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PACKAGING LIFECYCLE ASSESSMENT
ANALIZA ŽIVOTNOG CIKLUSA AMBALAŽE

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ABSTRACT

Used and discarded packaging represents a significant environmental problem. In addition to the impact of used and discarded packaging, the entire lifecycle of packaging can affect the environmental disruption.

Llifecycle begins with the production of packaging materials and packaging, continues throw the packing process, after which packaging protects product to consumption, and then continues its lifecycle as discarded packaging.. In all stages of its lifecycle packaging has an impact on the environment, through the exhaustion of natural resources, energy consumption and pollution of air, water and land. To evaluate environmental suitability of each packaging material, balanced approach is required. Definitions and different models of lifecycle analysis as well as the procedure of evaluating the obtained data are given in the paper.

***Key words**: packaging, lifecycle, evaluation, ecology.*

REZIME

Osim pozitivnog uticaja na održivost upakovanih prehrambenih proizvoda, upotrebljena i odbačena ambalaža, može predstavljati značajan ekološki problem. Pored uticaja iskorišćene i odbačene ambalaže, na narušavanje životne sredine, u većoj ili manjoj meri, utiče i ceo životni ciklus ambalaže.

Životni ciklus ambalaže počinje proizvodnjom ambalažnih materijala i ambalaže, nastavlja se procesom pakovanja, ambalaža zatim prati upakovani proizvod do upotrebe, te nastavlja svoj životni ciklus kao odbačena ambalaža. Da bi se ograničio negativni efekat koji ambalaža ima na životnu sredinu, neophodno je definisati ekološki status ambalaže kroz analizu životnog ciklusa U svim fazama svog životnog ciklusa ambalaža utiče na okolinu, kroz iscrpljivanje prirodnih resursa, utrošak energije, zagađenja vaduha, vode i zemljišta. Iako finansijski opterećuje proizvod, a može predstavljati i ekološki problem, ambalaža je neophodnost.

Pri oceni ekološke podobnosti pojedinih ambalažnih materijala neophodnan je pristup uravnoteživanja pozitivnih i negativnih efekata. Analiza životnog ciklusa ili ocenjivanje životnog ciklusa (LCA - Lifecycle Assessment) je proces izračunavanja, pri kome se analiziraju i sumiraju svi utrošci (inputi) i sve emisije (autputi) tokom životog ciklsa određenog ambalažnog materijala. Pri ocenjivanju, vrednuje se potrošnja energije, emisija u vodu i vazduh, kao i nastali čvsti otpad. Osnovna metodologija se sastoji iz rastavljanja definisanog sistema na komponente, tj. korake procesa, te merenja masenog i energetskog bilansa za svaki izdvojeni korak procesa. Sumirani rezultati se mogu prikazivati preko eko bodova, ili multifunkcionalnih indeksa. Kranji cilj analize životnog ciklusa je smanjenje uticaja na životnu sredinu.

U radu su date definicije i različiti modeli analize životnog ciklusa, kao i način vrednovanja dobijenih podataka.

***Ključne reči:** ambalaža, životni ciklus, vrednovanje,ekologija.*

INTRODUCTION

The basic definition of packaging, "Packaging is a means to accept the product and protect it to use" includes all the integrated functions of packaging (*Lazić et al., 2008, Pajin et al., 2006*). Packaging protects the integrity and quality of the packed goods, preventing the loss of value of the product, as well as loss of energy and resources used for product production (*Robertson, 2006, Lazić et al., 2008, Lazić and Gvozdenović, 2007*). From the aspect of ecological production, use and disposal of packaging materials and packaging require comprehensive examination (*Lazić et al., 2009*).

The methodology of lifecycle assessment (LCA) is very dependent on the reasons why it is done.Lifecycle assessment of packaging may be needed for: defining the existing environmental burdens of a product or package, identifying possible improvements which is used to guide the development of production, or to support eco-labelling shemesand other kinds of information for consumers (*Boustead and Hancock, 1989, Lox, 1992, Boustead, 1990*).

Defining the current environmental burden of products or packaging allows comparison between different packaging materials and packaging. Often there is no simple answer to which packaging material is more suitable for the environment, but the analysis provides information about the compromises that can be achieved with any of the studied systems (Lazić and Gvozdenović, 2007).

Application of LCA to the existing packages can show where to apply improvements to environmental protection. In the LCA list can be seen which component releases harmful substances in what stage of the lifecycle, and accordingly improvements can be introduced.

To guide the development of production, and identify possible improvements of the existing packaging, lifecycle assessment may allow environment load to be seen through the development of new types of packaging. Different variations must be compared during development, so they need quick assessment of the lifecycle. This requires a model that is easy to use, a complex study which would take several months, would not be of much use.

Lifecycle assessment is used as a basis for the establishment of eco-labels for the dissemination of information to consumers about the impact on the environment. Manufacturers who are introducing packaging that is improved in terms of impact on the environment, for example, will want to quantify and publicize achieved improvements. This causes pressure for further development and standardization of lifecycle assessment methodology. Otherwise, there is a danger that political pressure to im-

plement will outpace efforts to provide scientifically valid and acceptable method of labelling.

Lifecycle assessment can be used for comparison, it allows comparison of environmental burdens associated with a number of packaging systems. Comparisons are made between, basically, similar systems, such as the original packaging as opposed to reduced packaging weight. In such simple cases, life-cycle assessment is used to confirm the intuition, but also to measure the effects of such changes.

Sometimes, however, the same product can be packaged in different packaging, where the determination of the lifecycle is used to compare the overall environmental load.

