The Role of Green Product Development in Building Relationship in Supply Chain

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***Abstract*—The aim of this paper is to define the role of environmental management in the processes of research and development conducted by the partners in the supply chain. The publication describes the emerging trends related to the requirements of international companies (especially Original Equipment Manufacturers - OEMs) on reducing suppliers' negative impact of new products on the environment. Increasingly, these requirements are taken into account during the initial assessment and periodic suppliers. The expectations that international companies have of suppliers include an ever wider range of implementations of the concept of environmental management contained in the ISO 14000 series of International Standards. These expectations include: the implementation of an environmental management system (in accordance with the guidelines of ISO 14001), the implementation of LCA (ISO series 14040), and the use of environmental labels and environmental statements (as required by series 14040). OEM companies are not limited to placing stringent requirements on suppliers. Many multinationals offer their suppliers special programs to support the implementation of environmental management.**

***Index Terms*—green product development, supplier relationship, environmental management**

I. Introduction

Many OEMs (Original Equipment Manufacturers), especially international companies, which have implemented the concept of environmental management based on ISO series 14000 standards also expect to limit the their suppliers' negative impact on the environment. The scope of the requirements for suppliers may include compliance with legal provisions relating to environmental protection, implementation and improvement of an environmental management system based on the requirements of the ISO 14001 standard, the introduction of the assessment of environmental aspects in all phases of the product life in accordance with the concept of LCA, as set out in the guidelines contained in the ISO 14040 series of standards (such as design, purchase of materials, production preparation, production, packaging, storage and transport to the customer, after sales service, installing the product at the customer, use of the product, maintenance and handling of the product after use), applying for environmental labels and environmental declarations (according to the rules specified in the standards ISO 14020 series), or using the Design for the Environment approach ("Ecodesign") [1]-[5]. It can be observed that the cooperating partners in the supply chain undertaking joint research and development projects take into account the improvement of environmental. Therefore, cooperating partners connected to the objectives of product design focus primarily on:

Improved material efficiency (by minimizing the consumption of materials, use of materials with a low impact on the environment, the use of renewable raw materials and/or the use of recovered materials);

Improved energy efficiency (by reducing energy consumption, use of energy sources with a low impact on the environment, the use of energy from renewable resources);

Design (of products and processes), taking into account the concept of cleaner production and safe use (through the use of cleaner production techniques, avoiding the use of hazardous materials);

Design which is focused on ensuring the safety and stability of the product (including in this respect the length of the operation, maintainability product improvements resulting from the emergence of these technologies).

II. Trends Related to the Improvement of Product Quality

Is increasingly significant importance of product safety for the users and the environment? It is conditioned by both the need for regulatory compliance, as well as marketing activities of enterprises forming a positive image of their surroundings, they want to be perceived as socially responsible. The confirmation of the technical quality of certificates and declarations of compliance (with the requirements of the directives and technical standards), safety signs, signs declarations of conformity and compliance with technical standards, as well as certificates of producers.

Particularly important companies' efforts aimed at reducing negative environmental impact of products and processes associated with them (supply chain) on the environment. Increasingly, manufacturers are taking these issues into account during design, involving the suppliers

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and customers, for whom it is related to many advantages, such as reducing operating costs, reduced level of failure, or end-product can be converted to the newer. Environmental awareness of consumers, (particularly individuals) in our country only begins to shape and is just as in the case of enforced regulations. Adapting to the increasingly stringent regulations in this respect in most cases, try to make environmental investments and make more and more safe and energy efficient materials. This is most evident in the case of multinationals, which regardless of the place of trying to have this type of activity by demonstrating that their social responsibility.

