Guide for Material Flow Cost Accounting

(Ver.1)

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Environmental Industries Office, Environmental Policy Division
Industrial Science and Technology Policy and Environment Bureau
Ministry of Economy, Trade and Industry

Introduction

Material Flow Cost Accounting (hereafter referred to as “MFCA”) is an environmental accounting method originally developed in Germany, with increasing international recognition and an emerging trend of introducing into business administration in Japan.

The “Guide to Introducing Material Flow Cost Accounting” describes basic steps and concepts of introducing MFCA, as assistance to businesses planning its introduction. The Guide was compiled by JMA Consultants Inc., which was entrusted with the MFCA Development and Promotion Project of FY2006 by the Ministry of Economy, Trade and Industry, with instructions and advice from the MFCA Development and Promotion Project Committee of FY2006.

The MFCA Development and Promotion Project Committee comprises the following members (The members are listed in the alphabetical order).

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The Ministry of Economy, Trade and Industry has pushed forward the development and promotion of MFCA since it launched the Environmental Management Accounting Project in FY1999.

For the policies for MFCA development and promotion by the Ministry of Economy, Trade and Industry, visit its website at:
http://www.meti.go.jp/policy/eco_business/index.html

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Warm Up (Before Reading the Guide)

Your waste dump is your "gold mine". Make "visible" how much "gold" is found in your waste.

Estimate the monetary value of your company's waste.

Look up your environmental report for material balance, which indicates the environmental impact of your production facilities by means of input (major materials used) and output (waste generation). The material balance data provides approximate quantities of overall materials used and of overall materials wasted ("negative product"). You will have the quantity of materials made into company products ("positive product") by subtracting the negative product from the overall material input.

Your company's data on raw material cost will be found in the securities report or similar documentation. Estimate the unit price of input materials using that data. For example, you will have the unit material price by dividing the overall material cost by the overall material input.

By multiplying the above negative and positive products by such unit price, you will have approximate positive and negative product costs ("material cost").

Estimating the amount and value of "gold" from material balance data

Input: materials used		Output: waste (a gold mine)		Output: company products	
Major materials	Quantity (tons)	Waste (negative product)	Quantity (tons)	Company products (positive product)	Quantity (tons)
Steel materials	23,450	Industrial waste	4,320		
Aluminum materials	6,780	Recyclable waste	7,650		
Chemical materials	900				
Total (tons)	31,130	Total (tons)	11,970	Total (tons)	19,160
Quantity percentage	100%	Quantity percentage	38.5%	Quantity percentage	61.5%
Cost of input materials		Cost of wasted materials (negative product)		Cost of materials used for positive product	
Total (million yen)	50,000	Total (million yen)	19,226	Total (million yen)	30,774

The table above indicates an example of estimating the amount of "gold" in your waste, in terms of quantity and monetary value. Estimate "gold" in your company's waste in the same method, using the table below.

Input: materials used		Output: waste (a gold mine)		Output: company products	
Major materials	Quantity (tons)	Waste (negative product)	Quantity (tons)	Company products (positive product)	Quantity (tons)
		Industrial waste			
		Recyclable waste			
Total (tons)		Total (tons)		Total (tons)	
Quantity percentage	100%	Quantity percentage		Quantity percentage	
Cost of input materials		Cost of wasted materials (negative product)		Cost of materials used for positive product	
Total (million yen)		Total (million yen)		Total (million yen)	

How large is your company's gold mine? If you succeed in reducing your negative product, you will receive a gift of "cost reduction" in return. (In the above calculation, the quantities and material costs of material loss are made visible. MFCA enables you to have a clearer picture of overall loss, including processing cost and other expenses. You will also have data calculated by product and by process. MFCA is an extremely effective tool to realize both waste and cost reduction at the same time. Read the Guide for more details.)

Chapter I. Overview of Material Flow Cost Accounting

1 What is Material Flow Cost Accounting (MFCA)?

Material Flow Cost Accounting (hereafter referred to as “MFCA”) is one of the environmental management accounting methods aimed to reduce both environmental impact and costs at the same time, as a tool of decision making by business executives and on-site managers. MFCA seeks to reduce costs through waste reduction, thereby improving business productivity. The prototype of MFCA was developed at the Institute of Management and the Environment (Institut fur Managementund Umbelt, IMU) in Augsburg, Germany. In Japan, MFCA are modified for increased facility of use, by segmenting materials into raw materials and energy sources, as well as measuring them by process for easier improvement plans.

MFCA measures the flow and stock of “materials,” which include raw materials, parts and components in the manufacturing process, in terms of both physical and monetary units. The costs are managed in the categories of material cost, system cost, and transportation and waste treatment cost.

You can identify the costs of loss by defective products, waste and other emissions, through calculating their quantities and the resources used in each manufacturing process and converting them into monetary value.

In addition to the cost of raw materials, labor cost, depreciation cost and other processing cost are allocated under such loss cost, and waste cost is calculated by the same means as production cost. That is why waste is called “negative product” in MFCA.

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

- MFCA helps businesses reduce the amount of waste generation itself, instead of expanding waste recycling.
- Reduced waste generation directly leads to the reduction of material input and material cost, which realizes direct cost reduction.
- This also leads to increased efficiency in processing and waste treatment operations, thereby enabling reduction of not only material cost but of manufacturing cost in general.
- Reduction of waste generation and of material input (resource consumption) are one of the key activities in environmental management, to lower the environmental impact of manufacturing industry.

2 MFCA and its significance, 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, you must note that the recycling process also requires the input of substantial expenses and energy, in addition to those spent from the resource input to the waste generation.

Therefore, it essential to reduce waste generation itself. MFCA identifies the quantities and costs (incl. material, processing and waste treatment costs) of waste generated from each process of manufacturing activities. This enables us to look at the very source of waste generation and crystallize 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 consideration in manufacturing process, as well as realizing slimming of resource procurement and increased efficiency of business operations. MFCA is an effective management tool that helps business management realizing the "harmony of environmental aspects and profitability", through simultaneous improvement of environmental consideration and cost reduction in manufacturing.

3 Waste from manufacturing process = Material loss

In a processing-type manufacturing, waste and resource loss occur in various steps of the manufacturing process. Waste generated from processing includes the following.

- Material loss during processing (e.g. listing, swarf), defective products, impurities

- Materials remaining in manufacturing equipment following set-ups

- Auxiliary materials (e.g. solvents and other volatile materials, detergents to wash equipment before set-ups)

- Raw materials, work-in-process and stock products discarded due to deterioration or other unusable reasons

MFCA traces equally the both flows of final products and emissions (wastes) in processes. And MFCA recognizes even the emissions as one product. MFCA calls products "positive products" and the emissions "negative products".

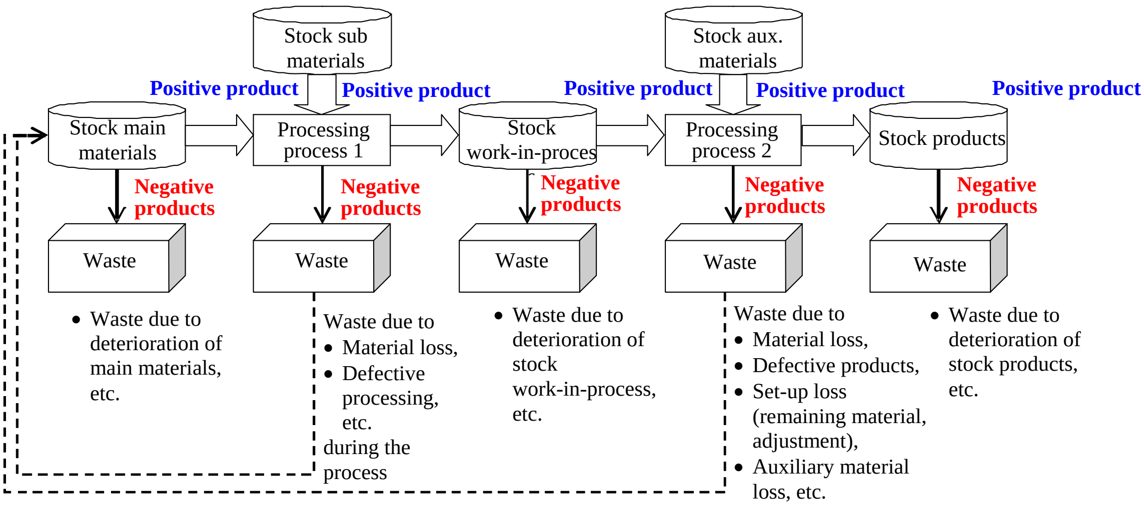


Figure 1. Types of waste generated from manufacturing process

4 Material flow and MFCA

One of the methods to clarify material loss in the manufacturing process is material flow analysis. An example of material flow analysis is indicated in Figure 2.

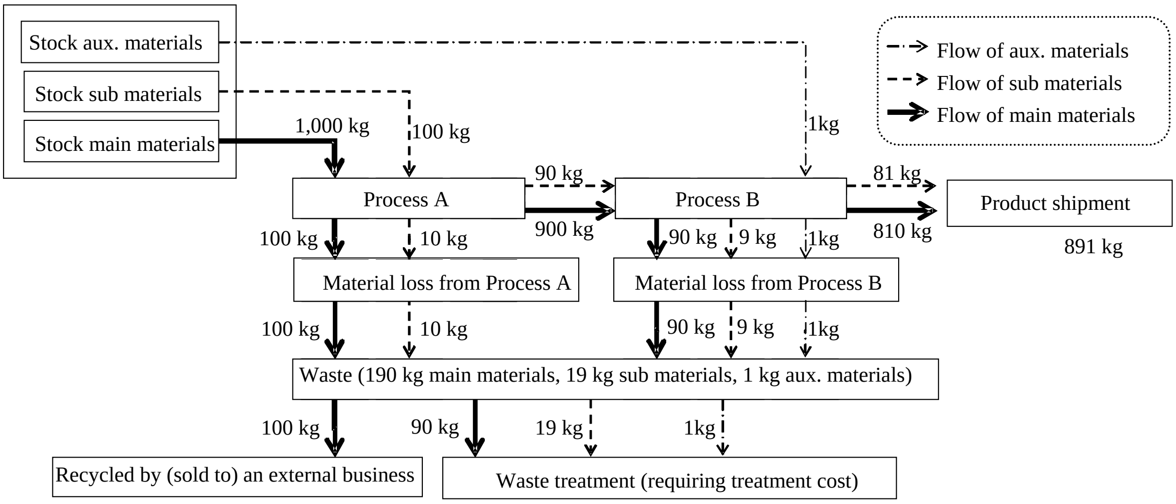


Figure 2. Material flow chart

In Figure 2, 1,000 kg of main materials are input in Process A, and causes loss of 100 kg in Process A and 90 kg in Process B. While 100 kg of main materials lost in Process A is recycled by an external business, while 90 kg in Process B is discarded as waste.

Of sub materials input in Process A, 10 kg and 9 kg are lost in Processes A and B respectively. A total of 19 kg of sub materials are discarded as waste. Auxiliary materials of 1 kg are input in Process B, all of which becomes waste.

Consequently, 1,101 kg of materials are input in this process, of which 891 kg become company products and 210 kg are regarded as material loss. As 100 kg are recycled by an external business, the final material loss is estimated at 110 kg.

Material flow cost analysis identifies economic loss (loss cost) indicates the costs of main, sub and auxiliary materials that became waste, which are given by multiplying individual waste quantities by purchased unit prices (Figure 3).

	Unit	Main materials	Aux. materials	Sub materials	Materials total
Input quantity (materials purchased)	kg	1,000	100	1	1,101
Positive product quantity (products shipped)	kg	810	81	0	891
Negative product quantity (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
Positive product cost (material cost)	yen	81,000	8,100	0	89,100
Negative product cost (material cost)	yen	19,000	1,900	100	21,000

Figure 3. Calculation of material loss cost

If a company has the data of its material balance, it can easily calculate the above material loss cost by multiplying individual quantities (kg) by their unit prices. The figures indicate that even if you recover some material cost by external recycling, it is miniscule compared to the material loss cost (negative product cost). Although external recycling is an important activity, you will see that it is more significant to reduce waste generation itself if you consider economics.

Economic loss (loss cost) caused by lost materials is not limited to the material cost. As long as each process requires the input of labor, depreciation, energy and other costs, material loss causes the loss on such costs as well. Emitted waste needs to be treated, which also requires treatment costs.

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 flow of each raw material throughout and adding the quantity and cost information to that flow.

Therefore, a business can analyze with MFCA the economic loss (loss cost) by material loss not only in terms of material cost but also as loss relating the entire manufacturing cost including 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 concepts in MFCA.

(1) Dividing costs into positive and negative product costs for calculation

- Positive product cost: Costs put into process products (positive product) released to the next process
- Negative product cost: Costs put into wasted or recycled items (negative product)

(2) Calculating costs throughout all the process

- Positive product cost of a process is added to the new input cost in the following process, totaling the input costs for calculation.

(3) All manufacturing costs are categorized into the following four groups for the above calculation.

- MC: Material costs (costs of materials including main materials put in from the initial process, sub materials put in during midstream processes, and auxiliary materials such as detergents, solvents and catalysts)
- SC: System costs (Processing costs including labor, depreciation, overhead costs, etc.)
- EC: Energy costs (Electricity, fuel, utility and other energy costs)
- Waste treatment costs

6 Making material loss "visible" through its quantity and cost

MFCA calculates the cost put into negative product as "negative product cost," which represents economic loss (loss cost) caused by material loss.

This enables you to make the "negative product (material loss) visible", throughout the manufacturing processes or for every process, using the quantities of lost materials and the overall costs including processing costs input into such materials.

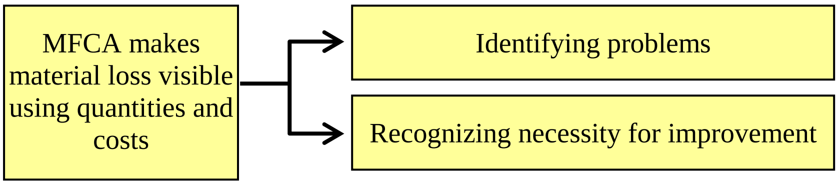


Figure 4. Advantages of MFCA

By making material loss "visible", MFCA provides a business entity with opportunities to "identify problems and recognize the necessity for their improvement" (Figure 4).

1) Identifying problems

A business has a chance to realize the existence of material loss and the resulting economic loss through MFCA, which it has not recognized on a systematic basis.

