LCA Technology to Support Design for Environment – Application of LCA Standard Tool –

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1. Introduction

The Mitsubishi Electric Group has employed Life Cycle Assessment (LCA) as a product assessment item to secure Design for the Environment while verifying the effects of improvements employed throughout the life cycles of products. For the introduction of LCA, we have constructed a database and assessment procedure and made efforts to diffuse and establish LCA technology. This paper reports the outline of "Company standard data directory" which has been developed by the designers for evaluating environmental load from the initial stage of development.

2. Trend of LCA

Today, to reduce greenhouse gases and create a recycling-based society which promotes zero emission, reduction of environmental load should be considered from the initial stage of product development, namely the design stage. To do this, great emphasis has been placed on LCA technology that can quantify environmental load in all stages of the product or service life cycle, including resource mining, design, manufacture, transportation, usage, and disposal. As shown in Fig. 1, LCA is a technique to analyze the environmental load on the global environment throughout the life cycle stages; LCA technology is specified as an ISO 14040 series standard by the International Organization for Standardization (ISO) and also as a JISQ 14041 standard in JIS (Japanese Industrial Standards).

A five-year national LCA project "Development of Assessment Technology of Life Cycle Environment Impacts of Products and so forth," sponsored by the Ministry of Economy, Trade and Industry, started in 1998. The project ended in March 2003, achieving objectives such as constructing a Japanese public database and establishing a Japanese version of the assessment method. Following on from this, the second phase LCA project "Development of Technology to Assess and Verify Life Cycle CO_2 Emissions" was started. Some of the project activities have been developed to be applicable to practical LCA. The progress and achievements of the projects are introduced on the Web(1).

On the other hand, the EuP Directive, which effectively makes LCA in product design compulsory, was enacted in Europe, for reducing product-related loads on the environment. At the same time, clients have increasingly requested that LCA data be submitted as a green procurement requirement. Furthermore, with the ECO LEAF and Swedish EPD program, as a Type III Environmental Label, LCA results have increasingly been disclosed publicly(2),(3).

The Mitsubishi Electric Group has also performed LCA on the basis of "3R (Reduce, Reuse, and Recycle) Product Assessment" standards consisting of 14 major

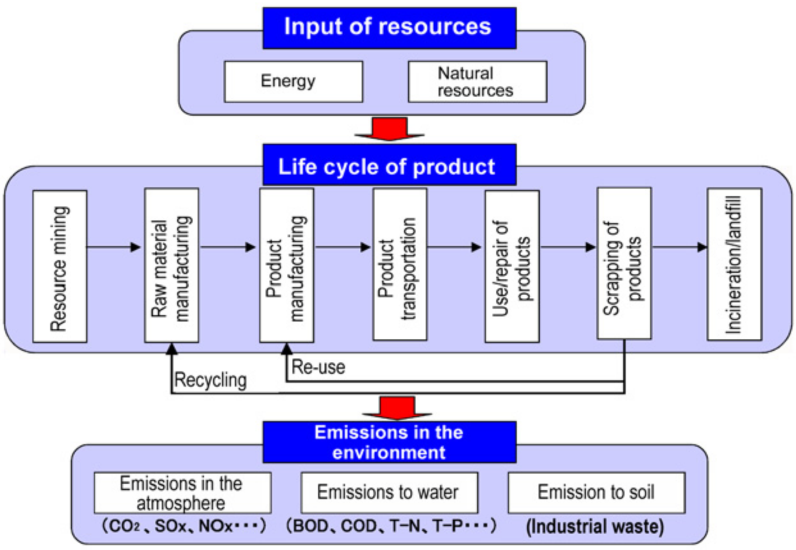

Fig. 1 Concept of LCA

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division items and 51 medium division items, which are defined from the MET (Material, Energy, and Toxicity) perspective to promote the Design for Environment while verifying the effects on reducing environmental load throughout all stages of product life cycles.

3. Outline of Company Standard Data Directory

Figure 2 shows the execution procedure of LCA specified in ISO 14040.

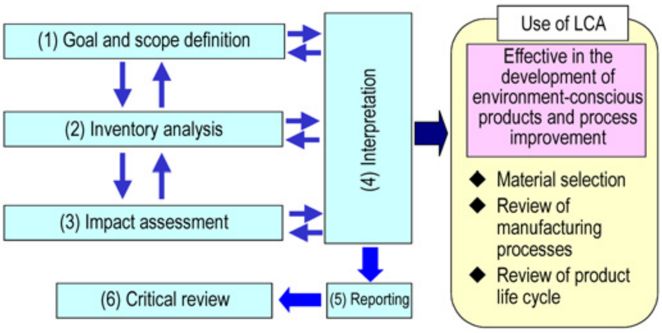

Fig. 2 Execution procedure of LCA

The first step is "Goal and scope definition," in which the scenario of the life cycle subject to assessment in accordance with the objective is defined. In the central step of LCA "Inventory analysis," the input and output data related with the environment in each phase of products are collected and processed. In "Impact assessment," the results obtained from the inventory analysis are divided into "Global warming," "Acid rain", and other division items for quantitative assessment of the items on the basis of the characterization coefficients defined for the respective division items. In the step "Interpretation," the results of the inventory analysis and impact assessment are interpreted and concluded in accordance with the goal and scope of the assessment. This procedure will clarify how to effectively improve and modify the product. Furthermore, preparation of reports and verification through the steps of "Reporting" and "Critical review" ensure the objectivity of the LCA results. Mitsubishi Electric has compiled the LCA execution procedure based on practical cases that conforms to the ISO requirements in "LCA Assessment Manual." In addition, Mitsubishi Electric has created an "Company standard data directory" so that designers can assess the environmental burden from the initial stage of development and has also constructed Company standard LCA tools.

