Manufacturing and Environmental Management

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Abstract The relationship between corporate manufacturing activities and the environment focuses on aspects such as issues related to environmental problems, greenhouse gases, and materials and energy balance. A brief introduction to the concept of the environmental management system (EMS) to bring the low-carbon society into reality is presented. Most importantly, it is necessary to expound on the management of environment and energy based on the management cycle principle. From the perspective of the management of technology, the relationship between environmental management and other management is discussed. It is especially significant to enhance environmental protection awareness in East Asian countries in introducing the environmental management system.

Keywords Environmental management • Environmental awareness • Manufacturing • PDCA • Product life cycle • Social cost

1 Manufacturing and Environmental Problems

Human daily life and economic activities are closely related to the global environment. With the vast depletion of natural resources and energy, heavy emissions of carbon dioxide (CO_2) and other GHGs (greenhouse gases) coupled with a significant amount of waste emerge; therefore, we are confronted with a continuously increasing environmental burden that consequently exerts a negative impact on our daily lives and economic activities.

In 1997, the Third Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3) was convened in Kyoto, and the proposal

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from the developed countries for the reduction of greenhouse gas emissions was officially incorporated into the Kyoto Protocol. In recent years, global environmental awareness has experienced a continuous increase. With more attention devoted to corporate performance and the contribution of corporations to society, the impact of business operations on the environment has become a favorable gauge to measure corporate value. A heated discussion has consequently occurred regarding the external environment and corporate social environmental management (Japan Society of P.E., (The Institution of Professional Engineers, Japan 2004)).

1. Sustainable development: The demand of the social environment for the world.
2. Extended producers' responsibility: a demand for the activity of the ordinary organization.
3. Environmental management: a demand for an organization.

In Japan, the sustainable society is defined as follows: "our living environment is composed of air, water, soil and life forms, all of which are interconnected and interrelated to keep the system in a healthy condition with no negative impact exerted upon this system so as to maintain a sound and healthy society". Sustainable development represents the continuous development required to meet the demands of our descendants of subsequent generations while also satisfying the demands of the modern generation. Extended producers' responsibility means "after the use and disposal of the products manufactured by producers, they should be liable for the recycling and disposal of the relevant products," as defined by OECD. What is "environmental management"? Environmental management is the effective mitigation of the global environmental burden combined with an increase in social contribution; this principle represents the source of the new environmental competitiveness and can effectively guide corporate activities.

Pollution is primarily caused by the emission of pollutants resulting from the development of industrial activities, as shown in Fig. 1. For example, the combustion of fossil fuels releases air pollutants into the environment. Sewages often contain various types of toxic substances that further pollute public water areas (rivers, lakes, and marinas). In addition, there are also other types of pollution, such as ground water pollution, vibration pollution and noise pollution.

2 Environmental Management and Energy Conservation

2.1 Manufacturing Activities and Environment/Energy

The social economic system contains all activities of all organizations within an enterprise, products and service coupled with the correction awareness established in the manufacturing and processing course. The basic environmental law introduced in 1993 requires the protection of our living environment against problems related to issues such as air and water quality, soil, malodorous or offensive gases,

