment costs: Equipment costs encompassed depreciation and maintenance costs. The equipment costs were allocated to each QC. Subsequently, the losses were calculated, using the following formula:

    Equipment-cost per QC x [1 – (machine-hour/24 hours x 356 days)]; and

  - Other system costs: Other system costs were calculated by subtracting labor cost, equipment cost, energy cost, and waste management cost from the indirect manufacturing cost.

- Waste management cost: Waste fluid was considered to be waste for management. Waste management cost was calculated in each QC based on the volume of the waste fluid for management and incineration.

(4) Findings through MFCA analysis

Table 6.1 shows the material flow cost matrix based on the MFCA data collection.

Table 6.1 Material flow cost matrix

(Unit: JPY1,000)

	Material cost	System costs and service related cost	Waste management cost	Subtotal
Product	¥ 371,748	¥1,296,134	¥ 0	¥1,667,882
Material loss	¥ 586,761	¥ 628,345	¥ 157,836	¥1,372,942
(For waste)	(¥346,210)	(-)	(¥157,836)	(¥ 504,046)
Total	¥ 958,509	¥1,924,480	¥ 157,836	¥3,040,825

Table 6.2 Material flow cost matrix by type of cost and QC

Costs \ Quantity Center	Composi-tion	Refine-ment	Bulk Pharma-ceuticals	Weighing Capacity	Formula-tion	Packaging	Total
Material cost	¥259,330	¥207,996	¥34,483	¥20,437	¥23,737	¥40,778	¥586,761
(For collection process)	(¥125,510)	(¥88,762)	(¥2,116)	(¥19,591)	(¥3,038)	(¥1,535)	(¥240,551)
(For waste)	(¥133,821)	(¥119,234)	(¥32,368)	(¥846)	(¥20,699)	(¥39,243)	(¥346,210)
System cost	¥118,770	¥33,535	¥113,308	¥24,484	¥113,228	¥213,744	¥617,070
Service related cost	¥7,041	¥806	¥3,174	¥6	¥81	¥167	¥11,276
Waste management cost	¥126,048	¥2,100	¥23,868	–	¥1,941	¥3,879	¥157,836
Total	¥511,189	¥244,437	¥174,833	¥44,927	¥138,987	¥258,568	¥1,372,942

(5) Targeted points to be improved or improvements based on MFCA analysis

As a result of the MFCA analysis, processes that incurred the significant waste management cost and the material loss cost were identified:

- Waste management costs in the composition process were identified to be 126 million yen; and
- The costs for material losses from the composition to the bulk pharmaceuticals processes amounted to be 285 million yen.

First priority was placed on reduction of the aforementioned waste management costs, as cost reduction was considered to be easily achieved. Considering various countermeasures, change in the initial investment decision in chloroform adsorption collection (investment amount: approximately 66 million yen), alteration of manufacturing operation that promoted chloroform collection, and alteration of waste treatment practices were selected. Based on the FY 2003 performance, the following impacts were simulated:

- Impact related to alteration of the waste management practice
  The factory-wide waste fluid incineration treatment was changed; activated sludge treatment was adopted. Change of the practice reduced the waste management cost and collected more chloroform for reuse. This measure led to an annual economic benefit of approximately 54 million yen (including annual energy-saving benefit of approximately 33 million yen).
- Significant reduction of chloroform emissions
  Historically, 96% of the chloroform emission was collected for reuse, but the rest was emitted as waste gas or fluid. Investment in a chloroform-collecting equipment further reduced emissions of the waste gas. Consequently, a significant more emissions reduction (73% reduction) was achieved than initially targeted in the company's Environmental Voluntary Action Plan that aimed at reduction by 10% below the FY 1999 emissions level by FY 2003.

- Significant reduction in CO_2 emissions

  As a result of review of the waste management practice, it was decided that the waste liquid incineration treatment was completely halted. This led to annual CO_2 emissions reduction of 2,328 tons. This amounted to be 41% of the CO_2 emissions-reduction target set in the company's Environmental Voluntary Action Plan that aimed at 10% reduction (5,647 tons per year) below the FY1999 level.

(6) Conclusion

As shown in this case example, MFCA was considered to be extremely effective in identifying material losses and to practically assist an organization's environmental management. Furthermore, it was also noted that the most critical issue in the MFCA implementation was difficulty in its calculation at the introduction phase. In order to overcome this issue, we introduced a system using the mission-critical enterprise system called "SAP R/3". This system enabled the automatic MFCA calculation for all the products manufactured at the Osaka factory, the Onoda factory, and the Tanabe Seiyaku Yoshiki Factory Co., Ltd. However, there remain issues including an effective MFCA introduction of newly merged company sites and application of MFCA for a supply chain.

Case 7 Canon Inc.
Production characteristics: Dissolution, molding, machining (cutting-out, pressing and grinding), and rinsing of lens material

(1) Organizational profile

One of the products manufactured by Canon Inc. (hereafter referred to as "Canon") is the lens used for single-lens reflex camera and broadcast camera. The company's lens-manufacturing factory is located in Utsunomiya, Tochigi, Japan. The total employees of Canon numbered 25,412 as of the end of 2008. The company's sales were 2,721.194 billion yen with a capital of 172.746 billion yen.

The process selected for this project was a manufacturing process of lens products used for cameras. Canon successfully achieved to introduce MFCA through collaboration with its supplier in order to concurrently reduce cost and environmental impacts by technological innovation.

(2) Material flow model of main target process/es

Sources of material losses are described below:

i) Manufacturing process by a glass-processing manufacturer: both cutting-out and pressing were conducted by a supplier. These processes generated a significant amount of material losses; and

ii) Lens-manufacturing process at the Canon Utsunomiya factory: approximately 50% of the cut-out material and approximately 30% of the pressed material became material losses. At the same time, a significant amount of operating materials such as cutting-oil and grinding-material also became material losses.

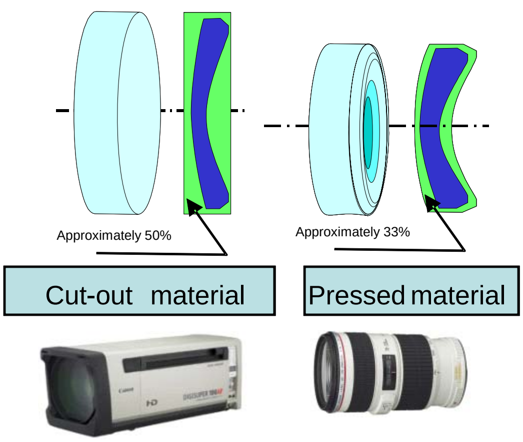
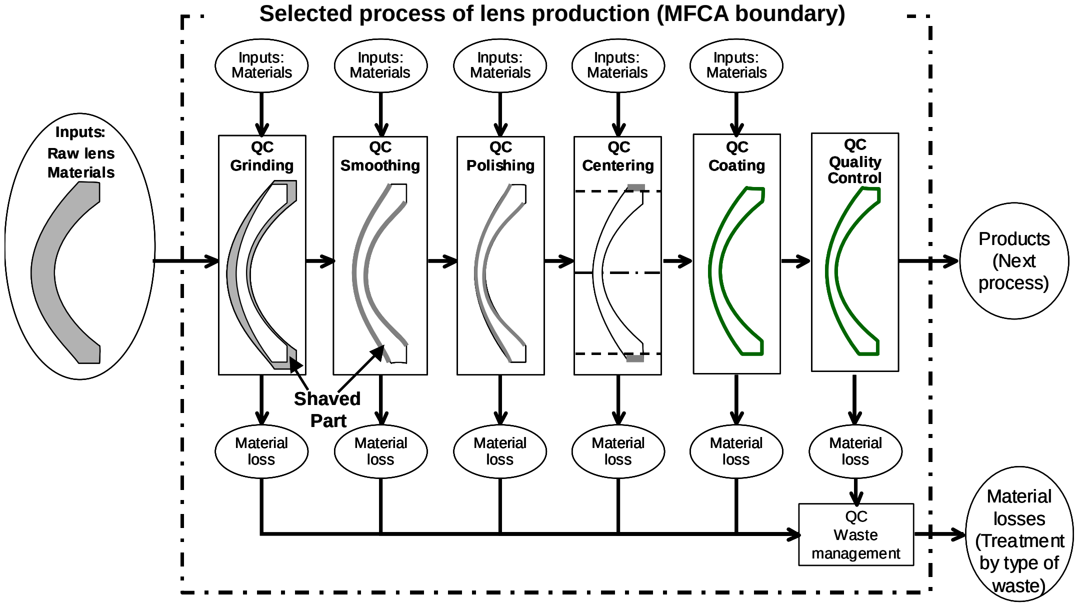


Figure 7.1 Image of products and materials

Material flow model of the selected process is illustrated in Figure 7.2 below:



QC: quantity centre

Figure 7.2 Material flow model of the selected process (MFCA boundary)

(3) Description of material losses

The types of material losses included the following:

- Sludge from cutting and grinding wastes generated in the cutting out and pressing processes in supplier;
- Sludge generated from the grinding and other processing of glass material in Canon; and
- Operating materials that were managed along with sludge upon disposal.

(4) Findings through MFCA analysis

Conventional production management and MFCA analysis indicated the following results:

- Conventional production management
  - Pressed material: yield rate 99% (i.e., loss 1%), and
  - Cut-out material: yield rate 98% (i.e., loss 2%).

The conventional production management tools were based on the number of final products. However, because MFCA highlighted the gap between input amount and output amount (product and material loss) in consideration of mass balance, significant room for improvement (i.e., significant opportunity for reduction of costs and material losses) was revealed by the MFCA analysis as indicated in the followings:

- MFCA analysis
  - Proportion of material loss,

- Pressed material: approximately 30%, and
- Cut-out material: approximately 50%.

Result of the calculation in the case of the pressed material is illustrated in Figure 7.3:

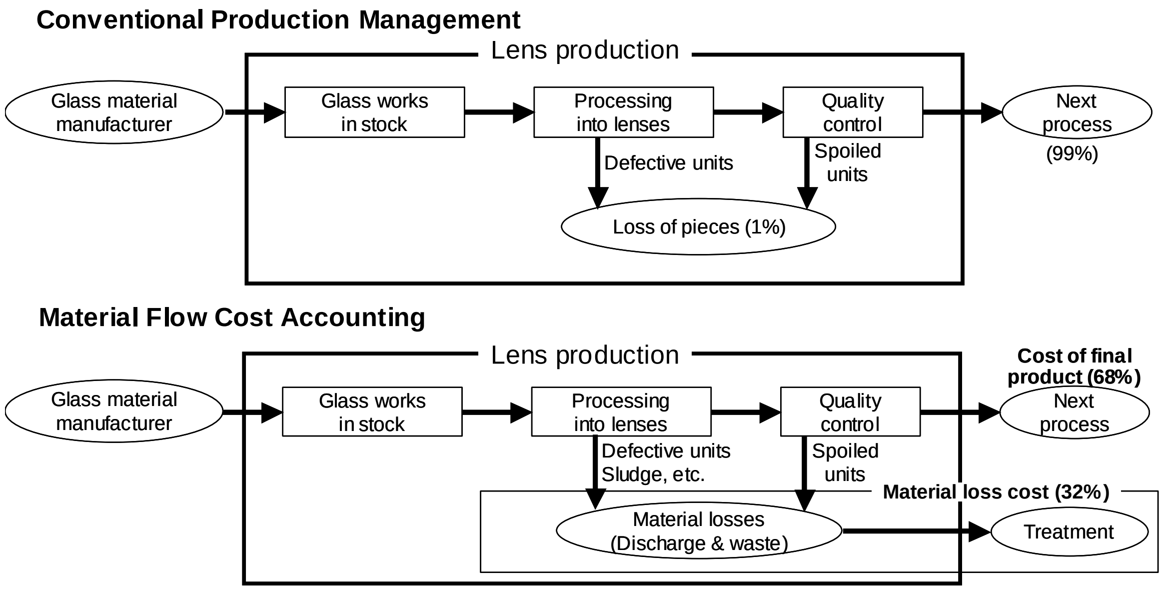


Figure 7.3 Comparison between conventional production management and MFCA

(5) Targeted points to be improved or improvements based on MFCA analysis

MFCA analysis was conducted through collaboration with the glass material supplier. Sharing material loss-related information, various measures for reduction of the material losses from the grinding process were discussed and the following measures were proposed:

- Near-shaping of the pressed material (lens for single-lens reflex camera); and
- Change from the cut-out material to the pressed material (lens for the TV broadcasting camera).

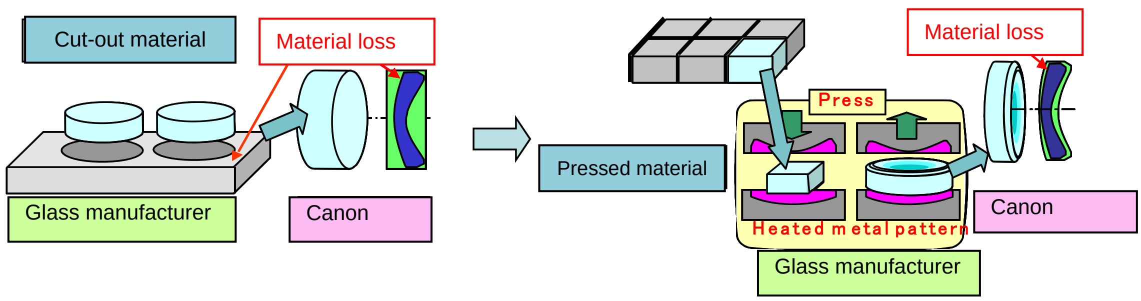


Figure 7.4 Conventional production and production based on new materials for lens production

Collaborating with the supplier, the new materials for the lens production called 'Near-shaping' was developed as shown in Figure 7.5.

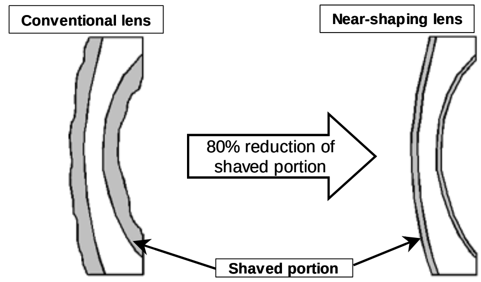


Figure 7.5 Figure of Near-shaping to reduce sludge in the process

(6) Conclusion

Improvements through MFCA analysis based on the comparison with the conventional manufacturing operation are shown below:

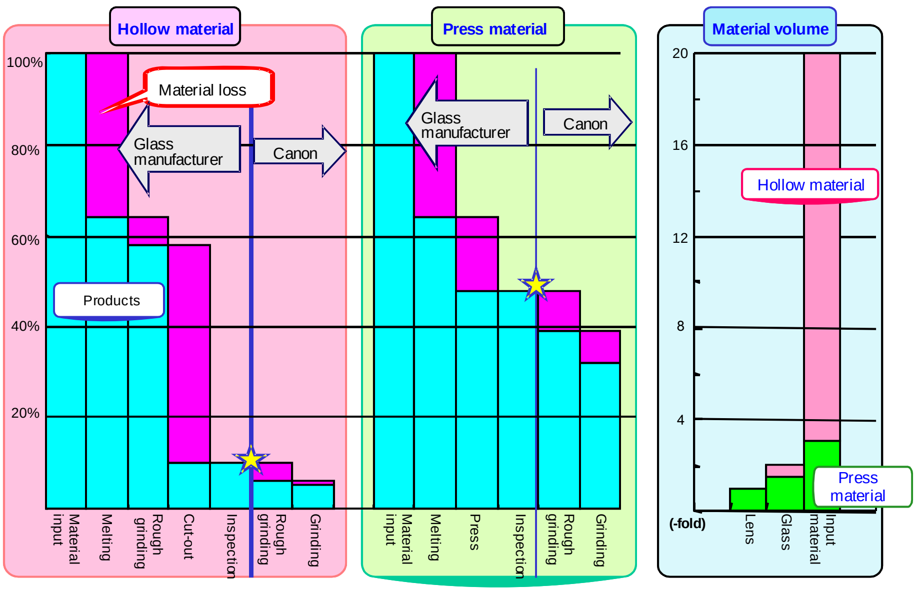


Figure 7.6 Impacts through MFCA analysis

(i) Positive impacts on the glass material supplier

Raw material input was reduced by 85% through improvements based on the MFCA analysis. Likewise, energy consumption was reduced by 85% and waste volume was reduced by 92%. Positive economic (increased cost-competitiveness) and environmental impacts were identified through various outcomes including reduced material use, and less energy consumption. In addition, as other positive impact based on the MFCA analysis, the working condition was improved through reduction of working hours in hot environment.

(ii) Positive impacts on Canon

The sludge volume was reduced by 50% through improvements based on the MFCA analysis. Furthermore, volume of oil and abrasive powder used in the grinding process were reduced by 40% and by 50%, respectively. Positive environmental impacts from less material, energy, and water inputs as well as less sludge generation were identified. Simultaneously, positive economic impacts were seen from reduced purchased price, less operations, less purchased amount of operating materials, less handling costs of sludge, waste oil and waste fluid. In addition, the frequency of on-site operations such as sludge treatment and replenishment of abrasive powder were reduced through improvements based on the MFCA analysis.

(iii) Positive impacts on the supply chain (the glass material supplier and Canon)

The glass material supplier and Canon shared the information related to material losses and cooperatively worked to reduce the losses. This collaboration brought about positive environmental, economic and technological impacts, enhancing market competitiveness and realizing a win-win relationship between the glass material supplier and Canon.

Case 8 Nagahama Canon Inc.
Production characteristics: Company-wide development of MFCA

(1) Organizational profile

As a member company of Canon Inc. group, Nagahama Canon Inc. (hereafter referred to as "Nagahama Canon") manufactures products including laser beam printers, expendable toner cartridges, and photoconductor drums for copying machines.

The management of the company decided to introduce MFCA, aiming to realize improvements in waste-generation sources. MFCA was initially implemented in processing areas and subsequently introduced to the non-processing workplace to achieve company-wide waste reduction.

The company employees numbered 1,339 as of June 2010. The company's sales were 53.4 billion yen with a capital of 80 million yen (FY 2009).

(2) Material flow model of main target process/es

(i) Product and range of process

MFCA was implemented for all products, including laser beam printers, toner cartridges, and photoconductor drums. In addition, it was implemented in all processes areas of the company including processing sites and non-processing sites.

(ii) Deployment method of MFCA

- Innovation for MFCA deployment at the processing workplace

  The company considered that on-site operators themselves needed to recognize the usefulness of MFCA and utilize it as a tool for improvement at sites. It also considered that MFCA would be embedded if MFCA implementation were achieved at the on-site level, in cooperation with the on-site staff, and together with a small-scale successful experience shared by the on-site staff. Therefore, the following four steps are taken to deploy MFCA at sites.

  Step 1: Training of expert staff

  Expert staff was assigned and a professional training was provided for them to help them acquire skills for MFCA analysis, deployment, and training.

  Step 2: Introduction to sites

  The company introduced MFCA at sites by using the following steps: conducting an initial analysis, examining the improvement plan, holding a debriefing session, and launching improvement. Departments including production technology, product technology, production management, procurement, and quality management were also invited to the debriefing session on a necessary basis. At the launch of the improvement plan, these departments were requested to cooperate by broadly understanding other departments and by matching their level of understanding of the current status.

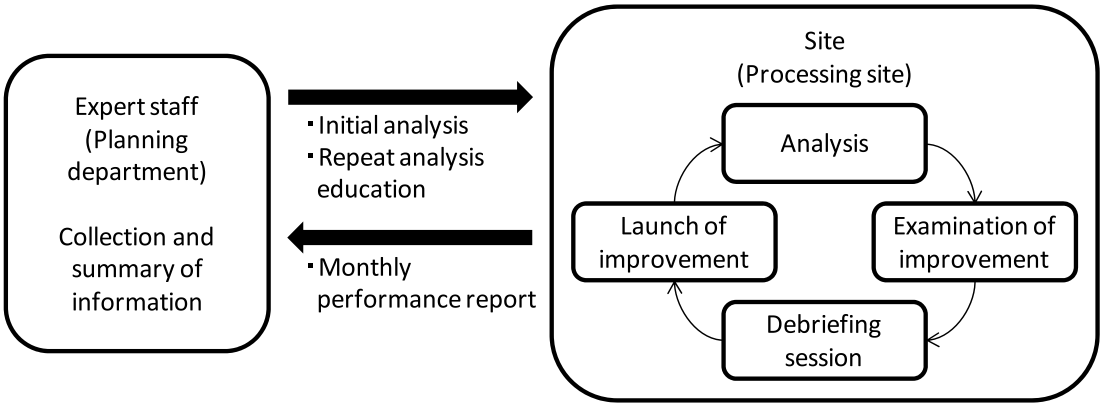


Figure 8.1 Structure of in-house MFCA deployment

Step 3: Dissemination to high-level employees

Training was provided to the management as well as the managers several times a year by utilizing the opportunity of the in-house managers' meeting. The MFCA topics ranged from the fundamental idea of MFCA to MFCA terms were explained.

Step 4: Dissemination to employees

MFCA was featured twice in the in-house quarterly newsletter in order to disseminate the idea of MFCA to the employees.

As the primary purpose and mission of sites is "Monozkuri (manufacturing)". If the staff is required to spare considerable time on MFCA analysis, a sense of stagnation tends to prevail at sites. Therefore, it is important to conduct MFCA analysis with minimum effort. Data such as daily/monthly reports, purchased goods data, expense budget information, manpower management data, entry and dispatch history of the stock, component transfer record, monthly inventory record, waste management record, and electric power data are available at the sites as well as the related operation areas. By utilizing these existing data effectively, the effort put on the MFCA analysis was significantly decreased.

– Innovation for MFCA deployment at non-processing sites

At non-processing sites, MFCA was developed using the MFCA macro-analysis, which was developed by Canon Inc. This technique uses detailed separate data and finds the possibility of improvement by directly tracking back to the site or process that generated waste, and clarifies the value and resource efficiency of the waste. Nagahama Canon introduced waste management at each department level from 2008, which enabled the smooth implementation of the technique.

As more than half of the wastes were generated at non-processing sites, significant reduction cannot be expected unless waste reduction is attempted at these sites. Therefore, the MFCA macro-analysis was conducted targeting papers, etc., which were used for product evaluation in the quality department, and wrapping materials, etc., which were used in the delivery of components or raw materials and for in-factory distribution. These account for a large part of company-wide waste and can both increase and decrease, corresponding to the production amount. The more the wastes are reduced, the more the outcome contributes to the management.

(3) Outcome

(i) Processing sites

- On-site motivation and effort were developed by reduction activities tracking back to the source of wastes that the management had considered an issue.
- Departing from defective products management, on-site load reduction was practiced by managing the management indicator best suited for the processing site.
- The accumulated effect of waste reduction was 132 ton, that of CO_2 reduction was 287 ton, and that of cost reduction was 128 million yen from 2005 (the launch year) to 2009.

(ii) Non-processing sites

MFCA macro-analysis became the catalyst in finding the clue for reduction in the distribution and quality departments, and began to function as a tool for resource productivity improvement from a company-wide perspective. Through this approach, the following measures were applied to the activities considered as issues by the management.

- Reduction activities tracking back to the source of waste and establishment of a mechanism to eliminate all kinds of loss; and
- Improvement of employee awareness on environmental friendliness and progress of activities with participation by all the employees.

(4) Conclusion

Nagahama Canon deploys MFCA at both processing and non-processing sites, and company-wide activities begins to progress. The next two issues in MFCA deployment are "implementation of retroactive application of the analytical outcome to upstream departments including R&D and production technology" and "total optimization based on analysis in the entire supply chain".

(i) Retroactive application to upstream departments such as R&D and production technology departments

In the area of yield improvement of main materials which eventually become products, areas for improvement by a single manufacturing site or factory are limited. The company considers it necessary to involve and seek corporation among the upstream manufacturing departments such as R&D and production technology.

An important future issue is to continuously appeal the analytical result of MFCA in the factory toward these related departments and to gain their understanding and cooperation. As a secondary side-approach, the company also considers it necessary to provide information to the cost management department, which monitors product cost over the complete life period.

(ii) Total optimization by analysis in the entire supply chain

Nagahama Canon produces end products by procuring components and raw materials from hundreds of suppliers. A supply chain is formed in the upstream of each material flow of each supplier, starting with the assembly manufacturer and followed by the second processing manufacturer, first processing manufacturer, and material/raw material manufacturer.

The company considers that by deploying MFCA in this company group within a supply chain, sharing MFCA analytical information between two companies positioned before and after one another (upstream/downstream) in the supply chain, and experiencing the trial and error process together, the possibility or extent of improvement by MFCA will further increase compared to that implemented by a single company.

In this case, the fundamental principle that the relationship of the companies in the supply chain that share analytical information of MFCA is always equal should be strictly followed.

Case 9 OMRON Corporation
Production characteristics: MFCA application in a group-based company

(1) Organizational profile

OMRON Corporation operates business in the fields of industrial automation, electronic components, automotive electronic components, social systems, and healthcare, etc., and its principle is “working for the benefit of society.”

The company constitutes a corporate group with many domestic and overseas offices. In 2002, the OMRON group established the “Green OMRON 21” vision to achieve corporate activities suitable for significance of its corporate existence. An environmental management vision and environmental action plan clarifying the planned activities and targets are specified in the vision.

OMRON’s mission is to utilize the business resources (people, goods, money, energy, and material resources) deposited by the society and to offer beneficial “products and services.” It is important to achieve an ideal balance between the ecology and economy to aim for the status of an environment-conscious leading company.

As an environmental approach to business, the OMRON group has adopted MFCA to analyze the amount and cost of material and energy loss (CO_2 emissions) generated during the production process and to reduce these through the in-processing activities.

The employees in the entire OMRON group numbered 36,299 (OMRON corporation: 5,133, domestic subsidiaries: 6,368, and overseas subsidiaries: 24,798) as of March 31, 2010. The company’s sales were 524.694 billion yen (OMRON group, FY 2009) with a capital of 64.1 billion yen as of March 31, 2010.

(2) Material flow model of main target process/es

(i) History of MFCA introduction to the model line

The company initiated a trial introduction of MFCA in 2006. The OMRON KURAYOSHI Corporation (currently the Kurayoshi Factory of the OMRON SWITCH & DEVICES Corporation), which is involved in component processing such as switch became a model factory for MFCA introduction. A production line that has pressing and molding processes is selected as a model.

As the price of copper used as pressing material soared in 2006, the high cost of raw material increased the pressure on the company’s profits and resource saving became urgent matter. Therefore, integrated improvement activities called gear-change activities are popular in OMRON KURAYOSHI Corporation, and the MFCA analysis is also selected to be one of the activities for the company engagement.

(ii) MFCA implementation and result in the model line

As the improvement activities are popular in the company, the collection of data for MFCA implementation was initially considered easy. However, another investigation had to be conducted as the existing data were not for weight but for quantity, and many datasets were unknown.

Actual analysis revealed that they had not measured scrap during pressing or mold runner wastes because the generation of such wastes was inevitable. When the amount of scrap wastes was annualized, a significant loss was identified. Another surprising point was that only 30% of the material became products.

As OMRON KURAYOSHI Corporation had already experienced a lot of improvement activities, its improvement approach after the visualization of loss was speedily implemented and it has achieved the result shown in Figure 9.1.

