Life Cycle Assessment System Design for Packaging Industry

Qianjin Yang[1], Jiyong Liu[2], Xinmin Han [3]

Research Institute of Systems Analysis China Academy of Machinery Science & Technology No.2 Shouti south Rd, Haidian DistrictBeijing, P. R. China

Email: yangqj@139.com maitian3030@gmail.com hanxm@139.com

Abstract: This paper describes the application of LCA in the packaging industry, and then analyzes the status quo of typical LCA software and databases, as well as the existing problems. To solve such problems, fundamental data of packaging material, performance index, typical production process and consumption of related manufacturing processes are conducted, and then packaging life cycle assessment model is set up. WEB2.0 technology is introduced into the design of the browser/server architecture packaging LCA analysis system consist of various function modules, which is investigated by typical packaging. Finally, three suggestions to improve the application of LCA in packaging industry are given.

Keywords: packaging industry, status quo, WEB2.0, browser/server, LCA analysis system

1. Preface

LCA (Life Cycle Assessment) method, a key supporting technology for green packaging evaluation and green packaging grading, is commonly used in today's quantitative analysis for evaluative features in Evaluation index system of green packaging. According to ISO14040, LCA is compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.

Usage of LCA can be divided in to two fields, one is ecological design, and the other is waste management.

Eco-design is an initiative environmental response design methodology, whose ultimate objective is to protect both the environment and the resources, which should take the function of the packaging as well as the safety of the ecosystem in to account.

A common waste treatment order is: waste minimization, reuse, materials reclaiming, composting, energy reclaiming, burning (without energy reclaiming) and landfill.

However, deficiencies exist in such an order, such as: no sufficient theoretical basis, inapplicable to the joint options, e.g. materials reclaiming and burning vs. composting and landfill.

Nevertheless, LCA can be used to support the decision of the best solution to the waste management, which can help to achieve the object of sustainable development.

2. The Status Quo of Application Tools

According to our research, there are plenty common used commercial software such as Simapro and GaBi used in many fields, but only a few mature. Domestic software and database are mainly developed by universities and institutes, such as EPD Tools Suit 2007 which is a LCI tool developed by Sichuan University and Chengdu YiLin Environmental Technology Co., Ltd, but most of them are product-oriented, only few of them care about the producing process.

As for the database of LCA, the abroad database is mainly subject to foreign circumstance, on the contrary there are only few of domestic database subject to the domestic circumstance, besides, under constraints of domestic research, and there are also lack of many fundamental data in many areas.

Thus, we hope to build an open LCA analysis system, on the one hand to make the LCA method be populated, on the other hand can to share and collect fundamental data of various domains.

3 Fundamental Data Research of Materials, Energy Consumption and Environmental Burden for Typical Packaging Life Cycle

LCA for packaging need support of fundamental data of material, energy consumption and environmental burden of various period of life cycle, from material production, product manufacturing, and usage to the end recycle and disposal phase.

Considering a great variety of packaging，three dominating packaging in China are selected in the study: Corrugated box, tin box and PET beverage bottle. Data quality requirements shall be specified to enable the goal and scope of the LCA to be met. In this study, the data quality requirements are addressed in the following aspects, such as time-related coverage, geographical coverage, precision, completeness, representativeness、consistency, sources of the data, etc. However, it is unpractical and unnecessary to get all input and output data of the whole life cycle processes, so three main phases of

This paper is sponsored by "research on reclamation technology of package waste" (project ID: 2006BAC02A13).

packaging, material production; product manufacture and waste management are discussed in this study. (See Fig 1)

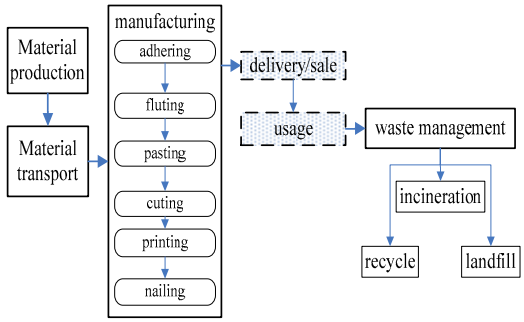


Fig.1 simple flow chart of corrugated box Life cycle

We've designed and mailed the questionnaire to many packaging manufactures, meanwhile, we've published such questionnaires on the website of China Packaging Federation. What's more, we've also conducted some field investigations to collect the data of various packaging. Finally, we've received approximately 10 feedbacks of the questionnaires, which covers the main manufactures of the above three categories.

During the field survey, we've also found that most of the modern packaging enterprises have implemented the automation production line, which make it difficult to obtain process based environmental impact data.

According to the requirements, some analysis processing is done with relative information, reports and database. In the end, we get basic professional representative data of materials, energy consumption and environmental burden for typical packaging, and build corresponding database.

