

# **Environmental Management Accounting for Sustainable Manufacturing: Establishing Management System of Material Flow Cost Accounting (MFCA)**

Michiyasu NAKAJIMA\*

Material Flow Cost Accounting (MFCA) is one of environmental management accounting tools, and this fundamental framework will be published as International Standard (ISO14051) in 2012. Studies of MFCA have been accumulated on both of theoretical and practical issues in Japan. This paper will introduce theoretical works and business results in Japan, and discuss about establishing of MFCA management system and its future issues.

Key words: Material Flow Cost Accounting (MFCA), Environmental Management Accounting, Sustainable Management, Management Accounting

## **1. Introduction**

Material Flow Cost Accounting (hereinafter referred to as MFCA). is utilized as a cost management technique concerning material losses (emissions or wastes) which are generated in manufacturing processes. In MFCA the quantitative data of material losses generated from manufacturing processes is measured and recorded and cost evaluation is carried out for material loss generated in each process using cost accounting data which is carried out by an enterprise. MFCA defines finished manufactured goods as “positive products” and material losses as “negative products”<sup>1)</sup>, and manufacturing costs of negative products are evaluated and calculated in the same way as finished products.

Manufacturing cost of negative product comprises material cost meaning the cost of input materials and system cost meaning the processing cost. System cost means processing cost in conventional cost accounting except energy-related cost

---

\* Professor of Cost Accounting, e-mail: nakajima@kansai-u.ac.jp

1) Previously “Material loss” was used in Japan, but the sound of “loss” was unacceptable especially for workers. Because workers do not occur all material losses, production process or machine produces some or bigger parts of material losses. These words, “positive and negative products”, were created from practice. Negative products means unintended products, consumed manufacturing costs, and “Muda” in production line.

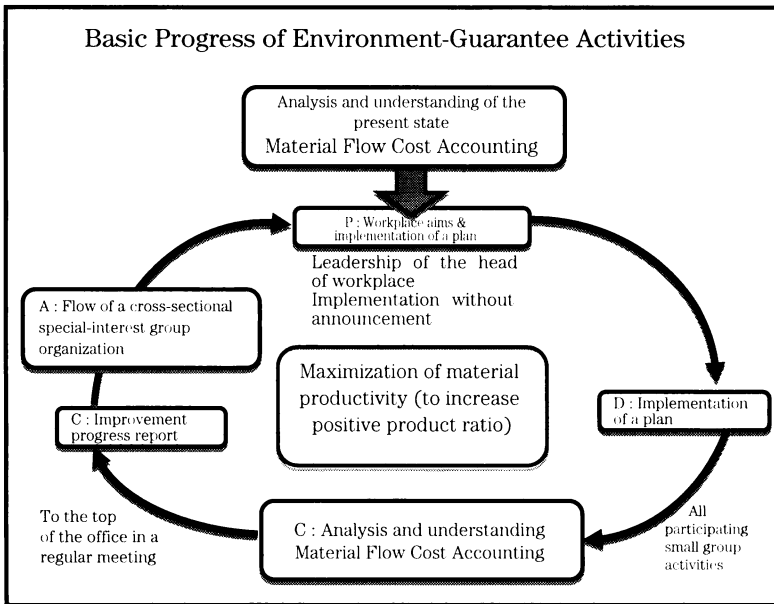
and waste management cost, which are included in factory expenses. They are calculated and recorded as independent cost items. Waste management cost related to the occurrence material losses, and energy cost are focused as independent cost items as influential factors on the environment.

In MFCA, negative product costs, which are unvalued in conventional cost accounting, are classified by material generated in manufacturing processes and further, cost items of negative product costs are systematized and established from the viewpoints of manufacture of negative products and environmental consciousness.

With this information of MFCA, enterprises can measure and evaluate the quantity of material loss incurred in such manufacturing processes. Enterprises have adopted product yields, shortened lead time, volume of daily product (the rate of operation), etc. as management indices because enterprises have preponderantly only the cost aspect from the viewpoint of minimization of manufacturing costs of products in general. As a result, the product yields of all input materials are management indices in a product design or a process design, but the current situation is that they do not function as management indices in manufacturing processes after start of mass production (commercial production date).

Behind such backgrounds, negative product costs in MFCA will be newly presented as new important management index (issue) in manufacturing processes. Concretely, where the product yields of a material input by a specified production order weighing 100kg at the time of the completion of the manufacture is 90% or higher, the fact that part of an input material (in some cases, 30% or more of that, for example) is wasted or recycled as material loss without output products is clarified at the manufacturing site as management information. Material losses clarified by MFCA is recognized as material loss on site where the material loss is incurred, and examination towards the reduction of material loss will start.

Reduction of material loss represented by this raw material to the maximum level is viewed as an improvement activity of MFCA, and will be carried out as management by the PDCA cycle aimed to realize material productivity. As an example of management system of MFCA, for example, Canon Inc. carries out the realization of material savings in manufacturing processes as a management system to realize environment-conscious production, using MFCA by the PDCA cycle as shown in the following Figure 1-1 as workplace based environment-guarantee activities.



Source: Nakajima, Kokubu (2008), p.197; Anjo (2006), p. 49 (additional writing made)

**Figure 1-1 Management System as Workplace-Based Environment Guarantee Activities at Canon Inc.**

Some enterprises have started to adopt a management system by the PDCA cycle using MFCA by not only utilizing MFCA as a technique of special cost studies but also viewing it as a technique of daily operational management. Enterprises announced as those utilizing MFCA as a daily management technique include, for example, Tanabe Seiyaku (presently Mitsubishi Tanabe Pharma), Sekisui Chemical, Shimizu Printing Inc., Sanden, etc. (Kokubu (2008)).

