Transactions of the Materials Research Society of Japan 25 [2] 613-616 (2000)

Environmental profiles for materials selection

Kiyoshi Ijima and Kohmei Halada

National Research Institute for Metals
Fax: 81-298-59-2301, e-mail ijima@nrim.go.jp

Key words: Inventory data, Database, Network

1. Introduction

The global environmental issues become serious more and more. All of the mankind has been putting large interest on the environmental issues. Many actions to solve the environmental issues have started in those ten years. In such actions, that on materials are important. Material's development has supported to extend the human activity until now. However, human activity and environment are closely related on the environmental issues by depending on the materialized cultures. Ecomaterial is a modern attempt to develop material into environmentally benign one. In order to evaluate the degree of benignity of Ecomaterial, environmemntal profile of material is required.

On the otherhand, LCA (Life-cycle assessment), which evaluate the total environmental impact through the life cycle, has become widely used to assess products, Environmental profiles of materials are also omportannt to utilize LCA as inventory data. In this report, the database on envoronmental load of materials, which was constructed in NRIM, is described, and the direction of further development of the database is mentioned.

2. Concept of ECOMATERIALS

The concept of ECOMATERIALS was born through discussion about the future state of materials in service for human life and activities and their relationship with the environment. Considering the finiteness of the earth and the environment, we should be conscious of the environmental load of our products and materials, The activities of humans produce materials from the environment to expand human frontiers and to make their life comfortable. These from the human system, which should interact with the geo-system and bio-system, as the latter two systems closely interact to from the ecosphere. While formerly the main interest was only in the human system in the traditional way of materials development, co-existence with other systems ha become important in recent years. ECOMATERIALS development follows a holistic view of the ecosphere and has three strands (Fig.1).

1. Expanding human frontiers: to develop activities of mankind. This is consistent with the traditional way of developing materials in which physical, chemical, thermal, or functional properties are improved to be utilized.

2. Co-existing with the eco-sphere: to minimize any harmful influences upon the environment. From the viewpoint of sustainable development, consumption of material and energies and the exhaust of emissions and wastes associated with material processing should be reduced to ease the impact on the resource circulation system.

3. Optimizing the amenities: to create a healthy life in harmony with nature. Materials should be friendly not lonely to nature but also to mankind. Material Material properties should be reconsidered from the viewpoint of ECOMATERIALS, e.g., how a required property can be obtained with less environmental load how materials can improve

recyclability, or how maximum performance can be acquired with least material consumption.

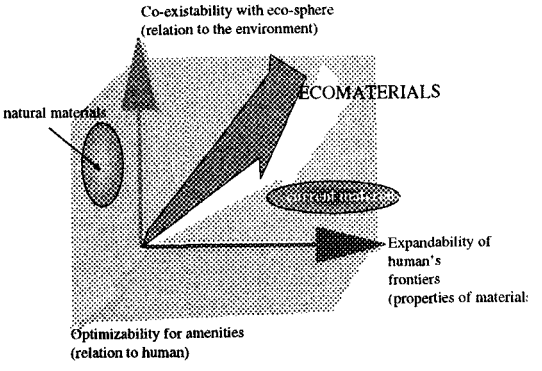

Fig. 1 Three strands for comprehensive development of materials

3. Materials environmental Life Cycle analysis

With the introduction of ECOMATERIALS it is necessary to know how much load a material gives to the environment. While we possess methods to evaluate the mechanical or functional performance of materials, until now we have had no appropriate method to assess the environmental load of materials. In order to develop an assessment method of this, we have to take the total life of material into the consideration because most materials give environmental load mainly in the stage of production and of circulation, not in the stage in which a material is directly used.

The material is used to utilize its properties for human life and social development. In this usage stage, some materials place a large load on the environment and others place less load. Before the usage stage, materials pass through several stage of production. Some materials are easily obtained without demolishing eco-systems, while others are produced with great energy consumption involving toxic emissions. After usage, materials are landfilled, incinerated, or recycled. Many types and degrees of environmental load exist at this disposal stage. To identify true ECOMATERIALS, we have to consider all the stages of the life of a material. Environmental life-cycle assessment(LCA) is appropriate as the basic method to evaluate the environmental load through the total life cycle of an object.

LCA is composed of three phase: goal and scope (1) inventory, (2) impact assessment, and (3) interpretation. In the inventory phase, a process tree is drawn from the extraction of raw material from the environment, and data are collected for inputs and outputs including the environmental load such as emission substances, energy consumption, etc. In the impact assessment phase, the environmental load data are added up and classified into environmental effects, such as a biotic depletion, greenhouse effect, ozone depletion, human toxicity, eco-toxicity, acidification, etc. In the interpretation phase,
the results are fed back to the selection of elements of assembly, transportation, or the way of using and disposal in order to minimize the environmental load.
Material environmental load data are necessary in order to execute the inventory. Environmental load data of each material is the inventory data.