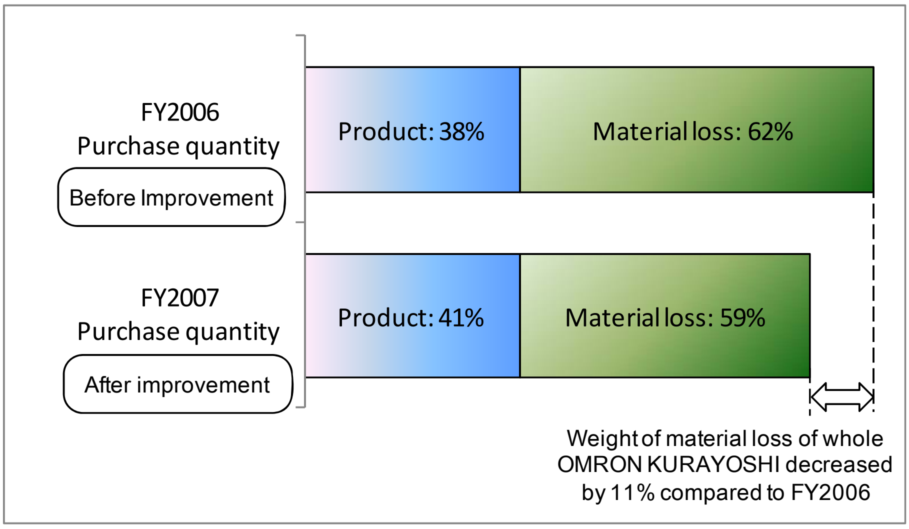


Figure 9.1 Comparison between the situations before and after the improvement

(3) Description of material losses

After its introduction in OMRON KURAYOSHI Corporation in FY2006, MFCA was also applied in other OMRON offices in FY2007. The MFCA implementation in 2007 covered not only visualization of material losses but also visualization of energy loss.

By collecting electricity waveform data in each facility unit and comparing them with the operation results, an obvious understanding was developed regarding electricity at the time of operation, loss of electricity when the facilitation was down, standby electricity, power factors, etc. Energy loss reduction was achieved by defining positive energy and negative energy and increasing transparency of energy loss. The analytical results also lead to a better understanding of the operating rate of the actual equipment and facilitate improvement in equipment productivity.

(4) Findings through MFCA analysis

Until FY2007, MFCA was implemented after improvement in the production process for the products being processed was evaluated. Therefore, the implementation was mainly related to the processing. This was due to the assumption that processing involves larger material loss and the scope for improvement is larger than in the assembling process; it is more reasonable in the trial stage or the early stage of the MFCA application.

According to the material loss factor analysis results for OMRON KURAYOSHI Corporation introduced in FY 2006, 95% or more of the loss was attributed to the design factor. In the punching process of metallic material by metal press dies and the molding process by molding dies, the main material loss factor was the design of the metal dies and equipments.

Therefore, the design improvement was emphasized as one of the targets in the offices that introduced MFCA in FY2008. According to the material loss factor analysis, a majority of the loss was incurred from the design factor. The dies and equipments were designed when raw material cost was relatively low, and at that time, lower cost and higher speed as well as easier components processing and assembling of equipment were more valued, while awareness regarding the importance of materials was limited. The result showed the significance of material loss.

(5) Conclusion

As shown in Figure 9.2, it is important to ensure that the product development, production technology, and manufacturing departments cooperate; likewise, it is important to ensure the application of MFCA in a supply chain as an outline of the future approach.

(i) MFCA approach from the development design stage

It is necessary to continue proposing improvements in the weight of material loss and cost information to the product development and production technology departments, while advancing improvements in material loss of the products being processed by the manufacturing department. Another important point is that the commercial product development and production technology departments utilize MFCA for their own problem-solving to accomplish technology and commercial product developments in order to improve material productivity.

(ii) MFCA implementation in a supply chain

Businesses that accomplish most of their processing in-house can easily understand and improve material loss. In contrast, businesses that outsource these processes require an approach to improve material productivity in a supply chain, and deploy MFCA for that purpose.

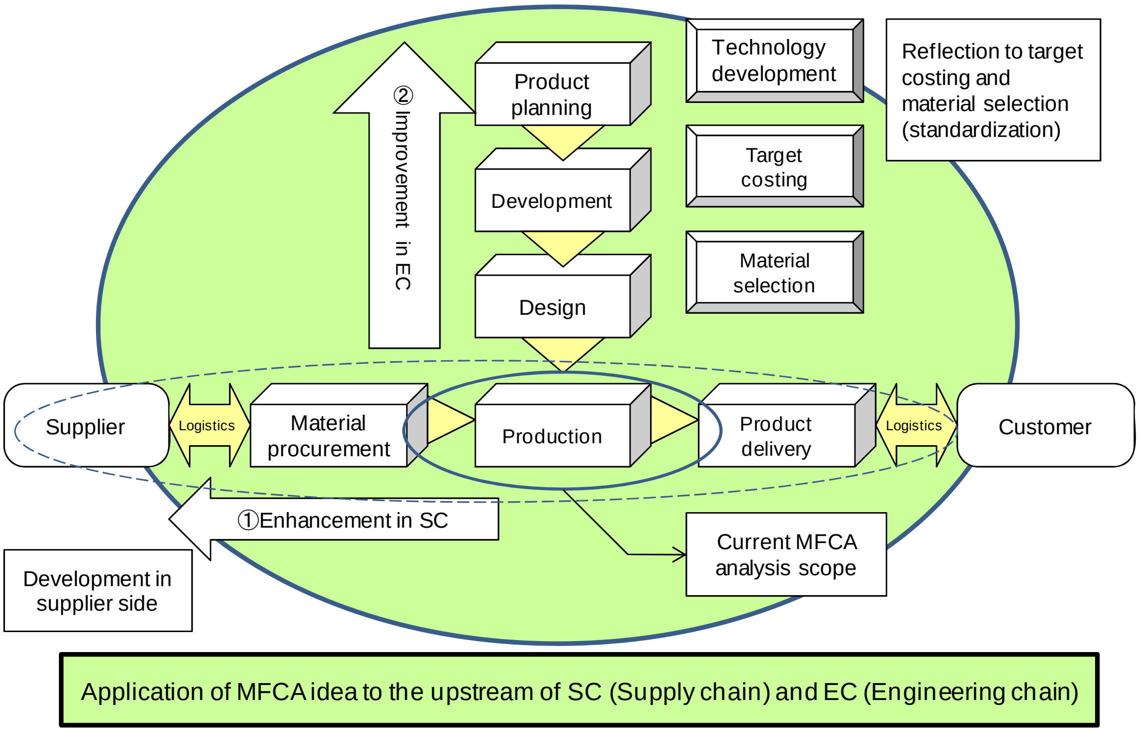


Figure 9.2 Overview of the medium- to long-term MFCA approach for the future

Case 10 TS Corporation
Production characteristics: Small-to-medium business and high-mix low-volume production by order

(1) Organizational profile

TS Corporation is located in Oyama-shi, Tochigi Prefecture, Japan. The total factory employees numbered 47 in 2007. The company's capital was 20.4 million yen. The process selected for this project was the manufacturing process of a stainless-steel.

(2) Material flow model of main target process/es

Figure 10.1 indicates the material flow and the selected process (MFCA boundary):

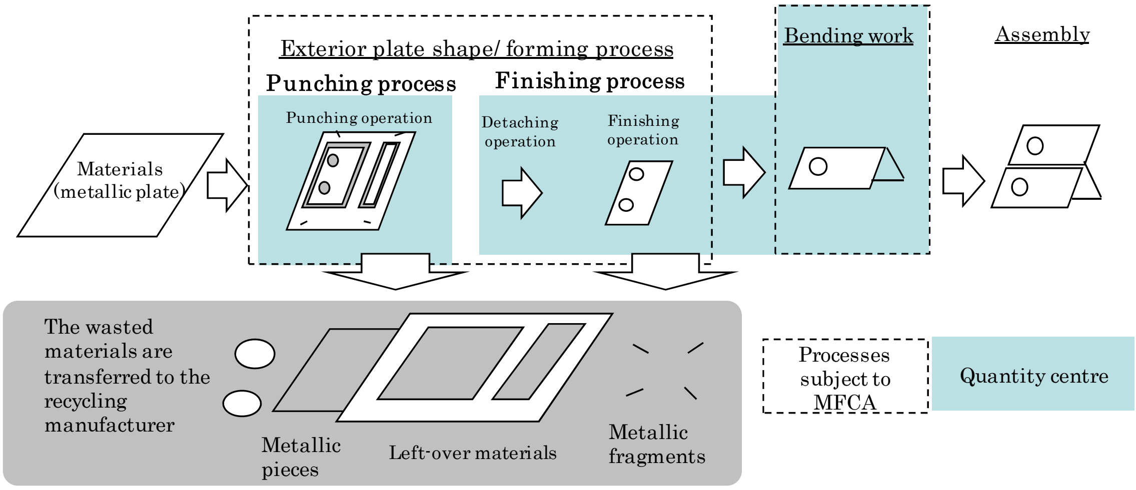


Figure 10.1 Material flow model of the main target process (MFCA boundary)

As shown in Figure 10.1, the process consisted of punching, finishing (detaching and finishing operations) and bending processes.

In this project, the punching process and finishing process were defined as a quantity centre. Further, raw metal plates were the subject material for MFCA analysis. System and energy costs were calculated by proportion of the number of raw material plates used for the process.

As a characteristic of calculation, in case of the made-to-order production or a wide variety of products in small quantities, multiple types of products were normally punched out from a single plate. Therefore, it was difficult to determine the raw material amount for a single product to conduct the MFCA analysis. In order to overcome this issue, the material flow per the single plate (sheet thickness 1.5mm) — the main raw material for the subject process — was traced.

(3) Description of material losses

Input and material loss at each stage of the manufacturing processes are described in the followings:

- Punching operation: Metallic fragments were generated as material losses. The fragments were gathered by material type and delivered to a recycling manufacturer;

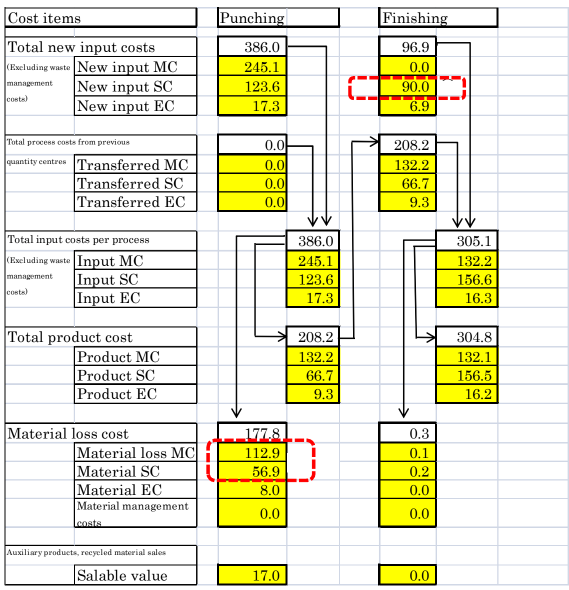
− Detaching operation: Left-over materials after the punching process became material losses. The materials were gathered according to type of material and delivered to a recycling manufacturer. In addition, if the left-over materials were large enough to be used for the production process, the left-over materials were re-input into the punching operation; and

− Finishing operation: After the detaching operation, protuberances at connecting points with the material plates were deburred by a file. Fine metallic powder was generated during this operation and became material losses.

(4) Findings through MFCA analysis

Table 10.1 Material flow cost matrix

	Material Cost	Energy Cost	System Cost	Disposal Cost	Total	Recycling selling price	Total
Products	132 27.3%	16 3.4%	156 32.4%		305 63.1%		305 65.4%
Material loss	113 23.4%	8 1.7%	57 11.8%		178 36.9%		178 38.2%
Disposal/recycling				0 0.0%	0 0.0%	-17 -3.7%	-17 -3.7%
Sub-total	245 50.8%	24 5.0%	214 44.2%	0 0.0%	483 100.0%		466 100.0%



NOTE Figures have been altered for publication. Figures are in units of JPY1,000.

Figure 10.2 Flow chart with data

It was found that costs for material loss accounted for approximately 40% of input costs, more than 60% of which were related to the input material. Also, it was found that majority of the material costs were from the punching process. Volume of the products was slightly less than 60% of the input materials, which was lower than the yield ratio calculated by the company.

(5) Targeted points to be improved or improvements based on MFCA analysis

Various improvement measures throughout all the operations were considered, including the followings:

- Introduction of a checking system for nesting operation (operation for setting a layout for punching multiple products from a single plate);
- Prioritization for manufacturing of repeatedly ordered products;
- Grouping of the multiple products for greater efficiency; and
- Adjustment of production-schedule at the phase of order-reception and order-placement.

(6) Conclusion

Although individual yield rates for every nesting had been known and managed prior to the MFCA application, the MFCA analysis made it possible to set clear targets for a total yield rate rather than the individual yield rates, and that the ground was fostered in which each employee was able to propose improvements from the operations that they were engaged in.

On the other hand, several issues for effective MFCA application were also identified, including the followings:

- Understanding of the purchase volume or usage volume of a wide variety of materials according to type; and

- Introduction of an automatic data output system for the NC turret punching-machine in order to reduce additional labor costs for transcription of nesting-design instructions by operators.

Case 11 Press manufacturer A
Production characteristics: Sheet metal processing improvement case in wide-variety-in-small-quantities production by MFCA

(1) Organizational profile

Press Manufacturer A is a medium-scale enterprise that develops and manufactures their own products such as inspection devices and abnormal substance separation equipment as well as original equipment manufacturers (OEMs) for other company's products. Recently, an outsourcing service has been deployed - this service covers everything from the design development to procurement and manufacturing all at once, and the products of many enterprises are characteristically manufactured in small lots at Press Manufacturer A.

By being eagerly engaged in productivity enhancement and environmental considerations, the company has improved productivity through the introduction of Industrial Engineering, ISO9001 for production and quality management, and ISO14001 for environmental management.

The introduction of MFCA at this project involves an examination of the yield ratio of material, and it aims to achieve further productivity enhancement, cost reduction, and environmentally friendly manufacturing. In addition, the company has been engaged in this project with the aim of ensuring that the person in charge at the site takes the cost side into consideration, and voluntarily works on the improvement.

The introduction of MFCA is led by the board member of the production department. Each section consists of production management, production, production technique, design, and procurement cooperates for improvement activities.

*Corporate information is not disclosed for this project.

(2) Material flow model of main target process/es

(i) Target product and scope of process

Inspection equipment was targeted for this project because this type of equipment is a representative product and the company received a lot of orders for it at the time of MFCA introduction (approximately 100 pieces of equipments per month). Moreover, a number of differently shaped parts are used because of the various designs. All body-manufacturing processes for the equipment where the material losses from input material are generated were subject to MFCA analysis.

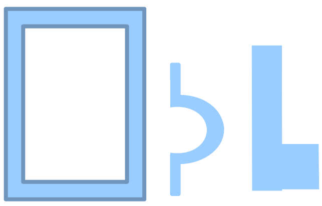


Figure 11.1 Example of differently shaped parts

(ii) Manufacturing process and quantity centre

− Outline of the manufacturing process of the target product

1. In the punching-press process, parts are punched from board material.
2. The punched parts are deburred.
3. Board parts are bent for transformation.
4. Spot-welding and welding are conducted and each part is connected.
5. External parts are polished for finishing.
6. Products are inspected prior to shipment to an assembly factory.

− Definition of quantity centre

The processes were divided into the punching-press process, in which a significant loss of the edged material was generated, and other processes in which defective products were generated.

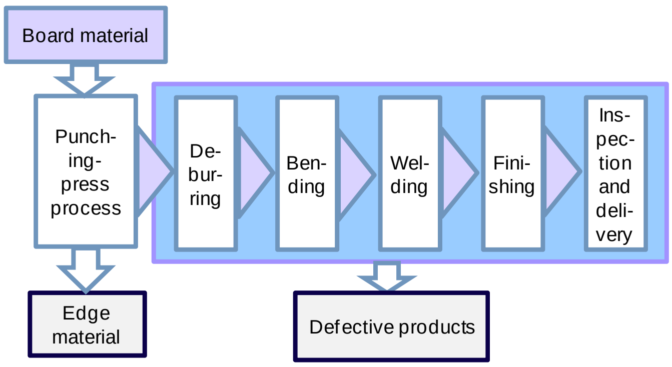


Figure 11.2 Input/output during body manufacturing process

(3) Description of material losses

(i) Material loss in the process

- In the punching-press process, the edge material of the board material is generated.

- In each stage of the chipping bur work, the inspection, and the shipment, defective products are generated.

(ii) MFCA data definition

- Physical quantity of material

Because production is conducted in a small amount with large variety, multiple parts are punched from a single board material. Therefore, the loss was a measure not of the units of parts but of each board by production order. Although the data produced by the nesting software is available, it cannot accurately indicate the loss because differently shaped parts are considered and calculated in a rectangle shape. Therefore, the loss was calculated with the ratio of the weights of individual parts and weights based on the assumption that the part was a rectangle.

- System cost and energy cost

The processing cost was calculated based on the manufacturing time of the target product.

(4) Findings through MFCA analysis

(i) Table and explanation on loss quantity

Punching-press process generated a particularly high rate of material losses. The loss rates of 3 × 6 boards and 4 × 8 boards are significant, as shown in Table 11.1, and the necessity for improvement is high.

Table 11.1 Material input/ output and defective products in the punching-press process

	15 machines	Weight calculation by MFCA using the net weight of products processed by the number of machines shown in the left cell					Defective product	
Type of board	Number of boards used	Weight of input per lot	Total weight of product per lot	Weight of loss per lot	Loss rate	Yield rate	Quantity	Weight
3X6 board	60	1,259,797.6g	610,054.8g	649,742.8g	52%	48%	2	555.2g
4X6 board	105	2,940,331.9g	1,866,823.8g	1,073,508.1g	37%	63%		
4X2000 board	150	918,638.4g	665,435.8g	253,202.6g	28%	72%		
4X8 board	15	559,910.1g	300,775.3g	259,134.8g	46%	54%	4	48.7g
Total		5,678,678.0g	3,443,089.7g	2,235,588.3g	39%	61%	6	603.9g

(ii) MFCA cost evaluation

Partly because of a significant amount of the input board material, the material loss costs for 4 × 6 boards are especially significant.

Table 11.2 Aggregated calculation of MFCA balance

Input						Output							
Total input cost				¥683,000		Product cost		¥414,000 61%		Material loss cost		¥269,000 39%	
Material	Material unit price (¥1,000/kg)	Amount (kg)	%	Cost (¥1,000)	%	Amount (kg)	%	Cost (¥1,000)	%	Amount (kg)	%	Cost (¥1,000)	%
3X6 board	0.085	1,259.2	22.2%	107.0	22.2%	610.1	10.7%	51.9	10.7%	649.7	11.4%	55.2	11.4%
4X6 board	0.085	2,940.3	51.8%	249.9	51.8%	1,866.8	32.9%	158.7	32.9%	1,073.5	18.9%	91.2	18.9%
4X2000 board	0.085	918.6	16.2%	78.1	16.2%	665.4	11.7%	56.6	11.7%	253.2	4.5%	21.5	4.5%
4X8 board	0.085	559.9	9.9%	47.6	9.9%	300.8	5.3%	25.6	5.3%	259.1	4.6%	22.0	4.6%
Subtotal of material amount and cost		5,678.1	100.0%	482.6	100.0%	3,443.1	60.6%	292.7	60.6%	2,235.6	39.4%	190.0	39.4%
System and energy cost				Cost (¥1,000)	%			Cost (¥1,000)	%			Cost (¥1,000)	%
Total process cost				200.0	100.0%			121.3	60.6%			78.7	39.4%
Subtotal of system energy cost				200.0	100.0%			121.3	60.6%			78.7	39.4%

(5) Targeted points to be improved or improvements based on MFCA analysis

The loss rate of the cutting plan can be understood from the numerical value through the introduction of MFCA, which was historically understood on feel. In particular, it is necessary to improve the cutting plan in the punching-press process. Countermeasures will be considered in consideration of its impact by simultaneous use of the Job Work Instructions and physical quantity calculation by MFCA. The improvement aspects involve the following three points:

- Change in board size, board thickness, and board changes (custom-designed material and fixed-scale material);
- Change in combination of the parts produced from one board; and
- Change in directions of the parts input into the processing machine.

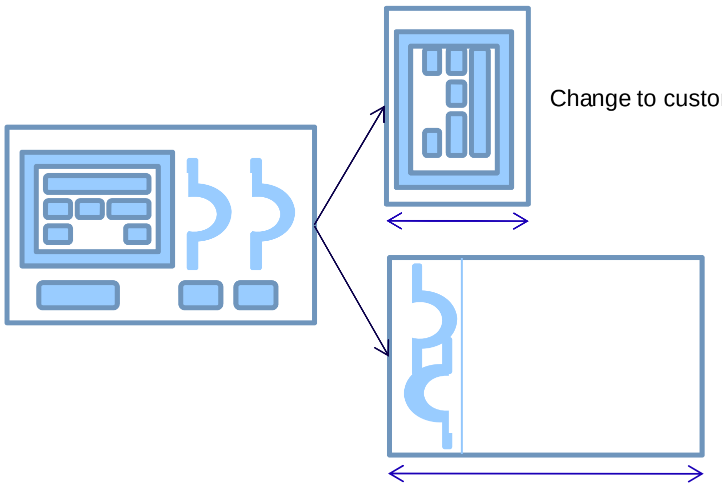


Figure 11.3 Example of improved cutting plan

(6) Conclusion

Establishment of a mechanism with which the actual material loss can be understood by the MFCA introduction is an important achievement. Previously, only the person in charge of nesting looked at the cutting plan; this information is now shared in-house to enable an understanding of material losses and employees began to be engaged in loss reduction. Further, through this activity, the person in charge voluntarily strives to improve material loss through this activity.

Press Manufacturer A is engaged in production of a variety of small lot products, and various products are manufactured that cover their own designed products to outsourced products. The MFCA application to other products will be necessary in the future.

In regard to products designed in other companies, the additional value of Press Manufacturer A will be realized through its proposals to customers from the viewpoint of “material loss.” In detail, the proposals consist of “Proposal of the selection of the material (board thickness and material),” “Proposal of low-cost processing based on examination of cutting approach for the board material,” and “Proposal in regard to the size and the shape of parts from the viewpoint of material loss.”

As for the products that are designed in-house, the cutting approach for board material and board thickness using the MFCA data at the design stage will be discussed.

In addition, in regard to outsourcing activity, MFCA calculation can also be used to determine parts for outsource manufacturing, and in this way material losses will be reduced in outsourcing material processing.

Case 12 Katagiri Seisakusho Co., Ltd.
Production characteristics: Manufacturing process of a cold forging product

(1) Organizational profile

Katagiri Seisakusho Co., Ltd. (hereafter referred to as “Katagiri Seisakusho”) manufactured precision cold forging, using cold forging technology, in order to manufacture automobile parts and other precision cold forging parts, as well as the manufacture and sale of super-abrasive tools. The company’s employees numbered 260 at the time of the project. The company’s sales were 4.5 billion yen (FY 2007). The company’s capital was 70 million yen (FY 2007).

The objective of this project was twofold:

- To establish an indicator for process improvement and cost reduction, and
- To connect it with the goals of enhancing quality, resource-saving, and energy-saving which are raised as ISO 9001 and ISO14001 policies, and to identify issues such as effective use of resources, productivity and quality improvements.

(2) Products and processes subject to MFCA implementation and their characteristics (material flow model of main target processes)

The target process was the manufacturing process for AT SOL housing. Further, the selected processes consist of the followings:

- Cutting process which involves cutting approximately. 4 m rod materials into several hundred materials using a round saw;
- Annealing process, lubrication process, and forging process which were repeated three times each;
- Machining process which involved machining to conform with drawing specifications of the client; and
- Heat treatment and plating process at an affiliated company, and the in-house inspection, and shipment (packaging) process.

Although the annealing, lubrication, and forging processes were conducted 3 times each and conducted at different locations, little material losses were generated from these processes; these processes were considered as one quantity centre (see Figure 12.1).

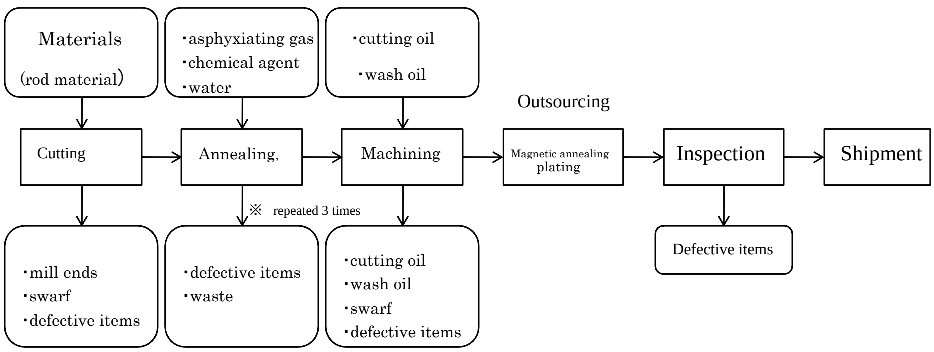


Figure 12.1 Input and output at each quantity centre

(3) Description of material loss

Following material losses were identified during the course of the project:

- Losses from each process
    - Cutting process: rod mill ends, swarf, defective items;
    - Annealing process: defective items;
    - Lubrication: water, chemical agent, steam;
    - Forging: defective items;
    - Cutting work: wash oil, swarf, defective items; and
    - Inspection: defective items.

- MFCA data definition
    - The volume of disposed mill ends generated from the cutting process was determined from the number of materials that could be obtained from one rod and the number of used rods after cutting;

    - As the annealing and lubrication processes treated other materials not included in this project, the time and volume of the material loss for this project was calculated from the number of treated items;

    - System costs included the machining oil and cutting blades used in cutting, the nitrogen gas used in annealing, heavy oil used for lubrication treatment (boiler), mold used in forging, and cutting tools used in machining;

    - Electricity costs that accounted for energy costs were aggregated for the entire factory, and were calculated by proportionally allocating them according to the number of the main equipments; and

    - Electricity costs for the annealing process which accounted for a significant proportion of the electricity consumption was calculated from the number of target products handled at the annealing process.

(4) Findings through MFCA analysis

As shown in Table 12.1, the most significant material losses were identified in the QC 3 (machining process) where 25% of the input materials became material losses. The next largest losses were identified in QC 1 (cutting process) where approximately 8% of the input materials became material losses.

Table 12.1 Material output volume

	Type of material cost	Item type	Units	QC1 Cutting	QC2 Annealing, lubrication, processing and forming	QC3 Machining	QC4 Outsourcing	QC5 Inspection/shipment
Output (Products)	Products (intermediate products) for next process	Quantity of products	kg	38603.5	345487.9	26841.1	27793.7	27535.2
Output (Material losses)	Emissions and wastes	Quantity of water, chemical agents, cutting oil, etc.	kg	16.2	1591.9	723	0	0
	Valuable materials	Quantity of main materials	kg	3569.3	69.7	9396.1	0	139.1

It could be seen from Table 12.2 that material loss costs (MC) accounted for a large portion of the material losses.