Many companies say that they monitor their materials yield. 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 sub or auxiliary materials. Workers in manufacturing sites 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 loss. This happens because the company's waste management only focuses on waste treatment.

In such cases, MFCA helps the company realize the so-far-uncontrolled material loss. Systematic activities to reduce loss begins when you identify problems.

2) Recognizing necessity for improvement

A company may be aware of material loss, but be lacking improvement measures in place. A variety of reasons are presented 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," "It is technologically impossible," and so on. 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 lies 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 signifies to start addressing improvement requirements beyond such excuses.

By applying MFCA, you will see loss costs including processing costs, caused by material loss. In many cases, the scale of the identified cost is far larger than you had assumed. Not a few executives are surprised at the enormous loss cost. They also realize that cost improvement activities are more effective than their previous recognition, which often paves the way for improvement actions that had been passed up.

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

7 Manufacturing loss cost seen through MFCA

The types of manufacturing loss in the scope of calculation and management by MFCA are as follows.

1. Occurrence and materials yield of material loss by process
2. Causes for material loss by process (swarf, listing, set-up loss, defects, tests, etc.)
3. Procurement cost for lost materials (main, sub and auxiliary materials)
4. Waste treatment cost for material loss (materials not becoming products)
5. Procurement cost for materials lost but sold to external businesses for recycling
6. Processing cost put into lost materials (labor, depreciation, fuel, utility and other costs)
7. Processing cost required to reprocess materials that have been lost and recycled within processes
8. Material and processing costs for stock products, work-in-process or materials, that were discarded due to switch to a newer model or deterioration of quality, or for such stock that has been aging

Many companies control the first three items above, at least for main materials. Unfortunately, only fewer companies control sub or auxiliary materials on a corporate basis. Sub and auxiliary materials are often controlled on a process or equipment basis, and the quantities of materials input (and lost) for each model are rarely under control. Sometimes such quantities are controlled in batch by a factory.

The overall waste treatment cost (Item 4) is generally controlled on a factory basis by waste type. However, few companies identify such cost by material type, by product model and by generating process.

Businesses are often unaware of loss on recyclable waste as indicated in Item 5, because such waste is reused as resources and sometimes sellable to external recyclers for value.

Items 6 to 8 are difficult to identify unless calculated throughout processes as in MFCA.

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 5 indicates the calculation of MFCA, using a simplified MFCA trial tool, using template data provided for trial experience 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). The diagram shows the image of a calculation flow chart with cost figures (Waste treatment cost is omitted).

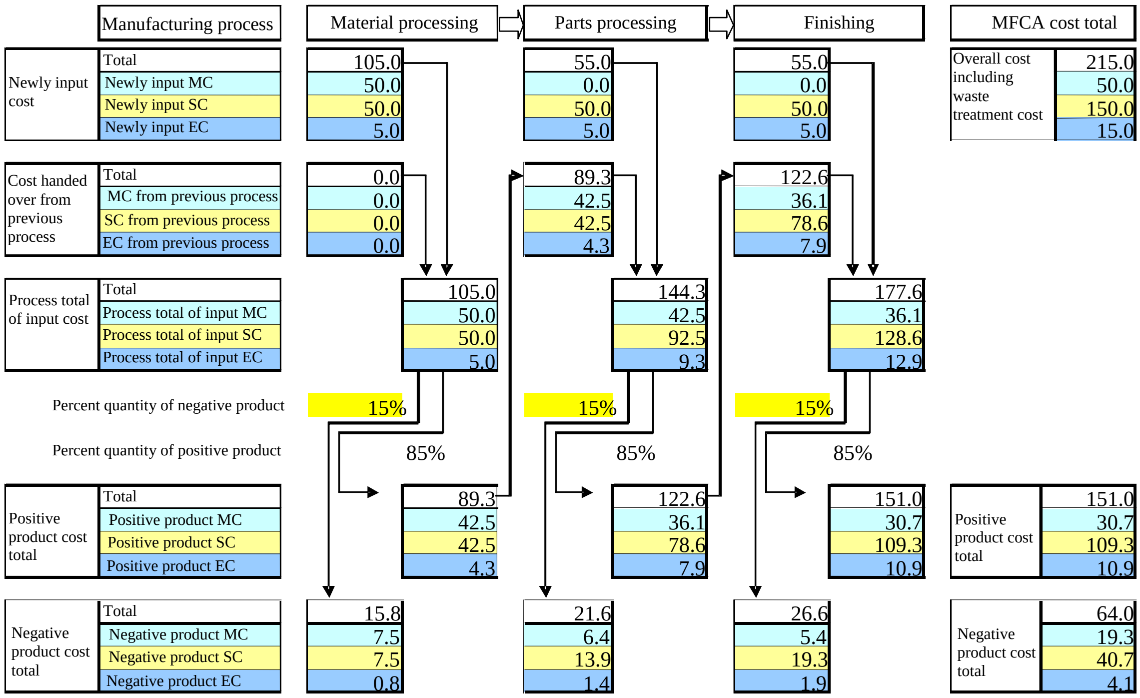


Figure 5. Example calculation by simplified MFCA trial tool

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

MFCA includes processing and energy costs put into negative product (wasted materials) in the “negative product cost.” In this example, the total negative product cost pertaining to processing cost and overheads throughout the manufacturing process is 40.7 yen, while the total negative product energy cost is 4.1 yen. By adding these two to the negative product material cost above, you will have the overall loss cost in the manufacturing process, which stands at 64.0 yen in this example. This takes up 29.8% of all costs (215.0 yen).

Such negative product cost is identified on a process-by-process basis in MFCA.

In the above example, respective negative product costs for material processing, parts processing and finishing processes are 15.8, 21.6 and 26.6 yen. The quantity percents for positive and negative products are calculated as 15% and 85% respectively, in materials put into each process. Because processing and other costs from the previous process are included in the negative product cost, manufacturing loss causes greater negative product cost in later processes.

9 Difference between MFCA and usual cost accounting

Usual actual cost accounting is aimed at calculating gross profit on sales. Normally you compile all the costs occurring in a factory by product to give manufacturing cost for each product. Therefore the scale of loss in manufacturing process is not identified as part of cost in usual cost accounting.

The standard cost accounting method is widely adopted in the manufacturing and other industries. In this method, businesses define standard costs, with which actual costs are compared and causes for the “cost variance” are analyzed and addressed.

Cost variance in the standard cost accounting does not reflect all material losses, because the pre-defined “standard” costs include materials lost as waste. Therefore, only materials used beyond such standards are considered as loss. On the other hand, MFCA regards all materials that do not become products as loss. Their quantities are identified as negative product, and their costs are recorded as negative product MC. While MFCA identifies all material losses, standard cost accounting does not represent material loss (See Figure 6).

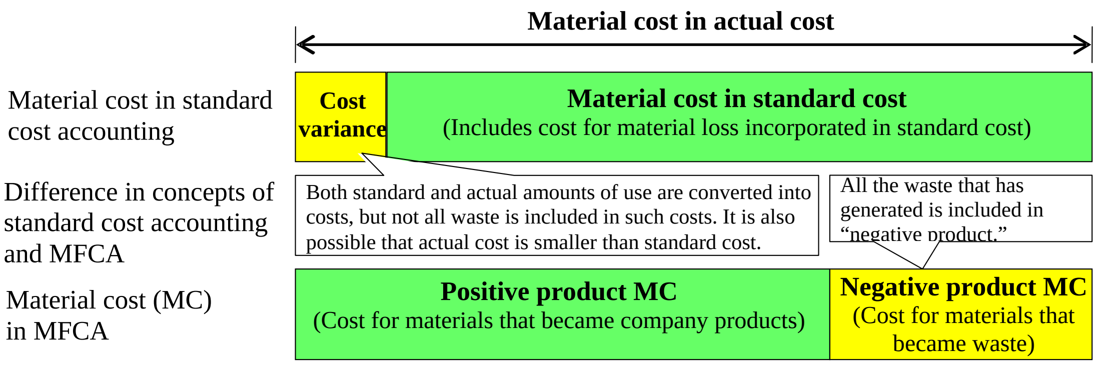


Figure 6. Difference in definitions of material costs in standard cost accounting and MFCA

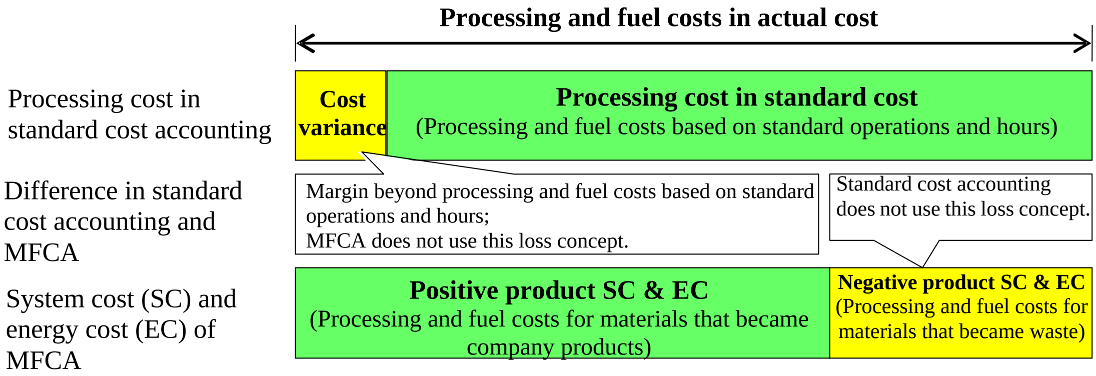


Figure 7. Difference in definitions of processing costs in standard cost accounting and MFCA

In the case of processing and fuel costs as well, standard cost accounting also regards the difference from standard costs as loss (See Figure 7). For example, if you needed to work more hours than defined as standard, the excessive working hours is considered as loss. The relevant processing cost is identified as cost variance. On the other hand, MFCA does not look at processing cost beyond the standard as loss, but instead all processing and fuel costs used for negative product (material loss) are classified as negative product system cost (SC) and negative product energy cost (EC).

At many companies, waste treatment cost is accounted for by each factory, separately from manufacturing cost that is identified on a product basis. This is why businesses only regard waste treatment cost as a type of business expenses. However, MFCA includes this cost in loss, as one of the components of negative product cost.

MFCA regards all the materials that did not become company products as loss (negative product), and makes visible all the relevant costs as negative product cost (loss cost). This is the most remarkable characteristic in contrast with other cost accounting methods.

10 Characteristics of negative product cost in different production styles

Figure 8 shows comparison of characteristic examples selected from the reports of research study projects on MFCA sponsored by METI targeted at large enterprises in FY2004 and FY2005. The negative product cost proportions in the selected cases are identified and compiled.

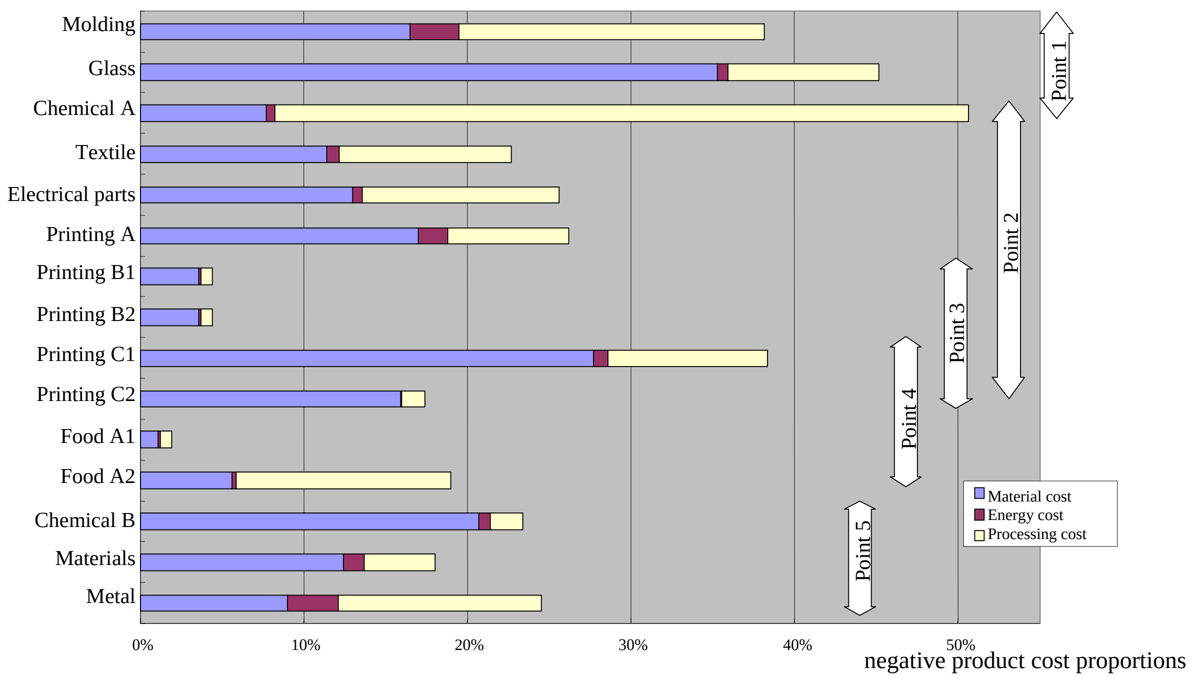


Figure 8. Product characteristics and MFCA results (negative product cost)

This comparison highlights the following five points.

Point 1. Negative product cost is particularly large in new technology areas

The cases selected for the above comparison from the Molding, Glass and Chemical A industries involve relatively new technology areas. Loss tends to grow larger on product in new technology areas, because control and improvement are not sufficient yet. Such businesses may be aware of the poor yield of raw materials, they often cannot afford to address that problem due to urgent priority on quality issues and production capacity.

In such areas, the management is able to realize the scale and cause of loss by making the loss cost visible.

Point 2. MFCA makes visible loss cost on multi-product small-lot production

In Figure 8, the cases selected from Chemical A, Textile, Electrical parts, Printing A, Printing B1 & B2, Printing C1 & C2 all represent multi-product small-lot production. The negative product cost proportions are quite high except Printing B1 & B2.

Businesses may be aware of the large loss on multi-product small-lot production because of frequent set-ups and other reasons, but they usually do not have the figures of overall loss cost. The common case with multi-product small-lot production is the focusing of control and improvement activities on inventory reduction and the shortening of manufacturing leadtime for that purpose. They know that frequent set-ups expand their loss, but they sometimes have too small inventory because of the lack of distinct figures of loss cost.

By making visible loss cost due to set-ups, businesses are able to start formulating production plans and schemes to optimize their inventory and production lots.