In this paper, environment-conscious production is defined as realization of the maximum level of material productivity, and MFCA is discussed as the most useful environmental management accounting technique for that purpose. Naturally, the method to consider the environmental effect of raw material as LCA (Life Cycle Assessment) or the method to utilize carbon footprint can be a factor to consider the environment. However, this research is specialized in MFCA which more than 200 enterprises in Japan have now introduced.

The next section will explain about the classifying of the technique and methods of MFCA which supports environment-conscious production using the results of the introductions and studies of MFCA which have so far been publicized.

## **2. Classification of Previous Studies**

In 2000, the basic concept of MFCA was introduced to Japan from the Institut für Management und Umwelt (IMU), Augsburg in Germany, and has since been developed from the execution of the introductions and operations in a project, sponsored by the Ministry of Economy, Trade and Industry (METI), Japan. The METI project started as the development and evolution of techniques of MFCA and have continued to be carried out for MFCA to spread to domestic enterprises and to further develop its techniques in accompaniment of the commencement of works relating to international standardization (ISO14000 families) of MFCA. As a result, the number of enterprises which have introduced MFCA as at 2009 is estimated to exceed 200. Behind the backgrounds for such development of techniques and spread of MFCA, it is possible to classify previous studies in Japan into three categories, i.e. the statements of results from the execution of METI project, the theoretical studies carried out mainly by researchers, and the enterprise self-introduction cases.

### **(1) Previous Studies in Japan: Relating to Projects sponsored by Ministry of Economy, Trade and Industry (METI), Japan**

As stated above, the METI projects have an important role in the development of the techniques and spread of MFCA in Japan. The results were summarized and issued as a report at every year end. They can be largely classified into two, i.e., “Development of Theories of MFCA and Techniques by Company Cases Studies” and “Spread of MFCA by Company Cases Studies”, and reports relating to the former are those concerning the JMAI (2000; 2001; 2002; 2003; 2004; 2005). MFCA was widely carried out in these METI projects by making the implementation of MFCA possible to be carried out on enterprises widely and the realization of the improvement of material productivity in inhouse processes as central study issues by finding out how to improve techniques of carrying out MFCA within enterprises. In addition, in the role of the latter, i.e., spread of MFCA, reports relating to METI projects were publicized as guidebooks concerning the introduction of MFCA. Extension of business lines concerning the introduction of MFCA and introductory cases of MFCA in the supply chain, etc. were made from the viewpoint of spreading to large enterprises, and reports on project results of the JMAC (2005; 2006; 2007; 2008; 2009) were publicized. Furthermore, from the viewpoint of spread of MFCA to the industrial level, the spread business of MFCA was also carried out to small- and medium-sized enterprises comprising the overwhelmingly large proportion of

business people. As a result, reports on the Organization for Small and Medium Enterprises and Regional Innovation, JAPAN (2005) were published. The summaries and general comments concerning such METI projects include Kokubu (2004), METI (2007), Hoshino (2008), Shimogaki (2005), Konta (2008), Kitagawa (2008) and Ban (2006).

## **(2) Previous Studies in Japan: Theoretical Studies mainly by Academic Researchers**

Studies have been carried out into the usefulness of management accounting techniques as well as the technical evolution of MFCA and environmental management accounting mainly by academic researchers. Theoretical and technical basic explanatory books on MFCA in Japan have been written by Nakajima, Kokubu (2008: the first edition in 2002). For example, Miyazaki (2002) explains the view of MFCA in Europe where Germany acts its central role, and Nakajima, Kokubu (2008) and Nakajima (2003a) examine the differences between conventional cost accounting and MFCA. In addition, Nakajima, Kokubu (2003; 2008), Kataoka, Koizumu (2003), Nakajima (2005), Ohnishi (2006), Enkawa (2007) have written about the usefulness and location of MFCA in management accounting. Mizuguchi (2001), Miyazaki (2002; 2003), Kokubu (2003; 2007a; 2007b), Kokubu, Nakajima (2003; 2004), Kokubu (2004), Shibata, Nashioka (2006), Kokubu, Itsubo, Mizuguchi (2007) have written about the usefulness and view of MFCA in environmental management accounting.

Furthermore, alliance with environmental evaluation techniques such as LCA and evolution as a material saving technique by introducing MFCA to the supply chain are being attempted as enhancement of MFCA. For example, Kokubu, Itsubo, Nakajima (2006), Kokubu, Shimogaki (2007a; 2007b), Kokubu, Itsubo, Mizuguchi (2007) have written about alliance between MFCA and LCA. The preponderance of MFCA is the minimization of input materials, and the evolution of MFCA is being examined as a technique to reduce the effects of other environmental factors. Higashida (2006; 2008), Kokubu, Shimogaki (2008c), Shimogaki (2008), Nakajima (2009) have written about the evolution of MFCA to the supply chain, i.e., the introduction of MFCA to among multi-enterprises.

In this way, MFCA has been introduced and spread as a technique with a new name to Japan through METI projects, and research has been carried out into how to view MFCA in the accounting study field, finding out the differences from conventional cost accounting and management accounting technique, and the usefulness and potential of MFCA.

Furukawa (2007), Kokubu (2008b) have started to report on the relationship between surveys and enterprise practice in accompaniment of works to bring MFCA under ISO (ISO14000 families).