Table 12.2 Material flow cost matrix (units: JPY 1,000)

	Material cost	Energy cost	System cost	Waste management cost	Sub-total	Selling price for recycled materials	Total
Product	15,683.0	893.4	13404.4		29,980.9		29,980.9
	42.6%	2.4%	36.4%		81.5%		84.6%
Material loss	4,674.3	322.4	1,697.6		6,694.3		6,694.3
	12.7%	0.9%	4.6%	0.0%	18.2%	0.0%	18.2%
Waste/recycle				110.3	110.3	-1331.2	-1220.9
				0.3%	0.3%	-3.8%	-3.4%
Subtotal	20,357.3	1,215.8	15,102.1	110.3	36,785.4		35,454.2
	55.3%	3.3%	41.1%	0.3%	100.0%	0.0%	96.4%

(5) Targeted points to be improved

Focus was placed on improvements of the “machining process” and the “cutting process” that were identified to cause significant material loss costs.

− Machining process

In this process, more than 85% of MC was from swarf. Generally, by improving the forming method in order to match the forging shape with the finished machining shape as much as possible, the amount of swarf was dramatically decreased from the machining process. In other words, this measure leads to higher yield ratio. However, this was not implemented this time. The reason for non-implementation of this measure was the following three points:

  − Forging processes, as well as annealing and lubrication treatment processes will increase, and costs may also increase;

  − Forging surface roughness may be increased by reducing the machining operation; and

  − The material composition and performance of parts can be changed by changing the forging shape, and they might not conform to the needs of clients.

- Cutting process

  In the cutting process, improvement measures were implemented for two purposes: reduction of swarf; and reduction of mill ends. In reducing swarf, blade thickness was made thinner. This was expected to reduce swarf by 21%. In reducing mill ends, reuse of the mill ends was implemented. This was expected to lead to 69% less mill ends than before the introduction of this improvement measure.

(6) Conclusion

The following impacts were identified through the MFCA implementation:

- All input costs, product costs, and material loss costs were clarified;
- Breakdown of cost for material losses per process was also clarified;
- Improvement measures could immediately be simulated; and
- Transparency of problematic areas was increased.

In the future, it was desirable to summarize and implement improvement measures identified during this project. The company will conduct process improvements and cost reductions, and introduce these measures in other processes as a means of realizing the effective use of resources, improving productivity, and improving quality. In addition, the company will make plans to link these activities with reduction of environmental impacts as targeted under the company's plan for the ISO14001 activities. In the future, the company would also like to link the MFCA related activities with the product design phase.

Case 13 GUNMA GOHKIN Co., Ltd.
MFCA case study of aluminum die-casting
for environment-friendly die-casting factory

(1) Organizational profile

Established in 1947, GUNMA GOHKIN Co., Ltd. is a specialized aluminum die-casting manufacturer. The manufactured die-casted product (formed and fabricated materials) is mainly supplied to the assemblers and processing manufacturers of auto parts.

Recently, aided by prefectural and national subsidies, the company has started exploring the potential ways in which the energy intensity in a melting furnace involved in the die-casted production process can be decreased with an aim of becoming a more environment-friendly die-casting factory.

The objective of their participation in the MFCA project is to link MFCA with existing company-wide production management practices such as Total Productive Maintenance (TPM), to establish a new management system that enables them to evaluate both sides of the business, the environmental impact and the cost, and to disseminate a similar system to the Philippine production site GGPC (Gunma Gohkin Philippines Corporation). GGPC comprehensively conducts a range of processes for aluminum- and zinc-related die-casted products, from casting to cutting and processing.

The MFCA introduction initiative was headed by the management-planning section and cooperated by various sections such as casting, production technology, production management, and development design.

The company's employees numbered 82 as of January 2011. The company's sales were 3.523 billion yen (as of March in FY 2010) with a capital of 150 million yen.

(2) Material flow model of main target process/es

The project targets the processes related to melting of the aluminum and molding of the die-casted products. All on-site products are included in the MFCA calculation. The machining and molding processes process is conducted by an external contractor. These processes were excluded from the scope of the project.

(3) Description of material losses

Figure 13.1 shows a schematic representation of the manufacturing process and the material losses. Material losses consist of edge materials, including the losses due to runner and overflow, and defective items such as those with hot water wrinkle, and those involved in the burning process in the molding (casting, trimming, and inspection) process of the die-casted product. However, these material losses are recycled as a return material for the process.

In addition to squeezed aluminum loss, out-of-spec aluminum which cannot be recycled as a return material are generated in the melting process. In the molding process, material losses include consumerable parts in the casting process, oils necessary for operating the equipments, spare parts and consumerable parts necessary for repair and maintenance of the equipments and molds.

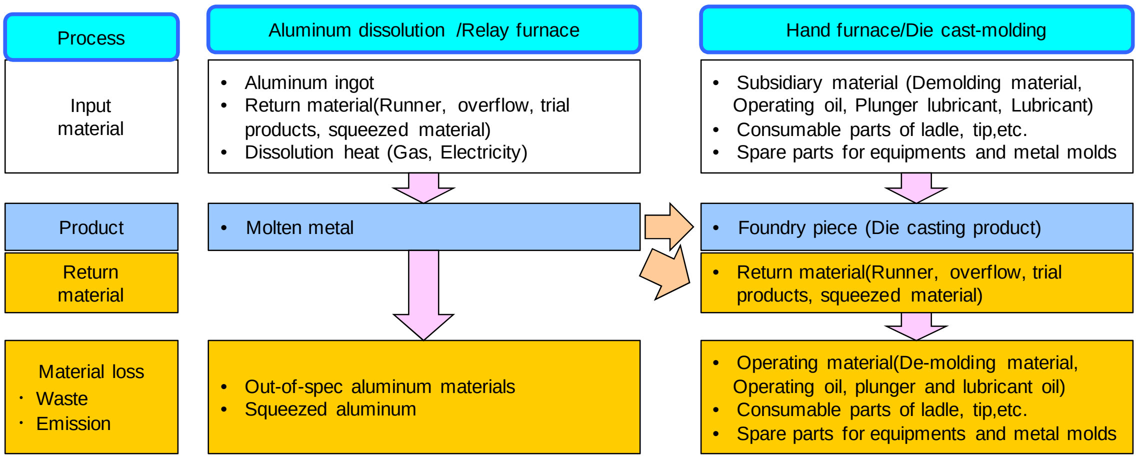


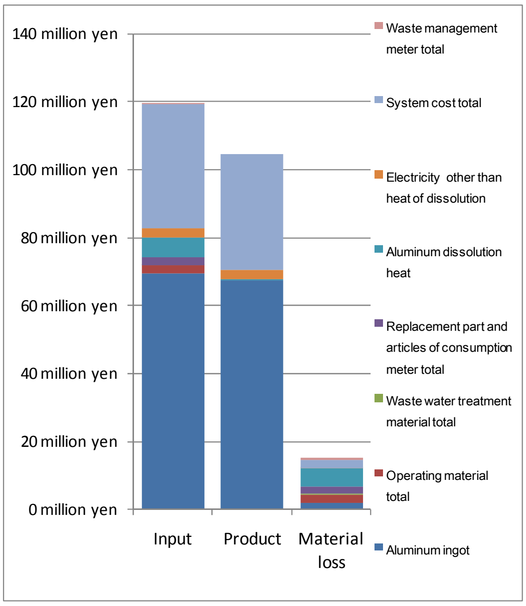
Figure 13.1. Manufacturing process and material loss

(4) MFCA analysis findings (Model case)

MFCA cost calculation is shown in Figure 13.2; it is based on the results of the measurement of the material balance of all types of products over a period of one month (October 2010). In addition, costs specifically related to material loss, heat loss during aluminum melting, and waste management are shown separately in Figure 13.3.

In particular, the energy consumed for the aluminum melting is separated from other energy consumption and the heat loss was calculated. In this MFCA implementation, the gross heat loss volume was calculated as follows:

Gross heat loss volume ＝ Input calories (Amount of energy (e.g., electricity and gas) used for casting × Energy intensity) － Calories necessary for product melting (Amount of products × Amount of heat used for melting of raw material)



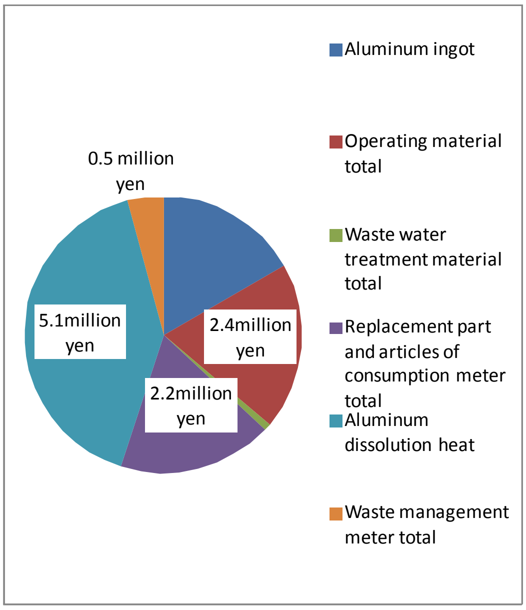


Figure 13.2 MFCA calculation result

Figure 13.3 Cost for material loss, heat loss, and waste management

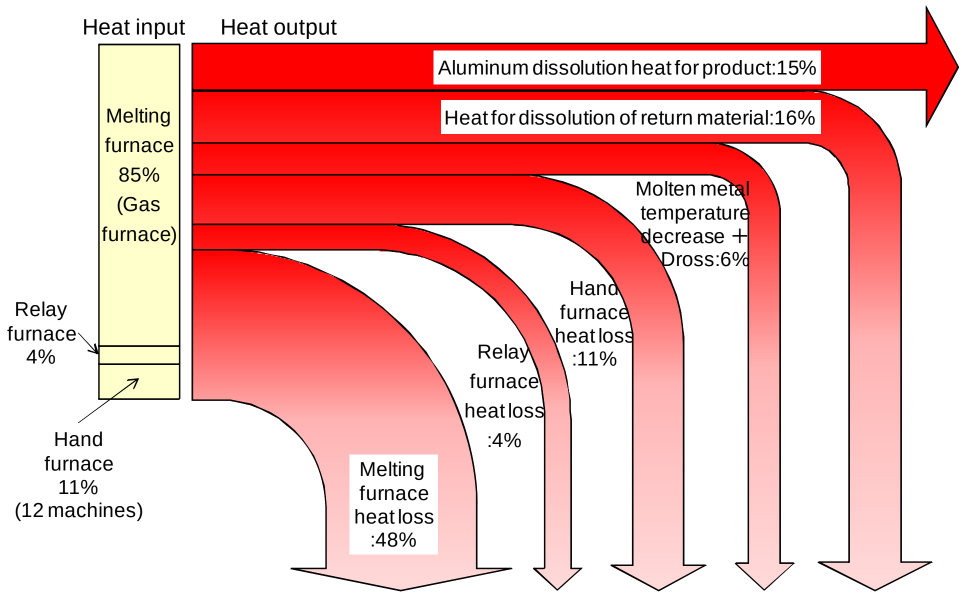


Figure 13.4 Heat calculation result for line that involves concentration melting furnace

(5) Targeted points to be improved or improvements based on MFCA analysis

As a result of the MFCA calculation, many issues have been revealed such as ways of minimizing the heat loss in the aluminum melting process and how there is a significant room for improvement in the efficient use of operating materials in addition to the existing loss-reduction practices applied for the raw aluminum materials.

In particular, it is well known that the heat loss from the aluminum melting process is substantial. However, it was a surprise that the loss of heat was significant in terms of both environment and cost.

During the course of this project, in addition to the total heat loss, energy use was measured at each furnace and heat calculation and analysis of heat loss were partially performed, as shown in Figure 13.4.

As a consequence, the heat loss from various sources and its associated cost was revealed; it was found that the heat loss through the furnace and its emitted gas, and the wall-side panel of the holding furnace was significant. The energy-saving measures to be taken at the time of the future renovation and replacement of furnaces, etc., are clarified.

(6) Conclusion

GUNMA GOHKIN Co., Ltd. aimed at making their die-casting factory more environment friendly, and the MFCA project enabled them to compute the capital investment required to meet their objectives. Furthermore, certain issues to be tackled by the company mainly for the day-to-day implementation of TPM were also clarified.

The company has resolved to implement the improvements suggested, and to introduce MFCA at its Philippines production site, GGPC, for carrying out MFCA and MFCA-related improvement in the future.

Case 14 Mitsuya Co., Ltd.
Production characteristics: MFCA implementation in the metal plating process

(1) Organizational profile

Mitsuya Co., Ltd. (hereafter referred to as "Mitsuya") was involved in plating of gold, silver, and nickel etc. In this project, MFCA was implemented to improve the nickel-plating process which has traditionally not been a focus for much improvement due to the fact that the unit price of nickel was not high. The company's employees numbered 299 at the time of the project. The company's sales were 4.39 billion yen (FY 2007) and the company's capital was 15 million yen.

(2) Products and processes subject to MFCA implementation and their characteristics (material flow model of main target processes)

- Target products and range of processes
  Metal items to be plated were not selected for the MFCA analysis, as it was rare for the products subject to being plated to become material losses. In this project, one of the plating materials, nickel and its plating process were selected for the MFCA analysis.

- Manufacturing processes and quantity centres
  Manufacturing processes consist of plate-processing, water-rinsing (dragging out), and inspection. In order to understand the nickel flow that was not plated and washed away with water, MFCA was implemented by defining the entire process as a single quantity centre as indicated in Figure 14.1.

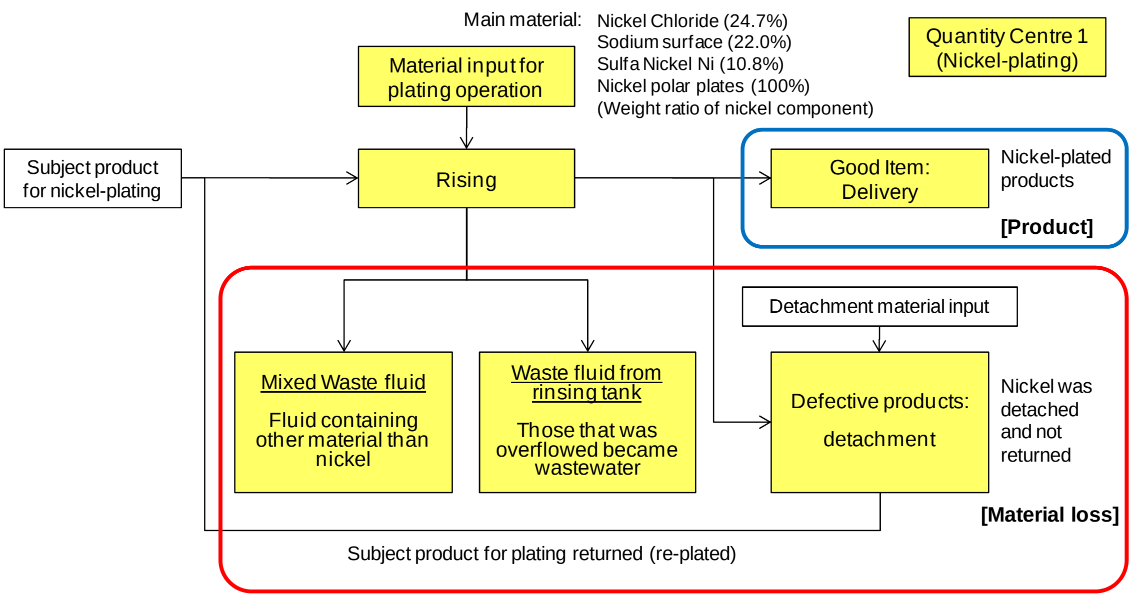


Figure 14.1 Input and output at the quantity centre

(3) Description of material losses

- Losses from each process
  - Nickel detached from defective items as identified at the time of inspection;

- Nickel included in the wastewater; and
- Indirect (operating) materials such as hydrochloric acid, boric acid, varnishing material, and water necessary for nickel plating.

- MFCA data definition
  - Material costs (MC): treatment costs of spalling fluid were included in the costs for material losses;
  - System costs (SC): depreciation costs for equipments were assumed to be zero in this project; and
  - Energy costs (EC): electricity costs.

(4) Findings through MFCA analysis

Input and output flow in the selected process was identified as shown in Table 14.1:

Table 14.1 Input and output in the subject process

NOTE Figures have been altered for publication. Units are in kg.

Nickel plating	Input material	
	Product	Material loss
Nickel within product plating	71.7	
Total good items in next process	71.7	
In-process recycling		0.0
Emissions, waste		429.0
Valuable material		0.0
Total material loss		429.0

Total material loss consisted of indirect (operating) materials (i.e., chlorine, boracic acid, brightening agent, water), and the nickel that did not become products.

As shown in the figure above, emissions and waste amounted to be 429 kg, the most significant material losses of all. These losses consisted of the indirect (operating) materials such as hydrochloric acid, boric acid, varnishing material, and water for nickel-plating, as well as nickel (amount of nickel: 25 kg).

The ratio of SC was significant. Furthermore, material loss costs were 8,400 yen. Moreover, waste management costs were 5,500 yen.

Table 14.2 Material flow cost matrix

NOTE Figures have been altered for publication. units: 1000 yen.

	Material cost	Energy cost	System cost	Waste management cost	Total
Products	16.5	343.5	23.3		383.3
	3.1%	65.4%	4.4%		73.0%
Material loss	8.4	119.8	8.1		136.3
	1.6%	22.8%	1.5%		26.0%
Waste/recycle				5.5	5.5
				1.0%	1.0%
Subtotal	24.9	463.3	31.4	5.5	525.1
	4.7%	88.2%	6.0%	1.0%	100%

(5) Targeted points to be improved or improvements based on MFCA analysis

Although SC accounted for 88% of the material loss costs, this was proportionally distributed SC which was allocated to nickel that was washed away with water. For this reason, a focus was placed on improvement of MC.

Of MC, while 8,400 yen became material losses, this was the total plating material which was washed away with wastewater during the water-rinsing process. Nickel which had been washed away with wastewater all became material losses. This suggested that 8,400 yen was disposed of every month from the nickel plating process. Likewise, it was necessary to consider these losses in combination with the waste management costs (5,500 yen). Reduction of the amount of the nickel material that flowed to the water-rinsing tank led to reduced costs for the material loss and the waste management.

(6) Conclusion

Reduction of the nickel material flowed to the water-rinsing tank was found to be a key issue. The same could be applied to processes in use of other plating-materials. This issue was considered to be related to the drainage system throughout the facility. In this regard, this issue was recommended to be considered from the perspective of equipment investment. Furthermore, in this project, water was not fully taken into consideration, while water was used in various ways including adjustment of plating fluid and the water-rinsing process, etc. In order to fully evaluate costs associated with the material losses in the process, water should be thoroughly traced and calculated.

As MFCA can be applied to other lines, it was desirable to conduct a horizontal MFCA deployment to cover a perspective of an entire facility.

Case 15 KOSEI ALUMINUM CO., LTD.
Production characteristics: MFCA implementation in the manufacturing process for automobile aluminum wheels

(1) Organizational profile

KOSEI ALUMINUM CO., LTD. is involved in production and sales of automobile aluminum wheels, major security parts for automobiles and motorbikes, various equipments and their parts. The factory for MFCA application was established in 1990, and as the mother factory for aluminum wheel production, is currently manufacturing pure wheels and aftermarket wheels for delivery to various automobile manufacturers. In order to identify losses for minimal staffing, improving productivity, and improving quality, MFCA was implemented for process improvement and cost improvement which eliminates waste, and to improve environmental performance by reducing energy costs through the efficient use of resources. The company's employees numbered 349 at the time of the project. The company's capital was 199.5 million yen.

(2) Products and processes subject to MFCA implementation and their characteristics (material flow model of main target processes)

One of the models manufactured at the facility was selected as the target product and all production processes of aluminum wheels were selected as the target process for this project. Quantity centres consisted of dissolution, forging, cutting, machining, pressure measurement and appearance inspection, balance inspection, paint appearance inspection, and shipment process (see Figure 15.1).
Further, the dissolution process was shared by other non-selected processes for this project. In the dissolution process, molten metal was allocated to each holding furnace by a dissolution furnace facility (see Figure 15.1).

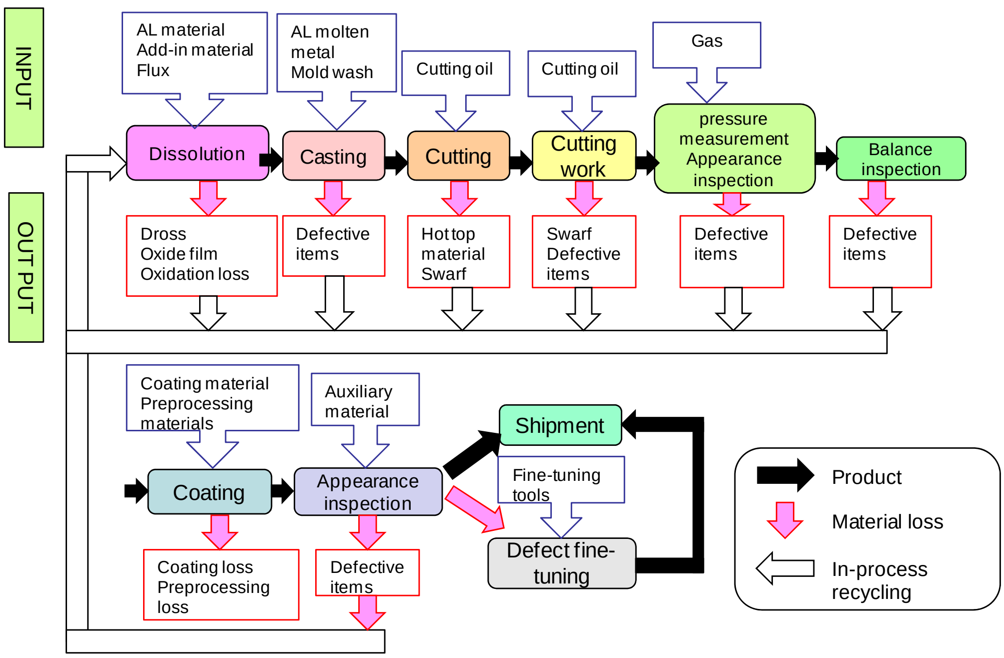


Figure 15.1 Input and output per quantity centre

(3) Description of material loss

- Losses from each process
  - Material losses: additive loss, coating loss, auxiliary materials, and operating materials; and
  - In-process recycling: oxide film, oxidation loss, hot top-materials, swarf, and defective items.

- MFCA data definition
  - The per unit weight of input volume and turnover volume for each process, except for the dissolution process, were multiplied. As the dissolution process was conducted by a common facility, each input material was calculated by multiplying the total allocated weight of molten metal by the target line ratio and the target model production ratio.
  - A standard unit cost was used for aluminum material, and for materials which were also diverted to other models, calculation was conducted using a cost proportionally divided by the production ratio of the subject product, based on the weight cost information for the materials used actually for the process.
  - The aluminum oxide produced from the dissolution process was recovered, its treatment was outsourced, and it became one of the reclaimed materials for input to the subject process.

(4) Findings through MFCA analysis

Out of 135 tons of material losses, the in-process recycling quantity was found to reach 117 tons, or approximately 87 % of the material losses. This finding indicated importance of undertakings to reduce generation of material losses that flowed to in-process recycling.

Table 15.1 Material input/output amount

				QC1	QC2	QC3	QC4	QC5	QC6	QC7	QC8	QC9	QC10
	MC item categories	Item name	Unit	Dissolution	Forging	Cutting	Machining	Pressure measurement, appearance inspection	Balance inspection	Coating	Appearance inspection	Defect fine-tuning	Shipment
Output (product)	Good items from next process	Quantity of good items	kg	224635.6	231710.5	40278.5	30759.1	47256.2	31606.0	38601.7	28793.7	37309.8	99587.7
Output (material loss)	**In-process recycling**	Quantity of aluminum material recycling (defective items, swarf, hot top material etc.)	kg	0.0	770.0	40790.4	69917.8	638.0	3817.0	0.0	1529.0	0.0	0.0
	Emissions, material loss	Emissions, material loss quantity (additive loss coating loss, etc.)	kg	0.0	26.0	9.7	257.9	25.5	0.0	9191.3	0.0	0.0	0.0
	Valuable material	Quantity of valuable material loss (aluminum oxide)	kg	7871.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Material loss costs accounted for 25.4% of total costs as shown in Table 15.2.

Table 15.2 Material flow cost matrix

NOTE Figures have been altered for publication. Units: JPY 1,000.

	Material cost	Energy cost	System cost	Waste management cost	Total
Products	218.2	24.4	791.0		321.7
	49.9%	5.6%	18.1%		73.6%
Material loss	47.4	20.4	43.1		111.0
	10.9%	4.7%	9.9%		25.4%
Waste/recycle				4.3	4.3
				1.0%	1.0%
Subtotal	265.6	44.8	122.3	4.3	437.0
	60.8%	10.3	28.0%	1.0%	100%

(5) Targeted points to be improved

Through MFCA analysis, the followings were found to be key issues for improvement:

- Reduction of the internally recycled material losses;
- Improvement of yield ratio; and
- Improvement of coating efficiency.

- Reduction of internally recycled material losses

  As quantity of in-process recycling was identified to be significant, measures to reduce defective products during each process played key roles. 25.4% of the total cost was from the material losses, and the material losses generated from the machining process was the largest of all.

- Improvement of yield ratio

  Material losses (hot top and swarf) generated during the machining process and cutting process were re-input as returned materials. As returned materials were re-dissolved for reuse and such materials were hardly considered as material losses. However, as such material losses carried over energy cost and system cost from the initial production cycle, they were found to be significant losses from a cost perspective. It was surmised that improving yield ratio and lowering material loss ratio were key improvement measures.

- Improvement of coating efficiency

  Material costs at the coating process were also found to be substantial. Significant amount of coating was not added to intermediate products; increasing coating efficiency was also a key issue.

(6) Conclusion

MFCA was implemented toward a certain model of product in one specific line during the course of this project. As dissolution process was involved, there were returned materials (i.e., hot top, swarf, and defective items) that were returned to the dissolution process without proceeding to the next process as material losses. By highlighting the quantities and evaluating cost of such materials, key issues could be specified.

In the future, countermeasures to these issues will be steadily implemented. In addition, their deployment toward other lines and models will be implemented as well. Moreover, it was surmised that MFCA could also be applied in daily on-site management, and toward the design and development of new models in the technology department. MFCA could be considered as a useful management tool in evaluating investment impacts and cost and environmental impacts.

Case 16 MIWA LOCK Co., Ltd.
Production characteristics: Management and reduction of material loss in over 5,000 component units

(1) Organizational profile

MIWA LOCK Co., Ltd. (hereafter referred to as "MIWA LOCK") manufactures and sells locks and metal fittings for building. The products include numerous metal press components. In order to meet diverse customer needs, a wide variety of products in the building material sector are required to be covered. Hence, metal press components are ranged with a wide variety in small quantities. Metal press components are processed in MIWA LOCK's Ise and Tamaki factories in cooperation with many other metal press companies.

MIWA LOCK has pursued reducing material loss in the yield ratio management of material by developing an optimized punch die design. It then participated in the supply chain resource saving cooperation promotion project and worked on the visualization and reduction of pressing material loss with other pressing companies. The general manager of the production technology department supervised the whole project and related departments of MIWA LOCK, including the design, production technology, manufacturing, quality control, and materials departments, and partner companies such as Miwa Metal Co., Ltd. and Matsuya Co., Ltd. cooperated in this endeavor.

