

# Product Development Based on An Environmental Management System

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**Abstract.** In this paper, the difficulties involved in analyzing and designing a management system for product development are discussed with reference to reducing the impact of products on the environment. We propose some models and methods to analyze information behavior in the process of product development based on a fusion model which integrates the assessments of users' needs, the environment, and available technology. These models and methods are subsequently applied to the development of a new packaging material. The results of this case study allow us to identify effective information for the design of a management system for product development to reduce the impact of products on the environment.

**Keywords:** environmental management system (EMS), product development, assessment of users' needs, fusion model, information behavior

## 1. INTRODUCTION

In recent years, consumers have become more aware of environmental problems caused by industrial products and increasingly have demanded environmental quality (Wenzel *et al.*, 1997; Hauschild *et al.*, 1998; ISO14001, 1996). More companies are working on an environmental management system (EMS) in order to succeed in achieving sustainable development (ISO14004, 1996; Wilkinson and Dale, 2002). This emphasis has led to a heightened interest in products which meet environmental standards. Most innovations and improvements of products have been developed through trial and error by those in charge of research and development, and the evaluation of innovations has mainly focused on the success or failure of the results alone rather than on the causes and processes. Therefore, it is almost impossible to determine how to improve or redesign a management

system for the purpose of product innovation (Ichimura *et al.*, 1986).

We have developed and proposed models and methods to analyze information behaviors in the assessment of users' needs; we have also presented a product innovation process to improve or redesign the product innovation management system (Muramatsu *et al.*, 1990; Ishii and Ichimura, 1992; Ishii *et al.*, 2003). The concept of information behavior includes the structure and operation of the information collection process, the use of the collected information, and the process of decision-making by the generation of ideas in order to determine users' needs adequately and design a product according to those needs.

In this paper, we

- (1) propose a model and method to analyze information behaviors in the process of product development for the design of a management system that will reduce

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- the impact of industrial products on the environment, and
- (2) apply such a model and method to the development of a new packaging material and discuss the result.

## 2. ASSUMPTIONS

### 2.1 Fusion Model

Engineering divisions have tended to give priority to technological problems, solving them before solving other inherent problems in new product development without considering whether such technological problems are critical from the users' point of view. On the other hand, marketing divisions do not give adequate attention to clarifying the function of the product and determining the proper nature of product image, distribution, and advertising.

The basic concept behind our research on need assessment is *fusion* (Holt, 1977). In this concept, the assessment of users' needs and the available technology are fused into a new creative idea. The concept of *users' needs assessment* refers to problem definition derived from the perceived users' needs. *Technology assessment* consists of studying possible solution to problems arising in the process of new product development. The fusion of these two objectives is realized to facilitate the generation of new and effective ideas for the new product. In this study, the environmental policy of EMS is included under

*Policy* as Item 1 of the fusion model. Information regarding environmental aspects and the technology required to improve environmental performance in terms of reduction, reusing, recycling, and regeneration is included under *Engineering Information* as Item 5 of the model.

### 2.2 A Model of Information Behavior

Figure 2 shows information behaviors in the use of product characteristics, called *product characteristics deployment* in the field of Quality Management, and feedback obtained from the market and the environment based on the fusion concept. In this model, the fusion processes are classified into four phases consisting of four product characteristics: *merchandising characteristics*, *technical characteristics*, *manufacturing characteristics*, and *marketing characteristics*.

Merchandising characteristics are determined on the basis of information concerning policies, society, economic and environmental aspects, and users' needs. These product characteristics are required by users and presented in their language. Merchandising characteristics are translated into technical characteristics along with a target for development. Technical characteristics represent merchandising characteristics in terms of engineering measurements, such as "cm," "Kg," and "Km/h." The target for development might be decided by a policy based on an analysis of the product line, the competitiveness of the product, users' satisfaction/complaints, and an evaluation of the associated environmental impact. Manufacturing