Many companies notice efforts made by suppliers regarding building partnership marketing and their offering on-line technical advice, training, and/or team-building meetings. They also often take advantage of the opportunity to place orders on-line. An increasing number of companies improve relations with suppliers by means of joint research and development of new products and offering training to suppliers. International companies pay more attention to the ability of suppliers to conduct joint research and development of new products. To encourage them to cooperate in the design of new products and the development of existing products many OEMs offer their suppliers special support by development programs which are based on the principle of win-win

III. Ecodesign and Life Cycle Assessment of Products

The Ecodesign approach is based on Environmental Effect Analysis (EEA) and takes into account: identification of legal requirements, design planning, conceptual design, construction and evaluation of a prototype, production and packaging). Life cycle assessment (LCA) is a complex process involving the analysis of the profitability of investment projects with simultaneous emphasis on reducing a product's negative impact on the environment. This concept takes into account measures to determine the quantities of used materials, energy and waste generated in each process (starting from raw material extraction, through manufacturing, distribution, use and reuse/recycling until final disposal) [6]-[8]. A particular stage in the design and development of a new product with the use of the Ecodesign approach is screening [9]. This analysis takes into account:

Legal requirements (including waste management and the restriction of use of hazardous substances) and the functionality of the product (specifications) and safety for the environment and for users);

Technological capability and business infrastructure;

Suppliers' capability of providing the appropriate (new) solutions, technical quality and requirements relating to the fulfillment of requirements for improving the environmental aspects.

The effective application of Ecodesign and the concept of LCA help companies meet the requirements relating to environmental supplier statements (environmental product declarations) and applying for the use of eco-labeling for products [10]-[11].

IV. Stages of Ecodesing Process

The Ecodesign approach takes into account environmental aspects at all stages of a product's design and development. This process includes: planning and design requirements, conceptual design, detailed design, survey / construction and evaluation of a prototype, production, product launch to the market, and a review of the product [12]-[14]. The first stage of the product design process includes planning. This stage begins with an analysis of external and internal factors affecting the planned product (screening analysis). The external factors include:

Legal requirements (including the current and future developments in the field of national and international regulations and legislation relating to product liability, reducing the use of hazardous substances and waste management);

The needs and expectations of customers (basic analysis functions to meet the product's technical functionality, price and safety for the environment and for users);

Positioning the company and its products against competitors (including environmental criteria);

Environmental requirements (including the cost-effective use of resources, protection of human life and the environment, the consequences resulting from industrial processes, such as emissions, waste, etc.).

The environmental awareness of society and its impact on shaping the image of the company and its products).

On the other hand, in terms of internal factors in the analysis of the screening, it includes: - Compliance with the objectives of the company, and in particular from the existing portfolio of production, or existing distribution channels;

Suitable human potential (knowledge and skills of specialized personnel);

The financial resources (and the ability to access external sources of funding);

The technological capabilities and infrastructure of the business;

The ability of suppliers to provide appropriate (new) solutions, technical quality and requirements relating to the fulfillment of requirements for improving the environmental aspects [15].

In the next stage of a new product's project development, the company defines measurable objectives and tasks related to the management of the environmental aspects, as well as considering the best possible solutions (to optimize the impact of the significant aspects of the life cycle). For this purpose, risk analysis and benchmarking analyses are used.

In the third stage of the company draft, a detailed product concept is produced which aims to define:

The parameters of the product (specifying the technical quality);

The technological processes (related to the production, distribution, installation, use and handling of the product after the operation);

The form of the product's technical documentation, and the processes associated with its evolution (production, quality control, packaging, installation and operation);

Requirements for suppliers (purchasing specifications, selection criteria) [16]-[17].

All defined specifications for materials, processes and requirements for suppliers should take into account their environmental aspects. In the next phase of the design process, prototypes of new products are designed, based on the specifications developed, which are then subjected to laboratory testing and production in line with the objectives of environmental aspects. The results of this assessment can be used to:

Improve the design of a new product (change of raw materials, design and technological solutions);

Improve operational processes (design, manufacture, transport, installation of the product the customer or after-sales service);

The need to change supplier.

The last phase of the process of product design and development is validation. The purpose of validation is to ensure that the objectives of the organization have been met, along with any legal requirements and the expectations of customers (or other stakeholders).