Point 3. Standard cost accounting does not indicate all material loss

Standard cost accounting is one of the cost accounting methods to identify loss. However, the material loss calculated by standard cost accounting is limited to the loss that can be controlled and improved at manufacturing sites, and loss determined by dies and other factors is not seen at as loss cost because it is incorporated in standard cost.

Of the cases selected from Printing B1 & B2, Printing C1 & C2 in Figure 8, the calculation of MFCA was only performed for the loss recorded by standard cost accounting for Printing B1 & B2, while the MFCA calculation for Printing C1 & C2 included paper cutting loss and others that are not regarded as loss under standard cost accounting. The negative product cost proportions for Printing B1 & B2 would be nearly 20% if the calculation was performed appropriately.

The standard cost accounting method often obscures loss included in standard cost, hindering improvement activities on the forgotten loss. MFCA shed light on such normally-forgotten loss.

Point 4. MFCA enables model-by-model comparison of losses

In the case of multi-model mixed production, processing cost and energy cost are often allocated to each model by the volume of production and other related factors. However, this may have a large gap with the actual proportions if the lots, set-up frequencies and set-up times vary by model.

In Printing C1 & C2, Food A1 & A2 in Figure 8, different models of the same lines are compared in their negative product cost proportions given by MFCA calculation. The proportions vary greatly by model.

By applying MFCA to products made in multi-model mixed production, businesses are able to make differentiate the overall costs and negative product costs “visible” on a model-by-model basis, thereby crystallizing improvement requirements and policies for each model.

Point 5. MFCA encourages businesses to challenge the ultimate technological ideal of “zero negative product cost”

In the few-item mass production industries using mature technologies, material loss has been reduced to a considerable extent based on techniques and know-how established over the years.

Chemical B, Materials and Metal in Figure 8 indicate the cases of applying MFCA to such industries. The negative product costs stand at around 20%. Businesses must develop new technologies or make additional capital investment to improve the remaining loss, because it has been unsolvable with existing equipment and technologies.

MFCA crystallizes their new technological targets by defining an ultimate ideal of manufacturing, “zero negative product cost,” thereby encouraging businesses to challenge capital investment and technological development that they have long given up.

With MFCA, you can calculate the effect of cost reduction by such challenge with fairly high accuracy, enabling businesses to identify required budget for capital investment and technological development, perform simulated Return on investment (ROI) calculation and the consequent decision making.

Chapter II. Procedures for the Introduction and Promotion of Material Flow Cost Accounting

1 Steps for MFCA promotion

MFCA is a relatively young management method, and not many Japanese businesses have introduced this method. While the systems and methods of production control, process control and standard cost accounting have been established at numerous companies over the years, the history of introduction and development of MFCA have but started.

Therefore, only a few members in a business know about MFCA at present, which requires gradual approach in its introduction.

Figure 9 indicates steps from introduction to application and to promotion of MFCA. From Step III (Model trial) and onwards, collaborative projects and activities by multiple corporate departments will be required. Therefore, those who plan to introduce and promote MFCA shall present the significance, benefits and specific methods of introducing MFCA to related personnel. That is why they are required to familiarize themselves well with MFCA and establish deep understanding in Steps I and II.

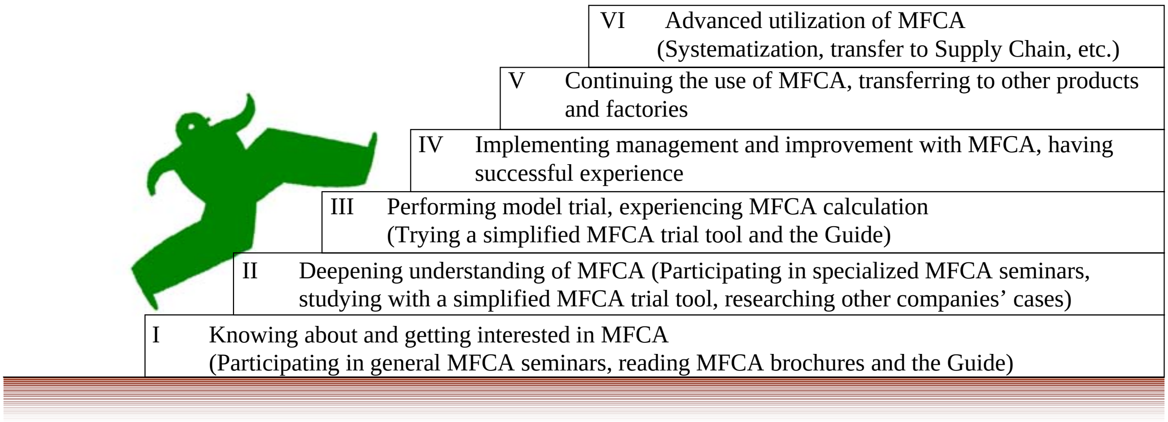


Figure 9. Steps for MFCA promotion

To promote MFCA as a corporate management method, you must verify its (expected) benefits at your company in addition to the cases and benefits at other businesses.

Therefore, when you perform model trial in Step III, it is desirable to "implement management and improvement with MFCA and have successful experience" at your company as expected in Step IV, in addition to experiencing MFCA calculation.

If you have completed the above successfully, your company will have established infrastructure to utilize MFCA. The shift to Steps V (Continuous management and promotion) and VI (Advanced utilization) will proceed smoothly.

2 Procedures for MFCA introduction

Figure 10 lists more detailed procedures for Steps III (MFCA introduction) and IV (Implementing management and improvement with MFCA) in Figure 9.

Basic procedures		Examination & operation items
1	Preparation	Determine targeted products, lines and processes.
		Perform rough analysis of targeted processes and determine quantity centers (theoretical processes in MFCA calculation).
		Determine models and periods to analyze.
		Determine materials to analyze and the methods of collecting their quantity data (measurement & calculation).
2	Data collection & compilation	Collect and compile the data of material types, their input & waste quantities in each process.
		Collect and compile the data of system (processing) cost and energy cost.
		Determine the allocation rules for system and energy costs.
		Collect and compile the data of machine operating status for each process (optional).
3	MFCA calculation	Establish an MFCA calculation model and input the required data.
		Confirm and analyze the MFCA calculation results (negative product costs and their causes by process).
4	Identifying improvement requirements	Identify and list requirements for improvement, including material loss & cost reduction.
5	Formulating improvement plans	Examine the extents and possibilities of material loss reduction.
		Calculate and assess the cost cut effect through material loss reduction (MFCA calculation).
		Determine priorities of improvements and formulate improvement plans.
6	Implementing improvements	Implement improvements.
7	Evaluating improvement effects	Identify the quantities of input and wasted materials following the improvement, and recalculate MFCA.
		Calculate the overall costs and negative product costs following the improvement, and evaluate the improvement effects.

Figure 10. Steps for MFCA introduction and utilization

The Basic procedures 1 (Preparation) to 3 (MFCA calculation) represent the steps of MFCA calculation and analysis.

The key in these steps lies in collecting and compiling the data of input and wasted material quantities in each process. Although it is desirable to measure such quantities on-site, the survey may take too much time if you make all the measurements on an on-site basis. You may accept estimates from theoretical values or calculated figures as long as they have tolerable accuracy. Inappropriate measurements may make it unable to identify losses. Examine what data should be usable considering that the required calculation accuracy depends on your objective of introducing MFCA. You must also note that on-site input management is often based on the numbers and other units of materials, not on quantities in kilograms. In such cases, you shall convert the on-site data of input and waste quantities into kilograms. You will also have to establish an MFCA calculation model to perform the required operations using the on-site management data as parameters.

In an MFCA calculation model established in the above, defined quantity centers (theoretical unit) may differ from actual processes. If the unit of defined quantity centers is too large, the figures of negative product cost will not be given appropriately. If the unit is too fine, the collection and compilation of raw data will take too much time. You must define your quantity centers at an appropriate unit.

The basic procedures 4 (Identifying improvement requirements) through 7 (Evaluating improvement effects) shall be undertaken similarly to those of other improvement activities. The application of material flow cost accounting enables clearer identification of cost cut effect from individual improvements, which helps better decision making on priorities and more accurate evaluation of improvement effects.

3 Flow of MFCA introduction and calculation

Figure 11 lists the examination & operation items for the basic procedures 1 through 3 in Figure 10, together with the relevant points of notice.

Basic procedures			Examination & operation items	Points of notice
1	Preparation	1-1	Determine targeted products, lines and processes.	Crystallize the objectives & targets of introduction and calculation. Products for which a calculation model is easily established do not necessarily produce substantial effects from MFCA application.
		1-2	Perform rough analysis of targeted processes and determine quantity centers (theoretical processes in MFCA calculation).	If you define quantity centers too roughly, you will lose sight of loss. If you define quantity centers too finely, data compilation will take too much time.
		1-3	Determine models and periods to analyze.	Start with models and periods for which required data are easily available.
		1-4	Determine materials to analyze and the methods of collecting their quantity data (measurement & calculation).	On-site measurement is desirable, but theoretical or calculated values can do. Auxiliary materials with miniscule environmental or economic impact may be excluded from calculation.
2	Data collection & compilation	2-1	Collect and compile the data of material types, their input & waste quantities in each process.	Convert the input and waste data of each material in each process into kilograms.
		2-2	Collect and compile the data of system (processing) cost and energy cost.	Collect and compile the data for each cost center, based on the company's accounting information.
		2-3	Determine the allocation rules for system and energy costs.	Determine persuasive allocation rules by process (e.g. as per relevant man-hours) and by model (e.g. as per production volumes), and allocate the costs.
		2-4	Collect and compile the data of operating status for each process (optional).	Basic data are available if TPM is in place. These data will enable the assessment of operating loss at the same time.
3	MFCA calculation	3-1	Establish an MFCA calculation model and input the required data.	Input the material data (quantities and costs) as well as system and energy costs in the format of MFCA calculation tool.
		3-2	Confirm and analyze the MFCA calculation results (negative product costs and their causes by process).	If you are using the simplified tool, modify a part of linked formula in accordance with the number of defined processes to establish a desired calculation model.

Figure 11. Examination items and points of notice for MFCA introduction

Benefits of applying MFCA depend on the basic procedure 1 (Preparation).

This must be noted because sometimes the following problems and mistakes are observed in the preparation stage of MFCA application.

- A business matches the "quantity centers" (a theoretical unit for MFCA calculation) with the cost centers (a unit of allocating processing costs, etc.) to facilitate the calculation and data compilation operations, resulting in too rough process units that do not give detailed negative product costs, or in ineffective data that are useless for improvement planning.

- Otherwise, a business matches the quantity centers (a theoretical unit for MFCA calculation) with the actual process for complete precision, resulting in excessive time and labor for data collection and compilation as well as calculation operations, which seem to overwhelm the cost reduction benefits from MFCA application.

- A business calculates negative product costs successfully, though the targeted products or lines had been so thoroughly sophisticated that very little room for additional improvement was left.

- A business identified improvement requirements based on the negative product costs given by MFCA calculation, but most of the required improvements need cooperation from upstream and downstream processes, which the business unfortunately cannot obtain, resulting in calculation and analysis by MFCA in vain.

MFCA makes “visible” loss cost in the form of negative product cost. As described above, however, the identification of loss cost is one thing and the success of its improvement is quite another. You will eliminate such mistakes by examining how you should apply MFCA in the preparation stage.

4 Preparation for MFCA calculation

To avoid the problems mentioned in the end of Section 3, a business shall take note of the following points, particularly when it is introducing MFCA for the first time.

- Select products and lines that are relatively easy to improve.

- If the cooperation seems necessary from business partners in the upstream or downstream of your company, such as in the case of outsourced processing, select products that are likely to obtain such cooperation.

- To minimize the labor of data collection and compilation, process and use readily available data for the initial calculation, and wait for the next phase for more accurate MFCA calculation.

- However, process or use such data for the input and waste quantities of major materials so that gap with the actual status will be minimum.

- Refrain from defining MFCA quantity center units too finely, and wait for the next phase for more accurate MFCA calculation.

- Note that if multiple types of waste are generated, you may need to segment a single quantity center (for example, separating the processing process from the relevant set-up process).

Detailed explanation follows in line with the steps listed in Figure 11.

Procedure 1-1 Determine targeted products, lines and processes

Select products and lines that are easy to produce improvement effects for the initial application of MFCA. The hints for selecting such products and lines are suggested below.

1) Products from multi-product small-lot production

As described in Point 2 of Figure 8, loss tends to be large for multi-product small-lot products. Loss pertaining to set-ups is particularly obscure. By making such loss visible, you are able to implement improvements effectively, thereby experiencing the benefits of MFCA application.

It is recommended to perform the calculation including all the models in the targeted line, combined with the calculation for each model if possible.

2) Products from processes that generate much waste in the latter part

Point 5 of Figure 8 referred to products made by few-model mass-production processes using mature technologies. All of such processes generate much waste in the latter part. This means that although technologies for such products are mature, there still remains room for technological innovation to reduce such waste.

Improvements through technological innovation require much time before realization, and businesses selecting such processes shall be aware that their goal is the achievement of "ideal manufacturing."

MFCA helps you examine your ideal manufacturing status through the ultimate goal of "zero negative product cost."

3) Products and lines using many types of materials

The inputs and losses by material type are often obscure with products and lines using many types of materials. Room for improvement is found particularly often where sub materials are added in the middle of a process, or where solvents and other non-product auxiliary materials are used.

It may take some time and labor to collect and compile data of such uncontrolled materials, but these data are indispensable for MFCA calculation. In some cases, businesses have succeeded in reducing the consumption of materials, slimming waste and cutting costs by simply starting to control such inputs and losses for the purpose of MFCA introduction.

Procedure 1-2 Determine quantity centers (theoretical units for MFCA calculation)

Quantity centers are theoretical units of MFCA calculation. Theoretically, it is desirable to regard all loss-causing points as quantity centers.

If you set calculation units too roughly, computation and the relevant data collection may become easy, but the types of losses and actual negative product costs may become obscure. In contrast, if you set quantity centers too finely, MFCA computation and the relevant data collection/compilation may become too complex.

Therefore, you shall identify the requested units of loss prior to the setting of MFCA computation units.

Figure 12 indicates the examination image of units and materials for MFCA calculation.

The examination shall proceed as follows.

1) First, you shall list the processes as units of on-site management.

2) Describe the process and manufacturing conditions for each process.

3) Processes involving substantial labor and material loss due to set-up between different models shall be divided into appropriate sub processes in this step.