4. Material environmental load database

Natl. Res. Inst. for Metals has started the construction the LCA inventory database on metallic materials.
At the first stage of the construction, the database of the environmental load of CO2, Sox, Nox which are related to the manufacturing of steel and its alloys was constructed.
Database is composed of three unit.

1. On steel and ferroalloy, unit requirement of fuel and row materials, are collected form national statistical data. CO2 and SOx, NOx is calculate by using the these data of unit requirement in to sub databases.
2. Composition of steels in JIS classification.
3. Mechanical property in JIS classification.

The database system has been composed of three systems.
First, input for the composition quantity.(Fig. 2)
2nd choosing the JIS symbol, designates the material. (Fig. 3)
The last chooses the material from the mechanical property.
By this three systems, the environmental load

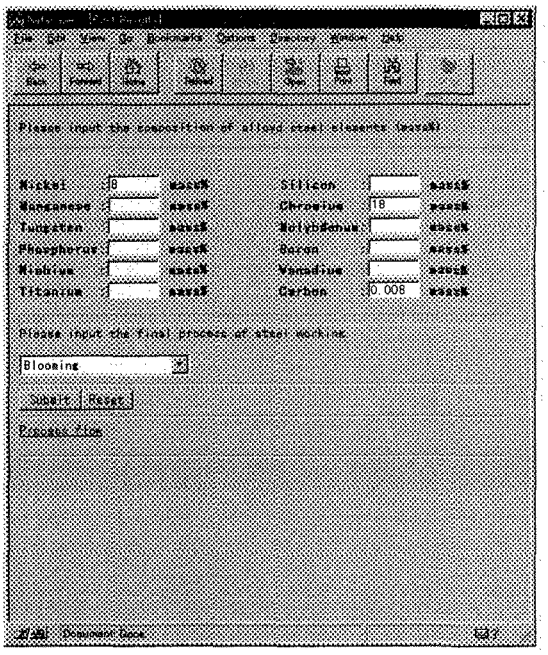

Fig. 2 Input Page

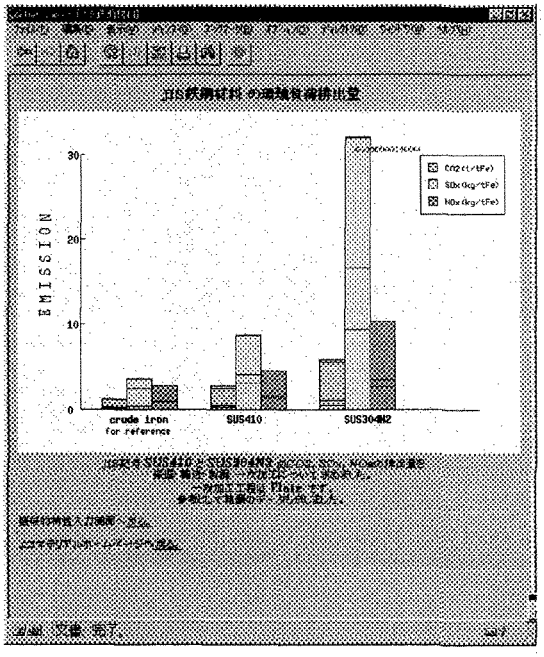

Fig. 3 Result Page

5. Futher development of database by using XML

Futhermore, we intend to expand the database to cover more matereals. Other attempts to construct the LCA inventory data are increasing.

These database should be shared globally to make better assessment of LCA and LCA's applications such as Design for Environment.

However, the database system can not be applied to the other material, since original data structure has been done. By unifying the data structure, it was considered that it did not go, if it is not a database also applied to other materials. The data structure by XML which attracted the attention recently was noticed.

Features of XML.

1. Data structure can freely define.
2. In the unification of the data structure, it is possible to adopt the data which dispersed on the network.
3. The function with good HTML · SGML is adopted.

From the features, the material database variously constructs it by unifying the data structure. And, the construction of the database system which utilized the internet becomes possible.