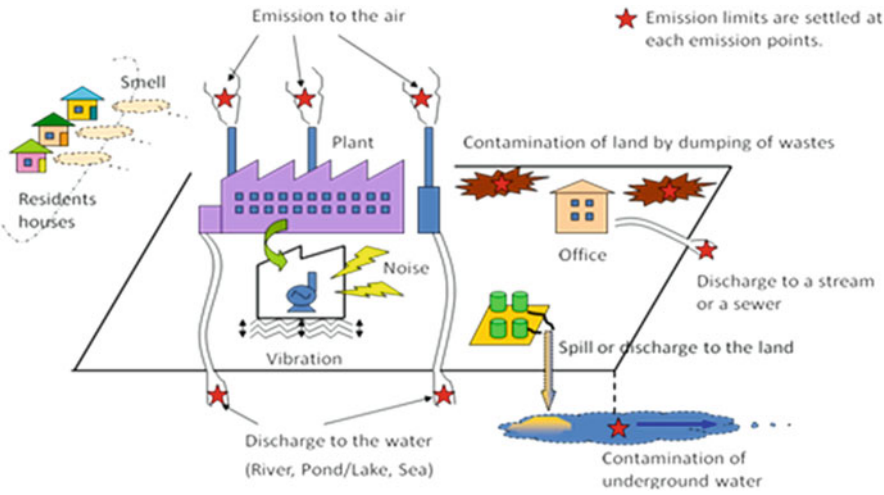

Fig. 1 Environmental issues caused by industrial activities (Source: Takakuwa 2013 by Ibusuki)

and noise and vibration. The protection of human health is the fundamental purpose of this law; therefore, it is necessary to formulate quantitative environmental standards.

In Japan, a large proportion of resources and energy for production, industrial activities and daily life activities is primarily imported from overseas markets. With respect to manufacturing plants, measures for the efficient utilization of energy, the management and protection of natural resources and the reduction of waste emissions, etc., are strongly supported by laws and regulations related to environmental energy.

It is very important for us to evaluate the impact of the life cycle of the relevant products and services upon the environmental burden while discussing the environmental issues. Generally speaking, the product life cycle consists of seven phases, including (1) resource consumption; (2) materials and parts manufacturing; (3) product manufacturing; (4) distribution; (5) sales and purchase; (6) consumption and use, and (7) disposal and recycling. Figure 2 fully demonstrates a typical example of a product life cycle in a recycling-oriented society.

It is of paramount importance to effectively evaluate the impacts of global warming and resource exhaustion on the entire life cycle of products; therefore, we use the Life Cycle Assessment (LCA). Furthermore, the supply chain consists of the acquisition of resources, raw materials, parts, product manufacturing, and distribution and sales. Japan has formulated relevant laws and regulations that concern recycling and reuse and has defined extended producers' responsibility. For example, in the product development and design process, it is necessary to incorporate LCA data related to the environment, Design for Environment (DfE) and eco-design, etc., into the cost and technical data.

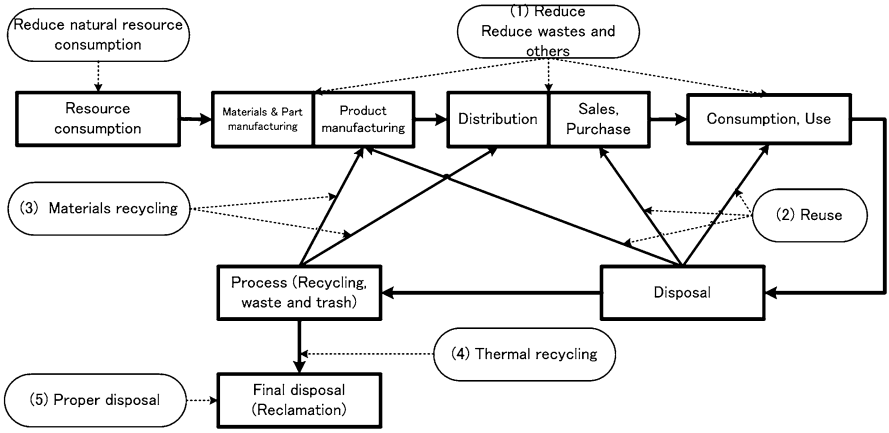

Fig. 2 Recycling-oriented society (Source: Ministry of Environment (MOT), Japan – modified 2009a)

2.2 Environmental Management System: EcoAction 21

The environmental management system is the systematic implementation of environmental management, and it is called the Plan-Do-Check-Act/Action (PDCA) cycle.

With respect to the PDCA, the environmental management system can be divided into four separate phases:

1. Environmental policy
2. Plan
3. Do and check
4. Review and act

In terms of the purpose and target related to the environmental policy, the top management and operation executives of the company will work out the implementation and correction framework, which is of particularly vital importance.