4) List input materials, energy and utilities, as well as output products, work-in-process and wastes, for each process identified in the above. List all the items regardless of data availability or measurability in this step.

5) Determine theoretical units for MFCA calculation (i.e. quantity centers). In this step, integrate any sequential processes that do not produce waste or other losses as a quantity center. Similarly, re-integrate any sequential sub processes divided in 3) as a quantity center, unless any particular losses shall be identified.

Name of actual process		⇒ Process 1 (adjustment)	⇒ Process 1	⇒ Process 2 (adjustment)	⇒ Process 2
Dept. in charge		Process 1 Dept.	Process 1 Dept.	Process 2 Dept.	Process 2 Dept.
Detailed description of process		• Mounting main materials (rolls) on the equipment and adjusting them • Washing and adjusting dies • Adjusting sub materials • Testing, verifying and adjusting process quality	• Applying sub materials to main materials and dry-setting them	• Installing and adjusting work-in-process (applied raw materials) • Washing and adjusting Process 2 equipment • Adjusting sub materials • Testing, verifying and adjusting process quality	• Coating sub materials over work-in-process (applied raw materials) and finishing their surface
Notes	(Manufacturing data, conditions, features, etc.)				
Set-up	(Necessity, frequency and time of set-ups)	Equivalent to set-up operation; Places much workload on Process 1		Equivalent to set-up operation; Places much workload on Process 2	
Name of MFCA quantity center		Process 1 adjustment	Process 1	Process 2 adjustment	Process 2
Names of input materials, and the relevant measurement & calculation methods	Main material 1	Tested raw material (Calculation method: e.g. Width 3 m x Input length 2,000 m x Thickness 0.01 m x Specific gravity 0.3; Varies by model)	Processed raw material (Calculation method: e.g. Width 3 m x Input length 2,000 m x Thickness 0.01 m x Specific gravity 0.3; Varies by model)		Work-in-process: Applied raw material (Calculation method: e.g. Width 3 m x Input length 2,000 m x Thickness 0.01 m x Specific gravity 0.3; Varies by model)
	Main material 2				
	Main material 3				
	Sub material 1	Applied material (when adjusted): ** kg per model	Applied material (when processed): ** kg (input quantity control data)	Coating material (when adjusted): ** kg per model	Coating material (when processed): ** kg (input quantity control data)
	Sub material 2				
	Sub material 3				
	Auxiliary material 1	Detergent A:	Roll cores (excluded from MFCA calculation because reused within the process)		Roll cores (excluded from MFCA calculation because reused within the process)
	Auxiliary material 2				
	Auxiliary material 3				
Energy and utilities	Input 1	Electricity consumption (relatively small): Allocate the overall electrical charges by operating hours	Electricity consumption (relatively small): Allocate the overall electrical charges by operating hours	Electricity consumption (relatively small): Allocate the overall electrical charges by operating hours	Electricity consumption (relatively small): Allocate the overall electrical charges by operating hours
	Input 2			Steam (for heating): Allocate the overall consumption by operating hours	Steam (for heating): Allocate the overall consumption by operating hours
	Input 3				
Names of output products & work-in-process, and the relevant measurement & calculation methods	Main product 1		Work-in-process (Applied raw material)		Work-in-process: Coated rolls (Coated & processed rolls)
	Main product 2				
	Main product 3				
	Sub product 1				
	Sub product 2				
	Sub product 3				
Names of output wastes & recycled materials, and the relevant measurement & calculation methods	Wasted material 1	Tested raw materials (with applied materials)	Listing from around the processed raw materials (with applied materials); Defective products	Tested or adjusted work-in-process (with coating materials)	Listing from around the rolls-in-process (with coating materials); Defective products
	Wasted material 2	Applied materials (remainder)	Applied materials (remainder)	Coating materials (remainder)	Coating materials (remainder)
	Wasted material 3	Detergent			
	Recycled material 1				
	Recycled material 2				
	Recycled material 3				

Figure 12. Examination sample of MFCA quantity centers

Procedure 1-3 Determine models and periods to analyze

Determine models and periods to analyze using the MFCA method.

- Targeted product types and models
- Reasons and objectives for selecting the targets
- Analysis period
- Reasons and objectives for selecting the period

It is better to calculate and analyze each model if material loss ratio varies substantially by model. If calculation by model is difficult due to multi-product small-lot production, calculate for all models at first.

If you focus on selected models, identify the reasons and objectives for selecting them in writing.

When you determine an analysis period for MFCA, take account of data availability and processability. Normally, analysis periods are set at one month, three months, six months, etc. for which the allocation of system and energy costs is distinct.

In the case of products manufactured by an around-the-clock plant, the analysis period was set to cover from the operation start to the yield point. In other cases, MFCA calculation was performed on a specified production lot basis. These are examples of selecting units for easy calculation of material inputs, rather than the facility of system and energy costs.

Procedure 1-4 Determine materials to analyze and the methods of collecting their quantity data (measurement & calculation)

In the next step, you shall fill the methods of calculating material inputs and losses in the form indicated in Figure 12.

In this step, you may also consider excluding auxiliary materials with extremely low unit prices and relatively small environmental impact from the scope of MFCA calculation.

The scope of identifying input materials

- All main and sub materials shall be included in the scope.
- Auxiliary materials may be excluded from the scope as necessary.
- Cutting oil and waste cloth: Better be included for equipment with much oil leak.
- Detergent: Shall be included if unit prices are high and/or waste detergent treatment cost is high.

The scope of identifying negative products (material losses)

- In many cases, you may regard the input quantity of auxiliary materials as the quantity of negative products (material losses). (Some cutting oil may be collected and reused or recycled, in which case the quantity of replenished cutting oil shall be regarded as input quantity.)
- Main materials (work-in-process), sub materials: Identify materials losses by causes, such as scrape, listing, defective products, tested products, etc. (This is because quantities of losses by causes are required to estimate the effects of improvement.)
- In the case of metal processing, the quantities of wastes such as listing and scrape are often given accurately by theoretical calculation.

- Quantities of defective products, tested products, etc. require measurements. (Such measurements are usually managed on an on-site basis.)

Quantity data shall be collected by on-site measurement in principle. However, if theoretical quantity values do not vary from measurement values, or if measurement is difficult, you may use calculated values instead.

5 Data collection and compilation for MFCA calculation

The explanation on data collection and compilation for MFCA calculation is provided in line with the procedures listed in Figure 11.

See also the operating manual for the MFCA simplified calculation tool, which provides more detailed explanation using actual data definitions.

(The MFCA simplified calculation tool and its operating manual can be downloaded from the following MFCA website.
http://www.jmac.co.jp/mfca/thinking/07.php)

Procedure 2-1 Collect and compile the data of material types, their input & waste quantities in each process

In MFCA, you shall define the input and output quantities of every material type in each process, in terms of tons, kilograms or grams. This is because of the following reasons.

- The output quantity is divided into the "positive product quantity," which refers to the quantity of materials transferred to the subsequent process, and the "negative product quantity," which refers to the quantity of wasted materials.

- The overall input quantity shall equal overall output quantity.

- System cost (SC) and energy cost (EC) shall be allocated to positive and negative product costs, in accordance with the proportion of positive and negative product quantities.

However, units for the on-site management of materials vary by process and material type, such as the numbers, rolls, sheets, meters, square meters, cubic meters, kilograms, and so on. Therefore you shall convert such on-site management units into the MFCA quantity units. The conversion methods shall be incorporated into the MFCA calculation model, so that the required operations will be performed using the on-site management data as parameters. This is because of the following reasons.

- The effects of improvement in percents defective and yield rates will become easier to simulate following the calculation of present figures by MFCA.

- A series of MFCA calculation will be performed easily by using the management units as parameters, if you continue the MFCA calculation on a monthly basis.

Procedure 2-2 Collect and compile the data of system cost and energy cost

In many cases, manufacturing costs are allocated by cost center, a unit of managing department. This unit varies by company or factory, but usually agrees with the organizational department, section, group or other units.

The data of system and energy costs are based on manufacturing costs. The collection and compilation of costs allocated by cost center shall form the basis of this step.

Procedure 2-3 Determine the allocation rules for system cost and energy cost

System and energy costs allocated by cost center require preprocessing before the MFCA calculation.

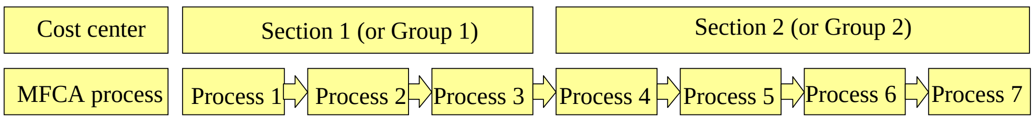


Figure 13. Cost centers and MFCA processes

As indicated in Figure 13, the cost center units may differ from the MFCA processes (quantity centers). In many cases, the MFCA processes are smaller than the cost center units. Therefore, you must allocate system and energy costs allocated by cost center to individual MFCA processes.

Multiple products and models may be produced in the same production line. If products and models selected as targets for MFCA calculation are only part of products and models produced on a single line, system and energy costs allocated by process shall be further allocated to targeted products and models.

Procedure 2-4 Collect and compile the data of operating status for each process

It is effective for improvement planning if you collect and compile the data of equipment operating status at the same time. If Total Productive Maintenance (TPM) is in place, this step will take no additional time because basic data are readily available.

If you have such data, you are able to evaluate the equipment operating loss (time loss) at the same time.

If the equipment is not operating at a maximum, you may expect improved material efficiency or reduced percent defective by slowing the production. In this manner, the above data are effective for improvement planning as well. (In the future, you shall develop better equipment and production technology that will realize improved material efficiency, more stable quality and faster production, but the above improvement will prove effective for the time being.)

6 MFCA calculation (establishing an calculation model)

In this section, explanation is provided on the concepts of establishing an MFCA calculation model and the required calculation outputs.

See also the developed and publicized MFCA simplified calculation tool. You are able to establish an MFCA calculation model easily with this tool for a simple manufacturing process. This tool is developed and publicized as part of promotion campaign for MFCA introduction. You can download the MFCA simplified calculation tool from the following MFCA website. http://www.jmac.co.jp/mfca/thinking/07.php

Procedure 3-1 Establish an MFCA calculation model and input the required data

First, you shall establish an MFCA calculation model.

The basic concepts for establishing an MFCA calculation model were outlined in Chapter 1.

In performing the actual computation, difficulties lie in the allocation of input system and energy costs in each process by the proportion of positive and negative product quantities, and including the positive product cost into the input cost of the subsequent process.

Figure 14 illustrates this idea with actual example. The same idea applies to both system and energy costs.

The process indicated in Figure 14 is in the middle of manufacturing process. In this process, the positive product (work-in-process) from the previous process is put in as the main material (100 kg), while additional material (50 kg) is put in anew as sub material.

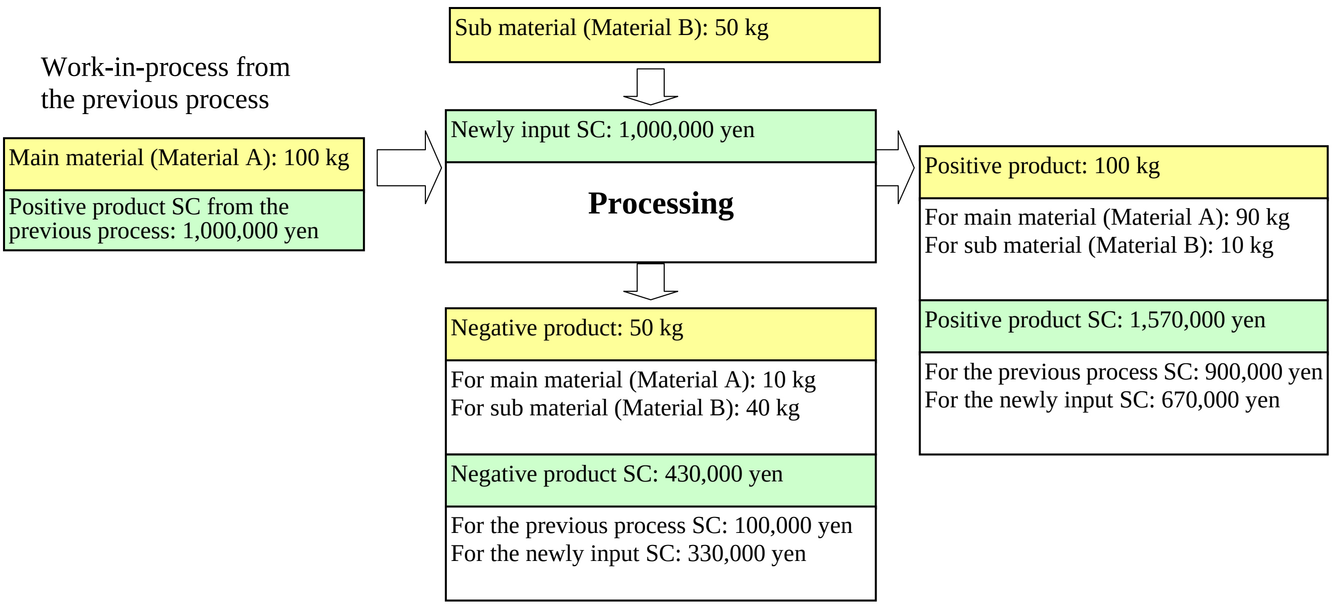


Figure 14. Concepts of MFCA calculation for system costs (SC)

In this step, main, sub and auxiliary materials are defined as follows.

- Main materials: The principal materials in the initial process and the work-in-process from the previous process in the following processes

- Sub materials: Materials added to the main materials to form part of the company products in each process

- Auxiliary materials: Materials that are used in each process but does not form part of the company products (e.g. cutting oil); The quantities of auxiliary materials shall not be included to calculate the positive or negative product system costs in principle.

In the above process, sub materials are mixed into main materials before processing. The processing operating generates the positive product that is released to the subsequent process as work-in-process and the negative products that becomes waste. Of 100 kg of input main materials, 90 kg becomes positive product and 10 kg becomes negative product. Of 50 kg of input sub materials, 10 kg becomes positive product and 40 kg becomes negative product. Positive and negative product costs with relation to materials costs are easily given by multiplying the quantities of positive and negative products by the unit prices of individual materials.

In this example, you shall calculate positive and negative product system costs as follows.

1) Positive product system cost from the previous process

In addition to the positive product (work-in-process) from the previous process, the positive product system cost from the previous process (1,000,000 yen) is put into this process. The input positive product system cost from the previous process shall be allocated in proportion to the positive and negative product quantities (90 kg and 10 kg respectively) from the previous process, which are calculated as 900,000 yen for the positive product SC and 100,000 yen for the negative product SC in this example.