Table 16.1 Profile of MIWA LOCK and its main partner companies

	MIWA LOCK	Miwa Metal Co., Ltd.	Matsuya Co., Ltd.
Number of employees	1,565 (as of 2009)	40	160
Capital (yen)	610 million	10 million	5 million

(2) Material flow model of main target process/es

(i) Target product and range of process

The loss of press material from 12 kinds of card lock system components used in hotels was analyzed using MFCA, targeting all the processing processes in MIWA LOCK and its partner companies.

(ii) Process for MFCA Introduction

Generally, in the pressing process, components with high production volumes are manufactured from coiled material using multiple hit dies and transfer press machines, and components with low production volumes are produced using plate material and processed using single hit die press machines. Thereafter, the material is post-processed by spot facing, crimping, welding, and surface treatment and then assembled.

As mentioned earlier, there are numerous components with a wide variety in small quantities, and the targeted products have low production quantity per lot: approximately 200 at a minimum and 1,000 at a maximum.

(3) Description of material losses

Press components are processed as shown in Figure 16.1. MIWA LOCK has over 5,000 press processing component units. The process shown in Figure 16.1 is conducted by MIWA LOCK and tens of other partner companies, and press material loss is incurred during the processing of each component.

- Loss at the stage of material arrangement: Edge loss during metal plate shirring, switching loss of coiled material (the ends of coiled materials, disposal of remainder stock left at the end of the process, and loss during malfunctions and die switching). Because one kind of material is used for more than one kind of component, many of these losses can be measured only for each material.
- Loss at the stage of punching-press process (plate removal loss or scrap loss during the pressing process): Edge loss per component, crosspiece part loss per shedding pitch, edge loss at the plate punching stage, and plate loss after punching (extra parts from holes and cutouts). As plate loss after punching cannot be reduced, it is not defined as a loss. The amount of plate removal loss either increases or decreases depending on the design of the component or die.
- Loss at the stage of post-processing and assembling: trial punch, sample products, defective products, and surplus stock disposal. Loss at this stage is managed by number of pieces, and in order to be consistent with management unit for the loss at the previous stage, it is necessary to convert the piece-based counts to weight data.

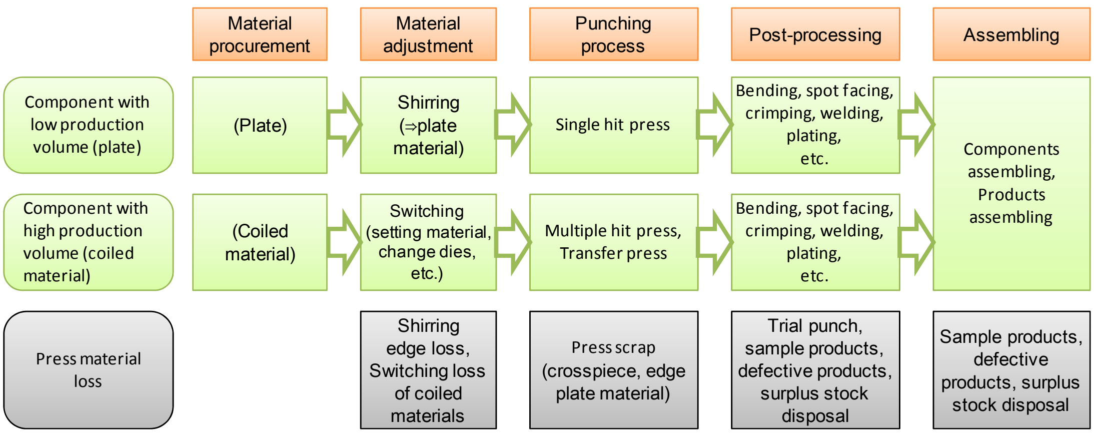


Figure 16.1 Example of the pressing process of components

(4) Findings through MFCA analysis (model case)

The analysis of the 12 kinds of components showed that nearly 40% of input material became material loss (Figure 16.2).

This analysis measured losses separately for the switching loss of coiled materials, plate removal loss, non-product loss (trial punch, sample products, defective products, and surplus stock disposal), and punching loss.

Figure 16.2 shows the quantity of material only, but the material cost was almost the same as in Figure 16.2.

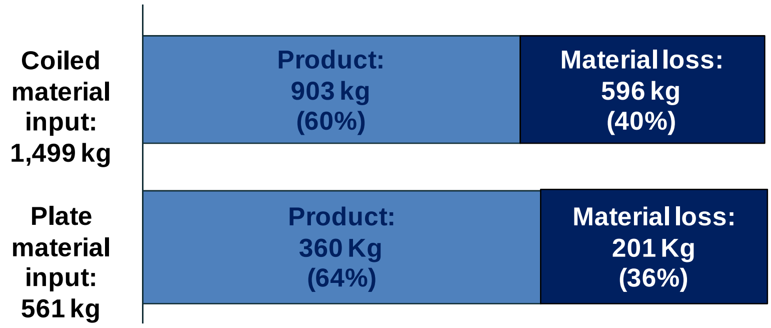


Figure 16.2 MFCA analysis

(5) Targeted points to be improved or improvements based on the MFCA analysis

Improvement measures were examined for each category of material loss from the MFCA analysis aspect: that consists of switching loss of coiled materials, plate loss, and non-product loss.

Punching loss was excluded from the target of improvement because the loss from holes and cutout losses in the components are necessary for the structure of product and also because the quantity of input material remains same when they are eliminated.

As MIWA LOCK produces over 5,000 units of pressing process components alone, if improvements are implemented for all the 12 kinds of components analyzed here, the effect will be minimal. Therefore, it is necessary to visualize material loss reduction and employ a mechanism to improve the material loss, targeting over 5,000 pressing process component units.

It is also necessary to examine the improvement mechanism by dividing the target components into two: in-production components (ongoing production) and new components for new products.

For the improvement of in-production components, the approach for improvement varies according to the factors of the loss generated:

- Switching loss of coiled material: Mainly handled by the manufacturing and production technology (equipment) departments
- Plate removal loss: Mainly handled by the production technology (die design) department
- Non-product loss: Mainly handled by the quality assurance and procurement departments

For the new components for new products, it is necessary that material input and quantity of material loss be evaluated at the stage of production design in order to implement product and die design with reduced material loss. Therefore, they were incorporated into the Design Review (DR) mechanism during the development process design stage as shown in Figure 16.3.

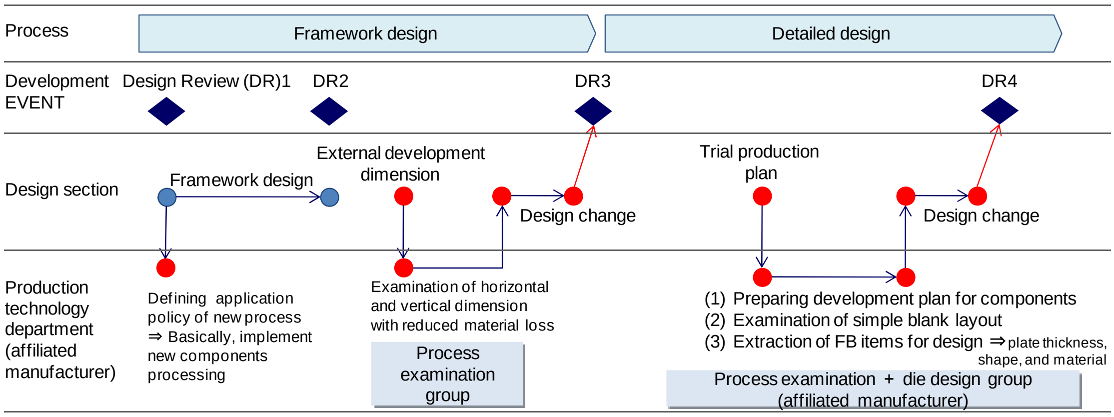


Figure 16.3 Mechanism of design development for reduced material loss

(6) Conclusion

As there are many kinds of press processing components and a die design section in the production technology department, MIWA LOCK has considerably worked on yield rate improvement in press processing. The company has found, however, that yield rate management only covered the loss at the punching process, as shown in Figure 16.1, and other losses were not shared within the organization. It has also found further room for improvement as to the loss at the punching process. All processing departments at MIWA LOCK and its partner companies cooperated to work toward loss reduction. A mechanism for improvement has been constructed, as described in (5). It is being gradually implemented, and its effects are coming to view.

These losses are incurred by MIWA LOCK and its processing partner companies. The number of component units exceeds 5,000. Therefore, it is necessary to create a mechanism to visualize material loss in order to identify the materials and components with ample room for improvement. To achieve this, the construction of mechanisms utilizing system data such as production management is currently under examination.

Case 17 NIPPON FILCON CO., LTD.
Etching process for raw copper foil and PET compound film materials

(1) Organizational profile

NIPPON FILCON CO., LTD. manufactures and sells plastic wire for use in paper manufacturing and precise metallic parts for electronic devices.

The company employees numbered 635 as of November 30, 2010. The company's revenue was 15.179 billion yen as of November 2010 with a capital of 2.685 billion yen as of November 30, 2009 on a non-consolidated basis.

(2) Material flow model of main target process/es

(i) Target products and the range of processes

The manufacturing process of the electromagnetic radiation shield mesh for the plasma display is aimed to undergo MFCA analysis.

(ii) Manufacturing process and quantity centre

Each manufacturing stage was defined as a quantity centre.

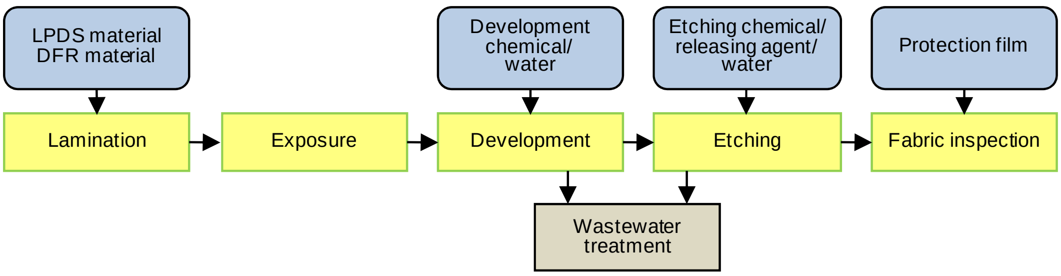


Figure 17.1 Material flow chart

(3) Description of material losses

(i) Loss at each process

- Lamination process: Edge material from among the DFR material.
- Exposure process: Edge material other than that with an exposure pattern (top-edge material, terminal-edge material, reserved parts for material-sending, reserved parts for edges, idle sending of the material at the time of technical trouble, etc.)
- Development process: Developing chemical and rinsing water.
- Etching process: Etching chemical, releasing agent, and rinsing water.
- Fabric inspection: Defective parts, protection film for non-patterned parts.
- Wastewater treatment process: The associated cost was calculated as treatment cost.

(ii) MFCA data definition

- The main material was assumed to be three materials (the LPDS material, DFR material, and protection film), and the amount of material used was calculated on the basis of the area.

- The treatment costs (all the wastewater treatment cost: material cost (chemical), energy cost (electricity), labor cost, depreciation cost, and collection cost by truck) are allocated based on the production volume.
- Considering the low cost of groundwater which is used as an on-site water source and that the groundwater-related data exists only factory-wide, the water cost was excluded from the MFCA data.
- The energy and system costs were limited to those directly associated with each process. Moreover, costs were allocated to products and material losses based on their weight ratio and calculated in a cumulative manner.
-

(4) Findings through MFCA analysis

The entire calculation result is summarized in the MFCA balance sheet as shown in the followings:

- Costs for material losses were approximately 27% of the entire cost (The internal yield ratio was 92%).
- The material cost and system cost account for 71% and 24% of the cost composition, respectively.
- The cost for LPDS material accounts for 82% of the material cost.
- 97% of the weight of the operating materials is attributed to the weight of the etching chemical.

Moreover, detailed inspection of the process reveals the followings:

- 8.1% of the DFR material loss is generated in the process of the lamination.
- The ratio pattern in the exposure process accounts for 18% of the total area.
- Defective products identified in the fabric inspection process account for 9% of the total area.

Table 17.1 MFCA Balance Sheet
(The quantities and related costs are changed for public disclosure)

	INPUT (%, ratio to the total cost)			OUTPUT (%, ratio to the input cost)					
				Product			Material loss		
	Quantity	Cost	%	Quantity	Cost	%	Quantity	Cost	%
Total		99,260	100		72,790	73		26,470	27
Material total		70,300	71		50,960	72		19,340	28
Main material	167,640 m^2	68,880	69	120,000 m^2	50,960	74	47,640 m^2	17,920	26
LPDS material	53,330 m^2	57,800	58	40,000 m^2	43,260	75	13,330 m^2	14,540	25
DFR material	57,970 m^2	7,150	7	40,000 m^2	4,920	69	17,970 m^2	2,230	31
Protection film	56,340 m^2	3,930	4	40,000 m^2	2,780	71	16,340 m^2	1,150	29
Operating material	78,400 kg	1,420	1.4	kg		0	78,400 kg	1,420	100
Development chemical	1,000 kg	240	0.2	kg		0	1,000 kg	240	100
Etching chemical	75,700 kg	1,140	1.1	kg		0	75,700 kg	1,140	100
Release agent	1,700 kg	40	0.0	kg		0	1,700 kg	40	100
Cost of disposal		2,500	2.5			0		2,500	100
Energy		2,800	2.8		2,240	80		560	20
Payroll		19,960	20		16,560	83		3,400	17
Amortization expense		3,700	3.7		3,030	82		670	18

(5) Improvements based on the MFCA analysis

- The generation of edge material from the DFR material is controlled by buying DFR material that matches the length of the LPDS material.
- Empty sending of the edge material in the non-pattern part during the exposure process, especially the top and the terminal parts of the LPDS material, and idling sending at the time of machine trouble is reduced.
- The arrangement, pattern design, and width of the LPSD material are adjusted to minimize the sending for the pattern.
- The width of the protection film is modified in accordance with the pattern. Further, the edge material loss is decreased by expanding the length scale.

(6) Conclusion

The following two points represent the findings of this project:

- It has been understood that material loss reaches as much as 27% for the yield at which the product ratio was formerly considered to be 92% by an internal quality control.
- The loss generation was understood in physical and monetary units. As a result, a concrete loss standard was established.

The recommended future tasks are summarized below:

- Internal dissemination of the MFCA technique and the concept (especially, with regard to loss).
- Implementation of MFCA in the most simplified way possible.

Case 18 Shimizu Printing Inc.
Production characteristics: Small-to-medium business and printing process

(1) Organizational profile

Shimizu Printing Inc. (hereafter referred to as “Shimizu Printing”) is located in Tokyo, Japan. The company’s number of employees was 39 at the time of the project. Also, the company was capitalized at 38 million yen, with sales of 1 billion yen.

(2) Material flow model of main target process/es

The selected process for this project was a printing process that involves one printing machine to print a single series (one product).

Figure 18.1 shows the work flow of the subject printing process:

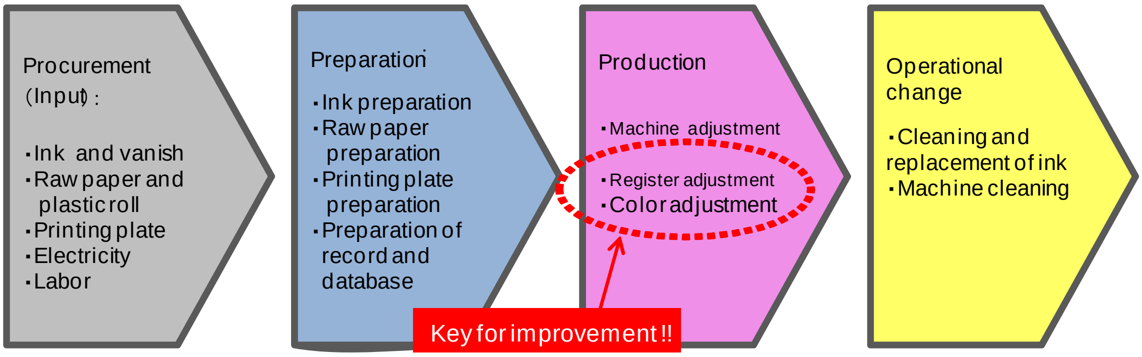


Figure 18.1 Selected process for this project (MFCA boundary)

Input materials consisted of ink, varnish, raw paper (paper and a plastic roll), and printing plate. Electricity, water, and personnel work was also considered, along with the input materials.
A single printing machine was subject for the MFCA analysis and the machine was defined as a quantity centre. The printing machine was capable of printing products in several colors.

(3) Description of material losses

Relatively large scale of test printing etc. was conducted (register and color adjustments) before printing of products, and a focus was placed on this non-product related printing operation. The following three items were identified to be material losses, or the elements associated with material losses:

- Ink: ink was used for test printing etc. (register and color adjustments) in addition to a regular printing process,

- Electricity: electricity was consumed to run the printing machine for test printing etc. (register and color adjustments) in addition to a regular printing process, and

− Personnel: labor was also devoted to the test printing etc. (register and color adjustments) in addition to a regular printing process.

In addition to calculating the loss costs above, the ratio of these costs per cost related to a single production process (printing cost of a single sheet) was calculated. Transition of the ratios was tracked on a yearly basis.

(4) Findings through MFCA analysis

Reduction of sheet losses (test printing etc.: register and color adjustments) through countermeasures implemented over a five-year period from FY 2003 (year of the MFCA introduction) were shown below:

Table 18.1 Transition of loss ratio over 5 years

FY	Number of sheets	Number of waste sheets	Loss ratio
2003	13,367,833	864,226	6.5%
2004	17,159,346	993,697	5.8%
2005	19,436,109	1,071,102	5.5%
2006	17,361,876	773,707	4.5%
2007	14,208,506	351,138	2.5%

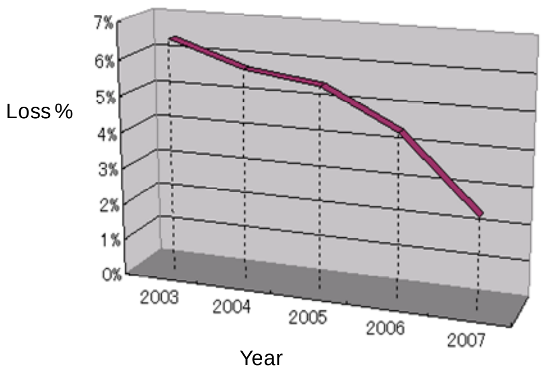


Figure 18.2 Transition of loss ratio over 5 years

Ratio of the loss cost (i.e., costs for ink, electricity and labor cost associated with the material loss) to variable expenses (ink, electricity, and labor cost) for various activities at the initial operation (register and color adjustments) were calculated.
Transition in the loss cost ratio associated with implementation of countermeasures was also reviewed. The following showed transitions over five years:

Table 18.2 Ratio of loss to variable costs

	2003	2004	2005	2006	2007
Ratio of loss to variable costs	6.5%	5.8%	5.5%	4.5%	2.5%

(5) Targeted points to be improved or improvements based on MFCA analysis

Based on the MFCA analysis, process review was conducted from the viewpoints of both the operation and the equipment as shown in the following:

Operation-related

Change in conventionally accepted operational rules that caused the material loss and its associated losses was raised as one of the countermeasures. The measure included re-examination of the test printing operation, etc. (register and color adjustments).

Equipment-related

- Complete switch-over of ink: switching to an ink which enabled color matching with limited spare ink; and
- Printing machine: application of various options to stabilize color in a machine.

Future issue

- Understanding of the marginal loss rate,
- Integration with other operation-related material losses (printing accidents and errors related to the pre-printing process),
- Exploration of approaches to curtail material losses, and
- Identification of material losses including those generated before/after the printing process.

(6) Conclusion

One of the measures conducted based on the result of the MFCA analysis was an investment in new equipments. The introduced machine was the world's first printing machine with UV10 color + coater and inversion mechanism. As this printing machine enabled all processes from double-sided printing to surface treatment to be conducted altogether, it was possible to significantly reduce number of sheets for the test printing etc.

Case 19 THE REBIRTH CO., LTD.
MFCA analysis in the paper-making process by used paper material

(1) Organizational profile

THE REBIRTH CO., LTD. (hereafter referred to as "Rebirth") manufactures toilet paper from difficult-to-process used papers and confidential documents. It is a young company that was established in 2002 and began manufacturing paper in 2004 at its factory.

Rebirth is extremely conscious of the significance of environmental conservation such as their certification for ISO 14001 in 2005, the company attempted to incorporate the efficient use of energy and resources as well as waste reduction in its business activities.

The company employees numbered 69 as of January 1, 2011. The company's sales were 2,979 million yen (FY 2009) with a capital of 10 million yen.

(2) Material flow model of main target process/es

(i) Target products and range of processes

Rebirth produces over 50 varieties of toilet paper as the end-product. In the MFCA analysis, all the processes from receiving raw material to shipping the end-product are included.

(ii) Target processes for MFCA analysis

Rebirth uses raw materials such as difficult-to-process used papers and confidential documents. For the MFCA analysis, the target processes were divided into three: the material-selection process where pure paper material is extracted from the wastepaper pulp, paper-making process where a jumbo roll is made from the extracted raw material, and processing process where the jumbo roll is cut in order to produce toilet paper.

(3) Description of material losses

In the material-creating process, the raw material is dissolved in a large volume of water in order to remove impurities. During this process, a large amount of operating materials is used for processes such as deinking, sterilization, bleaching, etc. Short paper fibers are submerged in drained water that is generated in the processes, and then are separated into water and sludge in a wastewater treatment facility. Most of the waste from the treatment process, such as sludge, is used as accelerator for combustion in an in-house boiler.

In the paper-making process, a jumbo roll is created with the wastepaper pulp generated in the material-creating process, and a large amount of water and energy such as steam is utilized in order to dry the paper.

In the processing process, jumbo rolls manufactured at Rebirth and other companies are cut in order to manufacture toilet paper. Thereafter, the cut toilet paper is wrapped and shipped. All the edged materials generated during the cutting process undergo the material-creating process again and are recycled as raw material.

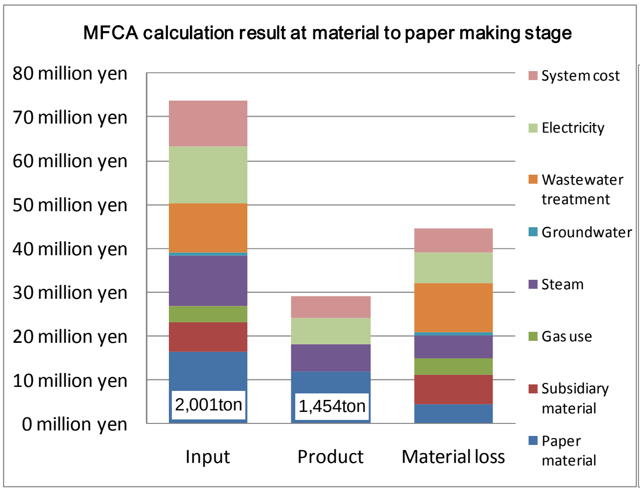
Process	Material-creating process Removing all impure materials in raw material to extract raw materials for toilet paper	Paper-making process • Manufacturing a jumbo roll from extracted used paper-pulp • Manufacturing more than 50 tons/a day of paper at the speed of 1,000m/minute or more.	Processing Cutting the jumbo roll for toilet paper processing
Input	• Material (milk carton and confidential document) • Return material (From paper making ,work process) • Various subsidiary materials (Deinking , Sterilization, Bleaching, etc.)	• Material pulp：Product from former process • Gum, adhesive, release agent	• Jumbo roll (Product from former process ＋ Purchase products) • Paper tubing • Wrapping material etc.
	• Underground water, pulp-containing water • Steam(as a result of heating water)	• Underground water, pulp-containing water • Steam(For drying)	
Loss	• Short paper fiber element ⇒ Sludge fuel	• Paper loss ⇒returned to the material-creating process	• Stencil paper loss ⇒returned to the material-creating process
	• Metallic substances (Clip of confidential documents, Stapler etc.) ⇒Waste metal(sellout) • Waste plastic(Lamination film of milk carton etc.)⇒RPF fuel • Ink element ⇒ Sludge ⇒Fuel	• Short paper powder (Paper fiber)⇒Sludge fuel	• Wrapping material loss ⇒RPF fuel, Waste (Edge)
	• Water⇒ pulp-containing water tank (for reusing), Wastewater treatment facility (Discharged after the treatment)	• Water⇒ pulp-containing water tank (for reusing), wastewater treatment • Steam release, used steam (drain water)	

Figure 19.1 Manufacturing process and resource (material and energy) losses

(4) Findings through MFCA analysis (model case)

In the processing process, the jumbo rolls purchased from other companies are cut along with those produced in Rebirth. Since there is already a stock of jumbo rolls to be considered for the analysis, the material-creating and paper-making, and processing processes were separated for the MFCA analysis.

There is a large amount of material losses in the material-creating and paper-making processes and the associated cost incurred reached as high as 61%, as shown in Figure 19.2. Further, as shown in Figure 19.3 that indicates costs for material losses and water treatment cost, the wastewater treatment cost, operating material cost such as that incurred in chemicals, and heat loss cost related to steam were astonishingly significant.



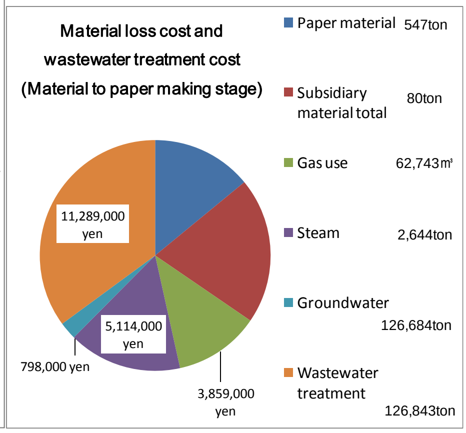
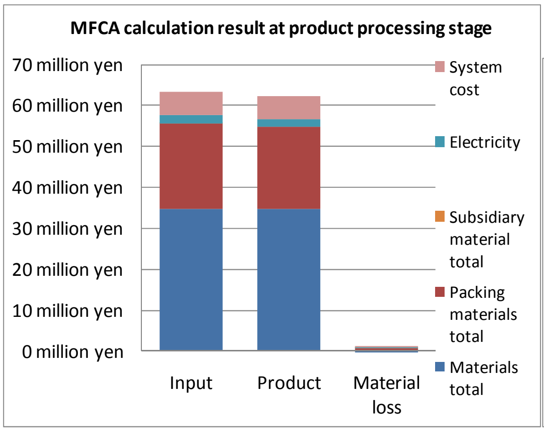


Figure 19.2 MFCA calculation result (up to paper-making process)

Figure 19.3 Material loss and wastewater treatment cost

On the other hand, when a jumbo roll is cut, edged material - which accounts for approximately 5% of the material - is generated in the product-processing process. However, because this material is returned to the material-creating process and recycled as raw material, it is not considered as material loss. Therefore, the material-loss cost changed to 2% or lower, as shown in Figure 19.4. Further, Figure 19.5 presents the cost for material loss.