To strongly encourage small and medium-sized institutions to pay more attention to the environment, it is necessary to effectively implement environmental protection measures, and the Ministry of the Environment has established a certification and registration system for EcoAction 21 in the environmental management system. "EcoAction 21" encourages the improvement of environmental protection awareness through environmental activities. Regarding a checklist of greenhouse gas emissions (focusing on carbon dioxide emissions), refer to Fig. 3 for more details.

From the operational perspective, enterprise operators should try their utmost to achieve comparatively greater environmental economic efficiency in addition to reducing the total environmental burden. To implement environmental management and enhance environmental performance, it is necessary to establish environmental indicators.

(1) Greenhouse gas emissions [Sample of information for CO_2 emissions only (required)]
Fiscal year: from / (YY/MM) to / (YY/MM)

				Unit	Amount consumed (A)	Emission ($kg\text{-}CO_2$) (A×B) or (A×B×C)	Percentage of total (%)	Emission factor (B)	Heat per unit (C)
Carbon dioxide emissions	Energy consumption	Energy purchased		kWh				($kg\text{-}CO_2/kWh$)*(see note)	
		Fossil fuels	Kerosene	L				0.0679($kg\text{-}CO_2/MJ$)	36.7(MJ/l)
			Fuel oil	L				0.0693($kg\text{-}CO_2/MJ$)	39.1(MJ/l)
			City gas	Nm^3				0.0513($kg\text{-}CO_2/MJ$)	41.1(MJ/Nm^3)
			Liquefied natural gas (LNG)	kg				0.0494($kg\text{-}CO_2/MJ$)	54.5(MJ/kg)
			Liquefied petroleum gas (LPG)	kg				0.0598($kg\text{-}CO_2/MJ$)	50.2(MJ/kg)
			Gasoline	L				0.0671($kg\text{-}CO_2/MJ$)	34.6(MJ/l)
			Diesel	L				0.0687($kg\text{-}CO_2/MJ$)	38.2(MJ/l)
			Total fossil fuels						
		Other	Heat supply (steam)	MJ				0.067($kg\text{-}CO_2/MJ$)	
			Total other						
			Total energy consumed						
	Industrial waste	Waste oil		t				2900($kg\text{-}CO_2/t$)	
		Waste plastics		t				2600($kg\text{-}CO_2/t$)	
		Total waste incinerated							
	Other								
		Other total							
		Total CO_2 emissions							

Note: Calculate using emission factors provided by the national government for each electrical power supplier. Factors for FY07 can be found at: http://www.env.go.jp/press/press.php?serial=10574

Fig. 3 Selected part of CO_2 emission in list of indicators for each burden (Source: EcoAction 21 Japan (Ministry of the Environment (Government of Japan) 2009b))

2.3 *General Idea of the Energy Conservation Law (Rational and Relevant Laws on Energy Use)*

At the top of the law, the objective is described as follows: "This law aims to contribute to the sound development of the national economy through implementing necessary measures for the rational use of energy in factories, buildings, transportation, and machinery and equipment, and other necessary measures to comprehensively promote the rational use of energy, while it seeks to ensure the effective utilization of fuel resources that would meet the economic and social environment of energy at home and abroad" (Table 1).

2.4 *Material Flow Cost Accounting*

Material flow cost accounting (MFCA), one of the major environmental management accounting tools, increases the transparency of material and energy use

Table 1 Scope of regulations under the EC law of Japan

(1) Manufacturing plants and business locations	Those who have factories and conduct business operations
	Those who have workplaces (hospitals, hotels, schools, etc.) and conduct business operations
(2) Transportation	Carriers; those who conduct transportation of freight/passengers as business
	Consigners; those who consign their freight for transportation to transportation carriers
(3) Residential buildings and structures	When a residence/building is newly built; Construction client of residence/building
	When an existing residence/building is extended or reconstructed/modified extensively; Owner/manager of the residence/building
(4) Machinery and applications	Manufacturers and importers of machinery and equipment consuming energies