2) System cost input anew in this process (Processing cost of this process)

The processing cost for the above process (1,000,000 yen) is regarded as system cost input anew. This processing cost is used for combining and processing main and sub materials. Therefore, it shall be allocated in proportion to the positive and negative product quantities (100 kg and 50 kg respectively), which are given by adding the work-in-process and sub materials put in this process (100 kg and 50 kg respectively). The positive and negative product system costs are calculated respectively at 670,000 yen and 330,000 yen.

For specified objectives of MFCA introduction, you may regard all the system costs put in a process as negative product costs.

In the next step, you shall prepare the MFCA simplified calculation tool, and define and input the data of material quantities and costs, as well as the data of system and energy costs.

Procedure 3-2 Confirm and analyze the MFCA calculation results

One of the major MFCA calculation outputs is a flowchart including calculation data.

Figures 15 and 16 indicate two forms of flowchart, which include the identical calculation data, but differ in that the former indicates calculation results before inter-process integration and the latter indicates calculation results after inter-process integration.

Explanation on inter-process integration follows, using the examples of Figures 15 and 16.

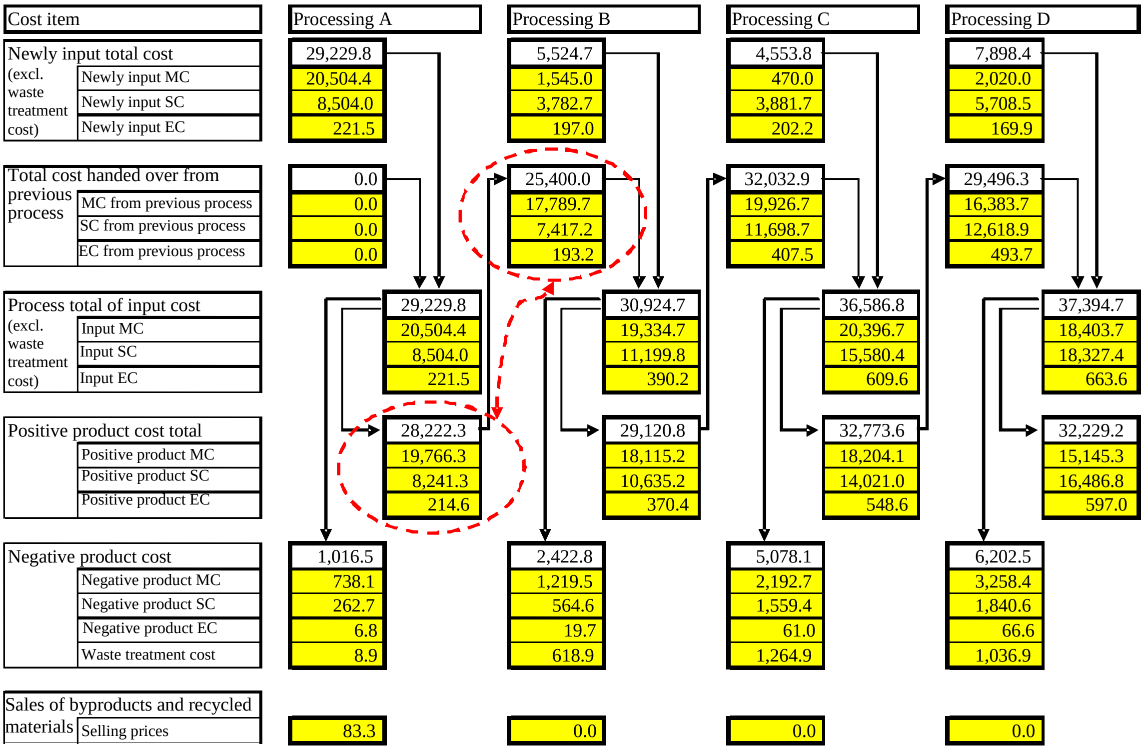


Figure 15. Flowchart including calculation data (before inter-process integration)

Figure 15 indicates the results of MFCA calculation using the raw data of input materials, yields, losses and costs of each process in a specified period (e.g. for one month). The given data shall be regarded as MFCA data for individual processes on the relevant time unit.

Taking account of the basic principle of MFCA that the positive product cost of a process shall be handed over to the subsequent process and included in its input cost. Therefore, the positive product cost of a process shall agree with the cost handed over from the previous process at that point. In Figure 15, however, the positive product cost in "Processing A" (Total: 28,222.3) does not agree with the cost handed over to the subsequent process, "Processing B" (Total: 25,400.0).

This is because the yield of completed products in "Processing A" differs from the completed products handed over to and put in "Processing B." This difference links to the increase and decrease in stock work-in-process, which shall be defined as a quantity center ("stock work-in-process" process) in MFCA calculation.

However, a calculation model will become too complicated if you incorporate stock work-in-process in the definitions using the MFCA simplified calculation tool. In addition, if stock work-in-process is not wasted as material loss, it produces no negative product cost and therefore does not impact the overall calculation process.

Based on the above, you will make the analysis of loss and cost improvement easier by excluding the impact of decrease and increase in inter-process work-in-process, and enabling MFCA calculation based on unit quantity of final products.

Figure 16 indicates calculation data following the conversion to coordinate the yield of work-in-process in a process with the input work-in-process in the subsequent process. This operation is called “inter-process integration” herein.

(Calculation based on the yield of 1,000 kg in the final process “Processing D”)

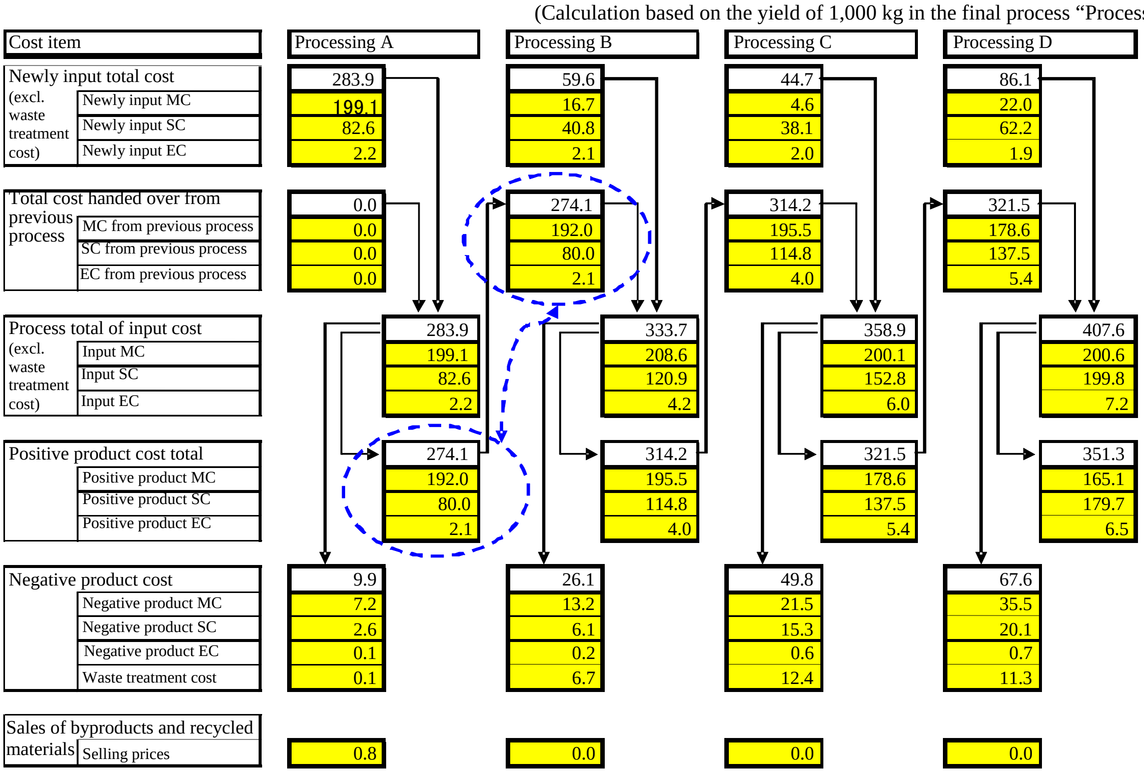


Figure 16. Flowchart including calculation data (after inter-process integration)

In Figure 16, the “positive product cost” of each process agrees with the “cost handed over from the previous process” of the subsequent process.

This inter-process integration is performed through the following conversion process.

(1) Calculate the integrated input quantity of the main material in the previous process and the integrated yield of the completed product, required to produce the specified yield (1,000 kg) of completed product in the final process.

(2) Multiply all the material, system, energy and waste treatment costs by the conversion factors to give the integrated quantities.

(3) Perform the above operations in the descending order starting with the final process.

The calculation data indicated in the flowchart of Figure 16 are provided through the following inter-process integration operation, based on the integration factors listed in Figure 17.

		Processing A	Processing B	Processing C	Processing D	Theoretical unit quantity for calculation
Calculation of inter-process integration factors	Input quantity of main materials (kg)	135,740.0	119,587.2	125,694.6	101,893.6	
	Yield of positive product (kg)	132,874.6	114,267.8	113,215.1	91,744.3	
	Inter-process integration factors	0.0097	0.0108	0.0098	0.0109	
	Theoretical input quantity of main materials for integration (kg)	1,318.3	1,290.4	1,233.0	1,110.6	1,000
	Theoretical yield of positive product for integration (kg)	1,290.4	1,233.0	1,110.6	1,000.0	

Figure 17. Factors for inter-process integration

In some cases, you may perform computation based on the actual yield of products (91,744.3 kg in the case of Figure 16) or on the unit number of products (1,000 pieces for example), instead of the theoretical yield of completed products in the final process (1,000 kg). If you want to use the unit number of products, you shall calculate the quantity value for the relevant number of products and perform the computation (as in Description 1 in relation to Figure 17).

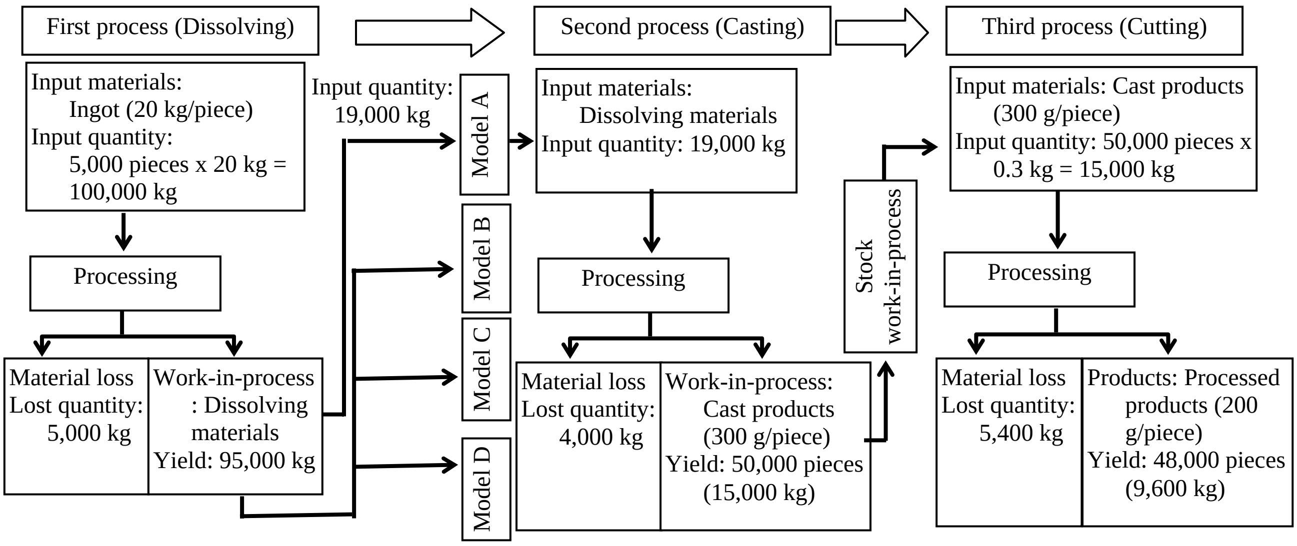


Figure 18. Significances of inter-process integration

The significances of inter-process integration is explained below, using the example of Figure 18. Inter-process integration has the three significances.

1) Cost calculation per unit of products in the final process

In the example of Figure 18, MFCA calculation results for a specified period are given as manufacturing costs required to produce 48,000 pieces of final products. You are able to evaluate the scale of loss by negative product cost and the effects of improvement easily, by converting the results into manufacturing cost per piece of product.

2) Agreement between the yield of completed products in a process and the input quantity in the subsequent process

If inter-process stock of work-in-process generates, the yield of completed products in the former process usually disagrees with the input quantity in the latter process, due to the increase and decrease in such stock.

If work-in-process does not generate waste, you can evaluate the effects of improvement more easily by adjusting the input and yield of each process based on the yield of products in the final process.

3) Calculation including processes shared by multiple models

In Figure 18, the first process “Dissolving” is shared by multiple models. If you perform MFCA calculation throughout all the processes for each model, you can evaluate the effects of improvement more easily by using the quantity values of the relevant models for such shared process.

A chart combining positive and negative product costs throughout all the processes based on the above flowchart including calculation data is called a “material flow cost matrix.”

Figure 19 indicates a material flow cost matrix based on the flowchart including calculation data after inter-process integration in Figure 16, and the graphical presentation of the matrix.