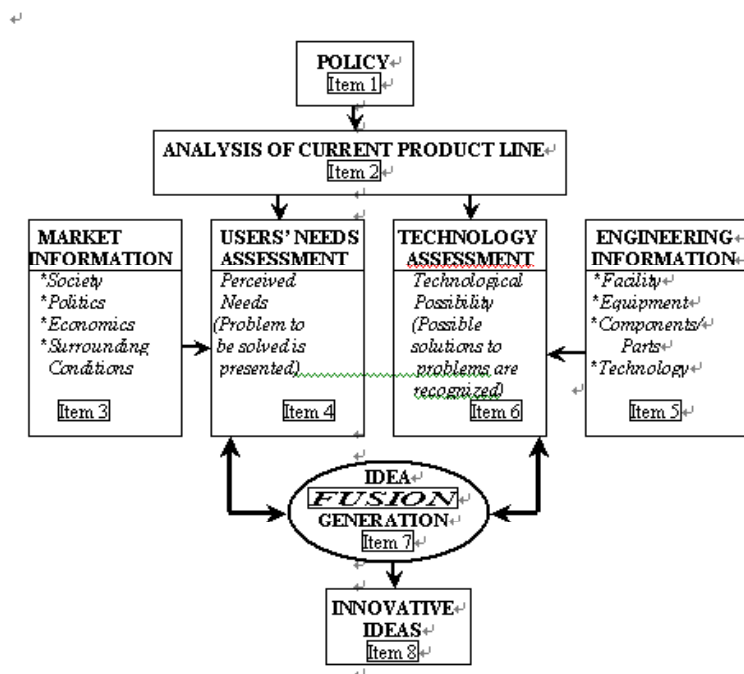


Figure 1. A fusion model for the development of new products

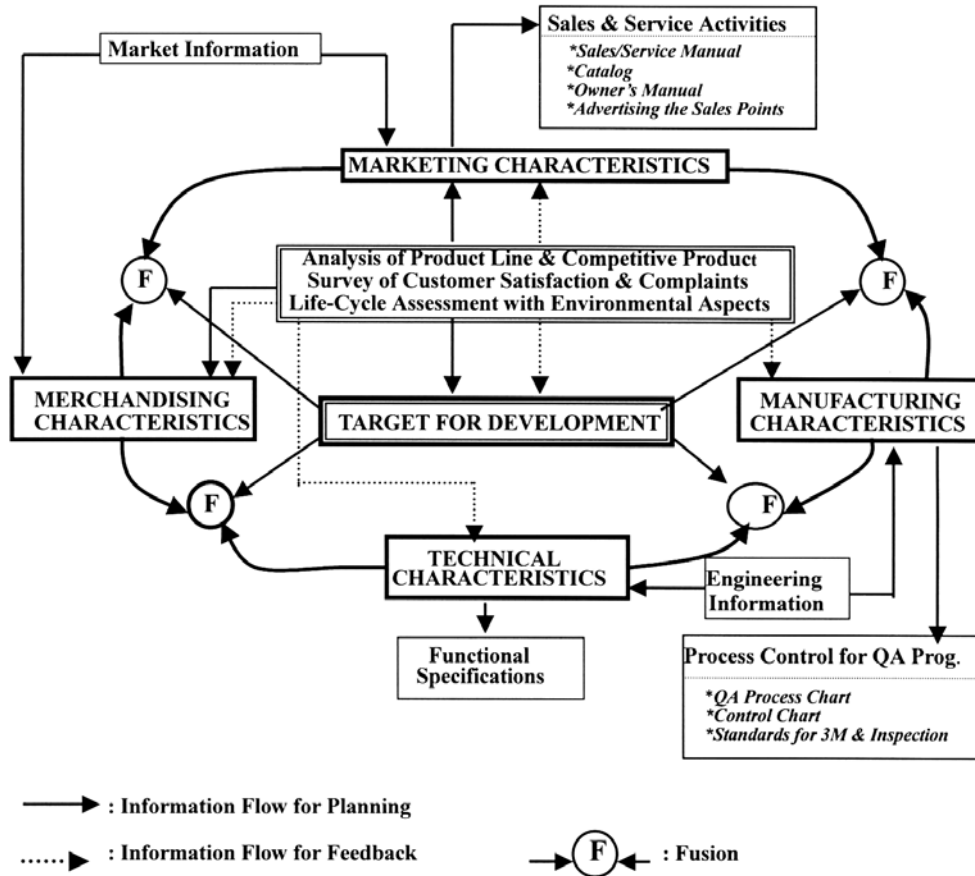


Figure 2. Model of information behavior based on the fusion concept

characteristics are derived from the technical characteristics on the basis of the target. Manufacturing characteristics are the control characteristics at the manufacturing stage. Marketing characteristics are derived from the merchandising and manufacturing characteristics. Marketing characteristics should be considered in selling, advertising, servicing, and distributing the product. The results of a survey of the marketed product might change or reinforce the target for development, the four product characteristics, and the priority of management concerns.