### **(3) Previous Studies in Japan: Mainly relating to Company Cases**

In the development of techniques of environmental management accounting in METI projects, development of techniques to be used and utilized for corporate practice was made the most important purpose. In addition to theoretical studies, verification of introduction of techniques into practice was therefore carried out simultaneously. At the time of MFCA having been introduced in 2000, it was carried out for the purpose of understanding the techniques of MFCA in the manufacturing processes at Nitto Denko, and the results of the project comprised two aspects i.e. classification of introductory techniques of MFCA and theoretical studies (METI, 2002; Nakajima, Kokubu, 2008). In this way, preparation of enterprise introduction cases since the initiation of introduction of MFCA has continued to be carried out until today, and the total number of enterprises both publicized and unpublicized is said to exceed approximately 200. To explain the techniques and usefulness of MFCA, there are reports issued by METI listed in the bibliography, and reports of METI projects issued by JMAI, JMAC, and the Small and Medium Enterprises and Regional Innovation, JAPAN. Behind such circumstances, enterprise cases concerning MFCA have continued to be announced by persons in charge of MFCA introductory projects of enterprises which have introduced MFCA and consultants who have introduced MFCA. In particular, in the magazine called "*Environmental Management*", enterprise cases, evolution of techniques, etc. have serially appeared under the title of 'Practical Material Flow Cost Accounting' since 2005 (as a collection of reported papers in Kokubu (2008)). enterprise cases can largely be classified into two types, one of which is cases introduced for the first time and the other is cases where clear results were obtained by introducing MFCA and applying that as a management technique. Cases of Canon (Anjo, 2003, etc.), cases of Tanabe Seiyaku (presently Mitsubishi Tanabe Pharma) ((Kawano, 2003), etc.; Funasaka, Kawano, 2008), cases of Sekisui Chemical (Numata, 2006, etc.) and cases of Omron (Harada, 2009; Nikkei Business, 2009) can be cited as those where enterprises have produced concrete results, while applying to corporate management.

### **(4) Previous Studies relating to MFCA in Overseas Countries**

Next, the concept of MFCA in Japan with respect to MFCA studies in overseas

countries originates from the MFCA of IMU, as mentioned above, and the first introductory case of MFCA to Japan was carried out under the interview survey at the IMU (JMAI (2001), pp. 79-112), and the explanatory book on MFCA published by the IMU (Strobel and Redmann, 2001) is viewed as the basic study book. Then, Wagner, Enzler (2006) was published by Prof. Dr. B. Wagner who is one of the founders of the IMU and S. Enzler who is one of the IMU staffs. Furthermore, study results concerning theories of MFCA and cases in Japan have been introduced through academic societies and publication of papers in overseas countries (Kokubu, Nakajima, 2004; Nakajima, 2004; 2006; 2008; 2009; Ohnishi, Kokubu, Nakajima, 2008).

There are other theories and techniques which are focused on material flow than those of the IMU, and they have been viewed as important environmental management accounting techniques. However, because MFCA is a technique developed by the IMU, the concrete terms and definitions and the techniques of evaluation and calculation are original. MFCA technique was introduced as one of the environmental management accounting techniques by IFAC (2005), for example, as a publication of study results of MFCA. Furthermore, because MFCA has started to be standardized by the ISO (International Standard Organization), studies of MFCA and its introductory cases will be widely carried out and many study results will be announced in the future. For example, a book on MFCA studies has been published by Jasch (2008) who has so far led mainly in environmental management accounting studies.

### **3. Establishing Management System of MFCA and its Issues**

Establishing management system of MFCA is discussed in this section, although it is based on previous studies mentioned in the preceding section. Previous studies are still insufficient, and it is therefore necessary to expand and deepen previous studies in the future.

The important point of MFCA is that it is useful as a tool to visualize a new loss (Muda) in manufacturing processes. While conventional cost accounting has functioned as a tool to visualize a loss of value (shifting the responsibility), MFCA visualizes material loss. Historically, standard costing is assumed to enable cost management in both aspects, i.e., quantity and monetary value. However, reduction of loss of value which appears to be represented by reduction of cost variance between standard cost and actual cost, and analysis of causes and improvement of cost variance are the main points in reality. In such circumstances, reduction of

material loss such as an input material in a process for the first time by MFCA and analysis of its causes and improvement of that loss are useful factors in corporate practice.

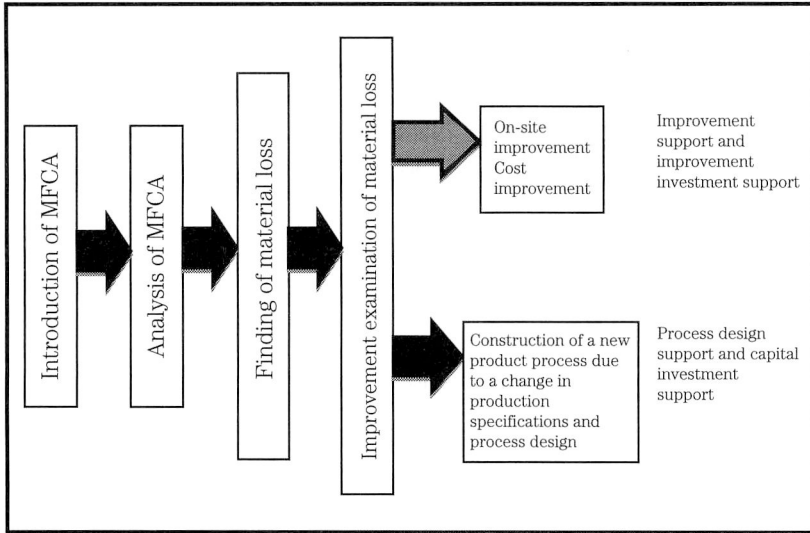


Figure 1-2 Utilization of MFCA Information Supporting Environment-Conscious Production

In many cases, MFCA tends to be introduced as it is evaluated because it provides a new viewpoint of on-site improvement (Kaizen) on the ground that material loss clarified by MFCA leads to improvement in manufacturing processes and that in cost, which is seen in the evaluation relating to the usefulness of MFCA at Japanese enterprises. In addition, reducing material loss is evaluated not as an end-of-pipe like environmental consciousness but as an in-process type environmental consciousness from the viewpoint of reducing input of materials, and is therefore viewed as activities with environmental consciousness at manufacturing on-site. In this way, MFCA tends to be utilized as improvement information to promote and enhance the reduction of materials used in manufacturing processes. However, MFCA should be evaluated in the two aspects shown in Figure 1-2.