The data directory we have developed this time consists of the database of the LCA project of the Ministry of Economy, Trade and Industry which has been rapidly introducing standardization and Mitsubishi's original database covering a total of 796 items, which include the data on Corporate common parts and the disposal process at Mitsubishi's Higashihama Recycling Center. The data are stored in the in-house standard LCA software and classified into six main categories: (1) material, (2) energy, (3) transportation, (4) processing, (5) waste product scenario, and (6) waste processing. Furthermore, the data are associated with the types of common materials and released on the intranet, together with the emission unit energy requirements. At least three substances such as CO_2, NOx, and SOx, are referred to as emitted substances, in compliance with the 14 substances stated in the LCA projects (emissions to the atmosphere: CO_2, CH_4, HFC, PFC, N_2O, SF_6, NOx, and SOx; and Suspended Particulate Matter/aquatic emissions: BOD, COD, total phosphorous, total nitrogen, and suspended solids).

3.1 LCA project database

The present LCA project database contains data provided by 53 industrial organizations(5). Figure 3 shows the flow chart of the scope of data collection by data type. The figure indicates that the data on aluminum-rolled products contain only the environmental load generated during the "domestic transportation" and "aluminum rolling" processes that are enclosed in the double line. The unit energy requirements have been calculated by integrating the data on "primary aluminum manufacturing," "secondary aluminum manufacturing," and "aluminum scrap transportation." The database has been constructed by defining the scope of data collection for relevant elements and parts on the basis of the

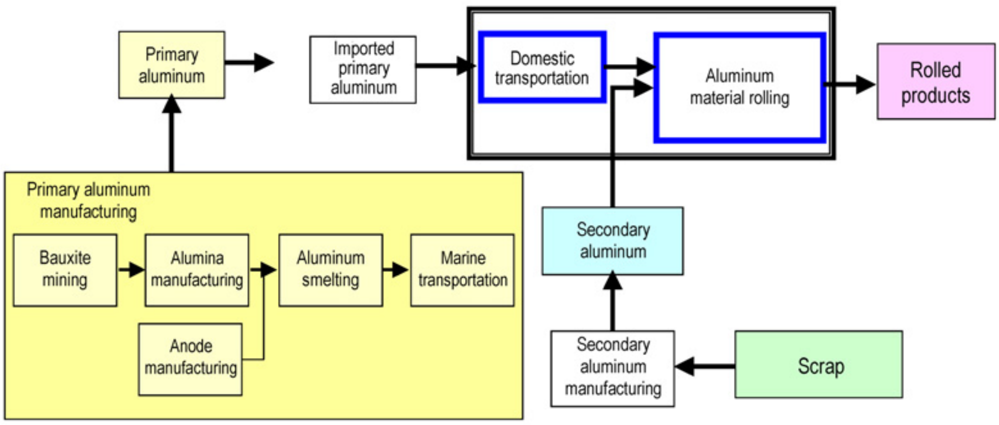

Fig. 3 Flow of aluminum rolling goods

flow charts and the like and collecting the data from public sources.

3.2 Embodied environmental intensity of Corporate common parts[6]

For the construction of the database of major parts used commonly in Mitsubishi, parts which are used in large quantities and whose material and manufacturing data can be obtained were identified. The applicable assessment range is defined as the steps from material preparation to parts manufacturing, including multiple parts for multiple model types. The environmental load of each type of part was assessed on the basis of those data, and also the energy unit requirement per unit weight of each part was determined. As a result, for example, it has become possible to calculate the environmental load of a motor by multiplying the motor weight by the unit energy requirement, without needing to investigate the constituent materials or weight.

On the other hand, IC packages were classified in accordance with the package sealing methods, package implementation methods, and types of framing materials. The environmental load of five to eight types having different pin-numbers was assessed for both plastic QFPs and glass-epoxy substrate type BGAs. As a result, it was found that IC packages cannot be unified on a 1-kg basis. The reason is that the environmental load is divided proportionally on the basis of unit weight between the extraordinarily large electric power consumption during the wafer manufacturing process and the greenhouse gas emissions, and that the environmental load is determined by the weight of chips (= Si weight) in each IC package.

Accordingly, the unit energy requirements of IC packages were defined on the basis of the weight of chips instead of the total weight of the IC package. This makes it possible to calculate the environmental load of each IC package from the chip dimensions, which can be obtained based on the manufacturer's model names.

4. Implementation of LCA

The Mitsubishi Electric Group today is using the standard LCA tool we have developed as described above to assess a variety of products, including heavy electric system devices, industrial system devices, household appliances, and electronic devices for enhanced environmental compatibility of the products. Taking household appliances for example, we conducted LCA of 11 major product models (air conditioners, Lossnay and the like) of the "Uni & Eco" series for the whole house, and hence reduced CO_2 emissions by about 49% (from the level in 1990). The results of LCA were exhibited at the Eco Products Exhibition and are included in the Uni & Eco product catalogs to publicize Mitsubishi's environmental activities, which include the development of environment-conscious products.

Furthermore, the Mitsubishi Electric Group has conducted LCA by focusing on the transition of environmental load associated with technological innovation. As a result, the environmental load has been reduced by 40% with power modules and by 30% with transformation systems[7],[8]. Mitsubishi Electric won an "Incentive Award" of the LCA Japan Forum for its outstanding achievements in LCA activities[9].

In its Environmental Vision 2021, the Mitsubishi Electric Group states its commitment to considering the 3Rs throughout the life cycle. As part of this, the Mitsubishi Electric Group is conducting recycling process assessments using the LCA approach[10], [11].

The Mitsubishi Electric Group is building the foundation for sharing and using product environmental information in its supply chain operations and promoting Design for Environment based on the results of LCA as well as disclosure of related information.

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