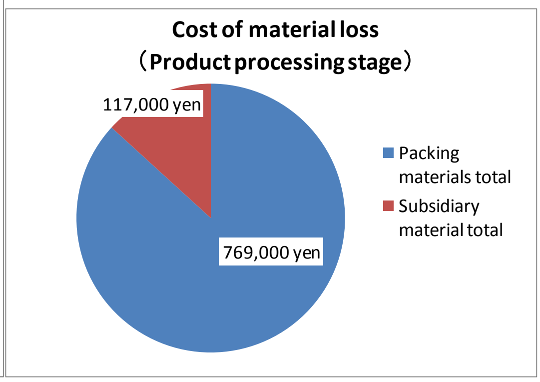


Figure 19.4 MFCA calculation result (Product-processing process)

Figure 19.5 Cost for material loss

(5) Improvements based on the MFCA analysis

In the material-creation and paper-making processes, wastewater treatment, operating materials such as chemicals, and heat loss such as through steam account for a large proportion of the material-loss costs. Therefore, it is necessary to review the processes and equipment as well as reduce water usage.

On the other hand, the MFCA analysis enabled an understanding of the material-loss cost related to packing materials, and, a new area for improvement could be identified in the product-processing process.

(6) Conclusion

The material-loss cost for the paper-making process exceeds 60%. Among all, wastewater treatment cost is significant. This fact clarified managerial importance of addressing the ‘Review of water usage’ issue, which was originally discussed for improvement.

Prior to this, monetary evaluation of the loss related to the deckle edge of packing material in the processing process has never been conducted. The deckle edge loss will be minimized when the new version of the PE bag is designed in the future.

Thus, the improvement approach that was clarified in this project will be implemented and MFCA will be used for the evaluation of the improvement approach. Moreover, the MFCA approach will be applied to water, steam, hot wind, compressed air, etc. in the future in order to assess associated losses.

Case 20 GUNZE Limited
Production characteristics: Manufacturing of wide varieties of products

(1) Organizational profile

GUNZE Limited (hereafter referred to as “Gunze”) is an apparel maker that manufactures various products including men's and kids' underwear and is located in Osaka, Japan (a factory is located in Kyoto). As of March 31st, 2009, the number of employees numbered 9,041 on a consolidated basis. The company’s sales were 151.5 billion yen on a consolidated basis as of March 2009. The company’s capital was 26.1 billion yen.

(2) Material flow model of main target process/es

The selected process for this project was a production line of inner wear at the Miyazu factory. Quantity centres were defined according to one processing unit. The detailed process flow was shown in Figure 20.1.
The selected process had the following characteristics:

- The process covered all the clothes-producing processes from weaving of original yarn to dyeing, cutting, and sewing;
- A major portion of the sewing process was conducted at several outsourced facilities; and
- Same processes were applied to production of other types of clothes, although apparel products consisted of an extremely wide variety of models, colors, patterns, and sizes.

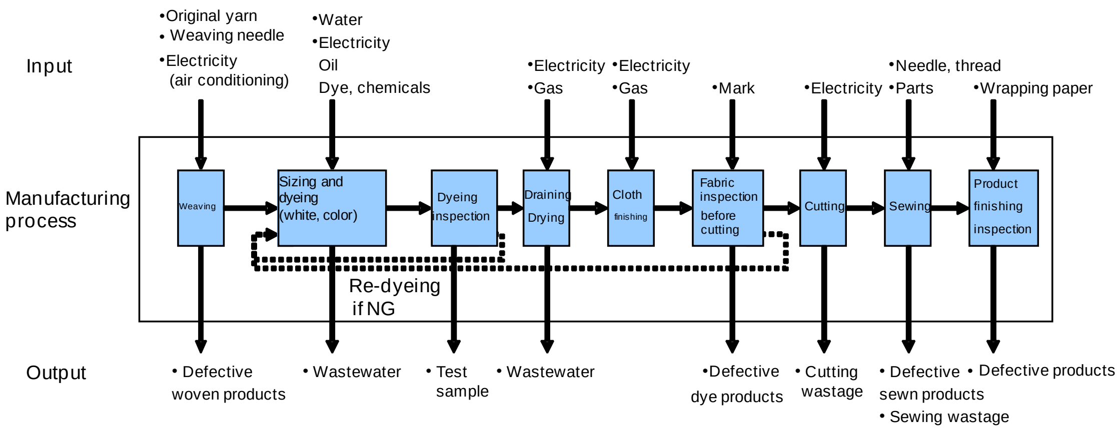


Figure 20.1 Selected process for this project (MFCA boundary)

All materials input into the process such as original yarn, parts, wrapping paper, colorant, and chemicals were subject for the MFCA calculation. The MFCA calculation was conducted for a product with one specific identification number.
In the weaving process, original yarn was woven to produce a single roll of cloth. At the following process, quantity was adjusted as intermediate products such as rolls of cloth that integrated more than one type of original yarn. For processes following the weaving, material quantity was calculated in units of partly-finished (intermediate) products.
Products were calculated as a single product according to product size (S, M, L etc.). There were cases where products passed either through a dyeing machine or through a bleaching machine;

costs associated with operation of these equipments including depreciation cost were considered discretely.

(3) Description of material losses

Various materials such as original yarn and colorants were input to each process, and materials loss were generated including defective products, cutting wastage, sewing wastage, and testing operations.

(4) Findings through MFCA analysis

Through MFCA analysis, the impact of defective products could be identified not only in terms of yield rate, volume of defective products, and residual volume, but also in terms of total cost. This ensured the significance of lowering the volume of the defective products. Observation of the production line and analysis of cause for defective products revealed that high defective rate was identified in some products but defective rates were generally low among many products; and
As a production-term was very short, it was difficult to establish an effective countermeasure to minimize material losses within the mass-production term
Table 20.1 shows the material flow cost matrix and the flow chart associated with the process, respectively:

Table 20.1 Material flow cost matrix
(figures have been altered for publication.)

	Material cost	Energy cost	System cost	Waste management cost	Total
Good items (product)	84.30	5.13	105.59		195.03
	34.3%	2.1%	43.0%		79.4%
Material loss	26.46	1.97	20.71		49.14
	10.8%	0.8%	8.4%		20.0%
Waste/recycling				1.43	1.43
				0.6%	0.6%
Sub-total	110.76	7.10	126.31	1.43	245.60
	45.1%	2.9%	51.4%	0.6%	100.0%

(5) Targeted points to be improved or improvements based on MFCA analysis

Based on the statements in clause 4, the most important target points at the Miyazu factory was to define an appropriate standard for newly used materials at the product development phase.

(6) Conclusion

Direct feedback of the MFCA analysis was not possible for the subject products as they were in the very short product cycle. As majority of the products in the Miyazu factory were made over the short term, the MFCA result could not be meaningfully applied to other items.
However, the MFCA analysis could be meaningfully used to evaluate practice at the design phase. In addition, the MFCA analysis could be also used as a common production indicator for factories in frequent use of new materials and those in little use of new materials. One of the issues for effective use of MFCA is factory-wide development of a simple MFCA calculation tool, the associated evaluation approach, and its implementation.

Case 21 Kohshin Rubber Co., Ltd.
Production characteristics: Molding with complex material flow (including in-process recycling)

(1) Organizational profile

Kohshin Rubber Co., Ltd. (hereafter referred to as “Kohshin”) produces a rubber sheet for flexible container bags for transportation. The company is located in Sendai City, Miyagi, Japan. The company’s employees numbered 357 at the time of the project. In addition, the company’s capital was 100 million yen at the time of the project.

(2) Material flow model of main target process/es

The selected process for this project was a manufacturing process of an original rubber sheet for flexible container bags for transportation. The detailed flow of the material was shown in the Figure 21.1:

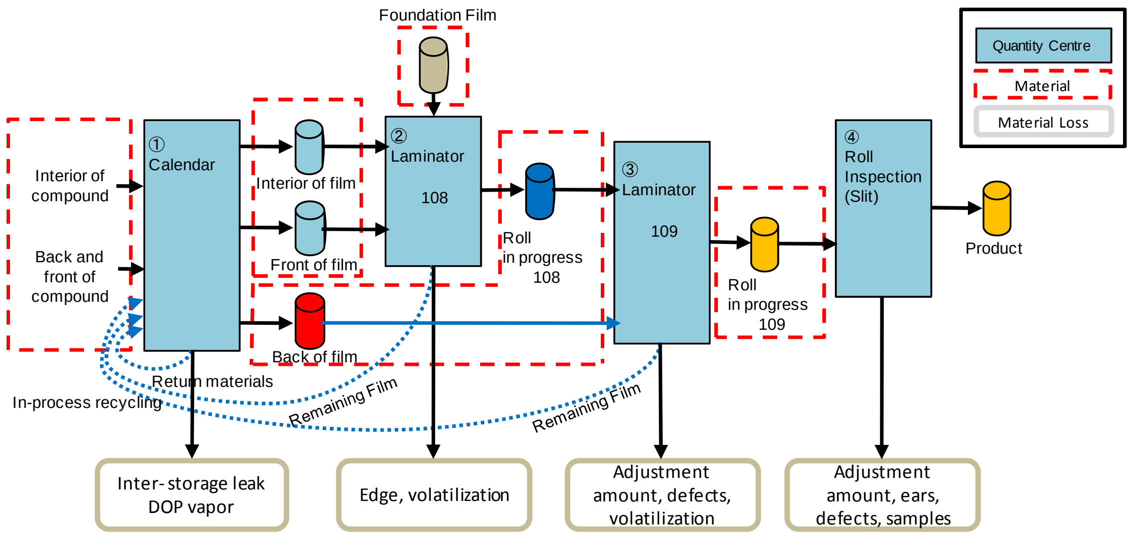


Figure 21.1 Selected process for this project (MFCA boundary)

The selected process had the following characteristics/steps:

- A compound was heated, dissolved, stretched in order to be formed into one film stretched by a rolling device. The film was rolled up in the calendar process (hereafter referred to as “process 1”). At this point, three rolls of film — a front film, interior film, and back film — were produced;
- Following the process 1, the front film, interior film, and foundation were adhered, being a single sheet (the roll in progress in the 108 process) in the laminator 108 process (hereafter referred to as “process 2”);
- In the next step, the roll in progress in the process108 and the back film were adhered, being a single sheet (the roll in progress in the process 109). This process was called the laminator 109 process (hereafter referred to as “process 3”); and

- Finally, in the roll inspection process (process 4), extra portions of the roll in progress were cut off, and the film was rolled up, becoming a product with length requested by a customer after inspection.

Based on the process noted above, four quantity centres — process 1, process 2, process 3, and inspection process - were defined. In this project, input materials were compounded substances and foundation film.

Furthermore, other characteristics of the MFCA calculation included the followings:

- Material losses from each process were re-input into the process 1. Although this did not result in material loss, system costs (SC) and energy costs (EC) were carried over with the re-input materials. Therefore, returned materials and remaining films were added to the weight of material losses in calculating an allocation ratio of SC and EC to products and material losses; and

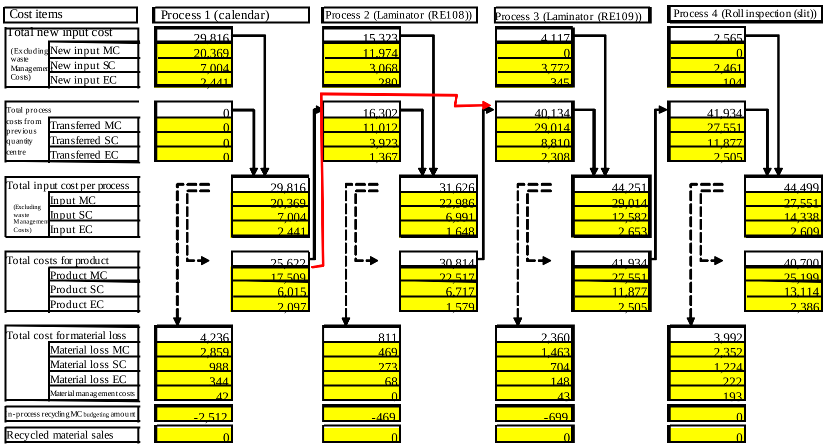
- Under the approach taken by the current simple MFCA calculation tool, as the product in progress from the previous process was considered as the “material”. As the subject process contained the quantity centre that did not necessarily receive the product from the centre defined prior to the subject quantity centre, the calculation was adjusted in consideration of mass balance at each quantity centre.

(3) Description of material losses

Material loss generated in the subject process was the film attached to the foundation film. This could not be returned to the in-process recycling and ended up in a material loss.

(4) Findings through MFCA analysis

The following shows the material flow chart and the material flow cost matrix associated with the subject process:



NOTE Figures have been altered for publication. Figures are in units of 1,000 yen.

Figure 21.2 Material flow chart for the targeted process

Table 21.1 Material flow cost matrix

	Material costs	Energy costs	System costs	Waste Management costs	Total
Good items (products)	25,199.0	2,386.0	13,114.0		40,700.0
	52.0%	4.9%	27.1%		84.1%
Material loss	3,463.0	784.0	3,191.0		7,439.0
	7.2%	1.6%	6.6%		15.4%
Waste/recycling				279.0	279.0
				0.6%	0.6%
Sub-total	28,662.0	3,171.0	16,306.0	279.0	48,420.0
	59.2%	6.5%	33.7%	0.6%	100.0%

NOTE Figures have been altered for publication. Figures are in units of 1,000 yen.

(5) Targeted points to be improved or improvements based on MFCA analysis

Although material losses in a monetary unit were decreased by half through the in-process recycling, SC and EC accounted for approximately 43% of the cost associated with the material losses. Likewise, the largest portion of the material loss costs from the roll inspection process occurred due to generation of the edged materials and specification adjustments etc. As these material losses were largely due to the outputs (intermediate products) from the previous processes (process 1 to 3), it was necessary to consider measures to promote loss reductions based on the processes prior to the roll inspection process. Moreover, looking at a proportion of the total cost of the product, as was known from the manufacturing cost for one-meter of the product, the highest percentage of the cost were from the processes 1 and 2 which had relatively high input costs.

Reduced cost by implementing individual improvement measures and a total improvement measures were simulated using the simple MFCA calculation tool. Based on these results, the management decisions will be made to implement improvement measures.

(6) Conclusion

An advantage of MFCA application was that losses (per process and for overall processes) and impact of improvement measures through investments etc. could be expressed in a monetary unit. This provided useful information for the management in their decision-making on introduction of new technologies and on fundamental reforms in production processes. On the other hand, issues related the MFCA application included the followings:

- Control of on-site operational load in collecting MFCA related information for quantification and incorporation of such activities into operators' daily tasks;
- Consideration of an interface for linking a cost management system with a daily report; and
- Coordination with ISO14001 activities.

Case 22 Shinryo Co., Ltd.
Example of MFCA model adopted by a food-processing SME

(1) Organizational profile

Shinryo Co., Ltd. produces brown sugar products. The company's number of employees was 36. Furthermore, the company's capital was 26 million yen at the time of the project.

(2) Material flow model of main target process/es

The MFCA was applied to the processes from producing to packaging brown sugar products. The manufacturing processes included: "the manufacturing process of material brown sugar", which is a series of procedures, starting with inputting raw materials, followed by dissolving, filtering, concentrating, and agitating them; and "the molding process", that is, molding material brown sugar to meet the purpose of a given product, measuring, and placing in storage boxes. These two processes are defined as the quantity centre (QC) for the brown sugar production. The molded finished products are stored and dried in a drying room for one day before packaging and shipment. For consumer products, the finished products are packaged in small bags and then packed in carton boxes, while those for industrial uses are packaged in large bags. These packaging processes are defined as the QC for the product packaging.

In the manufacturing process of material brown sugar, raw sugar, molasses, invert sugar, water, and other materials are input. Meanwhile, the input for the product packaging process include small bags for packaging, large bags, carton boxes, packing tape, and polypropylene (PP) strapping band.

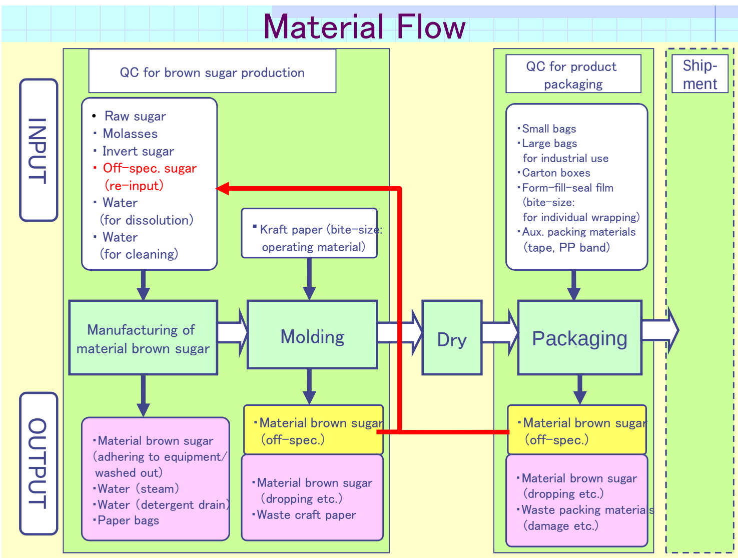


Figure 22.1 Outline of Material Flow

(3) Description of material losses

(i) Losses in manufacturing processes

- Off-specification products

Off-specification material brown sugar was generated in the both QCs, and such sugar was input again (or reused) in the manufacturing process when making the subject products next time.

- Losses from dropped products etc.

Among brown sugar material, there were material losses during the molding, delivery, and packaging processes, such as those dropped on the floor, washed out during the cleaning of the material brown sugar manufacturing equipment, or discarded when cleaning automatic packaging equipment.

- Losses from packaging materials for raw sugar

Upon purchasing raw sugar, it was contained in dedicated paper bags. All these bags were discarded after raw sugar was input in the manufacturing process. These costs were not highlighted in monetary units but they were actually considered losses in physical units.

- Losses from excessive packaging

Packaging material losses were rarely generated within the manufacturing facility in terms of quantity. However, such materials were discarded at the time when customers purchased or used the products. In this light, excessive packaging should be considered as loss from the specification.

(ii) Definition of MFCA data

- Material costs: All input materials (raw sugar, bag-in-boxes, craft paper, washing water, packaging materials, auxiliary packaging material, etc.). For material brown sugar, newly input raw sugar, input of off-specification products, and work-in-process were calculated separately;

- Waste management costs: Waste management costs for raw-sugar paper bags were added to the calculation;

- Energy costs: electric power and heavy oil costs were included in the calculation; and

- System costs: Personnel, depreciation, and maintenance/repair costs were covered.

(4) Findings through MFCA analysis

- Off-specification products accounted for 5% of overall products. As they were all input again (reused) as raw sugar, it appeared that they did not entail any material losses. However, they practically generated losses such as system costs and energy consumption during the manufacturing processes. In addition, the absence of off-specification products led to greater output of the products and a reduction in ongoing night duties.

- Losses from dropped products and others comprised 5% of overall products, suggesting losses in material costs, system costs, and energy consumption. It was also necessary to consider their negative impact in connection with night work as is the case with off-specification products.

- The estimate indicated that the losses from packaging materials for raw sugar caused a significant cost burden.

- The losses from excessive packaging came to the fore when reviewing the quality and size of packing tape, as well as the way to apply PP strapping band.

(5) Targeted points to be improved or improvements based on MFCA analysis

- The losses from off-specification products and dropped products stemmed from *muri* (unreasonable), *mura* (uneven), and *muda* (wasteful) operations. Therefore, it was essential to tackle with operational improvement and loss reductions concurrently. Such improvements should not require any marked investment but still boost labor productivity (efficiency and operating rate) considerably and probably reduced night duties.

- With respect to the losses from packaging materials for raw sugar, it was necessary to consider how to push the relevant cost down to a reasonable level, in collaboration with raw sugar production makers. Addressing this issue was expected to bring benefits in terms of costs and environmental impacts.

- For the losses from excessive packaging, it was important to consider them from a standpoint of customers. The excessive packaging should be considered as waste for customers. Changing to less costly materials, rather than prioritizing the quality, should lead to cost reductions and better customer satisfaction.

(6) Conclusion

The MFCA analysis this time highlighted small issues where the company will have to keep up efforts to improve, and each small improvement should generate benefits. The resultant effects were expected to emerge in various forms, such as less resource consumption, higher labor productivity, improvement in labor safety and labor health, better customer satisfaction, less material loss, and cost reductions.

Among others, the following challenges remained for consistent MFCA analysis and improvement activities: improvement in daily reports, methods to collect data, development of expertise to read data, and how to make better communication between management and on-site workers.

Case 23 KODAI SANGYO CO., LTD.
Production characteristics: Processing of timber products, small-to-medium business, and set-up of an internal production control system

(1) Organizational profile

KODAI SANGYO CO., LTD. (hereafter referred to as "Kodai Sangyo") processes wooden materials for "household drain boards". The company is located in Fukushima, Japan. The company's employees numbered 39. In addition, the company is capitalized at 65 million yen with sales of 572 million yen at the time of the project.

(2) Material flow model of main target process/es

The selected process for this project is processing of wooden materials for home-use "drain boards". The detailed flow of the process is shown in Figure 23.1.

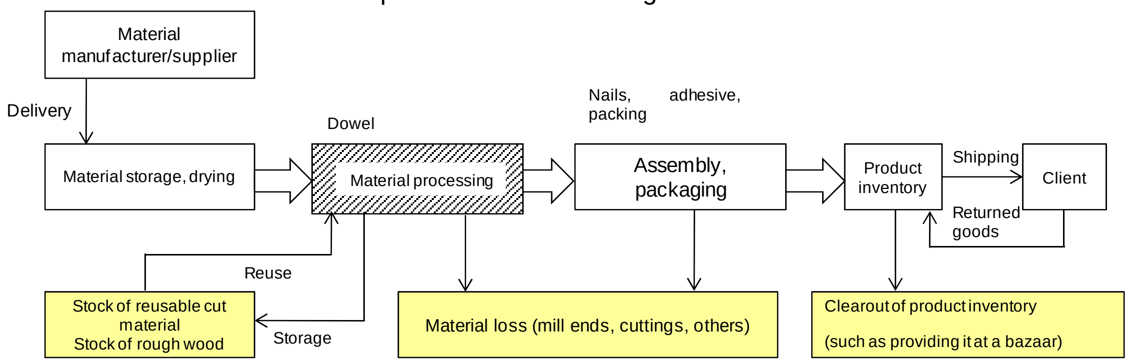


Figure 23.1 Selected process for this project (MFCA boundary)

The selected process contained the following characteristics/steps:

- Materials delivered from a supplier were stocked as input materials. Subsequently, they are naturally dried or artificially dried;
- The materials that have been dried to the specified moisture-content level were input into the process;
- The input wooden materials were firstly processed so that their length, width, and board thickness were consistent with a given design. Subsequently, hole-drilling, milling, and dowel insertion etc. were conducted as necessary; and
- In the assembly process, multiple parts were fixated by nails and adhesives etc. They were then inspected, packaged, and sent to a stock for finished goods. Products are shipped according to customer orders, and some products were returned in some cases.

The material-processing phases that generated entire material losses of the main materials were defined as a quantity centre. Post-assembly processes, packaging, material stocking and drying processes were not included in the scope of this project.

(3) Description of material losses

Among the delivered wood materials, those with excessively large knots and cracks were considered to be defective and called “rough wood.” The rough wood was provided to a material manufacturer/supplier at discounted price.

(4) Findings through MFCA analysis

Table 23.1 shows the material flow cost matrix associated with the process:

Table 23.1 Material flow cost matrix

		Material cost	Energy cost	System cost	Waste management cost	Total
Good items (Products)		300.0	20.0	220.0		540.0
		37.0%	2.5%	27.2%		66.7%
Material loss		150.0	10.0	110.0		270.0
		18.5%	1.2%	13.6%		33.3%
Waste/recycling					0.0	0.0
					0.0%	0.0%
Sub-total		450.0	30.0	330.0	0.0	810.0
		55.6%	3.7%	40.7%	0.0%	100.0%

NOTE Figures have been altered for publication. Figures are in units of 1,000 yen.

The results of MFCA calculation suggested a need to consider optimal standardization in lumber sawing and inventory amounts, as 33% of material loss in mill-ends and swarf came from the material length that was based on product design and length of purchased materials.

(5) Targeted points to be improved or improvements based on MFCA analysis

Considering losses due to the effect of knots in materials (hereafter, “B-class products”), it was necessary to consider an option of selecting wood materials that did not contain knots before the processing (i.e., exclude the rough wood before manufacturing B-class products).

(6) Conclusion

The subject process involved living materials. Hence, statistical analysis of the input materials, products and material losses were necessary. The results of the MFCA systematization scheme indicated that the MFCA management system can be established based on three sources of information: information from the “sales management system” (in operation), information from the “accounting system” (in operation), and information from the “production management system” (under consideration for its introduction). Furthermore, in addition to this information, the MFCA management system will need master data in basic unit for the input materials that constituent products, as well as information on unit prices of materials and products.

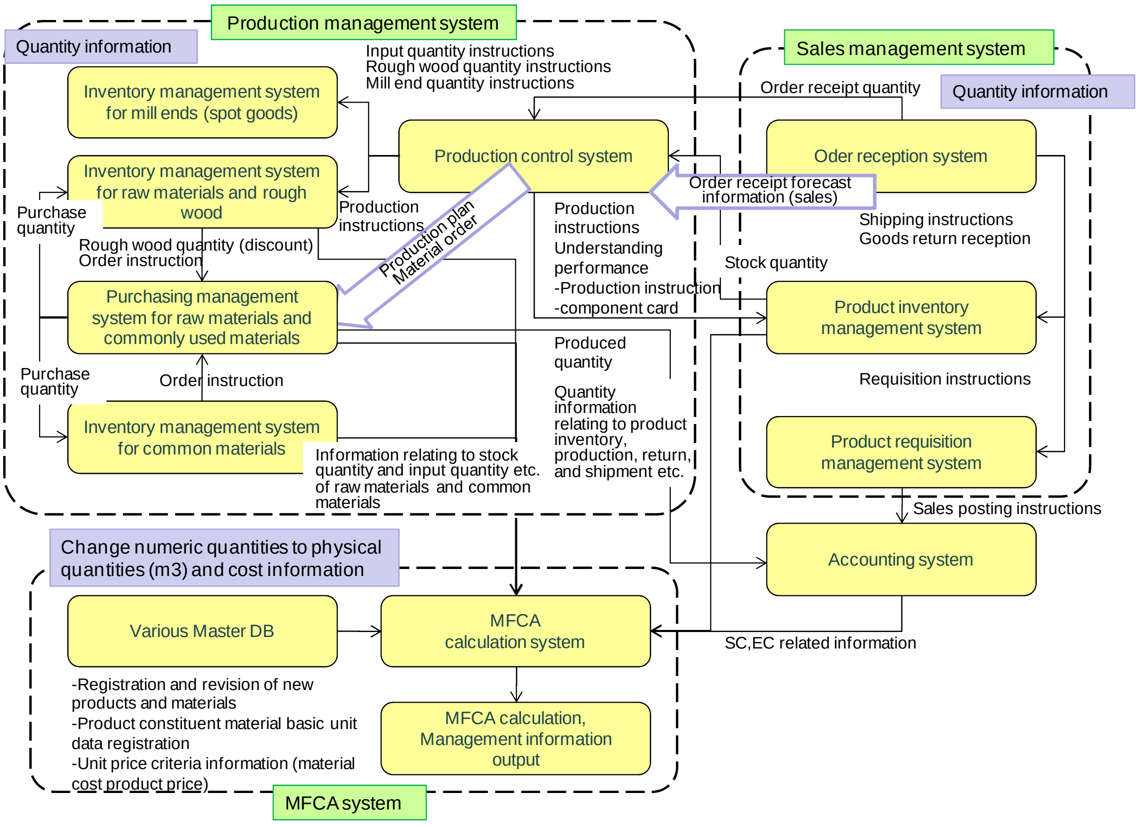


Figure 23.2 MFCA systematization scheme

The system shown in Figure 23.2 was a simplified MFCA calculation scheme and was considered necessary to be improved further for more accuracy and practicability. On the other hand, this scheme indicated that MFCA management system could be established in the form of a simple system. Likewise, speedy establishment of the system increased transparency of the flow related to material losses in the process, and was considered to enhance the company’s business performance.