As the first aspect, MFCA is utilized to support the shift to environment-conscious production on the premise of the present manufacturing processes, as shown on the top right shown on Figure 1-2. This is usage of MFCA which is improvement support and improvement investment support type, which is utilization of MFCA as a tool to find new loss (Muda) on the premise of conventional

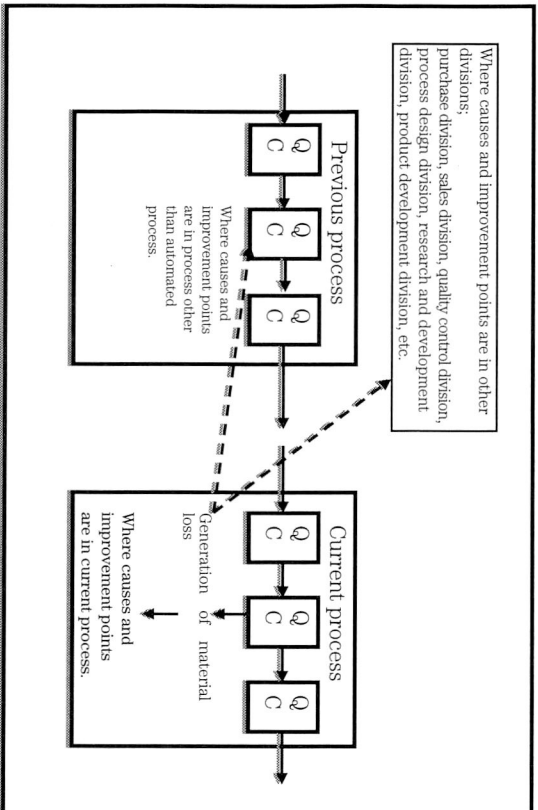


on-site improvement (Kaizen). This is to find on-site loss which has not been visualized in conventional management information and to improve only on the site. It can be evaluated as management where improvement from reduction of 'paper, rubbish and electricity' to find of loss in manufacturing from the viewpoint of environment and activities with environmental consciousness are merged.

As the second aspect, there is MFCA which supports the change to environment-conscious production in manufacturing processes as shown in the bottom right of Figure 1-2. This is usage of MFCA as process design support and facility investment (capital investment) support. Among many material losses, there are material losses which do not exist at the very site, the cause of the occurrence of which cannot be improved only at the site. It is necessary to resolve some problems in order to realize innovative reduction of material losses.

For example, as shown in Figure 1-3 on the following page, if occurrence of material loss in the current process is shown as quantity and cost, and measures for improvement are attempted, causes of occurrence in some cases lie in decision matters in the divisions which cannot be changed and improved in the previous processes and manufacturing processes, which are found as a result of analysis of causes of occurrence of MFCA. However, reducing such material loss will be one of the important aspects of the usefulness of MFCA. In addition, in the actual state of manufacturing processes in factories, the situation where there is no communication between the divisions which have been divided vertically is a major problem. It will firstly become necessary to communicate relating to MFCA information between the other divisions. In general, with communication, the present state of material loss and issues can be shared, but early examination for improvement is difficult in many cases. The greatest issue that should be resolved to carry out improvement activities is to solve the problem that the scope of the problem of a concrete occurrence of material loss and the scope of responsibility for management are different.

It can be understood by looking at enterprise cases that MFCA has a power which enables process improvement that can be seen throughout such a manufacturing process. In the cases of Canon Inc., Nitto Denko, Sekisui Chemical, etc., on-site improvement (Kaizen) and investment in plan and equipment between other divisions are carried out, using a material flow model of MFCA by owing both quantity and cost information of material loss, making the specification of the causes of the occurrence of material loss and the improvement in the causes of its occurrence all corporate activities. It is evaluated that visualization of quantity data and cost data has sufficient power to resolve future problems as its driving force.



(Note: QC indicates a so-called quantity centre in MFCA)

Figure 1-3 Cases where Causes of Material Loss and Points of Improvement are Outside Current Process

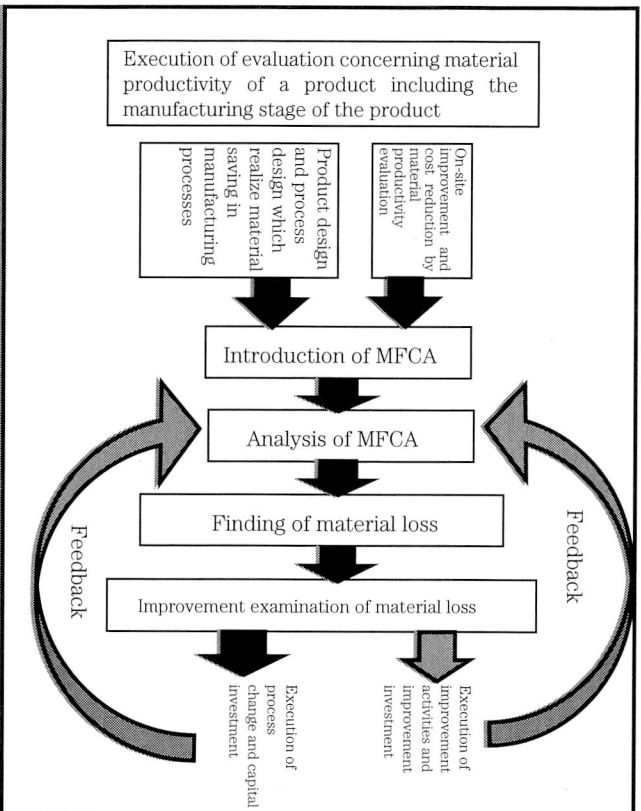


Figure 1-4 Environment-Conscious Production Management by MFCA

However, MFCA does not presently give such a breakthrough to all enterprises with ease, and it is therefore necessary to expand and deepen case studies of MFCA further, and further study on the construction of MFCA systems as management systems is required.