Source: Takakuwa (2013) by Taniguchi

Table 2 Contents of ISO14051

Items	Contents
Title	Environmental management—Material flow cost accounting—General framework
Content	1. Scope
	2. Terms and definitions
	3. Objectives and principles of MFCA
	4. Fundamental elements of MFCA
	5. Implementation steps of MFCA
	Annex A Difference between MFCA and conventional cost accounting
	Annex B Cost calculation and allocation in MFCA
	Annex C Case example of MFCA

Source: Takakuwa (2013) by Kokubu and Tachikawa

practices via understanding of physical input. Any costs that are generated by and/or associated with the material flows are subsequently quantified and attributed to them. In particular, MFCA highlights the comparison of costs associated with products and those associated with material losses, e.g., waste, air emission, and wastewater. In this regard, MFCA simultaneously contributes to economic and environmental management.

In September 2011, ISO 14051 was published, and MFCA was internationally standardized. MFCA was made one of the Japanese Industry Standards in March 2012. ISO 14051 clarifies the basic concept, the calculation method, and the steps for implementation of MFCA. The main purpose of the standard is to indicate the principle of MFCA; detailed steps for its introduction or implementation are omitted. The contents of ISO 14051 are shown in Table 2.

3 Environmental Management in Technology of Management

3.1 Technology of Management and Environmental Management

This topic entails the overall or comprehensive judgment over manufacturing and technology on the part of the enterprises in addition to the technology of management over each operation or process in the manufacturing activities and projects. To be more specific, it is necessary to conduct the management and judgment in light of the complete operation from the comprehensive perspective in making a decision, which is of great importance. Figure 4 indicates that production/economic management, human resource management, information management, safety management and social and environmental management should be effectively conducted from the perspective of technological management.

3.2 Human Resource Management

To promote environmental and energy conservation activities within enterprises, it is necessary to cultivate and train pollution control managers, energy managers

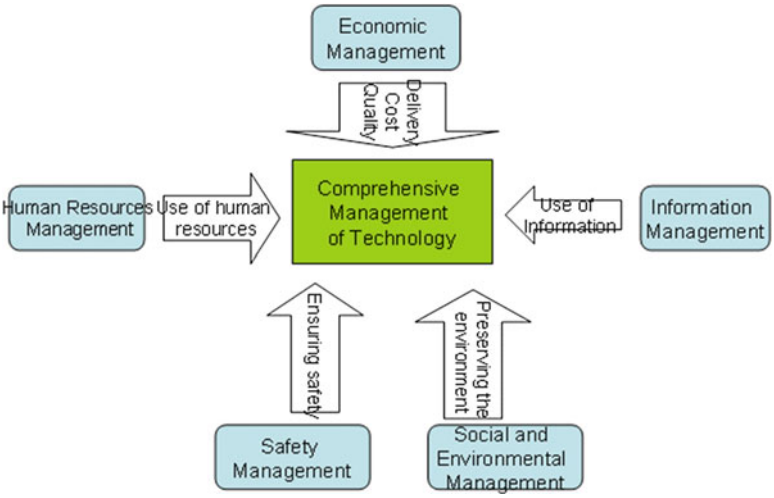

Fig. 4 Comprehensive management of technology (Source: Based on Japan Society of P.E. (The Institution of Professional Engineers, Japan 2004))

and qualified personnel for energy management and other professional holders of relevant qualification certificates related to the environmental energy. Furthermore, to more effectively manage the implementation of the environmental management systems of the relevant organizations and to enhance the environmental awareness of the working staff, it is necessary to establish corresponding cultivation and training mechanisms. Most importantly, enterprise operators, managers and working staff must have a better understanding and command of the relevant knowledge and education to enhance the environmental awareness of the persons thus involved.

3.3 Information Management

In general, the information communicated to external organizations can be divided into undisclosed, confidential information and information to be disclosed with a clear statement for accountability or PR information, which should all be determined by the organization based on open or non-open judgment. In fact, environmental accountability requires the organization to provide an external report related to relevant matters, which specifically includes the relationship between society and nature and the relationship between the society and the environment within its area, which epitomizes the corporate social responsibility and compliance of the organization or enterprise and should be published at the appropriate time.