III. Case Examples in the Nonmanufacturing Industry

Case 24 JFE group
(JFE Engineering Corporation, JFE R&D Corporation, and JFE Techno Research Corporation)
Production characteristics: Construction

(1) Organizational profile

JFE group (JFE Engineering Corporation, JFE R&D Corporation, and JFE Techno Research Corporation) were involved in this project. Each company played the following roles:

- JFE Engineering Corporation (hereafter referred to as “JFE Engineering”): Implementation of construction work;
- JFE R&D Corporation: Direction of the entire project; and
- JFE Techno Research Corporation (hereafter referred to as “JFE Techno”): Implementation of MFCA analysis.

MFCA was cooperatively conducted by the three companies noted above. The application of MFCA for this kind of construction was rare, and the attempt undertaken this time was meaningful for pioneering the application of MFCA in the construction field.
JFE holdings, the holding company of these three companies, made sales of 326.040 trillion yen on a consolidated basis. Also, the company capital was 142.3 billion yen.

(2) Material flow model of main target process/es

Table 24.1 describes the targeted work for this project.

Table 24.1 Selected process for this project (MFCA boundary)

Materials	MFCA input categories	Material type (categories for MFCA application for this project)	Quantity centre classification for MFCA application this time	Quantity and calculation approach for material cost
Existing installations	Existing refrigerator	Transported material	Targeted construction	The quantity of the existing refrigerator is clear, and the MC is calculated with the recorded cost.
				The estimated quantity of the new hatch and floor materials is used as the quantity for the existing installed facilities. (however, as the recorded cost is unclear, MC=zero).
	Hatch and floor	Transported material	Non-targeted construction	MC is calculated with the equipment costs estimated for the new refrigerator.
				The estimated quantity of the new hatch and floor materials is clear and the estimated cost is used as the MC.
New installations	New refrigerator	Newly added materials	Targeted construction	MC is calculated with the equipment cost estimate for the new refrigerator.
	Hatch and floor	Newly added materials	Non-targeted construction	The estimated quantity of the new hatch and floor materials is clear, and the estimated cost is used as the MC.
Construction materials and fuel	Protection materials and fixtures	Operating materials	Both targeted and non-targeted construction	Although it should normally be included in operating materials, it is included in ** entire construction, and after the end of the construction, as it will be reused for a separate construction activity, it was calculated by inclusion in “** entire construction.”
	Transportation of equipments and materials, fuel used for the installation activity	Operating materials (EC is often used for calculation)	Both targeted and non-targeted construction	Although fuel is often calculated using EU, it is part of the direct material costs for the construction, and it is deemed better to define it as operating material. However, this time, as it is included in the estimate as “** entire construction,” it was calculated by inclusion in SC “** entire construction.”

The targeted work was a renewal work for a large-sized refrigerating machine (dimensions: 5.3 ×3×3 mH, weight: 23 tons, and number of units: 3). Existing facilities were dismantled, removed, and replaced with new facilities (new refrigerating machine, hatch, and floor).Further, characteristics of material-flow related to the construction work were described in the followings:

- Little material flow was identified at the construction site, and
- No manufacturing operation was conducted at the site; those manufactured at an external facility were installed at the site.

Quantity centre was defined by dividing the construction project into the targeted construction work and the non-targeted construction work; no definition of a quantity centre based on the process flow was made. The reason for non-definition of the flow-based quantity centre was due to the fact that little material flow was present at the subject process.

Based on this approach, the project was divided as shown in the following:

- Targeted construction: originally planned construction to create added value (e.g., transport, replacement, and installation of the targeted equipments), and

- Non-targeted construction: disassembly, removal, boarding, and installation of protective materials for existing facilities (hatch, flooring). Although these activities were necessary from viewpoints of safety and actual implementation of the work, it was considered good to keep non-targeted construction at a minimum level from the MFCA viewpoint.

(3) Description of material losses

Determination of scope of the costs for calculation was one of the key points for this project. MFCA calculation was performed, using three types of approaches that defined different scopes of the costs for calculation, as shown in the followings:

- Approach 1: Evaluating total costs of both the construction outsourcer (owner) and the outsourcee (JFE group);
- Approach 2: Evaluating total cost of only the construction outsourcee (JFE group); and
- Approach 3: Evaluating total cost of the construction work only that excluded cost of the main facility.

Both originally planned construction approach (hereafter referred to as “A construction method”) and alternative construction approach (hereafter referred to as “B construction method”) were compared and evaluated based on the three approaches for the MFCA calculation.
The material flow cost matrix calculation results are shown in the Figure 24.1 below (Figures for each evaluation approach/construction approach were shown as a proportion to the total cost generated by evaluation of the construction approach A by Approach 1).

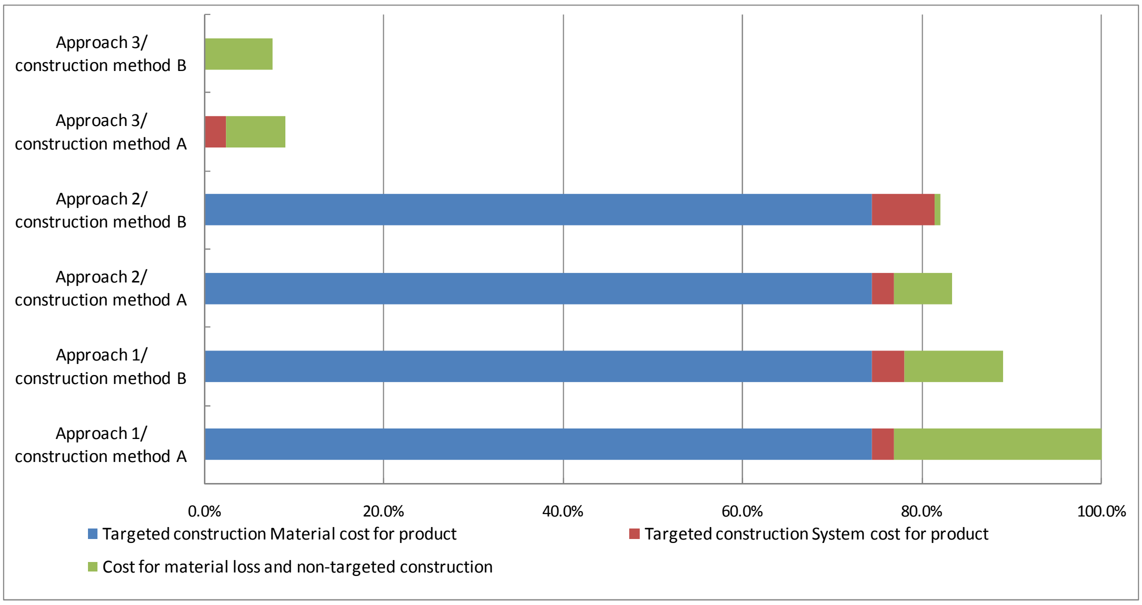


Figure 24.1 MFCA calculation by each construction approach and method

(4) Findings through MFCA analysis

One of the key findings was that business compensation cost was included as a service cost for material losses in evaluating the construction method A by the Approach 1. Although they were an unavoidable cost from the project owner's perspective, the MFCA-based evaluation made it possible to consider a relative advantage in each construction approach by incorporating such factors. At this point, the MFCA-based evaluation was considered to be effective.

(5) Targeted points to be improved or improvements based on MFCA analysis

Following points were identified as potential points for improvement:

(i) Evaluation with inclusion of the cost incurred by the outsourcer

- Total cost of the construction method B was 10% lower than that of the construction method A;
- Ratio of the material loss cost to the whole cost was estimated to be decreased from 15 % to 12 % by the construction method B. In addition, energy consumption was decreased by 44% through the construction method B; and
- Based on the two assumptions above, it was considered that the construction method B was the better approach.

(ii) Cost incurred by the construction company

Costs associated with the material losses including waste management cost were increased significantly by the construction method B. Likewise, cost of unintended construction was estimated to be reduced by one-forth by employment of the method B. Difference in the total costs was considered to be narrowed.

(6) Conclusion

MFCA application to the planning phase and the estimating phase enabled economic and environmental evaluations of multiple approaches, highlighting relative advantage of related parties to the project. MFCA can be used to quantitatively understand advantage and disadvantage between outsourcer and the parties jointly engaged in the project.

In addition, this case example was very advanced in that MFCA was applied to the construction activities. One of the key points identified from this example was that there were two ways of MFCA application that consist of MFCA from the viewpoint of the outsourcee, and the one that included both the outsourcer and the outsourcee. Furthermore, the latter approach enabled evaluation of the service from various viewpoints.

Case 25 GUNZE Limited
Production characteristics: MFCA application in clothing products distribution (Trial)

(1) Organizational profile

GUNZE Limited (hereafter referred to as “Gunze”) is an apparel maker that manufactures various products including men's and kids' underwear and located in Osaka, Japan (a factory is located in Kyoto). Gunze’s affiliated company is engaged in distributing activities of the Gunze’s products to retail stores located all over Japan. As of March 31st, 2009, the number of employees numbered 9,041 on a consolidated basis. The company’s sales were 151.5 billion yen on a consolidated basis as of March 2009. The company’s capital was 26.1 billion yen.

(2) Material flow model of main target process/es

The selected process for this project is a clothing distribution. The detailed process was shown in the Figure 25.1.

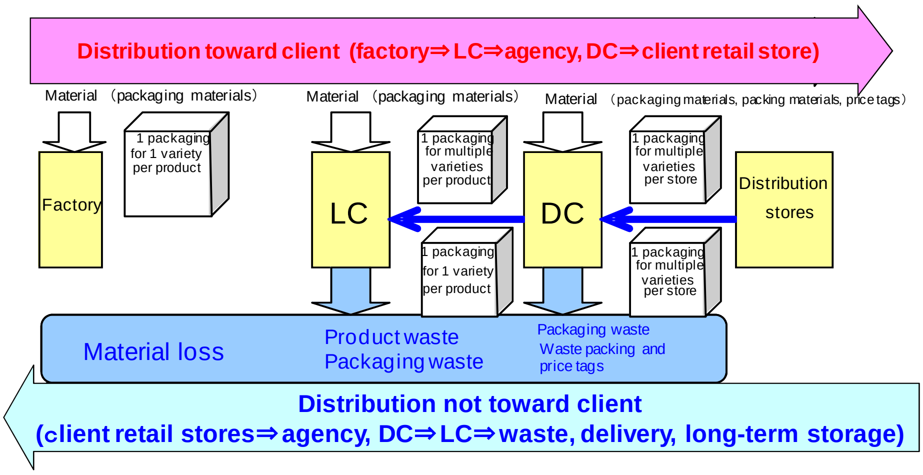


Figure 25.1 Selected process for this project (MFCA boundary)

This project was conducted on a trial basis. Characteristics of the subject process included the followings:

- Numerous types of products were subject for the MFCA analysis. Even with respect to men’s inner wear products, there were as many as 8000 product types for distribution, and several tens of thousands of product types according to size and color;
- Products were shipped to second distribution companies located throughout Japan; and
- It was necessary to track a wide range of physical product flow in the “Distribution MFCA”.

(3) Description of material losses

Logistic centre (LC) and distribution centre (DC) were defined as quantity centre. Further, following materials were subject for calculation:

- Material: products manufactured in a factory; and
- Auxiliary material: packaging materials and price tags attached to the material at LC and DC.

Losses from each QC

- LC: Product waste and Packaging waste
- DC: Packaging waste, Waste packing and price tags

MFCA calculation was conducted in the number of the products by tracing the inventory volume at the beginning and the end of the period, input and output volume at the LC and DC, and number of the transferred materials between LCs and DCs.

(4) Findings through MFCA analysis

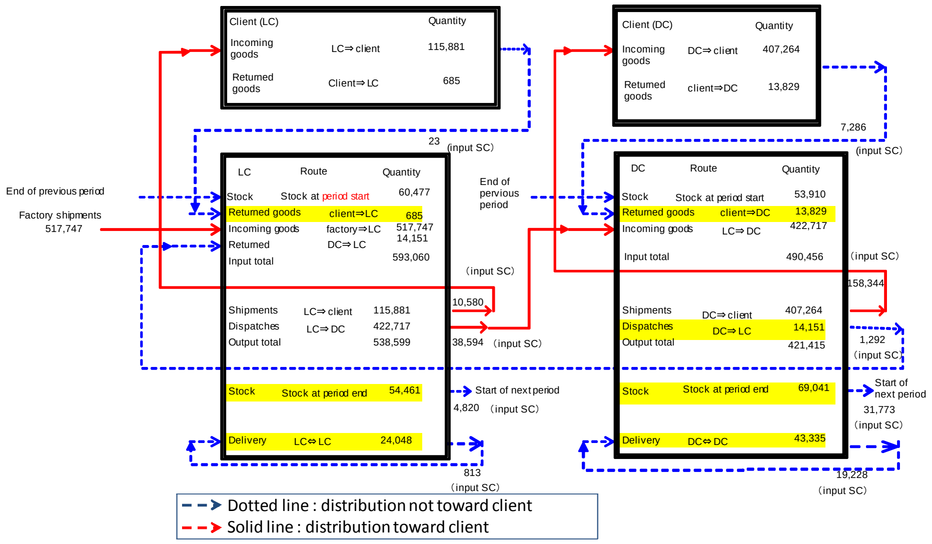
Distribution costs were calculated in two ways as shown in Table 25.1: the distribution towards client; and the distribution not toward client. Table 25.1 indicated that 25.91 % of the system costs were for the distribution not toward clients.

Table 25.1 Calculation of the distribution costs

NOTE Figures have been altered for publication.

Distribution costs	System costs for Distribution toward client	System costs for Distribution not toward client	Total
Products	192,986	67,493	260,479
	93.62%	0.00%	100.00%
Material loss	0	0	0
	0.00%	0.00%	0.00%
waste/recycling			
			0.00%
Sub-total	192,986	67,493	260,479
	74.09%	25.91%	100.00%

Instead of a material flow model in physical units, diagrams for quantity centre and a diagram showing the material flow between quantity centres was produced based on information about the system costs (SC). A separate diagram was also created for calculation of CO_2 emissions instead of SC.



NOTE Figures have been altered for publication.

Figure 25.2 Material flow diagram with SC data

(5) Targeted points to be improved or improvements based on MFCA analysis

Reduction of returned products and more efficient logistics were important points in order to reduce material loss for higher economic performance. In this case, no material losses were generated from the inventory. However, long-term inventory means presence of products that did not meet market needs. Other issues also included cash flow and lowered sales value due to the products obsolescence.

(6) Conclusion

Although MFCA approach for the logistic industry had not been fully developed, the analysis in this project indicates a potential to evaluate loss generated through the entire material flow from manufacturing of apparel products to delivery. Especially, the MFCA analysis for this project highlighted the following points:

- Expected advantages of MFCA application

  - The application of MFCA resulted in loss reduction (e.g., reduction in returned products, transfer of products from one stockroom to another stock room, and long-term inventory) during course of the distribution process; and
  - It became easier to consider action and measures to reduce CO_2 emissions in the distribution sector through the MFCA analysis.

- Issue in the MFCA application

  As the distribution MFCA required handling of an extremely large volume of data, a systematic approach for an effective MFCA calculation was considered to be necessary.

Case 26 OHMI BUSSAN, Inc.
Production characteristics: MFCA implementation in plastic material recycling

(1) Organizational profile

OHMI BUSSAN, Inc. (hereafter referred as "Ohmi Bussan") conducts plastic material recycling and sales recycled plastic materials. MFCA was implemented to accurately assess losses from processes in physical and monetary units, to gather basic data for process improvement and cost reduction, and to use the MFCA result as a source for decision-making when making an investment to curtail the identified losses. The company's employees numbered 49. The company's sales were 1.8 billion yen and the capital was 40 million yen (FY 2007).

(2) Products and processes subject to MFCA implementation and their characteristics (material flow model of main target processes)

- Target products and range of processes
  Recycled plastic materials were the selected product for this project. Pulverizing process, interim product stock, and mixed extrusion process were the selected processes for this project.

- Manufacturing processes and quantity centres
  - The subject recycling processes consisted of the following activities:
    - Inventory where material losses recovered from the market were stored,
    - Sorting and preprocessing process to sort raw materials for the process,
    - Pulverizing and rinsing process that crushes the material into chips,
    - Mixing process that mixes the material with additives, extrusion,
    - Pelletizing process that processes the chips into pellets of equal size, and
    - Quality-control process, packaging process, and shipment process.

Among the aforementioned processes, pulverizing process, interim product stockroom, mixing and extrusion process were defined as quantity centres. Input and output data are shown in Figure 26.1.

One of the characteristics of the recycling business was that fixed plans could not be made for purchasing raw materials. Raw materials were generally obtained when there was a supply. On the other hand, the recycler needed to provide a designated amount of the deliverables regardless of supplied amounts of the raw materials. This resulted in a large amount of long-term inventory, which was a point for potential improvement.

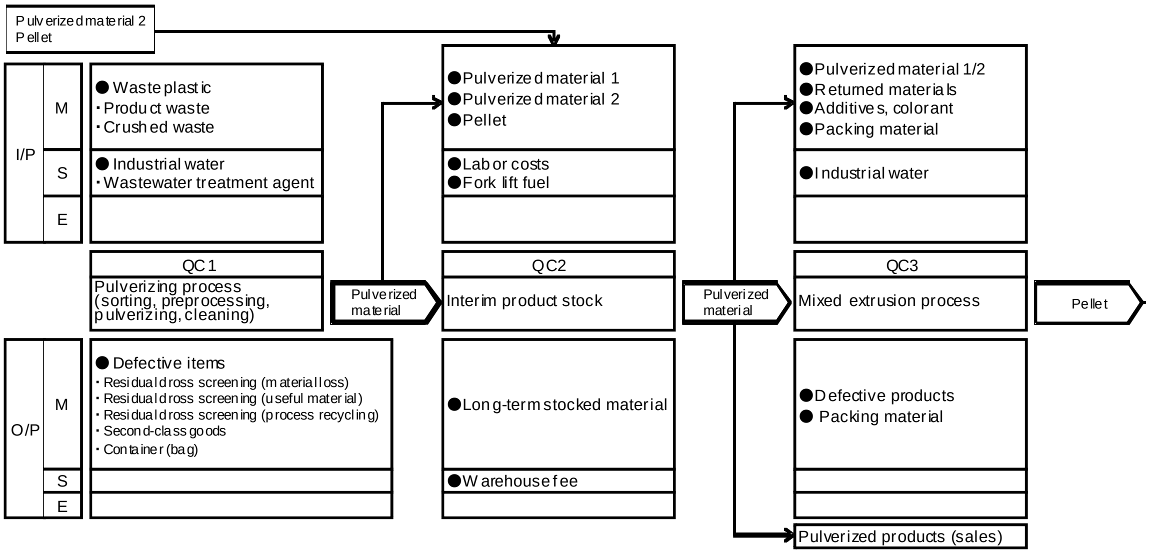


Figure 26.1 Input/output within MFCA boundary

(3) Description of material losses

- Pulverization process: defective items, residual dross screening (material loss);
- Intermediate product stock: stock clearance fee; and
- Mixed extrusion process: defective items, packing material (material loss).

- MFCA data definition
  - Input, output, emission gas amounts, and performance data for each material were gathered;
  - Energy costs (EC) were allocated according to operating time and number of processes based on the measured values for the entire factory; and
  - System costs (SC) were allocated according to operating time and number of processes based on the measured values for the entire factory.

(4) Findings through MFCA analysis

As shown in Table 26.1, wastes with a market value in intermediate product stockroom were found to be substantial. Likewise, material losses generated in the pulverization process were found to be also substantial.

Table 26.1 Material input/output amount

NOTE Figures have been altered for publication.

				QC 1	QC 2	QC 3
	MC item catgories	Item names	Unit	Pulverizing process	Interim stock	Mixed extrusion
Input	Products from previous process	Material input quantity	Kg	0	390000	970000
		Product quantity	Kg	0	320000	970000
		Material loss quantity	Kg	0	70000	0
	Direct materials	Material input quantity	Kg	565000	780000	2000
		Product quantity	Kg	550000	650000	2000
		Material loss quantity	Kg	15000	130000	0
Output	Material loss: Emissions, and waste	Quantity of product	Kg	550000	970000	972000
		Sliver, etc.	Kg	6000	0	0
	Material loss: valuable materials	Second-class items, raw materials stocked at the warehouse over the long-term, products in progress, completed product (interim stock), etc.	Kg	9000	200000	0

− MFCA cost evaluation (all processes)

Material costs (MC) were identified to be the most substantial of all input costs as shown in Table 26.2.

Table 26.2 Material flow cost matrix

NOTE Figures have been altered for publication.

	Material cost	Energy cost	System cost	Waste management cost	Total
Product	54.2%	3.9%	27.8%		85.9%
Material loss	11.0%	0.1%	2.9%		13.9%
Waste/recycling					0.1%
Sub-total	65.2%	4.0%	30.7%	0.0%	100.0%

(5) Targeted points to be improved or improvements based on MFCA analysis

Countermeasures to control long-term retained inventory, mixed extrusion process additives, and sliver generated from the pulverization process were considered as prioritized points for improvement.

The interim stock amounted to be 200 tons, based on the assumption that the interim stock accumulated over the long-term in the stockroom (i.e., raw materials, intermediate products and completed products) accounted for 10% of the monthly end stock. It was recommended to reduce such stocked amount and the inventory-related cost (600,000 yen), and to increase sales in consideration of the stocked volume.

Additives used in the mixed extrusion process were extremely costly. Approximately five-ton of the additives were currently input monthly. Improved blending method will enable the recycler to curtail the amount of the additives. However, change in the blending method required replacement of facilities. This will increase system costs; cost-effectiveness from the increased productivity by the new facility (i.e., reduced system costs) was recommended to be considered as well.

Approximately, six-ton of the sliver materials (material loss) were generated each month through the pulverization process. The amount of the sliver materials loss depended to a large extent on condition of the blade for the pulverizing machine. By reviewing the optimal period for the blade replacement, it will be necessary to curtail generation of the slivers, and to convert the subject material loss into product.

(6) Conclusion

Through the MFCA analysis, the input-output relationship at the recycling site was further understood. Even with respect to handling practice of intermediate products in a stockroom, level of its impact on the business was clarified. Likewise, this project became an opportunity to improve awareness of the material losses. Through in-depth understanding of “quantity × unit cost,” it became possible to understand the adverse affects of proceeding with business based on intuition.

Hereafter, by continuing to apply this know-how, measures for improved profitability will be promoted. In addition, the MFCA calculation tool used in this project will be a key tool for management. It is the Ohmi Bussan’s intention to play a role in building a recycle-based society through MFCA.

Case 27 Sanden Corporation
Service characteristics: Maintenance and cleaning service of equipments for retail stores

(1) Organizational profile

Sanden Corporation (hereafter referred to as "Sanden") manufactures and sales automobile-related devices, vending machines, and equipments for retail stores. Along with the manufacturing activities, at its store-equipments department, Sanden also provides a total service that includes store-design and maintenance after the opening of store in addition to production and sales. The company employees numbered 2,853 on a non-consolidated basis and 8,750 on a consolidated basis. The company's sales were 216.69 billion yen on a consolidated basis in 2008. The capital was 11.037 billion yen.

(2) Material flow model of main target process/es

(i) Characteristics of services subject for MFCA analysis

Sanden provides off-site maintenance and cleaning services for used equipments at clients' retail stores. MFCA was applied to this service flow. The clients were logistics and restaurant chain companies. Upon their closure of existing stores, refrigerator, showcases, shelves and other equipments occasionally became wastes. In one of such stores, for example, the amount of such wastes reached seven tons. According to industry source, a total of 4,113 stores were annually opened and 2,137 were closed. In other words, assuming that all equipments were disposed of, 14,959 tons of wastes were annually generated. However, among those disposed of, some of the used equipments were reusable and fulfill same functionality as new ones, being after maintenance and cleaning. Therefore, Sanden provided off-site maintenance and cleaning services for such equipments.

(ii) Definition of quantity centres

In consideration of the subject service flow, following two approaches were considered:

- Sanden: Subject for MFCA analysis as a provider for the service
- Client company: Subject for MFCA analysis as a receiver of the service

Materials used in the subject service:

- Sanden: Rinsing water, rinsing agents, spare parts , paint, and packaging material
- Client company: Used equipments and newly purchased equipments

Two quantity centres were established; one covered all material flows of the service provider (Sanden (upper part of Figure 27.1) and the other covered all material flows for the client company (lower part of Figure 27.1).

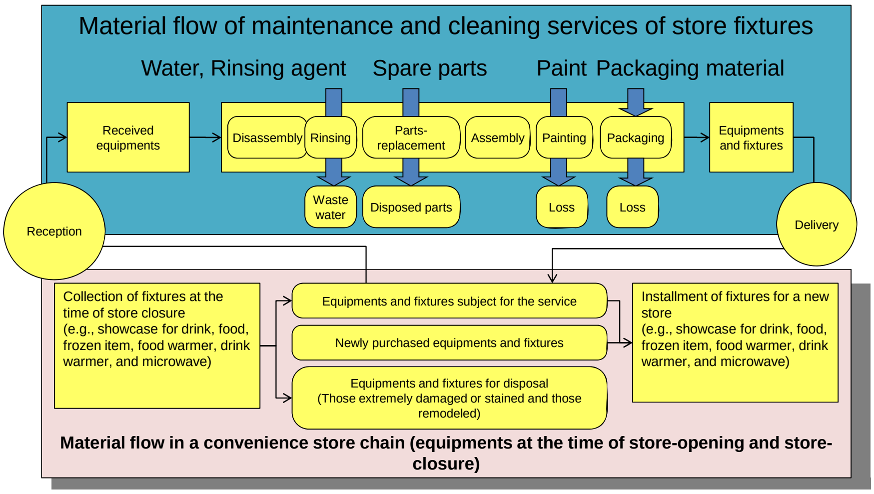


Figure 27.1 Material flow of maintenance and cleaning services

(3) Description of material losses

(i) Material loss

In Sanden's material flow, spare parts were used to replace used parts. As the process concerned only replacement activities, input and outputs were equal. Furthermore, minor amount of other materials were used and disposed of. In the material flow of the client company, type of disposed equipments varied from store to store.

(ii) Definition of MFCA data

Weight-based information was collected on maintenance equipments and spares parts. For the material flow of the client company, number and weight-based data were assumed based on the proposal submitted by Sanden to the client company. In addition, energy cost and system cost were out of scope for this project.