	Material cost	Energy cost	System cost	Waste treatment cost	Total
Conforming products	16,660	657	18,136		35,452
(Positive products)	32.7%	1.3%	35.6%		69.6%
Material loss	7,806	162	4,441		12,409
(Negative products)	15.3%	0.3%	8.7%		24.4%
Wastes/recycled products				3,076	3,076
				6.0%	6.0%
Subtotal	24,466	819	22,576	3,076	50,937
	48.0%	1.6%	44.3%	6.0%	100.0%

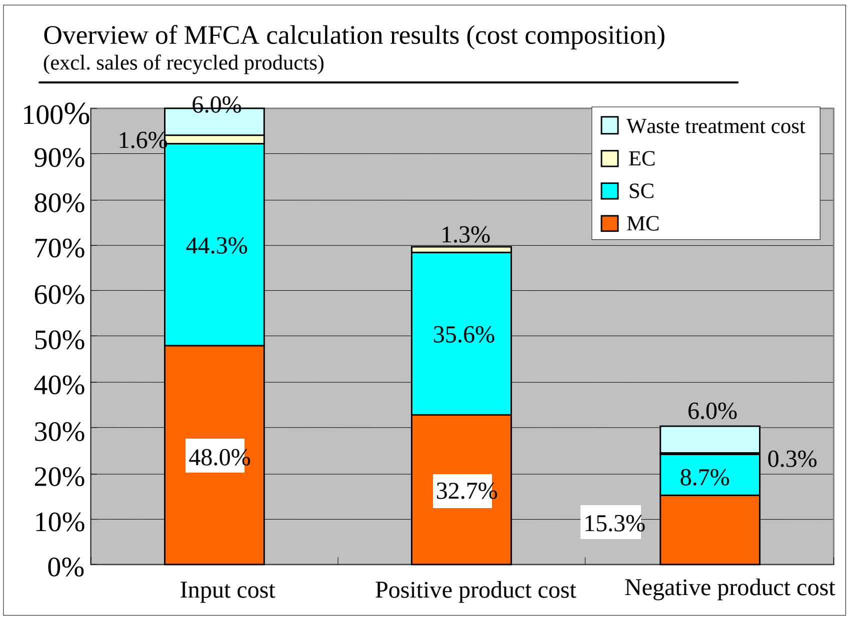


Figure 19. Material flow cost matrix

A material flow cost matrix represents loss cost throughout all the processes in the scope of MFCA calculation. In the example of Figure 19, cost used for materials forming the conforming products take up 69.6% of all input cost. The other 30.4% is regarded as loss cost.

These data overview the resource efficiency throughout the targeted processes in terms of cost, thereby contributing to the evaluation of overall loss scale, the effects of improvement, and difference between multiple models made by similar manufacturing process.

Chapter III. Utilization of MFCA Calculation Results

1 How to read MFCA calculation results

The flowchart including calculation data indicated in Figure 16, Chapter II, shows the status of cost input and negative product cost (loss cost) generation in each process.

Figure 20 is a graphical presentation of input cost and negative product cost in each process, based on the data indicated in Figure 16.

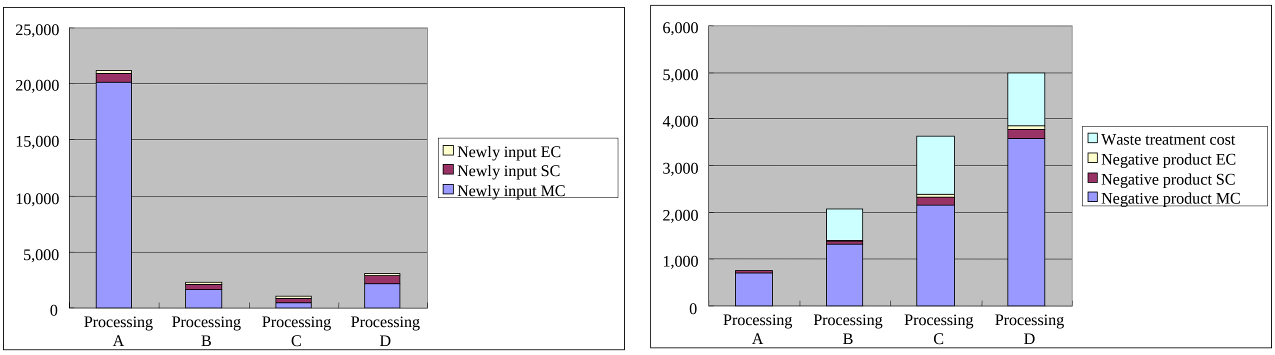


Figure 20. Input cost and negative product cost in each process

The material flow cost matrix indicated in Figure 19 shows the overall negative product cost (loss cost) throughout all the targeted processes. Evaluation may be difficult for a single model or product. You may evaluate the present values more appropriately and identify the models and requirements for improvement more effectively, by comparing MFCA values between multiple models (see Figure 21).

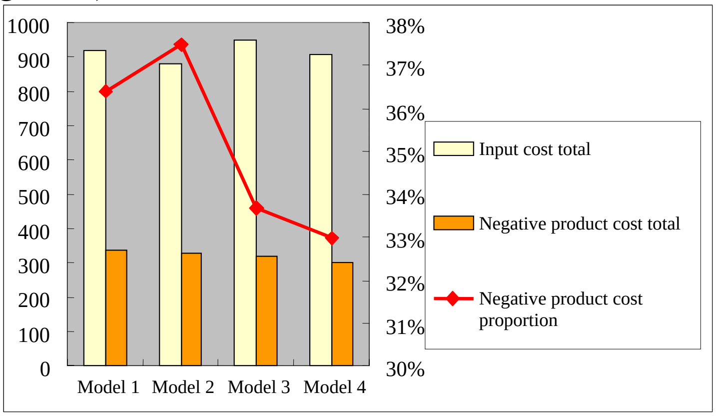


Figure 21. Comparison of MFCA values between multiple models

2 Identifying and classifying improvement requirements

Based on the MFCA calculation results as indicated in Figures 16, 19, 20 and 21, you shall identify your improvement requirements focused on parts with large losses and input costs, as well as taking account of material loss quantities and occurrence rates by causes.

The identified improvement requirements shall be classified using a table of improvement requirements (see the example in Figure 22).

Process	Loss type	Loss description	Loss scale	Direction and focus of improvement	Constraints in improvement	Improvement theme	Improvement target	Expected effects of improvement
Processing 1	MC	Cutting scrape	Material loss, 10% of negative product MC	Improve the cutting method by…	Abrasion, deflection, etc. of cutting tools	Improvement of cutting tools and conditions	Reducing cutting scrape by 20%	Negative product MC reduced by ** yen/piece
Processing 2	MC, SC	Cutting defects	Percent defective: **%	Reduce defects; Percent defective varies substantially by model.	-	Stabilization of quality through continuous operation	Halving the defects	Negative product MC reduced by ** yen/piece
Processing 2	MC	Cutting scrape	Material loss, 30% of negative product MC	Reduce the cutting cost for …; The cutting cost can be reduced by minimizing the variation in Processing 2.	Variation in Processing 2 (Die precisions and related conditions)	Reduction in processing variation	Reducing the cutting cost by 30%	Negative product MC reduced by ** yen/piece
Processing 2	MC, SC	Reduce the percent defective	Percent defective stands at **%	Reduce the percent defective, which increases and decreases dependent on the skill of operators.		Standardization of operations and tools	Halving the defects	Negative product MC reduced by ** yen/piece

Figure 22. Table of improvement requirements

- Identify the processes generating negative product costs, as well as the types, causes and scales of losses.
- Examine improvement methods roughly, identify the direction and focus of required improvement, and set the improvement targets.
- Analyze the methods and feasibilities of improvement, expect the effects of improvement, and identify the items to improve.

3 How to proceed with improvement

Figure 23 compiles how you should proceed with MFCA calculation, post-analysis management and improvement.

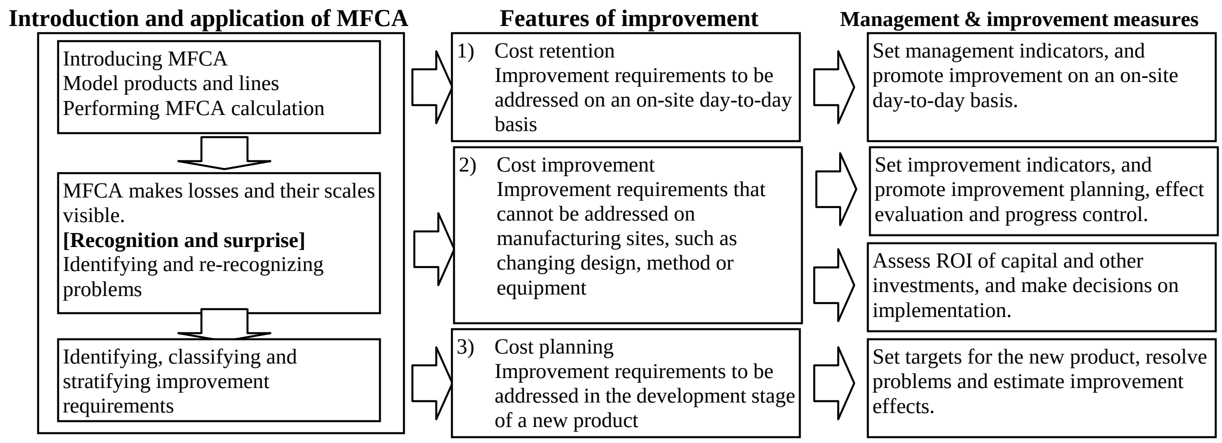


Figure 23. How to proceed with management and improvement based on MFCA

MFCA calculates the negative product costs (loss costs) as comprehensive evaluation of the present manufacturing productivity.

The given negative product costs (loss costs) result from various causes in processes. The types of improvement are categorized by the levels of relevant causes.

1) Utilizing MFCA in day-to-day management of manufacturing sites

This refers to day-to-day improvement activities led by manufacturing sites, promoted toward pre-set standard or target values based on management indicators such as yield rates, percents defective, operating rates, etc.

In this category, you shall promote the improvement activities led by manufacturing sites on the items identified through MFCA calculation. By translating the yield rates and percent defectives as targets or achievements of day-to-day management into cost changes through MFCA, you can make the significance of such improvement and management more visible to the manufacturing sites.

2) Utilizing MFCA for improvement in engineering and production engineering departments

This refers to improvement activities led by manufacturing or production engineering departments, focused on changes to existing equipment and design or on process improvements.

Improvement shall be promoted mainly by manufacturing or production engineering departments, for the items identified through MFCA calculation, calling for changes to existing equipment and design or for process improvements. You are able to estimate comprehensive cost reduction effects using MFCA. Therefore, MFCA is an effective tool to set priorities if there are numerous improvement requirements. It is also useful in the assessment of ROI.

3) Improvement in the development and design stages of a new product

This refers to improvement activities led by product development and design departments in the development stage of a new product.

For drastic improvement in material efficiency and cost reduction, you may need to review the design specifications. By applying MFCA, you are able to make visible the impact of process yield rates on costs, and have designers recognize how improvement in material yield rates in each process contributes to cost reduction. MFCA is therefore an effective tool for examining improvements in the cost planning stage.

Chapter IV. Evolution of MFCA

Chapters I through III have outlined the basic guide for introducing MFCA into a business. This basic guide focuses on the process from selecting model products and lines to performing Excel-based computations, thereby identifying the quantities and values of loss.

In Chapter IV, concepts for advanced utilization of MFCA are presented. In this year's MFCA Development and Promotion Project, Working Groups (hereafter referred to as "WG") are put up for the examination of the following four research themes, targeted at more advanced (more effective) utilization of MFCA.

(1) Systematizing MFCA
(2) Transferring MFCA to supply chain companies
(3) Linking MFCA and LCA
(4) Utilizing MFCA as an indicator for external environmental management evaluation

These themes will help more effective use of MFCA.

The overviews of each theme are provided below.

1 Systematizing MFCA

[Backgrounds and objectives]

This research theme is targeted at examining how to bolster and transfer MFCA as a management tool, combined with or incorporated into corporate information systems and management methods.

The introduction of MFCA into Japanese businesses started in 2000, and its effects and benefits have been proved. On the other hand, complexity in data collection and compilation as well as in computing operations has formed a bottleneck in transferring the application of MFCA from trial models and lines to others. Few companies are using MFCA calculation for regular monthly management.

For utilizing MFCA as a corporate management tool in bolstering competitiveness and improving resource productivity, it is important to establish a management system incorporating MFCA.

[Overview]

As the first step of MFCA introduction, you should download the MFCA simplified calculation tool from the MFCA website (http://www.jmac.co.jp/mfca/thinking/07.php), and apply it to model products and lines. To transfer MFCA to more products and lines, it is indispensable to minimize the workload of data collection. From this viewpoint, it is desirable to link the MFCA system with your cost accounting, production control and other existing ERP systems, so that data required for MFCA are automatically collected and processed.

In this way, MFCA calculation results are reported regularly, enabling regular and effective use of MFCA as a management tool of production status, identifying the locations and extents of existing losses. Figure 24 indicates the image of such MFCA systems.

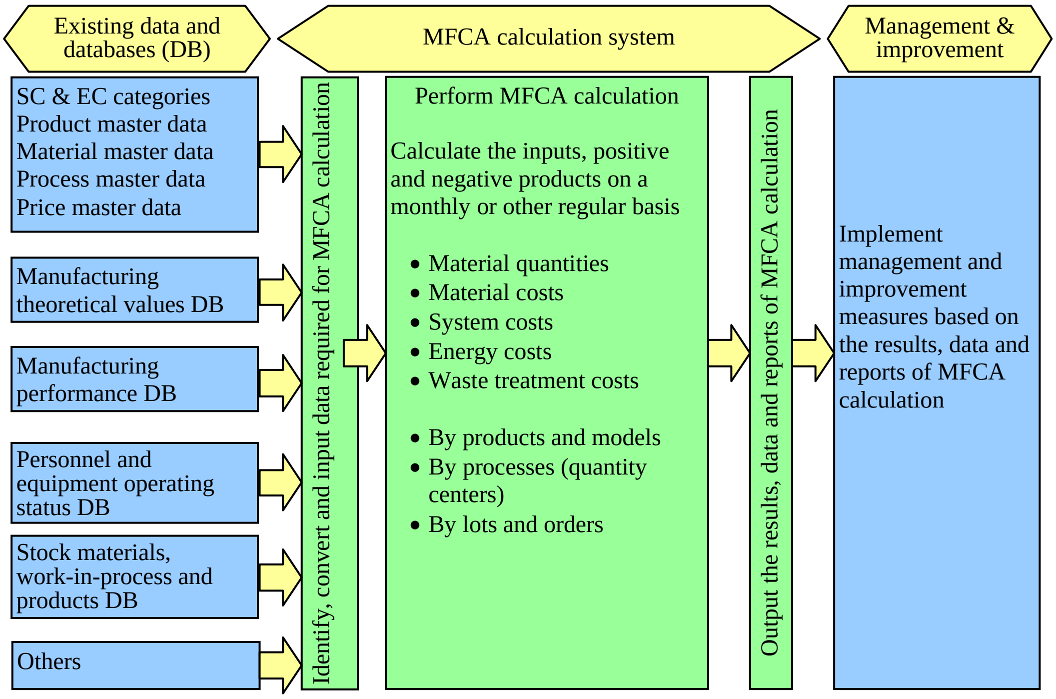
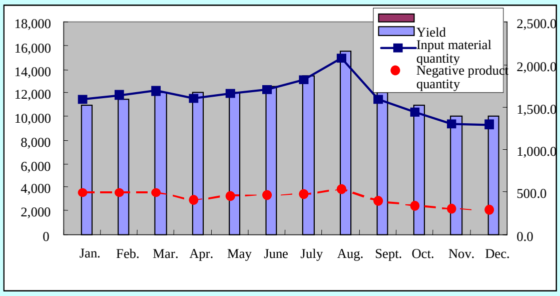
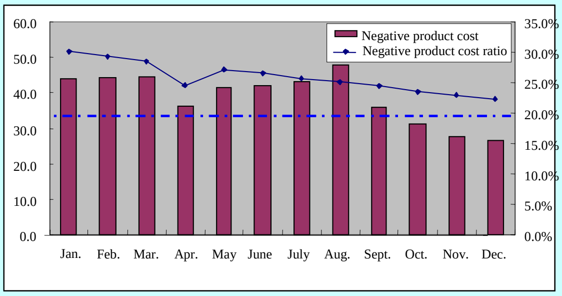


Figure 24. Image of MFCA systems

Figure 25 indicates the image of a form of monthly MFCA report.