4 Packaging LCIA Modeling Framework

LCIA (Life Cycle Impact Assessment) model is the operational framework of conducting packaging LCIA. Based on the given LCIA model, we can evaluate the potential impacts of product life cycle environmental exchange; explain relative importance of various environmental exchange and contribution for environmental impact of each life cycle stage or each component. In our study, packaging endpoint category LCIA model is built (see Fig.2) based on Eco-indicator 99 method.

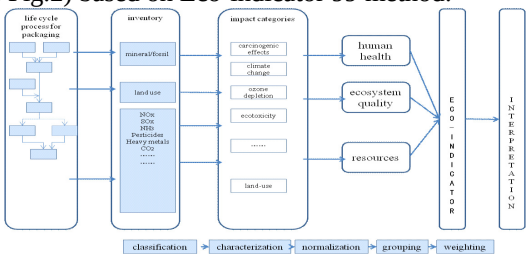


Fig.2 packaging LCIA model framework

Referring to the corresponding environment mechanism in Eco-indicator 99 method, packaging life cycle environment burden is divided into eleven impact categories: carcinogenic effects, respiratory(inorganic), respiratory(organic), climate change, radiation, ozone depletion, eco-toxicity, acidification/ nitrification, land use, minerals, fossil. These impact categories are divided in to three damage categories: human health, ecosystem quality and resources, finally a single eco-indicator is calculated from these three damage categories through normalization and weighting operation.

5 LCA Prototype System Design

Current LCA software is mostly desktop application with high costs of purchasing and use. As the internet development, web based system becomes the mainstream. Among various web systems, those based on B/S architecture can meet the LCA application demands of distribution and multi-domain.

We hope to build such a LCA management platform and tools to promote the communication among multi-participants to help gathering the fundamental data and analyzing the environmental impact.

The primary design goal of such system is to form a relatively complete chain of data collection and analysis, which can rapidly and effectively obtain and utilize information needed.

In the study, a B/S architecture based packaging LCA software system is developed which involves the technology of BPM（Business Process Management）and heterogeneous systems integration. It contains LCA common functions, and also integrates with database, all of which is in order to take advantages of data storage and processing, resource sharing. Users can build product life cycle process model and inventory data, assess product environment impact, interpret the LCA results, put forward measures to improve environment performance and establish product LCA report etc, which also realize collection and accumulation of LCA fundamental data .

To ensure maintainability and expandability of LCA system, the development of typical packaging LCA software system follows J2EE hierarchy mechanism strictly. The mechanism overcomes the defects of traditional C/S architecture, and conforms to the trend of the B/S architecture, providing an independent, transplantable, multi-user, safe and measured enterprise platform, which simplifies development, management and deployment of enterprise application.

Regarding to specific realization technique, basic framework of LCA system adopts MVC (Model/View/Control) three-tier hierarchy mechanism, and the struts framework is applied as the overall control engine. The system encapsulates core business into service layer, use spring component to realize business logic transaction and encapsulates relate components, persist data object model and manage database transactions with hibernate component. The software system uses SQL Server 2005 database management system. The WEB 2.0

978-1-935068-36-5 © 2010 SciRes

technologies such as AJAX, are used to develop flexible and various user interfaces.

6. System Functional Module

According to general system design philosophies, LCA system is divided into several functional modules (see fig 3).

1) Foundation functions module: it provides fundamental support services, including user management 、 authorization management、log management、system safety、system expanding and so on.

2) Product modeling module: the module realize research、analysis and definition of product LCA goal and scope product modeling, ensure function unit and allocation principle ,finish product model.

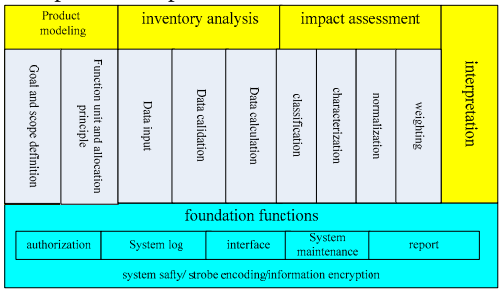


Fig.3 packaging LCA prototype system functional modules

3) Inventory analysis module: aiming at all energy and resource input and waste emission, the module evaluates product through quantitative analysis based on the data.

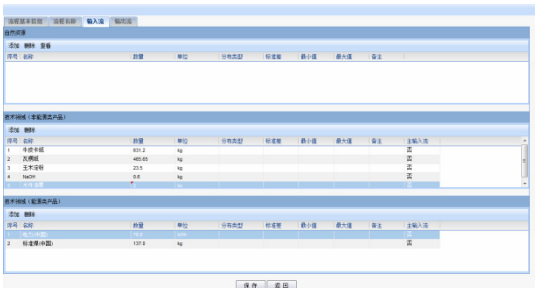
4) Impact assessment module: it aims at evaluating the significance of potential environmental impacts using the LCI results. The evaluation process is divided into five steps: classification、characterization、normalization、grouping and weighting.