V. Requirements for Suppliers Related to Material Flow Cost Accounting

It can be observed that more and more companies are beginning to implement a system to gather information on pro-ecological activities, analyze the associated costs and benefits achieved as a result of this reorganization. For these reasons, it can be noted that in recent years many enterprises have been implementing an environmental accounting system, using international guidelines such as: Environmental Management Accounting Procedures and Principles by the United Nations Division for Sustainable Development [18]. Environmental accounting takes into account both business units (subsidiaries, departments, processes) and individual products. In addition, it is not limited to individual business units, but it increasingly includes links between partners in supply chains. Enterprises implementing Environmental Management Accounting Procedures most often introduce the concept of Material Flow Cost Accounting (MFCA). In fact, Japanese managers have suggested the establishment of global guidelines on the implementation of the Material Flow Cost Accounting (MFCA) concept, in the form of an international management standard within the group of environmental management standards (especially ISO series 14040, regarding product life cycle assessment, and ISO 14064, specifying quantification guidelines and reporting on emissions and removal of greenhouse gases). Guidelines for implementing this concept have been included in ISO 14051 (environmental management - material flow cost accounting - general framework). This standard defines the guidelines for the identification and quantification of individual product components (weight, quantity) and cost measurement as part of flow rate analysis [19]-[20]. The ISO 14051 standard includes the following classification of costs.

Material costs relating to the material resources used to produce the expected ones;

Energy costs, referring to the energy resources used, such as electricity, natural gas, steam, fuel oil, diesel oil, gasoline, technical gases;

System costs, connected to the handling of materials (processing, storage, securing, transport, maintenance, depreciation) excluding energy costs and wastage. These are counted in relation to equipment operation time, production volume, number of employees and area used;

-Waste management costs, referring to the handling of material losses in quantitative centers (in single or multiple processes), such as repair of non-compliant products, recycling, transport and storage of waste, utilization, sewage disposal, emission management.

Information collected in this way allows the identification of the types of waste present in the flow (raw materials, parts, components) (losses from wastage, energy losses, or implementation of ineffective activities). The application of Material Flow Cost Accounting also allows the indication of possible ways of reducing any negative impact on the environment (by reducing the amount of waste, emissions, sewage, etc.), in operational processes related to the product (design, purchase, production, packaging, storage, delivery, use and withdrawal from use) as well as the identification of potential savings and optimization of the quantitative flow of materials and use of the infrastructure potential of partners involved in the design and development of products [21]-[22].

By identifying these wasteful elements, enterprises can limit:

Purchases of necessary quantities of materials (through the optimization of their consumption);

The level of waste resulting from product incompatibilities;

The level of energy usage, gas emissions or wastewater.

The application of the Material Flow Cost Accounting concept is not limited to individual companies but is increasingly transferred to the partners in the supply chain (both downstream and upstream) [23], one example of which is Canon, which, in 2005, began implementing the concept of Material Flow Cost Accounting among its suppliers [24].

In the years 2008-2011, the Japanese Ministry of Economy, Trade and Industry launched a project to implement the concept of MFCA in 50 supply chains. Among the enterprises that successfully introduced this concept with their suppliers were, among others, Ohu Wood Works, Panasonic Ecology Systems, Sanden Corporation, Sanwa Altech).

Currently, the concept of MFCA is increasingly being implemented in the supply chains of the automotive, chemical and rubber, metal, textile, wood and food

industries, office equipment, as well as medical devices [25].

VI. Green Supplier Development Programs

Many international companies try to assist local suppliers meet their stringent requirements by offering them help in the form of consultations and training in the implementation of product innovations and improving operational processes [26]. These activities focus on delivery of aid in terms of:

-Ensuring the technical quality of products,

-Improving the efficiency and effectiveness of processes,

-Improving working conditions and improving staff qualifications,

-Reducing the level of risk threats in the supply chain in order to ensure continuity of processes carried out by the partners.

Some supplier development programs are aimed at improving the environmental impact of products. Green supplier development programs are based on setting goals and formulating supplier task programs, which are associated with the use of less environmentally harmful materials and the implementation of more environmentally friendly technological solutions. Many industrial customers require that suppliers have implemented the requirements of the following European Union directives:

-RoHS (Restriction of Hazardous Substances) Directive EU 2003/95/EC,

-WEEE (Waste Electrical and Electronic Equipment) Directive 2001/96/EC,

-EuP (Eco-design for Energy using Products) Directive 2009/125/EC,

-Battery and Accumulator Directive 2006/66/EC,

-Packaging Directives 94/62/EC, 2004/12/EC, COM Decision 97/129/EC,

-REACH (Registration Evaluation Authorization and Restriction of Chemicals) Regulation 1907/2006/EC [27]-[29].