Monthly MFCA Report	Period	01/2006 – 12/2006	Reporting date	01/15/2007	Responsible person	Manager ***
Factory: Factory**	Products/ models	Product ***, all models	Line	Production line *** 1	Process/ equipment	All the relevant processes





MFCA monthly control chart

		MFCA quantity (kg)							MFCA cost (thousand yen)				Cost calculation	
Month/Year	Yield	Input main materials	Positive product from main materials	Input sub materials	Positive product from sub materials	Input materials total	Positive products total	Negative products total	Input cost	Positive product	Negative product	Negative product ratio	Mfg unit price (yen)	Mfg cost improve-ment (%)
01/2006	11,000	1,320.0	935.0	275.0	165.0	1,595.0	1,100.0	495.0	145.8	101.8	44.0	30.2%	13.25	0.0%
02/2006	11,500	1,368.5	977.5	276.0	172.5	1,644.5	1,150.0	494.5	150.7	106.4	44.3	29.4%	13.10	1.1%
03/2006	12,000	1,416.0	1,020.0	276.0	180.0	1,692.0	1,200.0	492.0	155.4	111.0	44.4	28.6%	12.95	2.3%
04/2006	12,000	1,340.4	1,020.0	264.0	180.0	1,604.4	1,200.0	404.4	147.2	111.0	36.2	24.6%	12.27	7.4%
05/2006	12,000	1,392.0	1,020.0	264.0	180.0	1,656.0	1,200.0	456.0	152.4	111.0	41.4	27.2%	12.70	4.2%
06/2006	12,500	1,437.5	1,062.5	275.0	187.5	1,712.5	1,250.0	462.5	157.5	115.6	41.9	26.6%	12.60	4.9%
07/2006	13,500	1,539.0	1,147.5	283.5	202.5	1,822.5	1,350.0	472.5	168.1	124.9	43.2	25.7%	12.45	6.0%
08/2006	15,500	1,751.5	1,317.5	325.5	232.5	2,077.0	1,550.0	527.0	191.4	143.4	48.1	25.1%	12.35	6.8%
09/2006	12,000	1,344.0	1,020.0	252.0	180.0	1,596.0	1,200.0	396.0	147.0	111.0	36.0	24.5%	12.25	7.5%
10/2006	11,000	1,221.0	935.0	220.0	165.0	1,441.0	1,100.0	341.0	133.1	101.8	31.4	23.6%	12.10	8.7%
11/2006	10,000	1,100.0	850.0	200.0	150.0	1,300.0	1,000.0	300.0	120.0	92.5	27.5	22.9%	12.00	9.4%
12/2006	10,000	1,090.0	850.0	200.0	150.0	1,290.0	1,000.0	290.0	119.0	92.5	26.5	22.3%	11.90	10.2%
Total, average	143,000	16,320	12,155	3,111	2,145	19,431	14,300	5,131	1,788	1,323	465	26.0%	12.50	5.7%

Improvement target: Reducing negative cost ratio 20% or below

Improvement measures:
(1) Introduce the *** method for material input control in the second process.
(2) Reduce the percent defective in the third process with improved dies.
(3) Optimize manufacturing conditions for the third process.
(4) Reduce the percent defective by changing specifications and improving quality of Material A.

Progress of improvement:
- The measures (1) through (3) have been completed with proven effects.
- The measure (4) is being entrusted with the relevant manufacturer.

Figure 25. Image of MFCA monthly report

The characteristics of this report are outlined below.

- The monthly report includes MFCA calculation results for individual processes or for all the processes by factory, by product or model, and by production line.

- The monthly MFCA calculation results are compiled in the table in bottom left, in the chronological order.

- Two monthly graphs are generated in the chronological order, based on the data compiled in the table in bottom left.

- The graph on the left visualizes monthly changes in product yields (on the left scale), as well as in input materials and negative product quantities (on the right scale).

- The graph on the right visualizes monthly changes in negative product costs (on the left scale) and negative product cost ratios (on the right scale).

- The dashed line in the right graph indicates the targeted standard of negative product cost ratios.

- In bottom right of the sheet are columns for indicating target values of negative product cost ratios, products in the scope of MFCA calculation, improvement measures and progress statuses. The responsible person for the production line or the process is expected to fill his/her remarks in these columns, and report the results to their supervisors.

To promote such operating system, it is necessary to identify your system requirements to your system vendor (system developer). An MFCA calculation system largely comprises the following three function areas.

(1) Data processing and input
(2) MFCA calculation
(3) Calculation results output

In addition, the following five requirements shall be satisfied when you have an MFCA calculation system designed.

(1) Realizing the concepts of MFCA
(2) Minimizing the constraints in application
(3) Enabling flexible response to changes in the MFCA targets
(4) Facilitating the system and data operations of MFCA
(5) Ensuring the extensibility of MFCA calculation results

For detailed concepts, procedures and examples of promoting such systematization, refer to ‘Studies for Systematizing MFCA: Advanced MFCA Study Project No.3’ in Chapter 4, Part 3 of the “Report of the MFCA Development and Promotion Project.”

2 Transferring MFCA to supply chain companies

[Backgrounds and objectives]

Manufacturing involves diverse production processes such as material excavation, raw material production, material production, part production, component production and product manufacturing. In most cases, such processes do not conclude within a single company, but are divided between multiple companies.

MFCA is basically targeted at the internal management of a company. The scope of MFCA is generally selected from the above series of manufacturing processes, which involves a specified company, division, factory, department or other organizational unit.

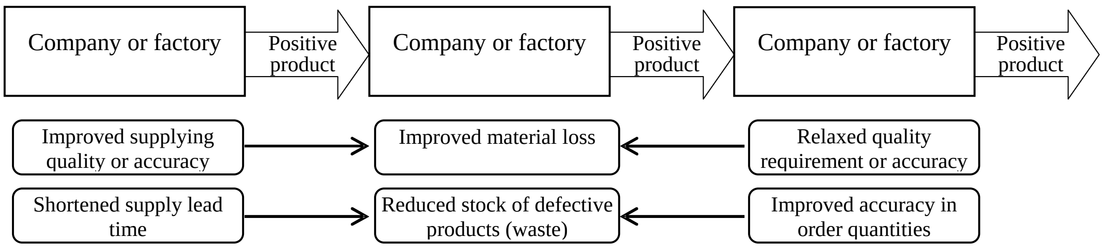


Figure 26. Image of improved coordination within supply chain (SC)

MFCA identifies the flow of materials throughout the manufacturing processes, and the relevant material losses. Many improvement measures can be implemented for better resource productivity on a quantity center basis (a theoretical unit for MFCA calculation), while others require coordination within supply chain as indicated in Figure 26.

Therefore, it is desirable for reducing material loss and improving resource productivity in the overall manufacturing process to extend the ranges of improvement measures, the relevant coordination and the application of MFCA. The effects of improving resource productivity will further enhance through such extension.

[Overview]

Under this theme, interviews with the participating companies suggested that it will be appropriate to categorize the scopes of transferring MFCA and resource productivity measures to supply chain in the three types as indicated in Figure 27: (1) Between different departments of the same factory, (2) Between different factories of the same company or between different companies of the same group, and (3) Between different independent companies.

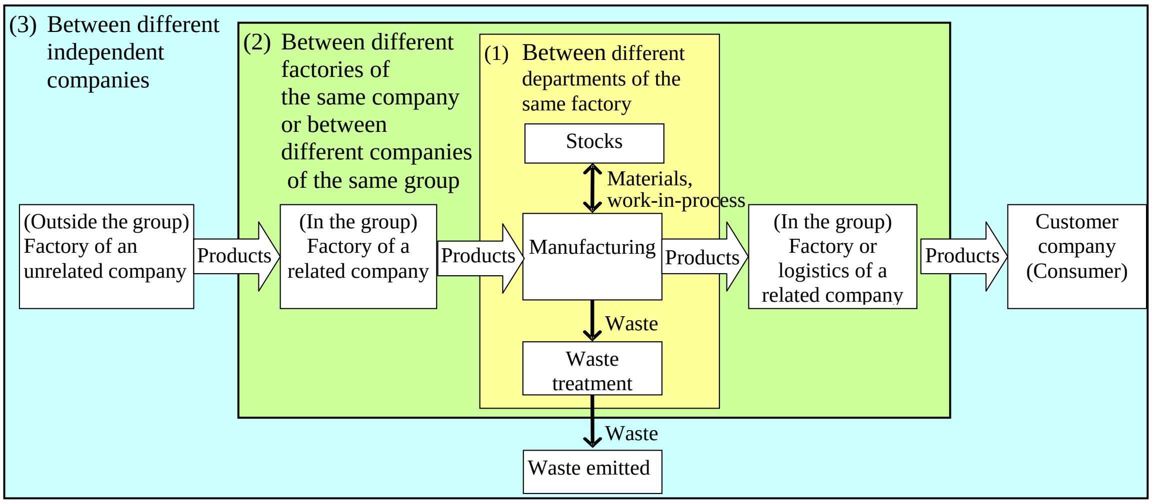


Figure 27. Types of transfer to supply chain

While the overall benefits from MFCA introduction will grow larger as the transfer proceeds from the initial model products and lines to (1), (2) and (3), the relevant difficulties will expand as well.

Due to limited space, this section focuses on the benefits of promoting MFCA information sharing.

By sharing information on material flows, quantities and loss costs between the upstream and downstream departments, factories and companies, you are able to ensure the effects of coordinated measures for reducing material loss generated in the relevant material flow, besides many other benefits. The following lists some of the remarks made by companies considering that the coordinated improvement and the sharing of MFCA information proved effective in material loss reduction.

- “In the MFCA for model products, we performed analysis and improvement planning jointly with related processors of major components. The disclosure and sharing of all the relevant data with each other proved quite effective.”

- “We consolidated the MFCA data within our group, thereby crystallizing common problems which we can address jointly as a group.”

The sharing of information on material flows and quantities between the upstream and downstream companies and factories is not only effective for reducing costs and environmental impact through improved resource productivity based on coordinated improvement activities, but are also important from the following perspective.

- An upstream company can obtain opportunities for proposing products or delivery styles that will realize improved processability or assemblability on its customer side, based on the knowledge of how its products are used in the downstream process. This will evolve the company into a proposal-oriented business, which is highly significant in bolstering its competitiveness.

At the same time, a downstream company may identify a useless processing operation caused by careless instructions in specifications or order plans issued by the company, through the knowledge of processing conditions for materials it purchases. Such useless operations result in higher prices, and the company may realize a better cost reduction through revising its specifications or order plan forms.

Under this theme, the examples of companies transferring MFCA to their supply chain are introduced, coupled with the explanation of benefits and difficulties in such transfer and the summary of possible solutions. For details, refer to ‘Studies for Transferring MFCA to Supply Chain: Advanced MFCA Study Project No.2’ in Chapter 3, Part 3 of the “Report of the MFCA Development and Promotion Project.”

3 Linking MFCA and LCA

[Backgrounds and objectives]

MFCA is a method of cost accounting to identify losses, regarding the quantities of wasted materials as “negative product”, as well as regarding the material, processing and all other costs put in the wasted materials as “negative product cost.” This is why many companies and factories introducing MFCA have successfully promoted improvement measures from new perspectives, realized the reduction of costs, waste emissions and material consumptions. MFCA is therefore considered a tool for promoting the simultaneous pursuit of economic effects and environmental impact reduction.

However, for more effective pursuit of this goal, the simultaneous pursuit of economic effects and environmental impact reduction, integration with Life Cycle Assessment (LCA) will become necessary, so that MFCA can be utilized more powerfully, thereby bolstering and making up for its environmental evaluation. To be specific, such integration aims at the simultaneous evaluation of corporate internal costs and external environmental costs, pertaining to the generation of negative products and the waste treatment.

[Overview]

Under this theme, research and studies are promoted with cooperation of participating companies, through developing examples of integrated calculation models of MFCA and LCA, and evaluating and discussing their calculation results at the relevant WG. For environmental impact evaluation, environmental damage cost (social cost) is calculated in monetary values using the Life-cycle Impact Assessment Method based on Endpoint Modeling (LIME).

For example, Figure 28 indicates the negative product cost and waste treatment cost of a specified product of Canon, as identified by MFCA calculation, coupled with the social cost required for the treatment of that negative product and waste (i.e. cost of damage to the natural environment (e.g. global warming) caused by the company’s activity), as identified by LIME.

