TALAT Lecture 2109

Life Cycle Analysis - from Environmental Consciousness to Design for the Future?

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Objectives:

– to introduce the currently most widely accepted methodology for life-cycle analysis and show possible effects on designing products

Prerequisites:

– none

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2109 Life Cycle Analysis - From Environmental Consciousness to Design for the Future

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2109.01 Life Cycle Analysis - Its Development and Goals

Life cycle analysis is an instrument to provide a more systematic analytical method for identification of the possible environmental effects due to the production and use of products and of recycling/ disposal.

The prime objectives of carrying out a LCA can be listed as follows:

– to contribute to the understanding of the overall and interdependent nature of the environmental consequences of human activities

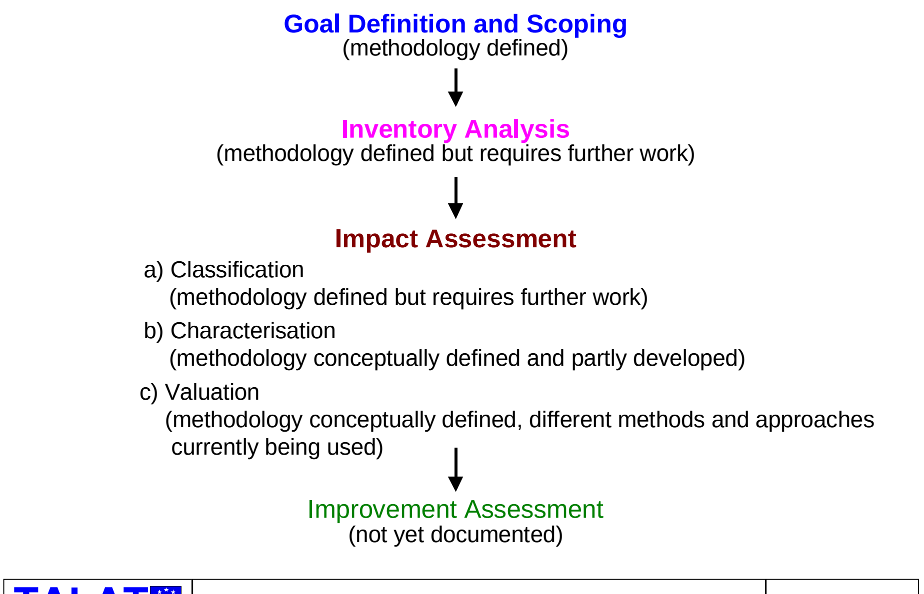
– to provide industry with information which defines more precisely the environmental effects of their activities and identifies opportunities for handling and use of products
– to serve as a communication tool in the sense that it facilitates constructive dialogue among different sectors in society concerned with the environmental quality.

2109.02 Methodology

- Goal definitions and scope
- Life cycle inventory
- Impact assessment
- Improvement Assessment

The most comprehensive and most widely accepted methodology so far has been developed over the last five years within the framework of the Society Of Environmental Toxicology And Chemistry (SETAC).

According to this methodology a life cycle analysis consists of the steps listed in **Figure 2109.02.01** (the parentheses indicate the state of the art of the methodology according to SETAC itself)



State of the Art of LCA according to SETAC 2109.02.01

A study described as *life-cycle assessment* should cover **the entire life-cycle** as described above. If the methodology is used in studies of a more restricted nature (for example studying only the parameter "energy" throughout the whole life-cycle), it cannot, by definition, be called an LCA.

Definitions of Goal and Scope

First of all, it is important to define the goal of the analysis. In order to do so it is necessary to state the purpose and reason for carrying out an LCA as well as the intended use of the results:

- What decision is to be based on the findings ?
- Will the results be used for internal (to improve the environmental performance of the product) or external (to influence public policy) applications ?
- What information is required, at what level of details ?