OEMs support their suppliers by providing expertise knowledge delivered through training and specialist advice. Enterprises engage providers in joint projects related to designing new product solutions that use the Ecodesign approach. Effective implementation of these programs allows the partners to improve the quality of products (lower level of non-compliance, introduce product innovations, increase reliability and security), shorten the cycle processes and reduce their costs (especially in relation to operational processes such as design, customer service before and after the sale, production/services, transportation and infrastructure maintenance), as well as improve mutual communication [30]-[33]. The successful implementation of these programs allows both the suppliers and customers to improve the quality of products (lower the level of non-compliance, introduce product innovations, increase reliability and security), shorten cycle processes and reduce their costs (in particular with regard to operational processes such as design, customer service before and after the sale, production/services, transportation and maintenance of infrastructure) and improve mutual communication [34]. Actions aimed at helping suppliers develop undoubtedly contribute to a reduction in transaction costs related to the exploration of new supply capacity, conducting audits and other forms of assessment, verification and qualification of the sources of purchase [35]. In order to ensure the effectiveness of supplier development, a program is necessary to produce a climate of cooperation based on mutual commitment, trust and an open exchange of information, especially in the area of performance quality (level of compliance with the requirements for the provision and improvement of products and processes) and cost (access to financial data relating to the joint ventures). Effectively implemented, the development programs of suppliers undoubtedly contribute to building the intellectual capital of the partners [36].

VII. Monitoring of Suppliers in the Contects of Green Product Development

Many OEMs monitor the activities of suppliers using a Supplier Performance Card and collecting data, and when conducting appropriate benchmarking studies they take into account technical quality, timeliness, cost reduction, technological development, the rate of implementation by the supplier of new solutions (adaptation time to changes in the process or the product), the possibility of introducing a new product, the reaction rate (for RFQ / preparation of the offer, a complaint/the reporting of a technical problem, the implementation of corrective/preventive measures), flexibility (adapting to changes in customer orders, changes in the economic environment), improving environmental impact (reducing the consumption of materials/energy, reducing greenhouse gases, reducing waste generation and increasing the reuse of materials through the introduction of recycling), and progress in the implementation of process improvement tools and products [37]-[39]. Many companies also assess suppliers on the basis of their level of management focusing on their system of certificates (which confirmed the implementation of organizational standards like ISO 9001 or ISO 14001). They also audit suppliers periodically.

Attention while carrying out audits aimed at the evaluation of functioning of suppliers' environmental management is most often paid to the following elements:

-environmental culture which is connected with adopting the environmental policy, identification of environmental aspects and defining environmental goals and tasks;

-adhering to laws concerning environmental protection;

-supervising the system of environmental management by means of ensuring appropriate documentation (records) and resources (infrastructure. process technology. information systems appropriately qualified employees) as well as employing environmental indicators (e.g. related to energy consumption. natural resources. waste economy. pollution);

-internal and external communication;

-employee trainings.

Some international companies require regular reports on progress in the improvement of management systems while monitoring suppliers. They also keep monitoring them regularly by means of Performance Feedback Report Cards which contain data on lowering costs, reducing incompatibility, improving effectiveness indicators and process efficiency indicators, reducing energy consumption, shorter cycles of process completion and optimization of using production capabilities.

VIII. Conclusions

To recapitulate the considerations presented in the article, it should be clearly stated that OEMs require suppliers to focus on taking account of their environmental aspects in the processes of product design and development. In the long term, the implementation of these requirements by suppliers allows them to derive many benefits. The most important benefits in this respect include:

Lower costs, by optimizing the consumption of materials and energy,

Increasing process efficiency and reducing waste;

Stimulating innovation and creativity in the design of environmentally friendly products which are safe for users;

Improving the image of the company;

Increased environmental awareness of employees.

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