MFCA could be developed as a management tool to evaluate material productivity of an enterprise and the whole of a business by the construction of MFCA systems, while up to the present time MFCA has been introduced to find material loss which had not been noticed on site. Material productivity should not be enhanced as the results of introduction of MFCA, but it is important to construct a management cycle where

- 1) MFCA is introduced in a positive manner for the purpose of enhancing material productivity as shown in Figure 1-4 on the previous page,
- 2) enhancement measures are taken on the basis of MFCA data,
- 3) improvement investment & investment in plant and equipment, process change, etc. are carried out, and
- 4) the results are evaluated by carrying out a fresh analysis by MFCA analysis of the results.

#### **4. Conclusion**

The number of enterprise cases has gradually increased, but classification of theories of MFCA is not sufficient. The next research will classify productions with environmental consciousness into types and models by MFCA, and classify the usefulness of MFCA.

The utilization of MFCA is considered to be successful as a tool to introduce the concept of environmental consciousness into on-site improvement (Kaizen) at Japanese enterprises. Concretely, it is the implementation of improvement activities to promote and realize material saving in manufacturing processes. The MFCA management on the basis of improvement information will be systematized, clarifying the difference from conventional management accounting techniques by carrying out surveys of enterprise cases.

On the other hand, case studies and theoretical studies which will lead to change in product design and process design for which MFCA is not fully utilized as its function are important. As a concrete study method, the next research would like to carry out research with reference to a review of literature and enterprise cases as this research has been doing in the past and firstly would like to continue to sort out the past MFCA studies.

In addition, the next research will carry out surveys on the actual state of MFCA management which supports production of environmental consciousness by carrying out surveys on enterprise cases, and would like to make theoretical enhancement of MFCA by carrying out research into utilization cases of MFCA information which may change production processes instead of limiting to the utilization of MFCA for on-site improvement activities. Furthermore, the future research also would like to consider the harmonization with new environmental information such as energy information, carbon footprint, life cycle thinking, etc.

## References

### (1) Reference in English

1. IFAC (2005), *Environmental Management Accounting*, International Federation of Accountants (IFAC).
2. Jasch, C. (2008), *Environmental and Material Flow Cost Accounting: Principles and Procedures (Eco-Efficiency in Industry and Science)*, Springer.
3. Kokubu, K., Nakajima, M. (2004), "Sustainable accounting initiatives in Japan—Pilot projects of material flow cost accounting", J-D Seiler-Hausmann, Liedtke, C. and Ulrich von Weizsaecker, E., ed., *Eco-efficiency and Beyond: towards the sustainable enterprise*, Greenleaf Publishing, pp.100-112.
4. Nakajima, M. (2004), "On the Differences between Material Flow Cost Accounting and Traditional Cost Accounting—In Reply to the Questions and Misunderstandings on Material Flow Cost Accounting", *Kansai University Review of Business and Commerce*, No.6, pp.1-20.
5. Nakajima, M. (2006), "The New Management Accounting Field Established by Material Flow Cost Accounting (MFCA)", *Kansai University Review of Business and Commerce*, No.8, pp.1-22.
6. Nakajima, M. (2008), "The New Development of Material Flow Cost Accounting (MFCA): MFCA analysis in Power Company and Comparison between MFCA and TPM (Total Productive Maintenance)", *Kansai University Review of Business and Commerce*, No.10, pp.57-86.
7. Nakajima, M. (2009), "Evolution of Material Flow Cost Accounting (MFCA): Characteristics on Development of MFCA Companies and Significance of Relevance of MFCA", *Kansai University Review of Business and Commerce*, No.11, pp.27-46.
8. Onishi, Y., Kokubu, K., Nakajima, M. (2008), "Implementing Material Flow Cost Accounting in a Pharmaceutical Company", Schaltegger, S., Bennett, M., Burrett, R.L., Jasch, C., eds., *Environmental Management Accounting for Cleaner Production*, Springer, pp.395-409.
9. Strobel, M., Redmann, C. (2001), *Flow Cost Accounting*, 2<sup>nd</sup> ed., (1<sup>st</sup> ed. 2000) IMU (Institute für Management und Umwelt).
10. Wagner, B., Enzler, S., eds. (2006), *Material Flow Management: Improving Cost*

**(2) Reference in Japanese**

(Note) JMAC: Japan Management Association Consultants Inc.