(4) Findings through MFCA analysis

MFCA analysis revealed several equipments that did not necessarily require replacement although amount of such equipments were small and associated rooms for improvements were also small. Hence, simulation based on MFCA was conducted with broader scope of the analysis subject; all logistics companies and restaurant chain companies were covered and simulated through MFCA as shown in Tables 27.1 and 27.2. Table 27.1 shows the result based on the assumption that all the equipments in 2,137 closed stores were disposed of. Table 27.2 shows the result based on the assumption that all these equipments went through same service as the one Sanden provided. As Table 27.2 shows, if Sanden provided the service for all the 2,137 stores, this reduces amount of the input as well as the material losses by 6,411 tons. In other words, this will lead to a cost reduction of 4.957 billion yen; this is equivalent to 12,220 ton-CO_2 reduction.

Table 27.1 MFCA results of all logistics and restaurant chains (in case that all the equipments in the 2,137 closed stores were disposed of)

Input						Output							
Total input cost				40,468million yen		Material cost		40,169million yen 99.3%		Material cost		299million yen 0.7%	
Material and material cost		Quantity (ton)	%	Cost (million yen)	%	Quantity (ton)	%	Cost (million yen)	%	Quantity (ton)	%	Cost (million yen)	%
Newly purchased equipment		28,791	65.8%	40,168.8	99.3%	28,791	100.0%	40,168.8	99.3%				
Reuse of existing equipment		0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%				
Non-reuse of existing equipment		14,959	34.2%	0.0	0.0%					14,959	100.0%	0.0	
Sub-total of material quantity and cost		43,750	100.0%	40,168.8	99.3%	28,791	100.0%	40,168.8	99.3%	14,959	100.0%	0.0	0.0%
Amount of waste and cost	Unit management cost (million yen/ton)	Quantity (ton)	%	Cost (million yen)	%	Quantity (ton)	%	Cost (million yen)	%	Quantity (ton)	%	Cost (million yen)	%
Non-reuse of existing equipment	0.020	14,959	100.0%	299.2	0.7%					14,959		299.2	0.7%
Sub-total of material quantity and cost		14,959.0	100.0%	299.2	0.7%					14,959.0	0.0%	299.2	0.7%

Table 27.2 MFCA results of all logistics companies and restaurant chain companies (all these equipments went through same service as the one Sanden provided)

Input						Output							
Total input cost				35,511million yen		Material cost		35,340million yen 99.5%		Material loss cost		171million yen 0.5%	
Material and material cost		Quantity (ton)	%	Cost (million yen)	%	Quantity (ton)	%	Cost (million yen)	%	Quantity (ton)	%	Cost (million yen)	%
Newly purchased equipment		22,380	59.9%	27,846.2	78.4%	22,380	77.7%	27,846.2	78.4%				
Reuse of existing equipment		6,411	17.2%	7,493.4	21.1%	6,411	22.3%	7,493.4	21.1%				
Non-reuse of existing equipment		8,548	22.9%	0.0	0.0%					8,548	100.0%	0.0	
Sub-total of material quantity and cost		37,339	100.0%	35,339.6	99.5%	28,791	100.0%	35,339.6	99.5%	8,548	100.0%	0.0	0.0%
Amount of waste and cost	Unit management cost (million yen/ton)	Quantity (ton)	%	Cost (million yen)	%	Quantity (ton)	%	Cost (million yen)	%	Quantity (ton)	%	Cost (million yen)	%
Non-reuse of existing equipment	0.020	8,548	100.0%	171.0	0.5%					8,548		171.0	0.5%
Sub-total of material quantity and cost		8,548.0	100.0%	171.0	0.5%					8,548.0	0.0%	171.0	0.5%

(5) Targeted points to be improved or improvements based on MFCA analysis

Few logistics companies and restaurant chain companies enjoyed this service; a significant room for expansion existed. It is necessary that efficient use of material at the time of provision of this service should be considered and dissemination of this service should be boosted.

(6) Conclusion

MFCA analysis revealed that dissemination of the subject service improved business performance and resource efficiency in logistics and restaurant chain sectors. However, in case of mid-to-small sized chain stores and individually owned stores, it is occasionally difficult to reuse such equipments. In this respect, establishment of the maintenance and cleaning services for equipments at mid-to-small sized chain stores and individually owned stores is considered to be necessary in the future. In this respect, Sanden has been expanding its service to include mid-to-small sized chain stores and individually owned stores as potential customers in order to promote establishment of reusing system where the used equipments are maintained, cleaned and reused with same functionality as new equipments.

Case 28 Convenience store A
MFCA case example on the distribution and sales service

(1) Organizational profile

Distribution and sales service business consists of the purchase and sale of items. Among the various businesses engaged in this field, a convenience store adds value in terms of offering convenience to its customers. Toward this end, a convenience store chain runs many stores within a small commercial domain.

Japanese convenience stores sell a variety of products, including food, magazines, and groceries, and provide various services, including photocopying, reception for delivery service, and payment for utilities. MFCA was applied to a typical convenience store, located in a rural city in Japan.

(2) Material flow model of main target process/es

(i) Material flow in a convenience store

At a convenience store, the remaining items are categorized into those to be disposed of at the convenience store and those to be returned to the provider. Food products such as lunch boxes, sandwiches, and other types of processed bread have very short lifecycles and are disposed of at the convenience store. The MFCA analysis on the target convenience store showed that it disposed of approximately 40 kg of food products, thus resulting in an annual waste of 15 tons per store. At present, there are approximately 43,000 convenience stores in Japan. Reduction and recycling of food waste is one of the critical issues with regard to environmental conservation in the convenience-store industry.

In addition to this, a convenience store utilizes other materials in its business activity, such as sales slips; these materials become material losses upon the completion of an operation. Electricity for lighting, air conditioning, refrigeration of items, freezing and heating, and water are also utilized during its operations. All the electricity and water become waste heat and wastewater, respectively.

(ii) MFCA Approach for a convenience store

As noted above, a convenience store sells a variety of items but sales volume of each item is low. In this case study, the food waste of the target store was subjected to an MFCA analysis.

In a convenience store, various food items are sold, including lunch boxes, sandwiches, and bread, each with their expiry date and time; these products are to be removed from shelves and disposed of a few hours before their expiry time.

The objective of this study was to determine the products that were yet to be sold and their associated costs. Three types of sandwiches— ham sandwich, egg sandwich, and cheese sandwich — were selected among many items with expiry date and time, as the items were regularly on shelves. Also, the target convenience store was defined as the quantity centre for the MFCA analysis.

(3) Description of material losses

(i) Definition of material losses

From all the purchased items, those sandwiches that are yet to be sold became material losses.

(ii) Collection of MFCA data

Data from the point-of-sale (POS) system for the targeted product was collected (i.e., number of items purchased, sold, and disposed of). In addition, energy cost (electricity expense) and system cost (labor cost and royalty) were included in the MFCA analysis.

Japanese convenience stores sell a variety of products, including food, magazines, and groceries, and provide various services, including photocopying, reception for delivery service, and payment for utilities. The target chosen in this case study was one such typical convenience store, located in a rural city in Japan.

(4) Findings through MFCA analysis

(i) Material cost for disposed items

As shown in Table 28.1, 41 pieces of the sandwich (3.5 kg; purchase cost: 2,900 yen) were disposed of. The three types of sandwiches accounted for a small share of food products on sale. As stated before, 40 kg of waste food were disposed of per day in the targeted convenience store. Estimations suggest that the purchase cost of these disposed items reached as high as 12,000 yen per day, a significant financial burden for running the convenience store.

Table 28.1 MFCA balance sheet (Figures have been altered for publication)

Input						Output							
Total input cost				25 thousand yen		Cost for the proucts sold		22 thousand yen 88%		Cost for the products remained		3 thousand yen 12%	
Material and material cost	Unit cost (thousand yen/piece)	Quantity (piece)	%	Cost (Thousand yen)	%	Quantity (piece)	%	Cost (Thousand yen)	%	Quantity (piece)	%	Cost (Thousand yen)	%
Ham	0.07	127		8.3	32.7%	112		7.3	28.9%	11		0.7	2.8%
Egg	0.07	107		7.0	27.6%	99		6.5	25.5%	8		0.5	2.1%
Cheese	0.08	111		8.6	33.9%	90		7.0	27.5%	16		1.2	4.9%
Ham (Negligence)										1		0.1	0.3%
Egg (Negligence)										0		0.0	0.0%
Cheese (Negligence)										5		0.4	1.5%
Ham (Carrying-over)						3		0.2	0.8%				
Egg (Carrying-over)						0		0.0	0.0%				
Cheese (Carrying-over)						0		0.0	0.0%				
Subtotal		345	0.0%	23.9	94.3%	304	0.0%	21.0	82.7%	41	0.0%	2.9	11.6%
Volume and cost for waste management	Unit management cost (Thousand yen/kg)	Quantity (kg)	%	Cost (Thousand yen)	%	Quantity (kg)	%	Cost (Thousand yen)	%	Quantity (kg)	%	Cost (Thousand yen)	%
Ham		1.1								1.1			
Egg		0.8								0.8			
Cheese		1.6								1.6			
Subtotal		3.5	0.0%	0.0	0.0%					3.5	0.0%	0.0	0.0%
Energy amount and cost	Unit cost (Thousand yen)	Usage amount		Cost (Thousand yen)	%			Cost (Thousand yen)	%			Cost (Thousand yen)	%
Electricity (kwh)		68		0.6	2.5%			0.6	2.2%			0.1	0.3%
Subtotal		68		0.6				0.6	2.2%			0.1	0.3%
System Cost				Cost (Thousand yen)	%			Cost (Thousand yen)	%			Cost (Thousand yen)	%
Water utility cost (water and sewerage)				0.0	0.0%			0.0	0.0%			0.0	0.0%
Labor cost (part-time worker)				0.8	3.2%			0.7	2.8%			0.1	0.4%
Subtotal				0.8	3.3%			0.7	2.9%			0.1	0.4%

(ii) CO_2 emissions associated with food waste

The CO_2 emissions associated with food waste were estimated. The purchase cost of the food waste was equal to the purchase cost of 200 pieces of sandwiches. On the basis of the estimated life-cycle data for sandwiches (74 g-CO_2), it was found that 14.8 kg-CO_2 was wasted;

this resulted in an annual waste of 5,402 kg-CO_2.

There are 43,228 stores in Japan. Total CO_2 emissions associated with the food waste from those convenience stores were estimated to be roughly 230,000 tons.

(5) Targeted points to be improved or improvements based on MFCA analysis

The MFCA analysis revealed that reduction in food waste had a significant impact not only on the financial performance of a convenience store but also on CO_2 emissions. In order to effectively control opportunity losses as well as the quantity of food waste, it was necessary to place orders accurately.

(6) Conclusion

As identified by the MFCA analysis, the products that were yet to be sold were disposed of and became material losses for the convenient store. However, ordering fewer products can lead to a sold-out situation, as a result of which the convenience store could miss a sales opportunity. In the current POS system, purchase and sales volumes are estimated, thus giving the store owner and manager the necessary information to avoid a sold-out situation. However, in the target convenience store, this information was not readily available to the store owner and manager. In this respect, it is necessary to improve the POS system, so that the store owner has access to information on the cost of the products yet to be sold and on the opportunity loss.

IV. Case Examples in the Supply Chain

Case 29 Sanden Corporation Supply chain team
Production characteristics: Mass-production of relatively small varieties of products

(1) Organizational profile

Two companies (Sanden Corporation and Sanwa Altech (consolidated subsidiary of Sanden Corporation) were involved in this project (hereafter referred to as “Sanden” and “Sanwa Altech”, respectively).

Both Sanden and Sanwa Altech are located in Isesaki City, Gunma Prefecture, Japan. The total factory employees of Sanwa Altech numbered approximately 70 in 2006 and those of Sanden numbered 9,170 in 2005. The capitals of Sanwa Altech and Sanden were 480 million yen and 11.037 billion yen, respectively. The process selected for this project was aluminum die-casting for compressor-parts and processing of machine.

(2) Material flow model of main target process/es

Figure 29.1 indicates material flow and the selected process (MFCA boundary):

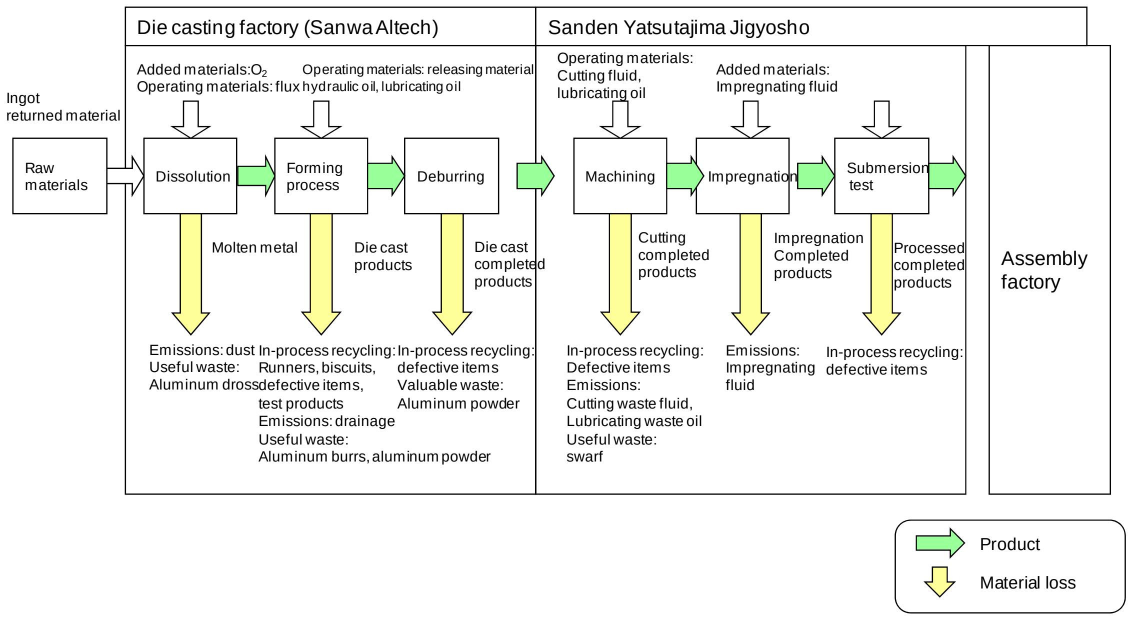


Figure 29.1 Material flow model of the selected process (MFCA boundary)

As shown in Figure 29.1, aluminum die-casting was conducted at Sanwa Altech, and processes following the machining process were conducted at Sanden.

The aluminum ingot – the material used in the die-casting process - was supplied by Sanden for the processes by Sanwa Altech. Further, with regard to left-over materials and defective products generated at Sanwa Altech and Sanden were returned to the dissolution process and reused. Further, aluminum dross, burrs, turnings and chips were sold as valuable materials.

The quantity centre (QC) was defined based on the process chart above. In addition, types of material for calculation were shown in the followings:

- Material: aluminum ingot, returned materials (such as left-over materials and defective products); and

− Auxiliary and operating materials: all of the auxiliary materials shown in Figure 29.1 were subject for calculation.

As noted above, this case example was based on the operations by two companies. In order to consolidate MFCA calculations between these two companies, the following approaches were taken:

− Two separate MFCA calculation models were established for the aluminum die-casting facility and the machining facility;

− Subsequently, two calculation results were consolidated for analysis; and

− The consolidated MFCA calculation was made based on information about system cost and energy which were partly related to allocation of processing unit costs as agreed between Sanden and Sanwa Altech.

(3) Description of material losses

Input and material loss at each phase of the operations consisted of the followings:

− Left-over materials and defective products at Sanwa Altech and Sanden that were returned to the dissolution process and reused; and

− Aluminum dross, burrs, and turnings and chips were sold as valuable materials and recycled.

(4) Findings through MFCA analysis

Input and output data in each quantity center were surmised in the material flow cost matrix as shown in Table 29.1:

Table 29.1 Material flow cost matrix

	Material cost	Energy cost	System cost	Waste management cost	Total
Products	339.9	77.2	257.6		674.7
	38.0%	8.6%	28.8%		75.4%
Material loss	64.8	55.3	99.6		219.7
	7.2%	6.2%	11.1%		24.6%
Waste/recycling				0.1	0.1
				0.0%	0.0%
Sub-total	404.6	132.5	357.2	0.1	894.5
	45.2%	14.8%	39.9%	0.0%	100.0%

NOTE Figures have been altered for publication. Figures are in units of 1,000 yen.

As stated before, material loss generated at the die-casting factory (e.g., runner, biscuit, defective products, and products from a trial operation) and defective products from the machining process were input as returned materials. These returned materials were re-input into the subject process and were not considered to cause any issues. However, these materials carried over the energy cost and the system cost (e.g., labor cost and depreciation cost) from the initial operation.

(5) Targeted points to be improved or improvements based on MFCA analysis

Following points were identified to be the target points for improvements based on the MFCA analysis:

- Further operational management in a supply chain;
- Review and reduction of the input material;
- Technological break-through; and
- Feedback of the MFCA information to product design.

(6) Conclusion

Based on the comparative analysis of various production measures including in-process recycling and collection of valuable resources, reduction of material loss was considered to be the most effective option for cost reduction.

Case 30 Panasonic Ecology Systems Co., Ltd. Supply chain team
Production characteristics: MFCA implementation in a supply chain

(1) Organizational profile

Panasonic Ecology Systems Co., Ltd. (hereafter referred to as "Panasonic Ecology Systems") manufactured heat-transfer elements used in heat exchange units through vacuum forming. PS sheets which are the main materials used for the product of Panasonic Ecology Systems, were processed through sheet forming by Nippon Sangyo Shizai Co., Ltd. (hereafter referred to as "Nippon Sangyo Shizai"). Table 30.1 summarizes the overview of these companies engaged in this project.

Table 30.1 Overview of Subject Companies

	Panasonic Ecology Systems	Nippon Sangyo Shizai
Number of employees	5,519 (as of March 2009)	–
Capital	12,092 million yen	–

(2) Products and processes subject to MFCA implementation and their characteristics (material flow model of main target processes)

Overview of the production processes conducted by two companies was shown in Figure 30.1. Nippon Sangyo Shizai blended virgin polystyrene (PS) material with butadiene rubber etc., and formed a sheet in which PS sheets were formed and finished to be rolls. Panasonic Ecology Systems conducted the vacuum forming process in which PS roll materials were used to form heat exchange sheets, being subsequently trimmed. At this time, cross-directional mill ends (borders) and feed-directional mill ends (feed) were crushed and sold as valuable resources.

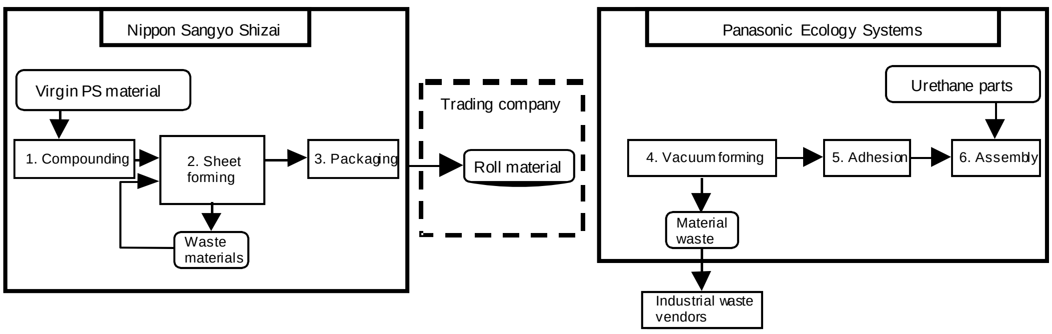


Figure 30.1 Process Flow for the Project

Parameters for MFCA data collection were defined as follows:

- Nippon Sangyo Shizai: butadiene rubber etc. was input with virgin PS material in the compounding process. Roll material at specified dimensions was produced in the forming process; and

- Panasonic Ecology Systems: PS roll materials were input as the main material. Urethane-made materials were input in the assembly process.

(3) Description of material loss

− Nippon Sangyo Shizai

Some purge materials, mill ends, and scrap materials were generated due to technical setting at the start of the operation of the forming process. Mill ends were generated in-line but the materials were immediately crushed, and re-input as raw materials. Purge materials and scrap materials were re-input during the next production process or used for another product.

− Panasonic Ecology Systems

Cross-directional mill ends (borders) and feed-directional mill ends (feed) were generated from the vacuum forming process.

(4) Findings through MFCA analysis

− Nippon Sangyo Shizai

All mill ends were recycled internally. Although it appeared that no material losses were generated because of the recycling practice, energy and personnel costs etc. for the formation and crushing of these mill ends were input to these losses and these associated costs were carried over from the previous production cycle. These costs were considered losses.

− Panasonic Ecology Systems

While selling material waste as valuable resources was considered to be reasonable, it was found that the selling price was extremely small compared to the production costs for this material waste (material loss costs); only 2% of the production costs were recovered from this practice.

(5) Targeted points to be improved or improvements based on MFCA analysis

− Nippon Sangyo Shizai

As gaps were identified between forming width and delivered product width, the minimum forming width required to guarantee thickness will be sought. In addition, purge losses were identified when materials were initially input at the time of the process changeover. Also, losses from final sheet scrap material were identified. The process-changeover practice will be re-considered, and reduction of material loss will be promoted.

− Panasonic Ecology Systems

As divergence existed between material width and product width, the edge space will be reduced by 10mm. In addition, as material losses were identified from trimming, minimization of the divergence between the mold and cavity will be promoted. Further, as there was loss in the feed direction, minimization of feed and placement of the positioning boss will be considered.

− Issues undertaken in cooperation by both companies

It was found that mill ends produced at Panasonic Ecology Systems could be re-input in the processes at Nippon Sangyo Shizai through re-pelletizing, which was also quite cost-effective. It was also found that the quality of scrap materials generated at the end of the sheet forming process were good enough to be input in the processes at Panasonic Ecology Systems; review of the processing company for waste material re-pelletizing, physical distribution, and commercial distribution will be conducted to establish a closed material recycling cycle.

(6) Conclusion

As a result of discussion by both companies, reduction of borders was considered. Test processing found that the standard width dimensions could be made 10 mm smaller. In addition, Panasonic Ecology Systems modified the vacuum forming mold and succeeded in making the dimensions in both the cross direction and feed direction 10 mm smaller. The purchase cost of the scrap materials was adjusted etc., and its deliveries were started.

Owing to these measures, mill ends which used to be an output to the recycling market was diminished. Amount of the virgin material input at Nippon Sangyo Shizai became equivalent to amount of the product at Panasonic Ecology Systems. In particular, the forming load at Nippon Sangyo Shizai was significantly decreased.

Although it used to be vaguely assumed that adequate streamlining of this process had already been conducted, it was found through implementation of MFCA that there was in fact much room for improvement. In particular, by conducting an analysis of the entire supply chain, large areas for improvement in the supply chain were revealed.

Case 31 OMRON RELAY & DEVICES Corporation Supply chain team Production characteristics: MFCA implementation with three companies in a supply chain

(1) Organizational profile

OMRON RELAY & DEVICES Corporation (hereafter referred to as “OER”) is a relay business company which belongs to an electronic and mechanical components business company of OMRON Corporation, and conducts various activities including development of business plans, marketing, development, and production in regard to magnetic relays and peripherals. It comprises one main factory, which controls three domestic and nine overseas factories.

After the introduction of MFCA in OMRON KURAYOSHI Corporation in 2006, the OMRON group has worked on the deployment of MFCA to its group companies. As OER relies heavily on outsourced processing, the deployment of MFCA in its supply chain was a necessary step in achieving the extended implementation of MFCA. At that time, the Ministry of Economy, Trade and Industry introduced the supply chain resource saving cooperation promotion project, and OER decided to participate in this project by implementing MFCA in the OER supply chain, which is composed of OER and its three supplier manufacturers: press processing, heat treatment, and plate processing.

The company employees numbered 1,034 as of April 1, 2010. The company’s capital is 300 million yen.

(2) Material flow model of main target process/es

(i) Objective of MFCA deployment in supply chain

At the beginning of the implementation, the four participating companies agreed on certain objectives, targets, etc., as follows:

- Objective: To introduce MFCA to the outsourced processing process by the suppliers with the aim of visualizing potential losses (e.g., material loss, energy loss, information transmission loss, and the loss due to rather complex issues arising from the relations between the companies).
- Target: To achieve a 10% reduction in material loss in the processes of pressing, heat treatment, and plating.
- To achieve a win–win relationship after introduction of MFCA through continuous effort, such as application of the subject process to the manufacturing of other components.

(ii) Processing of target product in supply chain

The target product was york (a magnetic iron-based component), which is a key component of magnetic relays. Figure 31.1 shows a schematic representation of the manufacturing process. When OER places an order, the press processing manufacturer manages the entire process, which includes pressing, heat treatment, plating, and inspection. Subsequently, the products are delivered to OER, and OER assembles the components. Figure 31.1 shows the input materials used and the waste generated in each stage.

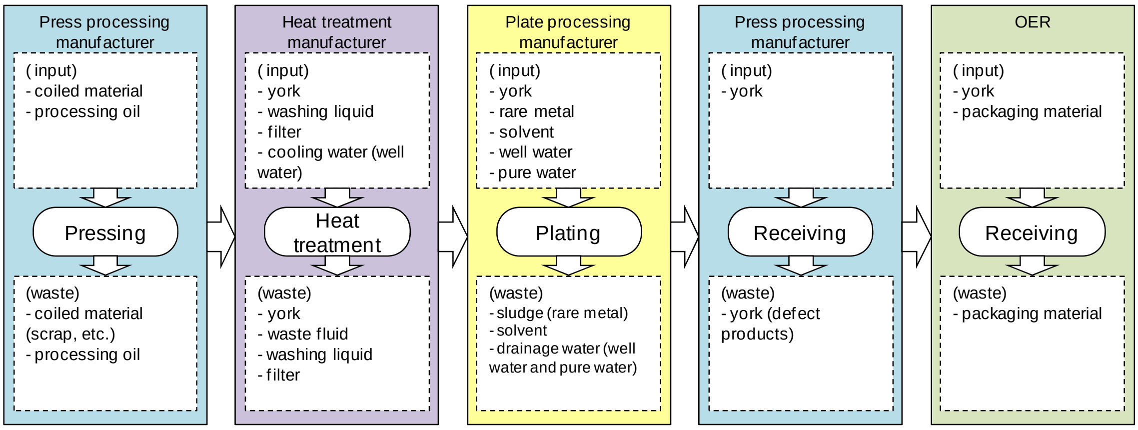


Figure 31.1 Input/output in each quantity center

(iii) Definition of quantity centre

The magnetic relay components are delivered to OER after the manufacturers carry out the processes of pressing, heat treatment, plating, and inspection as described above in (ii). Therefore, each company in the supply chain is defined as an independent quantity centre, and the material input and loss are measured in each quantity centre.

(3) Description of material losses

(i) Material input and loss in each quantity centre

1. Material input and loss in pressing process

   In the pressing process, the shape of york is created by inputting a metallic coiled material, punching it out, and bending it using a press die. In this stage, some metallic coiled material is generated as scrap, and auxiliary material such as processing oil also becomes a part of the loss.

2. Material input and loss in heat treatment process

   In the heat treatment process, the york is softened by heated it in a high-temperature furnace for a certain period of time in order to improve its magnetic property. Although the loss of york in this process is minimal, auxiliary materials such as filter and washing liquid also become a part of the loss. A large amount of energy is also consumed during heat treatment.