MFCA-LIME comparison of negative products (total of all processes by category)

Example of Canon

(Unit: thousand yen, 1,000 kg of products)

	Category	MFCA	LIME	Mark
Before improve-ment	Negative product (input materials)	92.8	13.0	◆
	Negative product (energy)	3.0	0.8	■
	Negative product (waste treatment)	6.7	0.3	●
After improve-ment	Negative product (input materials)	50.2	9.0	◇
	Negative product (energy)	1.3	0.4	□
	Negative product (waste treatment)	3.9	0.1	○

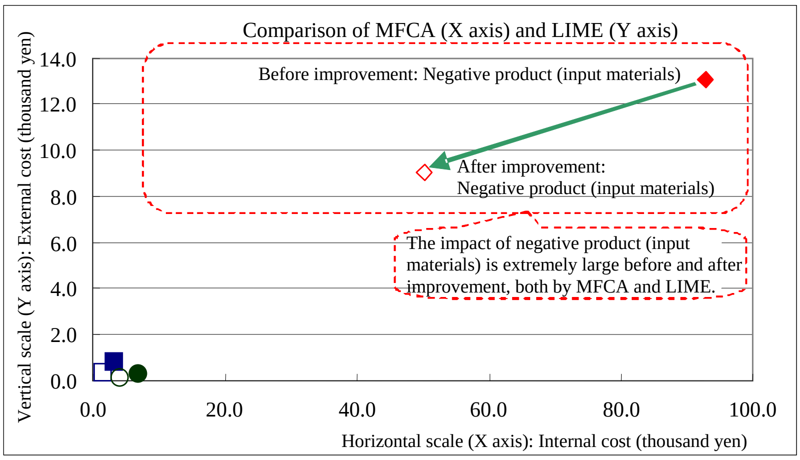


Figure 28. Comparison of MFCA and LIME values before and after improvement

The overall negative product value before improvement stood at 102.5 thousand yen by MFCA (total negative product cost, indicating the loss on manufacturing cost), and at 14.2 thousand yen by LIME (total environmental impact of the negative product, indicating the social cost). The LIME value equaled 13.8% of the MFCA. Before improvement, the negative product (material loss) from the manufacturing of the relevant product caused manufacturing cost loss of 102.5 thousand yen per 1,000 kg of products, while generating social cost of 14.2 thousand yen.

The overall negative product value after improvement stands at 55.4 thousand yen by MFCA (total negative product cost, indicating the loss on manufacturing cost), and at 9.6 thousand yen by LIME (total environmental impact of the negative product, indicating the social cost). The LIME value equals 17.2% of the MFCA. This improvement realized the reduction of negative product cost by 46% throughout the targeted processes based on MFCA, which realized at the same time the reduction of the consequent environmental impact by 33% based on LIME.

In this manner, a business will be able to identify its internal loss cost (negative product cost) using MFCA while crystallizing the external cost caused by the negative product on society, through the integrated method for environmental impact assessment.

At the same time, evaluation in terms of CO_2 emissions is also in place, taking account of global warming impact of business activities. Figure 29 indicates the values before and after improvement in the above example, in terms of CO_2 emission per 1,000 kg of products.

Material flow cost matrix in terms of CO_2 emissions (inter-process integration applied)

(Unit for CO_2 emissions: ton-CO_2 per 1,000 kg of products manufactured)

Before improvement	Material cost	Energy cost	System cost	Waste treatment cost	Total
Conforming products	2.998	1.163			4.161
(positive product)	61.1%	23.7%			84.8%
Material loss	0.582	0.163			0.745
(negative product)	11.9%	3.3%			15.2%
Wastes & recycled materials				0.000	0.000
				0.0%	0.0%
Subtotal	3.580	1.326		0.000	4.907
	73.0%	27.0%		0.0%	100.0%

Material flow cost matrix in terms of CO_2 emissions (inter-process integration applied)

(Unit for CO_2 emissions: ton-CO_2 per 1,000 kg of products manufactured)

After improvement	Material cost	Energy cost	System cost	Waste treatment cost	Total
Conforming products	2.998	0.788			3.786
(positive product)	71.1%	18.7%			89.7%
Material loss	0.361	0.071			0.433
(negative product)	8.6%	1.7%			10.3%
Wastes & recycled materials				0.000	0.000
				0.0%	0.0%
Subtotal	3.360	0.859		0.000	4.219
	79.6%	20.4%		0.0%	100.0%

Figure 29. Comparison of CO_2 emissions before and after improvement

The two tables indicate that CO_2 emissions were reduced by 0.6887 ton-CO_2 in total, from

4.907 to 4.219 ton-CO_2 per 1,000 kg of products following the improvement.

Also refer to 'Studies for Integrating MFCA and LCA: Advanced MFCA Study Project No.1' in Chapter 2, Part 3 of the "Report of the MFCA Development and Promotion Project," where many integration examples are provided, coupled with the concepts, difficulties and solutions pertaining to the integrated calculation of MFCA and LCA.

4 Utilizing MFCA as an indicator for external environmental management evaluation

[Backgrounds and objectives]

MFCA makes visible the quantities and monetary values of internal losses, for the purpose of corporate internal management. It is desirable to evaluate the external impact of the company at the same time, for more effective environmental management.

Of diverse environmental management indicators, expectation is rising for comprehensive indicators integrating the evaluations of different types of environmental impact. Although many companies disclose their performance against integrated environmental management indicators in environmental reports, there remains much room for improvement because the understanding is still insufficient of how to utilize such evaluations effectively. Popular Japanese methods for evaluating environmental aspects in environmental management include the Life-cycle Impact Assessment Method based on Endpoint Modeling (LIME), the Environmental Policy Priorities Index for Japan (JEPIX), and the Maximum-Abatement Cost Method (MAC). There are no guidance on which method should be applied to individual aspects of business management, and the selection is left to each company.

In '3. Linking MFCA and LCA,' computations were performed by MFCA and by LIME, one of the environmental impact assessment methods. Under this theme, the scope of studies is expanded to the examination of recommended environmental impact assessment methods for differing purposes, based on which results guidelines shall be compiled for effective utilization of environmental management indicators with the focus on MFCA and integrated environmental impact assessment methods.

[Overview]

Major concepts for integrated evaluation of environmental impact include (a) assessing the endpoint environmental impact, (b) basing the assessment on actual quantities of environmentally impacting substances and their distance to control values (the Distance to Target method), and (c) the maximum-abatement cost method. LIME, JEPIX and MAC are selected as typical methods developed in Japan respectively for (a), (b) and (c). These three methods have in common that they perform inventory analysis, multiple individual inventory data by the relevant evaluation factors, and add all the resulting values for integration. On the other hand, they differ in basic concepts and scopes for integration. Some of the most remarkable differences lie in the policies for integrated evaluation, targeted environmentally impacting substances, units for uniformed indicators, and others. Characteristics of the three methods are listed in Figure 30.

	LIME	JEPIX	MAC
Official name	Life-cycle Impact Assessment Method based on Endpoint Modeling	Environmental Policy Priorities Index for Japan	Maximum-Abatement Cost Method
Policy for integrated evaluation	Assessing the endpoint: environmental impact Evaluation is based on damage on the environment caused by environmentally impacting substances.	Distance to Target method: Evaluation is based on actual quantities of environmentally impacting substances and their distance to control values.	Maximum-abatement cost method: Evaluation is based on market costs required for the reduction of environmentally impacting substances.
Viewpoints	Citizen's viewpoint: How much to pay for the reduction of environmentally impacting substances	Policymaker's and corporate strategic risk controller's viewpoint:	Corporate viewpoint: How much it costs for the reduction of environmentally impacting substances
No. of targeted environmentally impacting substances (for which integrating factors are predefined)	Approx. 1,000 substances, covering both inputs (resource consumptions) and outputs (emissions)	Several hundreds of substances, covering outputs (emissions) only	Only 15 substances, covering outputs (emissions) only
Conversion into monetary values	Yes; Used for financial evaluation of social impact (i.e. influence on general citizens) caused by environmental measures.	No.	Yes; Used for comparing the internal costs required for corporate environmental measures.
Major applications at present	Often used for product environmental impact assessment, as an LCA method. The applications are expanding to the impact assessment of an entire business site.	Often used for the environmental impact assessment of an entire business site (identifying the site's environmental efficiency, etc.).	Often used for setting priorities for public procurement. Often used for setting priorities for green procurement and investment items with fixed budgets.

Figure 30. Comparison of LIME, JEPIX and MAC

The scopes of application of these methods by businesses are categorized into "products" and "business sites (factories)" as the targets of business activities. As for "products," businesses will typically apply these methods to individual functions directly related to manufacturing, such as design and development, procurement, production and sales. More specifically, common application targets will include environmentally-conscious design, green procurement, production control, and product promotion using environmental quality. On the other hand, typical applications to "business sites (factories)" will be based on the Plan, Do, Check and Action (PDCA) cycle of the entire environmental management systems. For example, common applications include the setting of environmental targets for the entire business site, capital investment, environmental performance evaluation, environmental reporting and others.

While guidance on individual applications is omitted here, the overview is provides of production control, the most promising area in he integration of MFCA and environmental impact assessment methods. As mentioned in '3. Linking MFCA and LCA,' negative products place diverse types of environmental impact, which include not only direct impact caused by the generation of unnecessary products (negative product), but also impact from upstream processes such as raw material makers (See Figure 31).

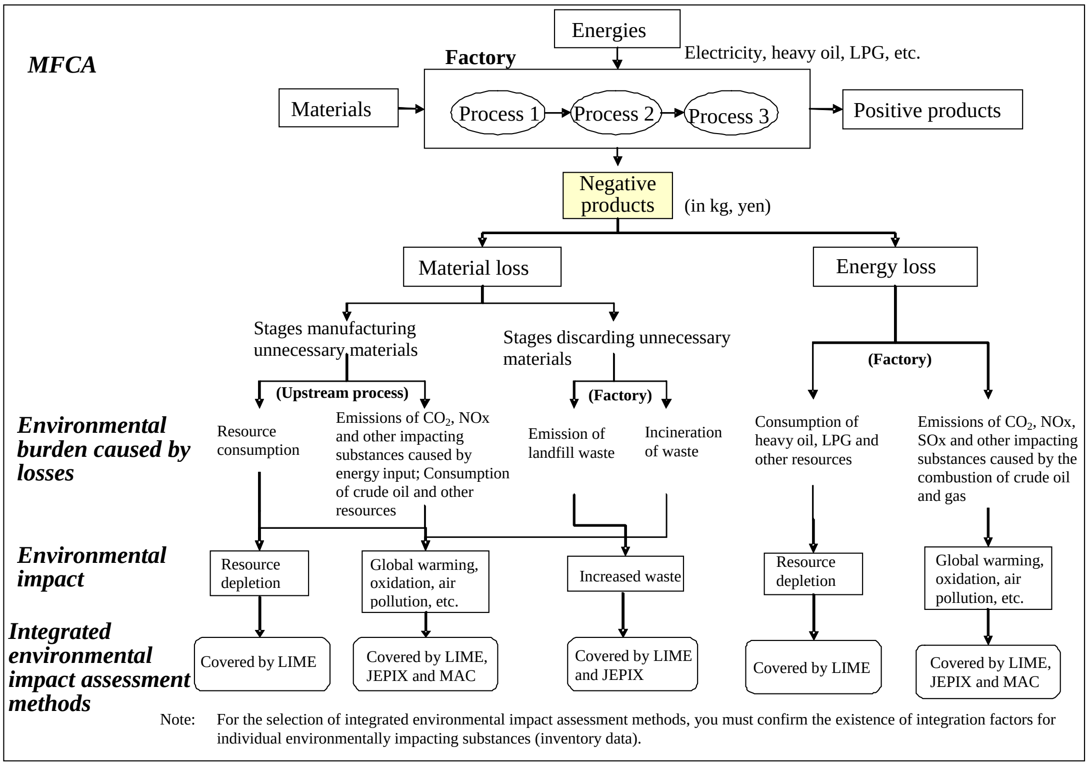


Figure 31. MFCA (negative products) and integrated environmental impact assessment methods

You are able to represent all these data by uniformed indicators or monetary values through applying integrated environmental impact assessment methods. By combining them with MFCA in the activities for reducing negative products, reduction effects will be made visible in both internal costs (as identified by MFCA) and external costs (as identified by integrated environmental impact assessment methods). Different methods involve varying concepts and characteristics, which require their careful selection and application. Figure 32 lists the features of MFCA and other methods pertaining to negative products.

Category	Environmental impact	MFCA	LIME	JEPIX	MAC	備考
Material loss	Resource depletion	Internal loss can be converted into monetary values	Applicable (can be converted into monetary values)	Excluded	Excluded	Integration factors for these three methods shall be predefined corresponding the targeted environmentally impacting substances (inventory data). In the order corresponding to the number of predefined integrating factors: LIME, JEPIX, then MAC.
	Global warming, oxidation, air pollution, etc.		Applicable (can be converted into monetary values)	Applicable	Applicable (can be converted into monetary values)	
	Increased waste		Applicable (can be converted into monetary values)	Applicable	Excluded	
Energy loss	Resource depletion	Internal loss can be converted into monetary values	Takes account of declines in mineral resources	Excluded	Excluded	
	Global warming, oxidation, air pollution, etc.		Applicable (can be converted into monetary values)	Applicable	Applicable (can be converted into monetary values)	

Figure 32 Features of MFCA and other methods pertaining to negative products

When a company seeks to introduce such integrated environmental impact assessment methods in combination with MFCA, it is important to select appropriate methods based on their characteristics.

For more details, refer to ‘Utilizing MFCA as an Indicator for External Environmental Management Evaluation: Advanced MFCA Study Project No.4’ in Chapter 5, Part 3 of the “Report of the MFCA Development and Promotion Project FY2006 Entrusted by the Ministry of Economy, Trade and Industry.”

For study reports and references on MFCA, see the literature list or the list of URLs of downloading sites on the MFCA website.

[Study reports on MFCA (in Japanese)]

(1) Report of the MFCA Development and Promotion Project FY2006

(2) Reports of research study projects on MFCA sponsored targeted at large enterprises FY2004 & 2005
http://www.jmac.co.jp/mfca/document/02_16.php#mdoc1

(3) Report of Joint Research on Model MFCA Introduction Targeted at Small and Medium-sized Enterprises FY2004
http://www.smrj.go.jp/keiei/kankyo/account/houkoku_16/index.html
http://www.j-management.com/mfca/2.htm

(4) Report of Environmental Management System Establishment Project for Rationalized Energy Consumption (Environmental Accounting Study) FY2004
http://www.jemai.or.jp/CACHE/account_details_detailobj1574.cfm

(5) Report of Study on Environmental Business Development Promotion, etc. (Environmental Management Accounting) FY2003
http://www.jemai.or.jp/CACHE/account_details_detailobj860.cfm

(6) Report of Study on Environmental Business Development Promotion, etc. (Comprehensive Environmental Management Methods) FY2002
http://www.jemai.or.jp/CACHE/account_details_grunge40.cfm

(7) EMA Procedural Workbook (June 2002, Ministry of Economy, Trade and Industry)
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The list of related papers published in magazines and journals is posted on the following website.
http://www.jmac.co.jp/mfca/document/04.php

A series of ‘Practical Material Flow Cost Accounting’ has been running since 2005 Vol.39 of “Environmental Management,” issued by the Japanese Environmental Management Association for Industry.

The Japanese Ministry of Economy, Trade and Industry supports the introduction of environmental management accounting that contributes to corporate decision making.
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