JMAI: Japan Environmental Management Association for Industry, Tokyo

METI: Ministry of Economy, Trade and Industry, Japan

11. Amano, T. (2006), "Application of MFCA to Electro-less Nickel Plating Line—Case study in Shimadzu Corporation", *Environmental Management (JMAI)*, Vol. 42, No. 9, pp. 67-71.
12. Anjo, Y. (2003), "Environmentally Conscious Management and Material Flow Cost Accounting", *Environmental Management (JMAI)*, Vol. 39, No.7, pp. 28-32.
13. Anjo, Y. (2004), "Environmental Management and Material Flow Cost Accounting in Canon", *Annual Report of Japanese Association for International Accounting Studies 2004*, pp. 156-160.
14. Anjo, Y. (2006), "Material Flow Cost Accounting as an effective Tool for Environmental Actives at GENBA of Canon", *Environmental Management (JMAI)*, Vol. 42, No. 2, pp. 46-50.
15. Anjo, Y. (2007a), "Application of MFCA in Recycle Process at Canon", *Environmental Management (JMAI)*, Vol.43, No. 6, pp. 75-82.
16. Anjo, Y. (2007b), "Introduction of Material Flow Cost Accounting into Canon", *Accounting (Chuokeyzai-sha)*, Vol. 59, No. 11, pp. 40-47.
17. Ban, R. (2006), "Approach in Small and Medium-Sized Enterprise of Material Flow Cost Accounting", *Environmental Management (JMAI)*, Vol. 42, No. 1, pp. 76-81.
18. Enkawa, T. (2007), "Material Flow Cost Accounting and Total Productive Maintenance", *Environmental Management (JMAI)*, Vol. 43, No.2, pp.171-178.
19. Fujita, T. (2008), "Ushio's Activity for improving Environmental Productivity: Introduction of Material Flow Cost Accounting", *Environmental Management (JMAI)*, Vol. 44, No.1, pp. 66-71.
20. Funasaka, T., Kawano, Y. (2008), "Introduction of MFCA at TANABESEIYAKU YOSHIKI FACTORY Co., Ltd.", *Environmental Management (JMAI)*, Vol. 44, No. 5, pp. 73-77.
21. Furukawa, Y. (2001), "Activities of Flow Cost Accounting at Nitto Denko", *Sangyo To Kankyo*, Vol. 30, No. 12, pp. 35-38.
22. Furukawa, Y. (2003a), "Material Flow Cost Accounting, Concept and Application at Nitto Denko, As a Business Management Tool", *Environmental Management (JMAI)*, Vol. 39, No. 7, pp. 12-18.
23. Furukawa, Y. (2003b), "Methodological Characteristics of Material Flow Cost Accounting: Focused on Case Study of Nitto Denko", *Sustainable Management (Sustainable Management Forum of Japan)*, Vol. 3, No. 2, pp. 3-15.
24. Furukawa, Y. (2006), "From Material Flow Cost Accounting to Decision-Making Flow", *Environmental Management (JMAI)*, Vol.42, No.4, pp. 73-76.
25. Furukawa, Y. (2007), "Material Flow Cost Accounting as Management Tool—Foresight of

- Company Practice and International Standardization of MFCA”, *Accounting (Chuokezai-sha)*, Vol. 59, No.11, pp. 33-39.
26. Harada, T. (2009), “The Challenge to Resource Productivity Improvement in Whole OMRON Group by Practical Use of MFCA”, *Environmental Management (JMAI)*, Vol.45, No. 7, pp. 66-70.
27. Higashida, A. (2006), “Material Flow Cost Accounting and Supply Chain”, *Environmental Management (JMAI)*, Vol.42, No. 8, pp. 80-85.
28. Higashida, A. (2008), “Development of Material Flow Cost Accounting to Supply Chain”, *Accounting (Chuokezai-sha)*, Vol. 60, No. 1, pp. 122-129.
29. Hiroka, M. (2008), “A Change of the Environmental Activity by the MFCA”, *Environmental Management (JMAI)*. Vol. 44, No. 4, pp. 61-67.
30. Hoshino, A. (2008), “International Standardization of Material Flow Cost Accounting”, *Chemical Economy (The Chemical Daily)*, Vol. 55, No. 7, pp. 34-38.
31. Ikeda, T. (2006), “Actual Example of the Financial Data Showed by Material Flow Cost Accounting”, *Environmental Management (JMAI)*, Vol.42, No. 6, pp. 77-84.
32. Iwata, Y. (2003), “Value Calculation of Raw Material Recycling”, *Environmental Management (JMA)*, Vol. 39, No. 7, pp. 26-27.
33. JMAC (2005), *Research Report of Project to Establish Management System of Rationalization of Energy Consumption (Model Project of Co-research to Introduce MFCA for Bigger Companies)*, sponsored by METI Fiscal 2004, JMAC.
34. JMAC (2006), *Research Report of Project to Establish Management System of Rationalization of Energy Consumption (Model Project of Co-research to Introduce MFCA for Bigger Companies)*, sponsored by METI Fiscal 2005, JMAC.
35. JMAC (2007), *Research Report of Project to Develop and Spread Material Flow Cost Accounting, in Projects to Establish Management System of Rationalization of Energy Consumption, sponsored by METI Fiscal 2006*, JMAC.
36. JMAC (2008), *Research Report of Project to Develop and Spread Material Flow Cost Accounting, in Projects to Establish Management System of Rationalization of Energy Consumption, sponsored by METI Fiscal 2007*, JMAC.
37. JMAC (2009), *Research Report of Project to Develop and Spread Material Flow Cost Accounting, in Projects to Establish Management System of Rationalization of Energy Consumption, sponsored by METI Fiscal 2008*, JMAC.
38. JMAI (2000), *Report to Research Promotion and Development of Environmental Business (Environmental Accounting)*, sponsored by METI Fiscal 1999, JMAI.
39. JMAI (2001), *Report to Research Promotion and Development of Environmental Business (Environmental Accounting)*, sponsored by METI Fiscal 2000, JMAI.
40. JMAI (2002), *Report to Research Promotion and Development of Environmental Business (Environmental Accounting)*, sponsored by METI Fiscal 2001, JMAI.
41. JMAI (2003), *Report to Research Promotion and Development of Environmental Business (Total Environmental Management Tool)*, sponsored by METI Fiscal 2002,

JMAI.

