Product Development Based on An Environmental Management System

Kazuyoshi Ishii†
Kanazawa Institute of Technology,
Ohgigaoka 7-1, Nonoichi-machi, Ishikawa 921-8501, Japan
Tel: +81-76-2946710, Fax: +81-76-2946710, E-mail: ishiik@neptune.kanazawa-it.ac.jp

Masayasu Koitabashi
Kanazawa Institute of Technology,
Ohgigaoka 7-1, Nonoichi-machi, Ishikawa 921-8501, Japan
Tel: +81-76-2946710, Fax: +81-76-2946710, E-mail: koitabas@neptune.kanazawa-it.ac.jp

Ichiro Mihara
Kanazawa Institute of Technology,
Ohgigaoka 7-1, Nonoichi-machi, Ishikawa 921-8501, Japan
Tel: +81-76-2946710, Fax: +81-76-2946710, E-mail: mihara@neptune.kanazawa-it.ac.jp

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
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
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

<table>
<thead>
<tr>
<th>Elements of Characteristics</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification/Efficiency</td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td></td>
</tr>
<tr>
<td>Maintainability</td>
<td></td>
</tr>
<tr>
<td>Ease of Operation</td>
<td></td>
</tr>
<tr>
<td>Transportability</td>
<td></td>
</tr>
<tr>
<td>Feeling</td>
<td></td>
</tr>
<tr>
<td>Warranty</td>
<td></td>
</tr>
<tr>
<td>Total Life Cycle Cost (TLCC)</td>
<td></td>
</tr>
<tr>
<td>Ease of Recycling/Disposal</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Model of information behavior based on the fusion concept
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\textsubscript{x} and SO\textsubscript{x}; amount of CO\textsubscript{2} 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\textsubscript{x} and SO\textsubscript{x}, and amount of CO\textsubscript{2} 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

<table>
<thead>
<tr>
<th>Item</th>
<th>Goal</th>
<th>Input</th>
<th>Source</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>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.</td>
<td>Information</td>
<td>Source</td>
<td>Packaging materials to improve environmental impact</td>
</tr>
<tr>
<td>2</td>
<td>Product Group For Development</td>
<td>Annual product developing plan</td>
<td>R&amp;D center of the division</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Environmental Performance Indicators</td>
<td>The factors affecting the depletion of resources, global warming, and emission of acidifying compounds</td>
<td>*Quantity of energy used *Pollutant quantities of SOx and NOx *Quantity of emission of CO₂</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sales Points</td>
<td>*Space-saving storage in a refrigerator *No classification in disposal</td>
<td>Users’ needs assessment</td>
<td>*Ease of disposal *Space-saving storage in a refrigerator</td>
</tr>
<tr>
<td>5</td>
<td>Engineering Information Gathering and Assessment</td>
<td>Technology on *Separability/ inseparability *Making an item hermetic</td>
<td>Survey by R&amp;D Center</td>
<td>The technology cannot easily satisfy the sales points mentioned above.</td>
</tr>
<tr>
<td>6</td>
<td>Technical Characteristics</td>
<td>Information with current products</td>
<td>R&amp;D Center</td>
<td>Volume, length, thickness, manufacturing cost, quality of the material, strength, readability, weight</td>
</tr>
<tr>
<td>8</td>
<td>Functional Specification</td>
<td>Inventory analysis of *paper *aluminum</td>
<td>Data base</td>
<td>*Paper *Weight: 27.0 (g)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Impacts</th>
<th>Quantity of Energy Used (Kgh)</th>
<th>SOx (Kg)</th>
<th>NOx (Kg)</th>
<th>CO₂ (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td></td>
<td>6.62878E-04</td>
<td>3.03053E-03</td>
<td>3.14224E-03</td>
<td>3.15665E+00</td>
</tr>
<tr>
<td>Aluminum</td>
<td></td>
<td>9.48916E-03</td>
<td>9.30600E-03</td>
<td>2.81274E-02</td>
<td>1.00351E+01</td>
</tr>
<tr>
<td>ELEMENT</td>
<td>MERCHANDISING CHARACTERISTICS</td>
<td>TECHNICAL CHARACTERISTICS</td>
<td>FAMILY TREE/SPECIFICATIONS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specification</td>
<td>Saving space in the refrigerator</td>
<td>Volume</td>
<td>Manufacturing cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Easy storage</td>
<td>Length</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can be located anywhere in the refrigerator</td>
<td>Thickness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLCC</td>
<td>Lower material cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of Disposal</td>
<td>Ease of disposal</td>
<td>Number of different kinds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No classification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fewer kinds of materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volume can be reduced</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volume can be compressed with ease</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Small volume</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material quality can be identified</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight can be lightened</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Impact</td>
<td>Environmental protection and effective use of natural resources</td>
<td>Prevention from depletion of resources</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy saving</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduction of emission of acidifying compounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduction of affect on the heating of the atmosphere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

- Material (paper) Weight (8.4g)
- Material (paper) Weight (18.6g)

Relation between product/parts and the technical characteristics.
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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This study was supported in part by a Grant-in-aid for Scientific Research of the Japanese Ministry of Education, Science, and Culture under Contract No. C(2) 16510126 (2004-2005). We would also like to thank Mr. Masato Yoshimura for his assistance and cooperation with this research

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