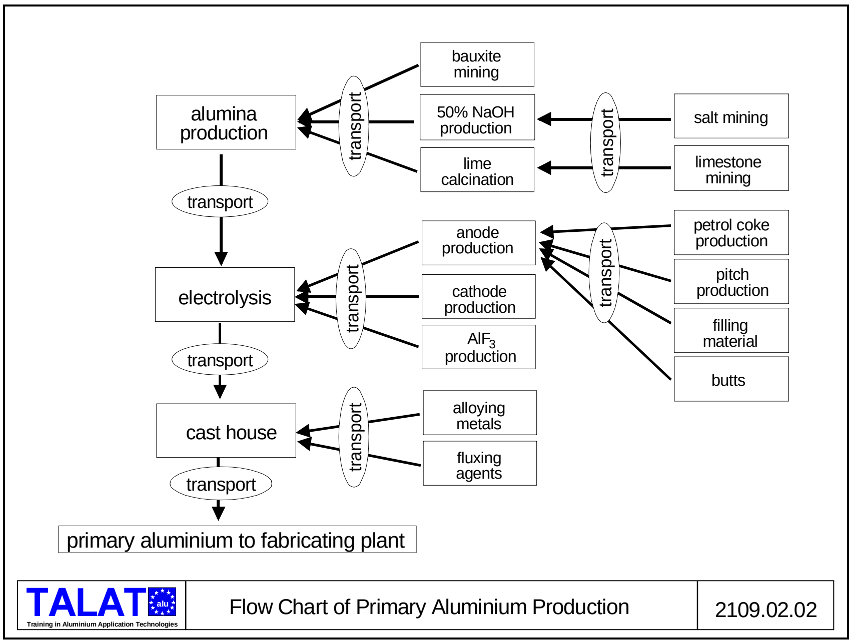
It is further important to define clearly and with sufficient details the scope of the study, i.e. the complete system, boundaries, data requirements, assumptions and limitations.

Life Cycle Inventory

From the environmental perspective, a product's life cycle can be represented as a circular movement which ties together resource extraction, production, distribution consumption and recycling/final disposal.

The life cycle inventory is - as far as possible - a complete and systematic description of the production and the use of a product achieved by identifying and quantifying the use of resources and outputs and their release to the environment, see e.g. **Figure 2109.02.02**.

It is the basis for all further analysis and, therefore, has to be carried out under high quality standards including data quality, representativity etc., which should be guaranteed by a peer review.



Impact Assessment

Within the "classification" SETAC has proposed the following list of criteria:

It is a technical, quantitative and/or qualitative process to characterise and assess the effects of the environmental burdens identified in the inventory component. This stage of the LCA is presently under development. It comprises three steps:

1. Classification

Classification is the step in which the data from the inventory analysis are grouped together into a number of impact categories.

For example: NOx ⇒ impact ⇒ 1. acidifying effect
⇒ ###2. eutrophicating effect

2. Characterisation

Characterisation is the step in which analysis/quantification and eventually aggregation of the impacts within the given impact categories takes place. This step should be based on scientific knowledge about environmental processes.

The characterisation step must still be developed, its outcome may be referred to as the impact profile.

3. Valuation

Valuation is the step which tends to arrive at a further interpretation and aggregation of the data of the impact assessment. At this stage, the contribution from the different specific impact categories are weighted so that they can be compared among themselves. The weight is defined from judgements of social values. If for instance, two alternative systems are compared of which one contributes to global warming to a lesser degree while the other poses lower risks to human health from toxic emissions, it is, in that case, almost impossible to tell which system has the least environmental impact.

The valuation step is also being developed in order to make of it a more rational and explicit process.

Improvement Assessment

The Improvement Assessment is the stage where options for reducing the environmental impacts or burdens of the system under study are identified and assessed.

At that stage, the inventory analysis can be used to reveal aspects which can be improved. It is important to include impact assessment as a necessary step in the LCA process in order

- to emphasise the need of using LCA to reduce the environmental impacts associated with the system under study,
- to ensure that the goal of an LCA is not to justify a status-quo and
- to recognise that all systems have environmental impacts to some degree which can eventually be reduced.

Even if SETAC has not yet documented the improvement assessment stage it is clear that at least at the production stage the careful analysis of the inventory will already lead to improvements.

2109.03 Use and Misuse of Life Cycle Analysis

The potential of LCA as an assessment tool for appropriate use as well as for misuse is quite significant and it is important that global development and application is done consistently. It is important to note that LCA does not address economic considerations or social effects.

One of the most promising uses of life cycle analysis addresses industrial enterprises. It will allow them

- to develop environmental strategies for the improvement of products and processes
- to identify environmental improvement opportunities and

- to track the progress of improvements.

Consequently, industry will have a better control over the overall environmental impacts of products in the market.

In addition, these approaches are contributing to consumer awareness of the invisible consequences of their actions as well, thus enhancing their own ability to consider alternative products and behaviour.

Whether LCAs can support the establishment of purchasing procedures or specifications (external uses) as well as the marketing of specific environmental claims will highly depend on the sophistication and standardisation of the methodology, since the major problem lies in the comparability of LCAs.