### 2.3 Application of the Method of Product Characteristics

Users' needs change according to their values and experiences using the products as well as according to social, economic, and technological conditions. The users' initial requests for the product are crystallized in the specifications. After consumers have accumulated experience in using the products, needs with regard to safety, ease of operation, and other considerations are added as necessary elements of product characteristics. In order to apply the method of product characteristics, it is necessary to use the product characteristics sheet shown in Table 1 to analyze information behaviors in the fusion

process of product development. Here, a concept of the hierarchy of product characteristics is introduced to present the process of use of information. As a result, levels are identified. This process, hereafter called *product characteristics deployment*, is one in which the *Life Cycle Assessment (LCA)* method (Wenzel *et al.*, 1997) can be effectively used.

The following benefits are derived from the use of Table 1.

Table 1. Product Characteristics Sheet

Elements of Characteristics	Contents
Specification/Efficiency Reliability Safety Maintainability Ease of Operation Transportability Feeling Warranty Total Life Cycle Cost (TLCC) Ease of Recycling/Disposal Others	

- 1) Important requirements cannot be overlooked in the users' needs assessment.
- 2) The measurement of users' valuation of the product is acquired through investigation based on Table 1. When the investigations are repeated periodically, a time series change of users' needs will be acquired.
- 3) In general, it is very difficult, from technical and economic points of view, to achieve all desirable product characteristics in cases where market competition is very intense. In order to develop a new product in a short time and in an efficient way, the manager in charge of developing and marketing has to choose one or two important product characteristics to emphasize out of a total list of product characteristics. These specified product characteristics are called *sales points*.
- 4) Priorities in technology development and production preparation are decided on the basis of the sales; promotion activities are planned.
- 5) Using product characteristics deployment, we can effectively establish idea generation in the fusion of users' needs, reduction of the impact of products on the environment, and technology assessment.

### 3. CASE STUDY

#### 3.1 Outline and Results of the Survey

The surveyed company was founded in 1894. It has about 14,500 employees and sold about 1,090,000 million yen worth of merchandise in 1997. The capital of the company is 109,000 million yen. This company has several divisions, such as printing/publishing, packaging materials, electric components, housing materials and components, and multimedia equipment.

Development of a new packaging material for food started at the beginning of 1997 and progressed to the trial stage of mass production in July 1997 by the packaging materials division, which produces packaging materials and plugging machines.

Table 2 shows the results of the development of the new packaging material. These results were surveyed and summarized based on the fusion model.

Figure 3 shows some of the results of product characteristics deployment. The information clarifies the relationships among merchandising characteristics, technical characteristics, environmental assessment parameters, and the configuration of the parts (Ishii and Ichimura, 1992; Ishii *et al.*, 2003) of the developed product.

#### 3.2 Discussion of the Results

The survey and subsequent analysis of information behaviors in the process of product development indicate

that development is initiated by a proposal to a food manufacturer as a line user, which is one of the routine jobs of the person in charge of development in the packaging materials division.

- 1) In determining the specifications of a product to reduce environmental impact, the following aspects are considered according to the product design standard developed by the division:
  - a) reducing the number of component parts,
  - b) reducing the weight, and
  - c) reducing the number of materials used in terms of their quality.
- 2) Furthermore, the specifications of the material chosen satisfy the requirements of users' needs, such as ease of disposal; reduction of environmental assessment parameters, such as quantity of energy used; pollutant quantities of NO<sub>x</sub> and SO<sub>x</sub>; amount of CO<sub>2</sub> emission; and reduction of manufacturing cost.
- 3) There is no evidence to explain why the environmental impacts identified, such as depletion of resources, heating of the atmosphere, and emission of acidifying compounds, are derived from the environmental policy.
- 4) There is no information source for the determination of environmental assessment parameters, such as quantity of energy used, pollutant quantities of NO<sub>x</sub> and SO<sub>x</sub>, and amount of CO<sub>2</sub> emission.
- 5) There is no information source for the determination of the time frame (horizon) under which the environmental impact should be observed.
- 6) There is no criterion for determining the target levels of the environmental assessment parameters mentioned above (in 4) in using a life-cycle inventory analysis.
- 7) In determining the quality of the material, only two kinds of materials are evaluated by the inventory analysis shown in Table 3. More kinds of materials should be evaluated in order to determine which has a lesser impact on the environment.

### 4. CONCLUSIONS

In this paper, a basic model and method to analyze information behavior are described based on the fusion concept to design a management system for product development that would reduce the impact of industrial products on the environment. The following conclusions were reached with respect to the usefulness and limitations of the proposed model and method.