42. JMAI (2004), *Report to Research Promotion and Development of Environmental Business (Environmental Management Accounting)*, sponsored by METI Fiscal 2003, JMAI.
43. JMAI (2005), *Research Report of Project to Establish Management System of Rationalization of Energy Consumption (Research of Environmental Accounting)*, sponsored by METI Fiscal 2004, JMAI.
44. Kajiwara, A. (2008), "Introduction of Cost Analysis in Forest-farming Business and Extension for MFCA", *Environmental Management (JMAI)*, Vol. 44, No. 3, pp. 36-48.
45. Kataoka, Y., Koizumi, Y. (2003), "Introduction of Kaizen Cost Accounting Model and Flow Cost Accounting", *Sangyo Keiri (The Japan Industrial Management & Accounting Institute)*, Vol. 63. No. 2, pp. 12-21.
46. Kawano, Y. (2003), "Practical Application of 'Material Flow Cost Accounting' toward Cost-saving and Environmental Load Reduction—A Challenging Case of Reexamination of Waste Disposal", *Environmental Management (JMAI)*, Vol. 39, No.7, pp. 19-26.
47. Kawano, Y. (2004), "Systematization and Strategic Development of ERP-integrated Material Flow Cost Accounting", *Annual Report of Japanese Association for International Accounting Studies 2004*, pp. 161-165.
48. Kawano, Y. (2005), "Material Flow Cost Accounting in Environmental Management, introducing Environmental Accounting to combine Corporate Management and Environmental Protection", *Business Research*, Vol. 974, pp. 58-66.
49. Kawano, Y. (2006), "The Development of Company-wide Material Flow Cost Accounting for TANABE SEIYAKU", *Environmental Management (JMAI)*, Vol. 42, No. 3, pp. 58-64.
50. Kawano, Y. (2007), "Introduction and Development of Material Flow Cost Accounting in Tanabe Seiyaku", *Accounting (Chuokeyizai-sha)*, Vol. 59, No. 11, pp.48-55.
51. Kitagawa, K. (2008), "Practical Use of Material Flow Cost Accounting in Small and Medium-sized Enterprise", *Environmental Management (JMAI)*, Vol. 44, No. 7, pp. 66-71.
52. Kokubu, K. (2003), "Material Flow Cost Accounting: A Basis for Environmental Management Accounting", *Environmental Management (JMAI)*, Vol. 39, No. 7, pp. 1-5.
53. Kokubu, K. (2004), "Diffusion and Development of Environmental Management Accounting Practices in Japan", *the Kokumin-Keizai Zasshi (Journal of Economics & Business Administration)*, the Keizai-keiei Gakkai, Kobe University, Vol. 190, No. 6, pp. 53-65.
54. Kokubu, K. (2005), "Development of Material Flow Cost Accounting in Japan", *Environmental Management (JMAI)*, Vol. 41, No. 10, pp. 58-65.
55. Kokubu, K. (2007a), "Vision and Significance of Material Flow Cost Accounting", *Accounting (Chuokeyizai-sha)*, Vol. 59, No. 11, pp. 18-24.
56. Kokubu, K. (2007b), "Continuous Implementation of Material Flow Cost Accounting", *the Kokumin-Keizai Zasshi (Journal of Economics & Business Administration)*, the Keizai-keiei Gakkai, Kobe University, Vol. 196, No. 5, pp. 47-61.
57. Kokubu, K. (2008), "International Standardization on Material Flow Cost Accounting: ISO

- 14051”, *Environmental Management (JMAI)*, Vol. 44, No. 8, pp. 1-5.
58. Kokubu, K. ed. (2004), *Introduction of Environmental Management Accounting*, JMAI.
59. Kokubu, K. ed. (2008), *Practical Material Flow Cost Accounting*, JMAI.
60. Kokubu, K., Itsubo, N., Nakajima, M. (2006), “Integration of Material Flow Cost Accounting and LIME”, *the Kokumin-Keizai Zasshi (Journal of Economics & Business Administration)*, the Keizai-keiei Gakkai, Kobe University, Vol.194, No.3, pp.1-11.
61. Kokubu, K., Itsubo, N., Mizuguchi, T. (2007), *Environmental Management and Accounting*, Yuhikaku.
62. Kokubu, K., Nakajima, M. (2003), “Positioning of Material Flow Cost Accounting in Environmental Management Accounting (EMA): Toward to Systematization of EMA”, *Kaikei (Moriyama Shoten)*, Vol. 164, No. 2, pp. 123-136.
63. Kokubu, K., Nakajima, M. (2004), “Research: Development of Environmental Management Accounting–Focused on Material Flow Cost Accounting”, *Disclosure Forum (Accounting Standards Board of Japan)*, Vol. 3, pp. 74-85.
64. Kokubu, K., Shimogaki, A. (2007a), “Significance of Integrated Use of MFCA and LCA: Analysis of Integrated Information of Cost and Environmental Impact on Material Flow”, *Environmental Management (JMAI)*, Vol. 43, No. 8, pp. 68-73.
65. Kokubu, K., Shimogaki, A. (2007b), “Process and Practice for Integrated Use of MFCA and LCA in Case of Canon”, *Environmental Management (JMAI)*, Vol. 43, No. 9, pp. 63-70.
66. Kokubu, K., Shimogaki, A. (2007c), “Development of MFCA on Supply Chain: Significance of MFCA Information Sharing”, *Environmental Management (JMAI)*, Vol. 43, No. 11, pp. 37-43.
67. Kokuryo, Y. (2007), “Introducing Material Flow Cost Accounting to SHIONOGI”, *Environmental Management (JMAI)*, Vol. 43, No.4, pp. 65-69.
68. Konta, H. (2008), “The MFCA Promotion in the Tohoku District”, *Environmental Management (JMAI)*, Vol. 44, No. 2, pp. 165-171.
69. Kunugi, S. (2006), “Environmental Activities on Material Flow–Fujitsu’s ‘Green Process Activity’”, *Environmental Management (JMAI)*, Vol. 42, No. 5, pp. 62-66.
70. METI (2002), *Workbook of Environmental Management Accounting Tools*, METI.
71. METI (2007), “Spread and Development of MFCA: Activities and Results in the Fiscal Year 2006”, *Environmental Management (JMAI)*, Vol. 43, No. 7, pp. 74-80.
72. METI (2008a), *Guide to Introduce Material Flow Cost Accounting Tool*, METI.
73. METI (2008b), *Case Studies of Material Flow Cost Accounting (MFCA)*, METI.
74. Miyazaki, N. (2002), *Integrative Environmental Accounting*, 2<sup>nd</sup> ed., Sousei-sha.
75. Miyazaki, N. (2003), “Theoretical Review of Flow Cost Accounting”, *Kaikei (Moriyama Shoten)*, Vol. 164, No. 3, pp. pp. 303-313.
76. Mizuguchi, T. (2001), “From Accounting for Environmental Protection Costs to Accounting for Environmental Protection–Making Suggestions of Flow Cost Accounting”, *The Economic Journal of Takasaki City University of Economics*, Vol. 43, No. 4, pp. 56-74.
77. Nakajima, M. (2003a), “A Comparative Study with Material Flow Cost Accounting and