The information from the environmental accounting process is disclosed to the public in the form of an environment report that enables people other than employees of the enterprise to have a better understanding of the supporting contents of the environmental protection plan of the enterprise and to enhance societal trust in the enterprise. “EcoAction 21”, in particular, is highly combined with the environmental activity evaluation program and may enable us to participate in simple environmental protection activities. Furthermore, “EcoAction 21” also serves as an announcement of the achievements of the relevant protection activities to the public.

During the implementation of the environmental management program, a considerable amount of data is generated that demands immediate processing; therefore, IT technology is indispensable.

3.4 Safety Management

At the operation field or site where hazardous chemicals are to be disposed of, it is very important to effectively implement the occupational health and safety assessment in the management system.

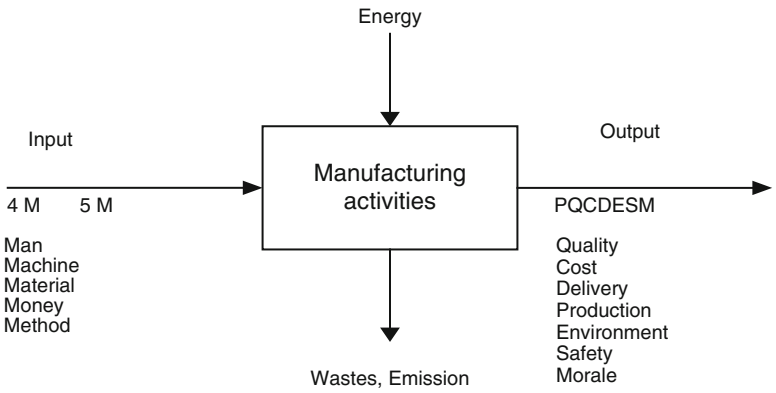

Fig. 5 Manufacturing activities

The corporate stakeholders related to the enterprise or organization should communicate the relevant information related to the nature and importance of the risk and degree of risk and control solution, which is actually the risk communication, and also pass judgment on the public acceptance of the risks related to the environmental issues, and then make the proper decision accordingly.

3.5 Trade-Off Between Manufacturing/Economic Management and Social and Environmental Management

We can see from Fig. 5 (from left to right) that the entire figure shows, from top to bottom, the input of energy and the output of environmental burden with a series of input substances brought about by manufacturing activities. In fact, Fig. 5 provides us the basic framework of the basic factors.

The management of quality, cost and content delivery closely related to the manufacturing activities is primarily based on the manufacturing and the economic management. In the process of the manufacturing and social environmental management of an enterprise and the implementation of JK (Jishu-Kanri) activities of self-motivated micro management, it is necessary to decide how to balance the relationship of the manufacturing activities, the social environmental management program and cost, during which the target value should be set, specifically "the top runner program". Consequently, similar enterprises should have effective environmental management programs that are coupled with improving their own energy consumption.

4 Measures for Environmental Problems

4.1 Some Measures for Environmental Problems

The strong governmental support related to environmental policy, consisting of regulations towards the global warming problem coupled with mediation among the industrial sectors and different enterprises, will play a vital role in strengthening the supporting management of the enterprise environmental problems. Most importantly, industry groups spearheaded by the Nippon Keidanren-Japan Business Federation play the central role. The industry groups that represent the enterprises in the industrial sector formulate the relevant plans that the enterprises will implement and will "independently" conduct the management and solution of the environmental problems. In recent years, research and development related to environmental operation and management has gained increasing attention. The development of environmental technology is a difficult problem for each enterprise involved, and the government should provide the corresponding support and assistance. At the same time, the research and development in the entire society requires industrial – academic – government cooperation and the cooperation from NPOs.

4.2 Understanding of Social Cost Related to the Environment

The external cost arising from the emissions of CO_2 and other wastes is referred to as "Social Cost." Figure 6 illustrates the relationship among corporate cost, lifecycle cost and energy consumption.