3. Material input and loss in plating process

   In the plating process, a rare metal is added to the surface for rust prevention. A large amount of water, such as used washing liquid, and plating liquid become waste fluid, which are drained after undergoing processes such as neutralization. Rare metal etc. remains in the waste liquid and becomes material loss. Moreover, the chemicals used for treatment of waste liquid also become material loss.

(ii) MFCA data definition

As it was a short-term project, the company narrowed down the focus of the analysis to the following points:

– Material: water, resources such as metallic coiled material, plating material, and washing liquid; and

- Energy in the processes of heat treatment and plating.

(iii) Points to be considered in MFCA implementation in a supply chain

- The company implemented the project by selecting promotion members from each company involved in the york processing supply chain.
- As there were no capital ties between OER and the other three companies, information disclosure standards and management rules were established.
- It was decided that improvement effect (monetary amount) for visualized loss was reflected to the cost or allocated upon confirmation of the effect from implementation of the actual countermeasures for improvements.
- The above condition is considered important for building a win–win relationship and for encouraging continuous effort.

(4) Findings through MFCA analysis

(i) Measured result of metallic coiled material

The product generated from metallic coiled material is 47% of input amount, and majority of losses are generated in the pressing process. In the pressing process, trial punching loss, end material loss, etc. accounts for approximately 0.5%, in addition to the scrap loss generated from each product.

(ii) Measured result of water

The amount of water consumed was estimated by converting it to production time per lot: 758 kg of well water was used in the heat treatment process, and 2,760 kg of pure water and 1,280 kg of well water were used in the plating process. As water is not part of the final product, all the water consumed becomes material loss. Although cost for the quantity of water resource as material loss is small, it has a significant impact on the environment due to the large use of groundwater.

(iii) Measured result of energy

A large amount of energy in the form of electricity, gas, and heavy oil is consumed in the pressing, heat treatment, and plating processes. CO_2 emission from the consumption was calculated and evaluated. By converting it to production time per lot, CO_2 emission in each process was found to be 65.7 kg-CO_2 in the pressing process, 135.3 kg-CO_2 in the heat treatment process, and 78.5 kg-CO_2 in the plating process, resulting in a total of 279.5 kg-CO_2.

(5) Targeted points to be improved or improvements based on MFCA analysis

With regard to the loss of metallic coiled material in press processing process, the following loss factors were determined for reduction in trial punching loss, end material loss, and scrap loss: on-site loss factor, design loss factor, and procurement loss factor. It led to an opportunity to build a mechanism that enables to propose improvement toward optimization that covers suppliers to OER in the entire supply chain.

Neither energy nor water resource had been ever considered to be an issue. From an environmental point of view, however, it became clear that the visualization of energy by CO_2 conversion and of water resource in actual used amount is necessary to be continuously monitored in the future as an approach to reduce associated environmental impacts.

(6) Conclusion

Through this approach, potential losses in the outsourced processing process were visualized from three different viewpoints: supply chain, resource productivity, and environmental aspect. Improvement activity has already partially started. The followings are the comments from supplier representatives:

- We would like to aim at improvement in cost and technological competitiveness;
- We have gained opportunities to change our current stereotype;
- We have achieved a wider spectrum of improvement; and
- We are communicating better than before.

Case 32 Ohu Wood Works Co., Ltd. Supply chain team
Production characteristics: Supply chain-wide MFCA implementation in the household stainless steel parts

(1) Organizational profile

Ohu Wood Works Co., Ltd. (hereafter referred to as “Ohu Wood Works”) is involved in various operations from the design to installation of wooden furniture. 85% of the furniture manufactured at the company is used at educational and medical facilities throughout Japan. Moreover, Miyoshi Industry manufactures stainless steel members.

The objective of introducing MFCA in the aforementioned two companies was to minimize total material losses in the supply chain by reviewing a layout at the design phase.

Table 32.1 Overview of Subject Companies

	Ohu Wood Works Co., Ltd	Miyoshi Industry
Number of employees	150	–
Capital	30 million yen	–

(2) Products and processes subject to MFCA implementation and their characteristics (material flow model of main target processes)

Originally, Miyoshi Industry produced stainless steel parts, another supplying company produced uniboards, and Ohu Wood Works assembled them. In this project, production lines for “training kitchen counters” and “installed household sinks” which are produced by Ohu Wood Works and a stainless steel sink, a main material for these Ohu Wood Works’s products, which is manufactured by Miyoshi Industry were selected for MFCA analysis. The manufacturing processes of these two companies were noted below:

- Manufacturing processes and quantity centres
  Each of their manufacturing processes and supply chains are shown in Figure 32.1.

  - The target processes in Ohu Wood Works consisted of production of the wooden structure from uniboard, and the finishing process. In the finishing process, the stainless steel sink-tops produced by Miyoshi Industry was set to this wooden structure; and

  - In Miyoshi Industry, based on the specification provided by Ohu Wood Works, requisite rectangular materials were cut in the shirring process from stainless steel materials which had been optimally cut to length. Subsequently, they were cut by the laser-cutter in order to conform to the external development-shape and underwent a bending process. Finally, a sink-top was produced through the welding and finishing processes.

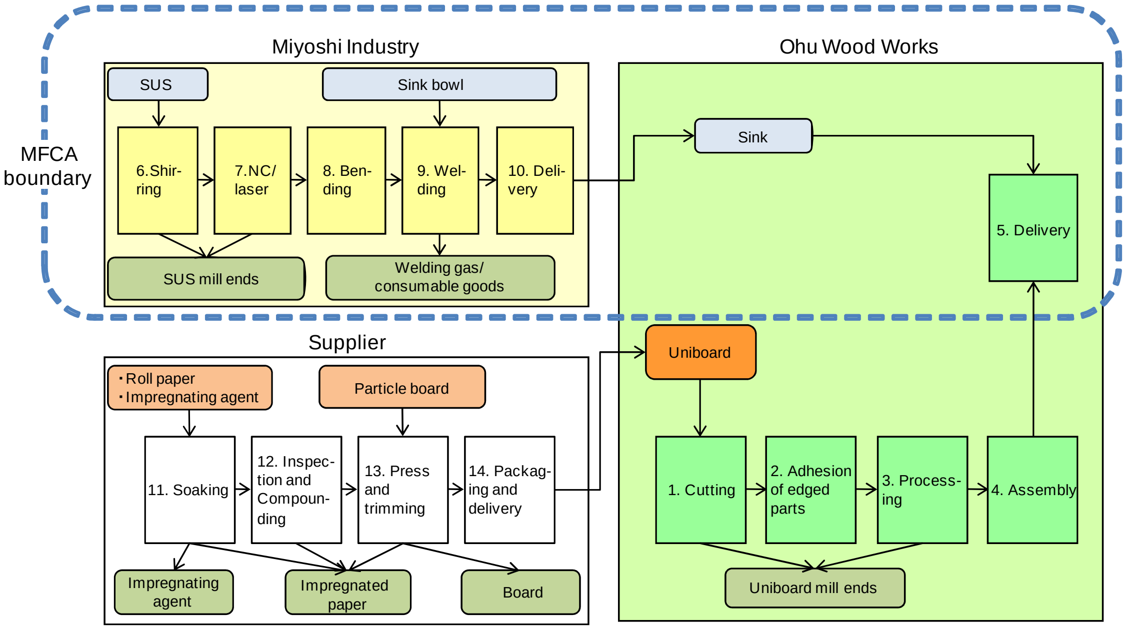


Figure 32.1 Input and output at each quantity centre

(3) Description of material losses (Description of material loss)

- Losses from the subject process
  - Ohu Wood Works: no material losses were generated; and
  - Miyoshi Industry: SUS mill-ends were generated through the shirring and NC/laser process. Grind stone and buffing material losses were generated in the welding-finishing process, and left-over materials of dew-condensation control sheets were generated from the shipment process.

- MFCA data definition

  In the process of Ohu Wood Works, the stainless steel parts supplied by Miyoshi Industry were substantial in terms of physical and monetary quantities while the process that involved these parts was limited to be the attachment process. As the material losses related to the stainless steel parts were considered to be nearly zero, this could keep the material loss rate very low, potentially distorting the analysis. Hence, the stainless parts were excluded from the MFCA analysis. Regarding the additional parts used for assembly, only cost-information for these parts were included in the analysis.

  For Miyoshi Industry, most of the materials input into the process were included in the MFCA calculation. As the externally supplied sink bowl did not incur any cost, it was excluded from the MFCA analysis.

(4) Findings through MFCA analysis

MFCA analysis found that the steel mill ends generated from the shirring process and the laser process at Miyoshi Industry accounted for the entire portion of the material losses. In particular, significant amounts of shirring mill ends were identified; cut lengths were considerably different from mill ends to mill ends. In addition to this, welding gas losses and labor losses were found to be substantial in the Miyoshi Industry's welding process and the finishing processes.

(5) Targeted points to be improved or improvements

− Improvements through collaboration between Ohu Wood Works and Miyoshi Industry

  With respect to the SUS mill ends generated through the shirring process, these material losses occurred due to adjustments to the cut length based on the ordered product. This led to issues of squabbling over the cut length dimensions of the SUS material and the instructed dimensions specified by Ohu Wood Works. Data on the yield ratio from the SUS material shirring process will be gathered on a monthly basis in order to explore the possibility for design standardization between two companies.

  During the sink-design process prior to an order-reception, when considering the cut lengths of stainless steel material and the basic shape of sinks for educational facilities, there were parts that could allow for free design to a certain extent. When designing a made-to-order sink, variable dimensions were decided in advance so that the sink will conform to the cut length dimensions of the stainless steel materials, without changing the basic specifications. This will be proposed to the client on a necessary basis.

− Miyoshi Industry

  Use of a large amount of welding gas and the associated labor costs during the welding process and the finishing process were found to be an issue. These losses were due to the welding technical standard. Systematic training in welding techniques will be conducted to minimize these losses.

(6) Conclusion

Transparency of source of material losses was increased through the MFCA analysis; losses were identified to be more substantial than originally expected. In order to reduce such losses, the furniture-design in consideration of the material yield ratio was crucial. To this end, Ohu Wood Works and Miyoshi Industry will work together to standardize designs, and will continue to improve yield ratio from the SUS shirring process. Likewise, it is desirable that by improving the yield ratio, reduction in the input volume of the raw material, less generation of the material losses, and cost reduction are achieved.

V. Annex (Overview of Material Flow Cost Accounting)

The annex is based on the first chapter of “Guidance on Introduction of Material Flow Cost Accounting (Third version)” issued by the Ministry of Economy, Trade and Industry of Japan in March 2009.

Overview of Material Flow Cost Accounting

1. What is Material Flow Cost Accounting?

Material Flow Cost Accounting (hereafter referred to as “MFCA”) is one of the environmental management accounting tools aimed to simultaneously reduce both environmental impact and costs. This tool is designed for organization’s decision-making. MFCA seeks to reduce costs through waste reduction, thereby improving business productivity.
MFCA measures the flow and stock of materials which include raw materials, parts and components in a process, in both physical and monetary units. The costs are managed in the categories of material cost, energy cost, system cost, and waste management cost.

You can identify the loss costs by defective products, waste and other emissions, through quantification of materials in each manufacturing process, and converting them in physical and monetary units.

In addition to the material costs, labor costs, depreciation costs and other processing costs are included in the loss costs. Costs for waste (material losses) are also calculated by the same means as product cost.

An increasing number of companies are introducing MFCA in Japan, for the following reasons.

- MFCA helps organizations reduce the amount of material losses, rather than recycling wastes;

- Reduced waste generation directly leads to the reduction of material input and material cost, which realizes direct cost reduction;

- Reduced waste generation also leads to increased efficiency in processing and waste treatment activities, thereby enabling reduction of not only material costs but also of manufacturing costs in general; and

- Reductions of waste generation and of material input (resource consumption) are one of the key activities in environmental management to lower the environmental impact.

2. Significance of MFCA, its economic effects and environmental contribution

A business entity is required to make “environmental consideration” in diverse phases of its operations. Many companies are promoting environmental management of their business facilities and emissions from such facilities through manufacturing activities, promoting waste recycling and achieving zero emission.

Although waste recycling is one of the important measures for effective resource use, it should be noted that the recycling process carried over the cost from the previous activities, requiring the input of substantial expenses and energy, in addition to those spent from the resource input to the waste generation.

Therefore, it is essential to reduce material losses itself. MFCA identifies the quantities and costs (incl. material, processing and waste treatment costs) of waste generated from a process. This enables us to identify the fundamental source of waste generation and clarify difficulties in its reduction, which leads to the reduction of waste generation itself.

Reduction of waste generation directly leads to reduced input of resources and enhanced environmental performance in manufacturing process, as well as realizing slimmed resource procurement and increased efficiency in business operations. MFCA is an effective management tool that helps business management to better understand the "harmony of environmental aspects and profitability", through improvement of material productivity and cost reduction.

3. Waste from process = Material loss

In a processing-type manufacturing, material losses are generated in various steps of the manufacturing process. Material losses generated from a process include the followings:

- Material loss during processing (e.g. listing, swarf), defective products, and impurities;
- Materials remained in an equipment following set-ups;
- Auxiliary materials (e.g. solvents and other volatile materials, detergents to wash equipment before set-ups): and
- Raw materials, work-in-process and stock products discarded due to deterioration or other unusable reasons.

MFCA traces and equally evaluate material flows for products and wastes (material losses).

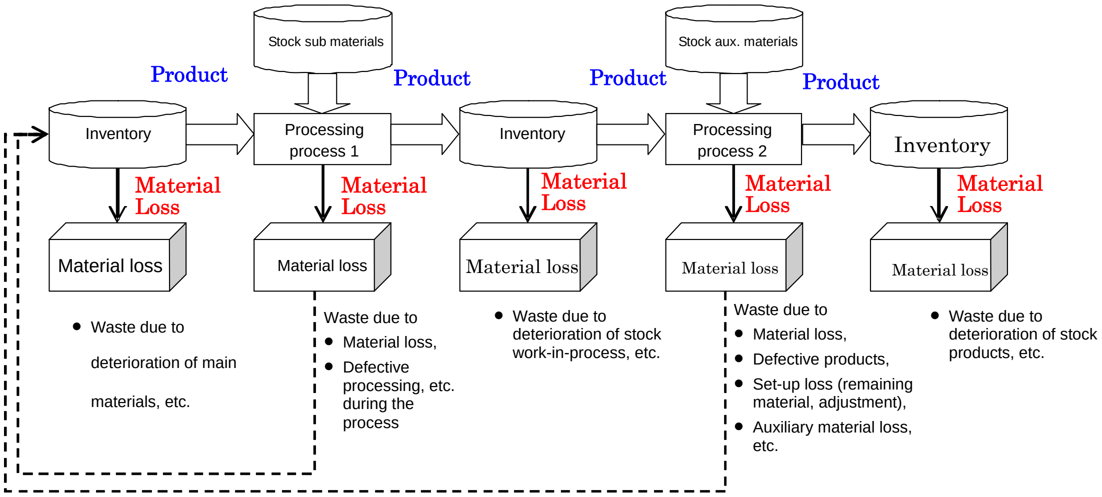


Figure V-1. Types of waste generated from manufacturing process

4. Material flow and MFCA

One of the methods to clarify material losses is material flow analysis. An example of material flow analysis is indicated in Figure V-2.

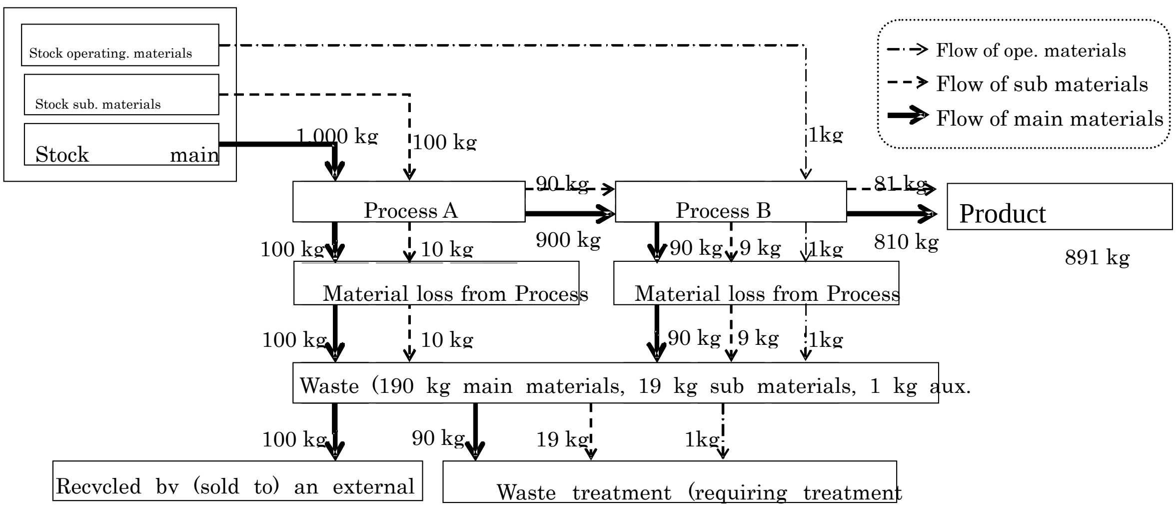


Figure V-2. Material flow chart

In Figure V-2, 1,000 kg of main materials are input in Process A, and generate 100 kg of the material losses in Process A and 90 kg in Process B, respectively. While 100 kg of main materials lost in Process A is recycled by an external contractor, 90 kg in Process B is disposed of as material loss.

Of sub (auxiliary) materials input in Process A, 10 kg and 9 kg become material losses in Processes A and B, respectively. A total of 19 kg of sub materials are disposed of as waste. 1 kg of operating materials are input in Process B, all of which become the material loss.

Consequently, 1,101 kg of materials are input in this process, of which 891 kg become products and 210 kg are material losses. As 100 kg are recycled by an external contractor, the final material loss is estimated to be 110 kg.

Material flow cost analysis evaluates the material loss (i.e., material loss costs associated with main materials, auxiliary materials and operating materials) (Table V-1).

Table V-1. Calculation of material loss cost

	Unit	Main materials	Auxiliary materials	Operating materials	Materials total
Input	kg	1,000	100	1	1,101
Product	kg	810	81	0	891
Material loss	kg	190	19	1	210
Material purchasing unit price	yen/kg	100	100	100	
Material purchasing cost	yen	100,000	10,000	100	110,100
Material cost	yen	81,000	8,100	0	89,100
Material loss cost	yen	19,000	1,900	100	21,000

If a company has the data of its material balance, it can easily calculate the material loss cost by multiplying quantities of each material (kg) by their unit prices. Table V-1 indicates that even if you recover some material cost by external recycling, this is significantly small compared to the material loss costs. Although external recycling is an important activity, it is more significant to reduce waste generation itself if you consider economics.

Economic loss (loss cost) caused by material losses is not limited to the material cost. As long as each process requires input of energy, labour, depreciation, and other costs, these costs are also assigned or allocated to material losses. Waste needs treatment activities and this cost is also added to calculation.

For calculation, MFCA adds all the cost information including material, processing, energy, waste treatment and other costs to the quantity data based on material flow, thereby tracking the entire flow of each raw material and adding the quantity and cost information to such flow.

Therefore, MFCA helps organizations analyze the economic loss (loss cost) by material loss not only in terms of material cost but also associated costs such as processing, energy, waste treatment and all other comprising costs.

5. Characteristics of cost accounting by MFCA

The calculation of manufacturing costs for a product is based on the following approaches in MFCA.

(i) Allocating costs to products and material losses

- Product cost: Costs assigned or allocated to products that flow to the next process; and
- Material loss cost: Costs for disposed or recycled items.

(ii) Calculating costs throughout the process

Product cost at one quantity centre is accumulated as the new input cost in the following quantity centre, totaling the input costs for calculation.

(iii) All manufacturing costs are categorized into the following four groups for calculation:

- MC: Material costs (costs of materials including main materials put in from the initial process, auxiliary materials put in during midstream processes, and operating materials such as detergents, solvents and catalysts);
- SC: System costs (all expenses incurred in the course of in-house handling of the material flows such as labor, depreciation, overhead costs, etc.);
- EC: Energy costs (Cost for the energy to enable operations such as electricity, fuel, utility); and
- Waste treatment costs.

6. Making material loss "visible" in its quantity and cost

MFCA calculates the cost of material losses which represents economic loss (loss cost) caused by the material loss.

This helps you increase transparency of material loss throughout the process, using the quantities of materials that do not become products as well as overall costs including energy and system costs associated with the material loss.

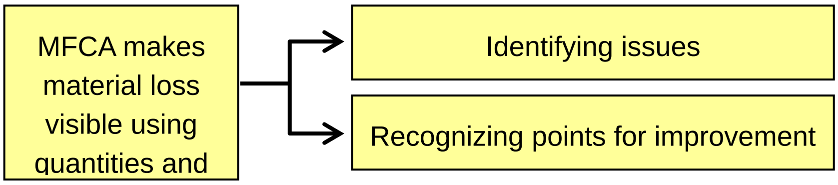


Figure V-3 Advantages of MFCA

By making material loss "visible", MFCA provides organizations with opportunities to "identify problems and recognize the necessity for their improvement" (Figure V-3).

(i) Identifying problems

Through MFCA, organizations have a chance to realize existence of material loss and the resulting economic loss, which has been overlooked by conventional cost accounting.

Many companies indicate that they monitor yield rate associated with the materials used in the process. However, the scope of such monitoring only covers part of materials, processes or losses in many cases. They often control main materials, without monitoring the amounts of use or loss in auxiliary or operating materials. On-site operators may be seeing materials getting lost, while managers of the manufacturing department, the production engineering department and the product design department are not aware of such losses. This happens because the company's conventional waste management practices only focuses on handling of wastes in typical cases.

In such cases, MFCA helps organizations highlight conventionally uncontrolled material losses. Systematic approach for material losses reduction is started when you identify problems.

(ii) Recognizing points for improvements

A company may be aware of material losses, but does not have appropriate improvement measures in place. There are varieties of reasons for not taking improvement actions, such as "This is standard operation," "This is the result of past improvement," "Capital investment is not likely to be retrievable," "We are busy," "We do not have sufficient human resources," and "It is technologically impossible". If you further analyze their claims, you may find out that they have "given up or ignored improving", not that "improvement is technically impossible".

In such cases, the true problems lie in not taking actions to break through technological limits, not in technological difficulty itself. Solving a problem is equivalent to breaking true familiar excuses such as "This is the limit," "This is the standard," "That's not impossible," and "We are too busy." Recognizing necessity for improvement is signified to start improvement measures beyond such excuses.

By applying MFCA, loss costs are identified including processing costs, caused by material losses. In many cases, scale of the identified costs is far more significant than you had previously assumed. Not a few managements are surprised at the enormous loss cost. They also realize that cost improvement measures are more effective than their previous recognition, which often paves the way for improvements that had been overlooked.

At the same time, MFCA presents an ultimate target for engineers: "the zero material loss cost". This ambitious goal urges engineers to make a breakthrough as mentioned above, through the recognition of necessity for improvements.

7. Manufacturing loss cost seen through MFCA

Types of manufacturing loss in the scope of calculation and management by MFCA are as follows:

(i) Occurrence and yield rate of material loss by process;
(ii) Causes for material loss by process (swarf, listing, set-up loss, defects, tests, etc.);
(iii) Procurement cost for material losses (main, auxiliary, and operating materials);
(iv) Waste treatment cost for material loss;
(v) Procurement cost for material losses sold to external recycling contractors;
(vi) System cost for material losses (labor, depreciation, fuel, utility and other costs);
(vii) System cost required to internal recycling of materials; and
(viii) Material and system costs for in-stock products, work-in-progress materials or materials that were disposed of due to switch to a newer model or deterioration of quality, or for such stock that has been aging.

Many companies manage the first three items above, at least for main materials. Unfortunately, only fewer companies control sub or auxiliary materials on a corporate basis. Auxiliary and operating materials are often managed on a process or equipment basis, and the quantities of materials input (and lost) for each model are rarely under management. In some cases, such quantities are managed in the unit of production lot.

The overall waste treatment cost (Item (iv)) is generally managed on a factory basis by waste type. However, few companies identify such cost by material type, by product model and by process type.

Companies are often unaware of losses associated with recyclable waste as indicated in Item (v), because such waste is reused as resources and sometimes sellable as valuable materials to external recyclers.

Items (vii) to (viii) are difficult to be identified unless process-wide MFCA calculation is conducted.

Many companies identify time loss due to equipment downtime, set-up and other reasons. Some of them promote improvement activities such as Total Productive Maintenance (TPM). Such loss is considered to be part of input cost included in equipment depreciation cost, and should preferably used in combination with MFCA.

8. MFCA makes loss “visible” for each process

Figure V-4 indicates the calculation of MFCA, using a simplified MFCA trial tool, using template data provided for trial of MFCA calculation. This tool is included in an MS-Excel file downloadable from the MFCA website (http://www.jmac.co.jp/mfca/thinking/07.php) (in Japanese only). The diagram shows the image of a calculation flow chart that include (Waste treatment cost is excluded).

	Manufacturing process	Material Processing	Parts processing	Finishing	MFCA cost total	
Newly input cost	Total	105.0	55.0	55.0	Overall cost including waste treatment cost	215.0
	Newly input MC	50.0	0.0	0.0		50.0
	Newly input SC	50.0	50.0	50.0		150.0
	Newly input EC	5.0	5.0	5.0		15.0
						0.0
Cost handed over from previous process	Total	0.0	89.3	122.6		
	MC from previous process	0.0	42.5	36.1		
	SC from previous process	0.0	42.5	78.6		
	EC from previous process	0.0	4.3	7.9		
Process total of input cost	Total	105.0	144.3	177.6		
	Process total of input MC	50.0	42.5	36.1		
	Process total of input SC	50.0	92.5	128.6		
	Process total of input EC	5.0	9.3	12.9		
	Percent quantity of material loss	15%	15%	15%		
	Percent quantity of product	85%	85%	85%		
Positive product cost total	Total	89.3	122.6	151.0	Product cost total	151.0
	Product MC	42.5	36.1	30.7		30.7
	Product SC	42.5	78.6	109.3		109.3
	Product EC	4.3	7.9	10.9		10.9
Negative product cost total	Total	15.8	21.6	26.6	Material loss cost total	64.0
	Material loss MC	7.5	6.4	5.4		19.3
	Material loss SC	7.5	13.9	19.3		40.7
	Material loss EC	0.8	1.4	1.9		4.1

Figure V-4 Example calculation by simplified MFCA trial tool

In this example, a total material loss cost of 19.3 yen is provided as procurement cost for material losses, based on quantity of the material losses generated.

MFCA includes energy costs and systems costs that are assigned or allocated to material losses as a part of the material loss cost. In this example, the total system costs for the material loss are 40.7 yen, while total energy costs for the material loss are 4.1 yen. By adding these two costs to the material loss costs above, you will have the total costs for the material losses in the manufacturing process, which stands at 64.0 yen in this example. This accounts for 29.8% of the total costs for this manufacturing process (215.0 yen).

Such material loss costs are identified on a process-by-process basis in MFCA.

In the example above, material loss costs for material processing, parts processing and finishing processes are 15.8, 21.6 and 26.6 yen, respectively. The ratios of products and material loss quantities are calculated to be 15% and 85%, respectively. Because energy costs and system costs from the previous process are included in the material loss costs for the following processes. In other words, the manufacturing losses cause the greater material loss costs in the later processes.

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