- Traditional Cost Accounting”, *The Shogaku Ronshu (The Business Review of Kansai University)*, Vol. 48, No. 1, pp. 63-83.
78. Nakajima, M. (2003b), “Material Flow Cost Accounting as CT Scanner for Company”, *Environmental Management (JMAI)* Vol. 39, No. 7, pp. 6-11.
  79. Nakajima, M. (2005), “Potentials of MFCA to Establish New Management Accounting”, *Environmental Management (JMAI)*, Vol. 41, No. 11, pp. 73-78.
  80. Nakajima, M. (2006), “Material Flow Cost Accounting–Analysis of Power Company”, *Environmental Management (JMAI)*, Vol. 42, No. 10, pp. 67-71.
  81. Nakajima, M. (2007a), “New Developments of Material Flow Cost Accounting (MFCA): Energy Analysis in MFCA, and Comparison between MFCA and Total Productive Maintenance (TPM)”, *Corporate Information and Changeover of Social System (Economic & Political Studies Series No. 146)*, The Institute of Economic and Political Studies, Kansai University, pp. 27-54.
  82. Nakajima, M. (2007b), “Establishment of Information System to Introduce Material Flow Cost Accounting”, *Accounting (Chuokezai-sha)*, Vol. 59, No. 11, pp. 25-32.
  83. Nakajima, M.(2009), “Significance of Supply Chain Management by Material Flow Cost Accounting: Possibilities of an Environment-Conscious ‘KEIRETSU’”, *Environmental Management (JMAI)*, Vol. 45, No. 4, pp. 60-65.
  84. Nakajima, M., Ishida, T. (2007), “Systematization of Material Flow Cost Accounting (MFCA), Integrated with IT System”, *Environmental Management (JMAI)*, Vol. 43, No.10, pp. 60-66.
  85. Nakajima, M., Kokubu, K. (2003), “ Significance of Material Flow Cost Accounting in Management Accounting”, *The Journal of Cost Accounting Research (Japan Cost Accounting Association)*, Vol. 27, No.2, pp. 12-20.
  86. Nakajima, M., Kokubu, K. (2008), *Material Flow Cost Accounting*, 2<sup>nd</sup> ed., (1<sup>st</sup> ed. 2002), Nihon-Keizai-Shinbun-Sha.
  87. Nikkei Business(2008), “The 3<sup>rd</sup> Chapter: Breakthrough from Adverse Circumstances, Changing from High Cost to Chance at OMRON”, *Nikkei Business*, 17<sup>th</sup> Nov. 2008, pp. 160-162.
  88. Numata, M. (2006), “Activities of Material Flow Cost Accounting at Sekisui Chemical Co., Ltd “, *Environmental Management (JMAI)*, Vol. 42, No. 7, pp. 66-70.
  89. Numata, M. (2007a), “Activities of Material Flow Cost Accounting–Case Study of Sekisui Chemical Group”, *Quality Management*, Vol. 58, No.6, pp. 68-73.
  90. Numata, M. (2007b), “Activities of Material Flow Cost Accounting at Sekisui Chemical Co., Ltd ”, *Accounting (Chuokezai-sha)*, Vol. 59, No.11, pp. 56-62.
  91. Okajima, J. (2007), “Material Flow Cost Accounting as Environmental Management Accounting Tool at Nippon Paint”, *Environmental Management (JMAI)*, Vol. 43, No. 5, pp. 58-66.
  92. Onishi, Y. (2006), “Cost Management using Material Flow Cost Accounting”, *Environmental Management (JMAI)*, Vol. 42, No. 12, pp. 70-75.

93. Organization for Small & Medium Enterprises and Regional Innovation, Japan (SMRJ) (2005), *Report of Model Project to Co-research Introduction of MFCA for SMEs, in Project to Establish Environmentally-conscious Management System for SMEs, Fiscal 2004*, Business Support Department, SMRJ.
94. Saito, Y. (2007), "Application of MFCA in a Metal Parts Machining Factory—An example in Sanden", *Environmental Management (JMAI)*, Vol. 43, No.1, pp. 67-72.
95. Shibata, H., Nashioka, E. (2006), *Evolving Environmental Accounting*, Chuokeizai-sha.
96. Shimogaki, A. (2005), "Application Method of Production Management from the METI MFCA Project", *Environmental Management (JMAI)*, Vol. 41, No. 12, pp. 63-70.
97. Shimogaki, A. (2008), "The Case Study of MFCA-Application for Timber Product and MFCA-Systemization of SMEs", *Environmental Management (JMAI)*, Vol. 44, No.8, pp. 91-96.
98. Shimogaki, A. (2008), "Application of MFCA to Supply Chain", *Ryutsu Networking (Japan Industrial Publishing)*, Vol. 233, pp. 66-70.
99. Tajima, K. (2007), "Application of Material Flow Cost Accounting to Manufacturing Process of Mini-Disc", *Environmental Management (JMAI)*, Vol. 43, No.3, pp. 55-59.
100. Uozumi, R. (2002), "Introduction Step of Material Flow Cost Accounting, achieving simultaneously to reduce Closed-up Costs and Environmental Loads ", *Junkan Keiri Joho (Chuoukeizai-sha)*, Vol. 994, pp. 58-61.

**Acknowledge:** This work was supported partially by KAKENHI (2124031), Grant-in-Aid for Scientific Research (A), Japan.