By using this XML language, database on nonferrous metal is newly developed. The datum of each material is put in the respective file. The composition of the file is as follows.

```
<プロセス名>
  <基準生産物>
    <部品X></部品X>
    <部品X製造>100個</部品X製造>
  </基準生産物>
  <入力>
    <原料>
      <素材A>1234kg</素材A>
      <素材B>5678kg</素材B>
      <物質C>9012kg</物質C>
    </原料>
    <エネルギー>
      <電力>345MJ</電力>
      <燃料D>678kl</燃料D>
      <燃料E>901kg</燃料E>
      <燃料F>2345MJ</燃料F>
    </エネルギー>
  </入力>
  <出力>
    <基準生産物>
      <部品X>100個</部品X>
    </基準生産物>
    <その他の産物>
      <加工A屑>567kg</加工A屑>
      <加工B屑>890kg</加工B屑>
      <物質G>12kg</物質G>
    </その他の産物>
    <処理すべき廃棄物>
      <廃棄物H>34kg</廃棄物H>
      <汚泥>56kg</汚泥>
    </処理すべき廃棄物>
  </出力>
  <環境項目>
    <大気への排出>
      <CO2>7890g</CO2>
      <SOx>123kg</SOx>
    </大気への排出>
    <水中への排出>
      <BOD>2456mg</BOD>
    </水中への排出>
    <土壌への排出>
      <Cd>78mg</Cd>
    </土壌への排出>
    <その他>……</その他>
  </環境項目>
  <データに関する記述>
    <記述1>……</記述1>
  </データに関する記述>
</プロセス名>
```

Fig. 4 Sample of the XML

1. Process name. (which is process proper name of the file it)
2. Product as a standard. (result of producing by the process)

4. Input. (raw material and parts and energy. used for the product)
5. Output. (product and other product)
6. Environmental load data. (pollutant. to atmosphere and water quality and soil)

Sample of the XML structure is shown in the fig. 4 .

By this using data file, the additional information is subjected by describing its process flow,. The environmental load is obtained by accumulating these data.

The nonferrous metal database was newly constructed using the data structure. (Fig.5) There are 13 types as a type of the nonferrous metal. And, the system in proportion to the nonferrous alloy was chosen.

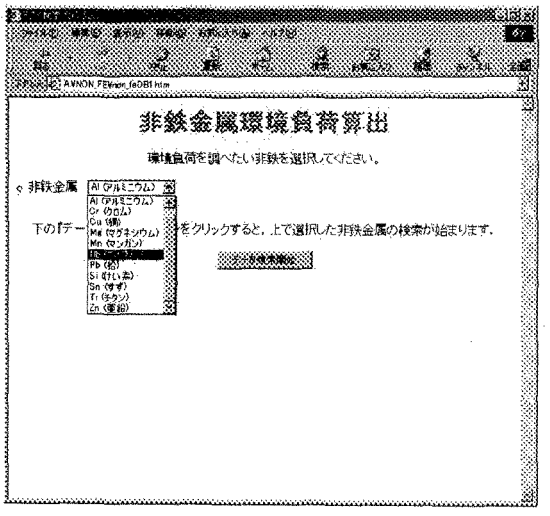

Fig. 5 Nonferrous Metal Database

The inventory data of nonferrous metals for LCA can be also opened by the database to public using the network.

URL:

http://www.nrim.go.jp:8080/ecomat/

(Fig. 6)

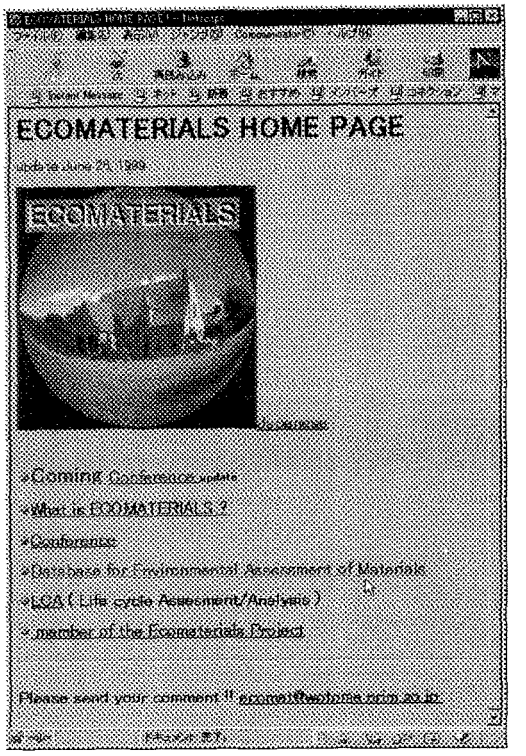

Fig.6 Main Page

3. Conclusion

In order to reform an earth environment, LCA is expected. Inventory data that is necessary for LCA prepared it accompanied with steel. Inventory data of other raw materials also mustn't don't prepare it.

In order to own data jointly, the data that are written with XML are valid.

For the database use XML, I am constructing it.

(Received December 16, 1999; accepted February 7, 2000)