2109.04 LCA - a Methodology in the Making

LCA methodologies are not fixed methods, but are constantly under development. There are many issues about coverage, the significance and credibility of "boundary determinations" and about the methods to deal with unknowns or impacts that are not readily quantifiable. To be recognised as a credible tool, the use of LCA must also be regulated by generally obeyed and accepted procedures capable of ensuring transparency through continuous and active participation of all parties concerned (consumer organisations, environmental organisations, trade and producers' organisations...). This standardisation is underway by the International Standardisation Organisation (ISO), in its Technical Committee 207.

The overall credibility of LCA will essentially depend on

- the achievement of comparability of LCAs,
- enhanced transparency of LCAs,
- international exchange of data.

As explained earlier, the development of LCA methodology is still in progress and, therefore, it is not possible to define rigid rules for all aspects at present. Moreover, assessments, when made, are followed by an interpretation which involves value judgements that cannot be expressed in terms of universally acceptable rules or criteria. There is a growing awareness that, for example, an impact assessment will have to be carried out on a regional or local basis, since environmental impacts depend also on the locally existing conditions. This dependency is not only relevant for the production stage but also for the distribution, use and after-life- treatments of products.

2904.05 LCA and Design

LCA will not only have an effect on improvement of production processes or on the use of products, it should also have an effect on design of processes and products.

Of course, the choice of a material is predominantly motivated by technical, economical and functional factors. However, more and more environmental aspects will play a role in the choice and selection of materials.

Looking particularly at the end of life of products it seems most desirable to have products or materials which can be partly or wholly re-used or recycled. Resource and energy savings play an increasingly important role in our world and thus should be reflected in the design of our products.

In this context aluminium offers a number of advantages for which some examples are given below:

1. Use of energy

Aluminium can be considered an "energy bank" storing the energy invested during the primary production stage throughout its whole lifetime. At the end of its lifetime an aluminium product will be recycled - a process which needs approximately 5 % of the energy for primary aluminium production. In the Western World 60% of the energy used for the production of primary aluminium comes from hydroelectricity, a relatively environmentally friendly and renewable energy source.

2. Use of aluminium in cars

Reducing the weight of a car by 100 kg saves approximately 6 litres of fuel per 1000 km. Tests conducted on aluminium intensive vehicles have shown that the additional energy required for the production of primary aluminium compared to traditional automotive materials is saved after 55,000 to 59,000 km.

In addition, 95% of aluminium in existing cars is reclaimed and is recycled into casting alloys for which there is still the greatest demand in the car industry. Designing cars with light-weight body components of aluminium requires in the long run the sorting of reclaimed materials by alloys or alloy groups in order to reproduce the same type of product via recycling. The tendency to pay more attention at the design stage to the requirements of reclamation processes of used components will in future make sorting easier and more economical.

3. Use of aluminium in buildings

The same holds true for buildings where the reclaimed aluminium today is also recycled into castings, but where due to new design techniques in the future the recovery rate of aluminium could rise above the present 70-80%, and where it will also be possible to recycle aluminium windows for example into windows.

4. Use of aluminium in packaging

In packaging applications aluminium fulfils the necessary barrier function in order to protect the filled goods. In applications where the material fraction is rather low the reclamation rate is also generally rather low. Saving resources in this area of application is being achieved by downgauging and new designs. Once collected and sorted the recycling of aluminium packaging waste is successfully done in many European countries. The high recycling rate of aluminium beverage cans in various countries is a valid example and demonstrates the possibilities of recycling in product loops.

2109.06 References

Assies, Jan A.: Introduction Paper to SETAC-Europe Workshop of Environmental Life Cycle analysis of Products. Workshop 2-3 December 1991, Leiden. Leiden 1991

N.N.: An Overview of the Life Cycle Approach to Product/Process Environmental Analysis and Management. Organisation of Economic Cooperation and Development (OECD), Paris 1994

N.N.: Society of Environmental Toxicology and Chemistry: Guidelines for Life-Cycle Assessment: ″A code of Practice″. Workshop 31 March - 3 April 1993, Pensacola/Brussels 1993

N.N.: Sustainability/Spold/Business in the Environment. The LCA Sourcebook. A European Business Guide to Life Cycle Assessment. London 1993

2109.07 List of Figures

Figure No.	Figure Title (Overhead)
2109.02.01	State of the Art of LCA according to SETAC
2109.02.02	Flow Chart of Primary Aluminium Production