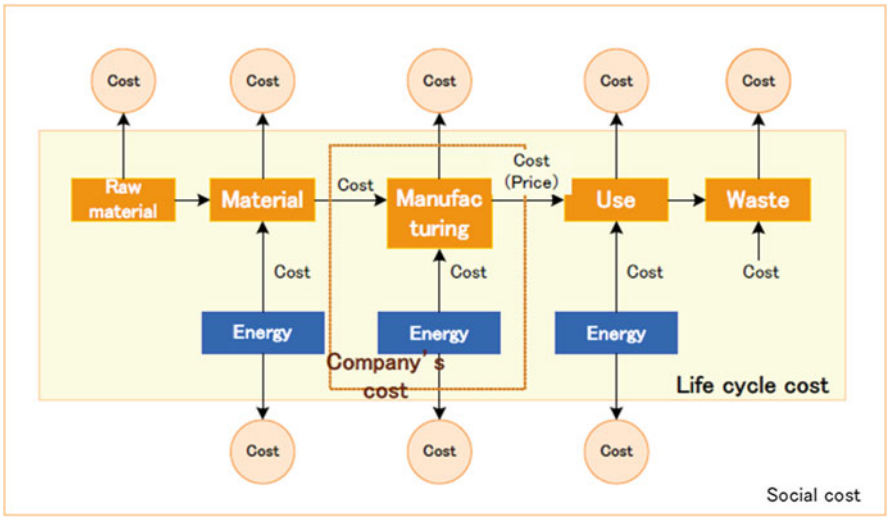

Fig. 6 Social cost (Source: METI 2002)

As enterprises consume environmental resources, the considerable emission of polluted substances and wastes will impose a heavy load upon the external environment; therefore, an economic theory has been proposed that specifies that enterprises should pay the corresponding taxes and compensation for the use of environmental resources.

5 Concluding Remarks

From 1950 to date, Japan has overcome and solved all types of environmental problems, specifically industrial pollution and domestic waste problems and the global environmental problem, and Japan has also paid closer attention to global environmental issues and formulated or promulgated corresponding policies and regulations. For quite some time, with the development and popularization of sophisticated technology, we could continue to formulate and update the countermeasures to achieve global environment protection with greater efforts. In conclusion, with the gradual implementation of the environmental and energy management system, the operators have considerably reduced the emissions of GHGs, particularly CO_2; however, priority should be given to countermeasures against global warming and the positive promotion of energy conservation and the obvious enhancement of the environmental awareness of the general public.

While Japan generously offers technical support to other Asian countries for environmental management, we continue to provide the target countries with the support to facilitate the formulation of environmental policies, the relevant environmental plans, the reinforcement of the corresponding environmental problem systems and the technical support to positively respond to all environmental problems. Meanwhile, because we are aware of the human environmental issues and our duty-bound responsibilities, we should conduct promotional and educational programs related to the attitude towards the participation in environmental protection activities and the solution to the environmental problems in a bid to continuously foster awareness and responsibility to promote closer attention to environmental protection. Furthermore, where corporate operators want to implement effective environmental management and energy conservation, etc., enhancing the environmental protection awareness of the employees is indispensable.

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References

Ministry of Economy, Trade and Industry, Environmental accounting workbook (2002) http://www.meti.go.jp/policy/eco_business/kaikeiWB/kaikeiWB-all.pdf. (20 Feb 2012) (in Japanese)

Ministry of the Environment (Government of Japan) (2009a) Annual report on the environment, the Sound Material-Cycle Society and the Biodiversity in Japan. http://www.env.go.jp/en/wpaper/2009/

Ministry of the Environment (Government of Japan) (2009b) EcoAction 21 guideline 2009. Ministry of the Environment, Japan

Takakuwa S (ed) (2013) Manufacturing and environmental management. National Political Publishing House, Hanoi

The Institution of Professional Engineers, Japan (2004) Comprehensive management of technology in terms of professional engineers systems, 2nd edn. The Institution of Professional Engineers, Tokyo (in Japanese)