- 1) The targets of the product development surveyed were successfully established on the basis of an effective assessment of both users' needs and the environment.
- 2) The relationships among users' needs, environmental assessment parameters, and information needed for

**Table 2.** Results of a new packaging material for foods surveyed on the basis of the fusion model

Item	Goal	Input		Output
		Information	Source	
1	Environmental Policy: Reduction of the depletion of resources, global warming impact, emission of acidifying compounds for environmental protection, and effective use of natural resources. Technological Policy: Use of effective technology outside of the company. Market Channel Policy: Use of the existing channel developed in food industry; the main user is a food manufacturer as a line user.			
2	Product Group For Development	Annual product developing plan	R&D center of the division	Packaging materials to improve environmental impact
3	Environmental Performance Indicators	The factors affecting the depletion of resources, global warming, and emission of acidifying compounds		*Quantity of energy used *Pollutant quantities of SOx and NOx *Quantity of emission of CO <sub>2</sub>
	Time Horizon (Scope Definition)			*Materials *Manufacturing
	Objective Levels of the Indicators	Inventory analysis of the previous year *Energy used: 1259.2 (MJ) *SOx: 93.7 (g) *NOx: 160.2 (g) *CO <sub>2</sub> : 96.8 (g)	Data base	Target levels of *Energy used: 1093.6 (MJ) *SOx: 89.9 (g) *NOx: 126.3 (g) *CO <sub>2</sub> : 92.1 (g)
	Users' Needs	Estimating end user needs by information gathering from food manufacturers	Meetings with food manufacturers	*Space-saving storage in a refrigerator *No classification in disposal
4	Sales Points	*Space-saving storage in a refrigerator *No classification in disposal	Users' needs assessment	*Ease of disposal *Space-saving storage in a refrigerator
5	Engineering Information Gathering and Assessment	Technology on *Separability/ inseparability *Making an item hermetic	Survey by R&D Center	The technology cannot easily satisfy the sales points mentioned above.
		Product design standard	R&D Center	Reformulation of the product to reduce its volume
6	Technical Characteristics	Information with current products	R&D Center	Volume, length, thickness, manufacturing cost, quality of the material, strength, readability, weight
8	Functional Specification	Inventory analysis of *paper *aluminum	Data base	*Paper *Weight: 27.0 (g)

**Table 3.** Table 3 life-cycle inventory analysis based on a database

Material \ Impacts	Quantity of Energy Used (Kgh)	SOx (Kg)	NOx (Kg)	CO <sub>2</sub> (Kg)
Paper	6.62878E-04	3.03053E-03	3.14224E-03	3.15665E+00
Aluminum	9.48916E-03	9.30600E-03	2.81274E-02	1.00351E+01