5) Interpretation module: in this module, user can write down their LCA analysis data and measures to improve product environment performance, form product LCA report with LCA goal and scope.

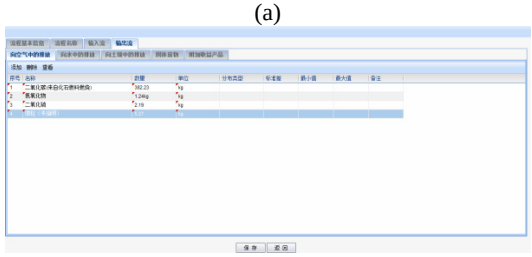
7 Pilot application and demonstration

We use the designed system to evaluate the life-cycle environmental impact of corrugated cardboard box. The following figures show different functions of the system.

Fig.4 Product process goal and landscape set of corrugated cardboard box



(a)



(b)

Fig.5 Input (a) and output (b) of corrugated cardboard box produce

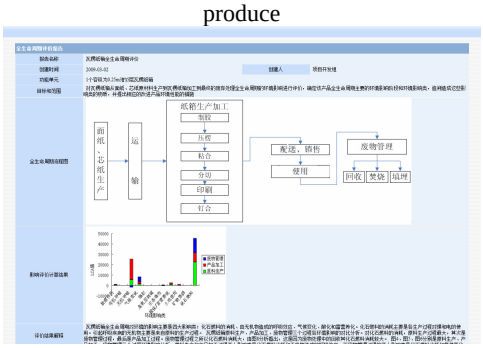


Fig.6 LCA report of cardboard box produce

8 Conclusions and Suggestions

With the advancement of China's packaging industry, the environmental impacts of both such industry and other related industries should be eliminated. The most important work to do is to set up a series of practical methods and support tools. Life cycle assessment has been proven to be an advisable method.

According to our practice, the biggest obstacle we've met with is the lack of fundamental data of raw materials as well as produce processes. So the web based open architecture LCA system is designed to facilitate fundamental data collecting and sharing, which can promote the LCA application progress in packaging industry consequently. The pilot application result shows that the life cycle assessment system designed can be used as a help software tool in LCA research and application of packaging. The software has a good performance in popularity and openness; it can also help to set up a more practical database conforms to the situation in China.

We also have some suggestions as follows:

(1)We should introduce the advanced LCA methods; carry out the research of environment impact mechanism

of emission substances, set up LCA methodology and database based on Chinese condition.
(2)Government authorities or industry associations organize and require enterprises to collect emission data during the production process actively, such as establish the “environmental report card” regulations, accumulate our own emission data, through which we can gradually build environmental analysis database.
(3)Put emphasis on LCA research of basis sources such as coal, oil and other basic industry materials, which supporting LCA application.

Acknowledge

This paper is sponsored by the “11th Five-Year Plan” to support science and technology project named “research on reclamation technology of package waste” (project ID: 2006BAC02A13).

Reference

[1] Qainjin Yang, Jiyong Liu, Xinmin Han “Investigation and application of LCA in packaging industry” Proceedings of 2008 China life cycle management conference-global trend and local practice

[2] Jiyong Liu, Qainjin Yang, Xinmin Han “Research of typical packaging’s life cycle assessment modeling” group technology& product modernization 2008,(04)

[3] Jiyong Liu, Qainjin Yang, Xinmin Han “Life cycle assessment of environmental impact of corrugated boxes” Research of environmental science, 2008(vol.21 No.6)

[4] Bihui Chen et.al, “LCA Analysis of Product Green Packaging”. PACKAGING ENGINEERING，2008，29（3）.

[5] Niels Frees. “Life cycle assessment of packaging systems for beer and soft drinks” Denmark: EPA,2005:6-7.

[6] Pascal Lesage.LCA in the economy-Where it seems to be going. USA: National Resource Conservation Challenge Workshop, 2008:10-12.

[7] CEN. ISO 14040:2006. Environmental management - Life cycle assessment – Principles and framework (ISO 14040:2006).: CEN，2006-07-01.

[8] CEN. ISO 14044:2006. Environmental management - Life cycle assessment -Requirements and guidelines (ISO 14040:2006).: CEN，2006-07-01.

[9] BoP.Weidema, Francesca Cappellaro, Raul Carlson et,al. Procedural guideline for collection, treatment, and quality documentation of LCA data.2003:12-13.

[10] Mary Ann Curran, Philippa Notten, Co-Chairs. “Summary of global life cycle inventory data resources” SETAC/UNEP, 2006:5-6.

[11] Mark Goedkoop, Michiel Oele, Ande Schryver, et al. SimaPro Database Manual Methods library. Netherlands: PRé Consultants, 2008:3-28.

978-1-935068-36-5