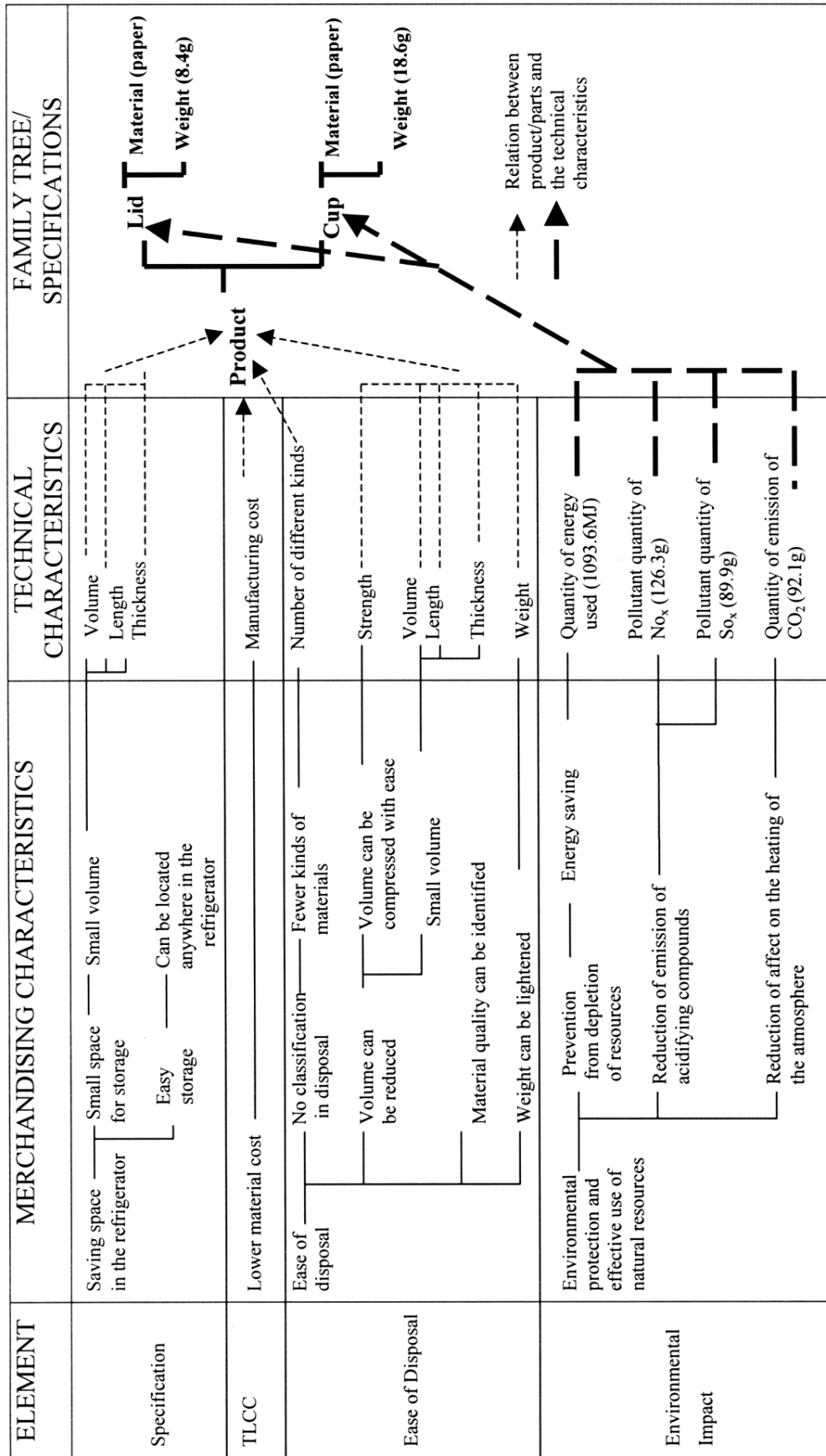


Figure 3. Results of the application of product characteristics on the design of packaging material

decision-making in the process of product development were clarified. In this way, the problems of redesigning or improving a management system for the product development surveyed could be defined.

- 3) Strategic product planning based on an environmental policy should be included in further research.

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## REFERENCES

- Akiba, M. (1971) Study on a Design and Applied Production Management System (in Japanese), Ph.D. Thesis, Waseda University.
- Copeland, M.T. (1927) Principles of Merchandising, A.W. Shaw Co., 3-4.
- Hauschild, M. and Wenzel, H. (1998) Environmental Assessment of Products--Scientific Background (Vol. 2), Chapman & Hall.
- Holt, K. (1977) Product Innovation, New-Butterworths, Trondheim.
- Ichimura, T., Ishii, K., Tuominen, M., and Piippo, P. (2001) Technology Management for Environmental Problems, The Proceedings of the 16th International Conference on Production Research, CD Version.
- Ichimura, T., Muramatsu, R., and Ishii, K. (1986) A Method for Analyzing Information Behavior in Need Assessment, in Hübner, H. (ed.), Proceedings of the International Conference on Product Innovation Management, Elsevier, Amsterdam, 131-141.
- Ishii, K. and Ichimura, T. (1992) A Process Design Approach Based on the Fusion Model, Technovation, **12**(8), 499-507.
- Ishii, K., Ichimura, T., and Hiraki, S. (2003) Analysis of Information Behavior in Determination of Product Specifications Based on a Conjoint Measurement Approach, Industrial Engineering and Management Systems, **2**(1), 55-62.
- ISO14001 (1996) Environmental Management Systems: Specification with Guidance for Use.
- ISO14004 (1996) Environmental Management Systems: General Guidelines on Principles, System, and Supporting Techniques.
- Neo, Y., Ishii, K., Takahashi, K., and Okazaki, H. (1986) Development of an Automatic Cleaning Machine: Case Study Based on the Fusion Model, in Hübner, H. (ed.), Proceedings of the International Conference on Product Innovation Management, Elsevier, Amsterdam, 165-176.
- Muramatsu, R., Ichimura, T., and Ishii, K. (1990) An Analysis of Needs Assessment and Information in Product Development Based on the Fusion Model, Technovation, **10**(5), 305-317.
- Wenzel, H., Hauschild, M., and Alting, L. (1997) Environmental Assessment of Products--Methodology, Tools, and Case Studies in Product Development (Vol. 1), Chapman & Hall.
- Wilkinson, G. and Dale, B.G. (2002) An Examination of the ISO9001: 2000 Standard and its Influence on the Integration of Management Systems, Production Planning and Control, **13**(3), 284-297.