MATERIAL AND METHOD

Lifecycle assessment is basically a process of calculation, in which all the necessary inputs and emissions of packing systems are listed, and then summed. This is an inclusive approach, because (*Hunt et al., 1992*):

– LCA includes all components of a packaging system. A full analysiswill include shipping materials as well as the primary and secondary packaging that reaches the consumer.
– LCA includes all inputs and emissions from the system. This includes not only direct inputs and emissions for production, distribution, use and disposal, but also indirect inputs and emissions, e.g. from production of the energy used during the processes.
– LCA integrates over time, i.e. all inputs and emissions over the whole lifecycle.
– LCA includes all sites involved.
– LCA integriše efekte svih sastavnih procesa u toku životnog ciklusa ambalaže. Postoji nekoliko različitih metoda koje se koriste za dobijanje sirovina ili stvaranje potrebne energije, kao što postoji i mnogo potencijalnih puteva za distribuciju ili odlaganje nakon upotrebe.
– LCA integrates the effects of all the constituent processes in the package's lifecycle. There may be several different methods used to obtain raw matwrials or to generate the power used, as there will be many possible routs for distribution or disposal after use.
– LCA integrates all issues. Different methods of reducing the environmental impact of packaging, such as source reduction, reuse or recycling can all be included, and their effect evaluated.

Comprehensiveness is very important in the analysis of LCA. It is necessary to assure that improvements in one area of the environment, or one phase of the lifecycle, does not mean greater pollution of the environment on the other side (*IMSA/IPRE, 1990*). Recycling of materials, for example, can reduce the amount of solid waste, but can result in increased energy consumption and emissions as a result of collecting, transporting and re-processing. Improvement of the environment, regardless of whether it is used for eco-labels or decision-making during the development of packaging, must be the result of evaluating the entire product lifecycle.

Analysis of the life cycle in terms of determining the usefulness and impact

This analysis includes adjustment of packages (or products) utility to the buyer, or society. Broadly speaking, in relation to the impact of the packaging on the local and on the global level (*Levy, 1993*).

It can be very difficult to determin the impact and utility of single packaging system. Utility to consumers and environmental impact can be balanced only with information from consumers. Therefore, in practice data obtained from consumers for evaluating two different products (packaging) is used to compare the impact on the environment for each products (packaging) separately. Measuring utility can be analyzed taking into account all the functions of packaging. Packaging has many functions, but most important is the transfer of products to consumers. As such, one of the measures of usability and therefore utility is the amount of product that is being delivered in good condition (no mechanical damage or contamination), to the consumer. Life cycle assessment of packaging is often compared to the same weight or volume of the packed products (*NAGEL, 1991, Lox, 1992*). The final utility measure is customer satisfaction.

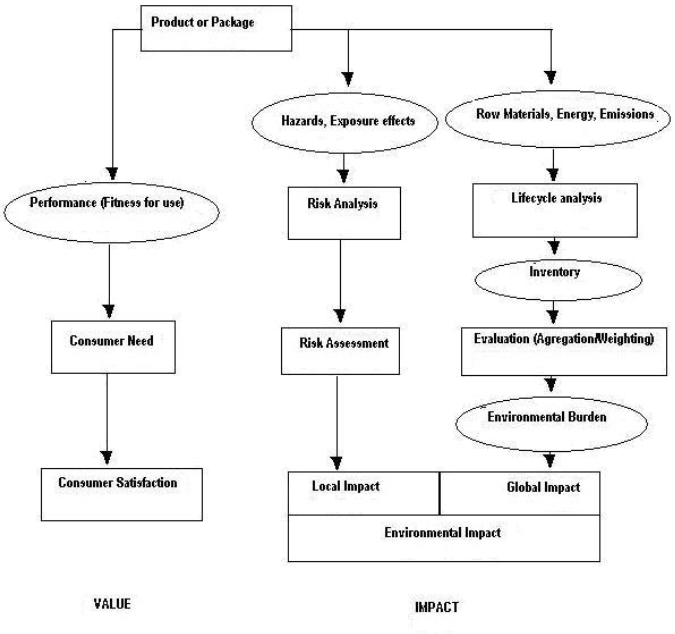

Fig. 1. Lifecycle analysis in context of value and impact

For example, in analyzing the lifecycle of plastic bottles the production of raw materials, ie. oil extraction, refining processes, polymerization and granulation must be taken into account. All these stages require energy and raw materials, and provide products that appear in the form of emissions to air, water or solid waste. After that, the bottles are produced by blowing, and closures by injection molding, each of these methods requires additional energy. Electrical energy is created in power plants using coal or oil, nuclear power plants, each of which requires its own raw materials and produces its own range of emissions. When the bottles are filled, distribution, use and disposal of waste must be taken into account. Then comes dealing with waste. Of a number of bottles throw the recycling process new bottles can be produced. This includes recycling collection, transport and then reprocessing

Complete packaging LCA should not be stopped on the bottle, but should include a complete system that is necessary to enable the product to come to the consumer (transport boxes, shrink film, as secondary and tertiary packaging).

Impact on the environment is not what the evaluation or analysis of the life cycle scale. What is obtained evaluating the life cycle, are some indications of the effects that lifecycle inventory has on the environment, and as such, can be defined as a burden to the environment. To determine the overall impact on the environment, risk assessment is required, which is basically a different procedure from evaluating the life cycle.

RESULTS AND DISCUSSION

Figure 2 shows the model that defines the procedure for calculating the sum of all inputs and outputs during the lifecycle. The basic methodology consists of defined process disassembly in the components of a process steps, and then measuring the mass and energy flows in and out of each process (*Habersatter, 1991*).

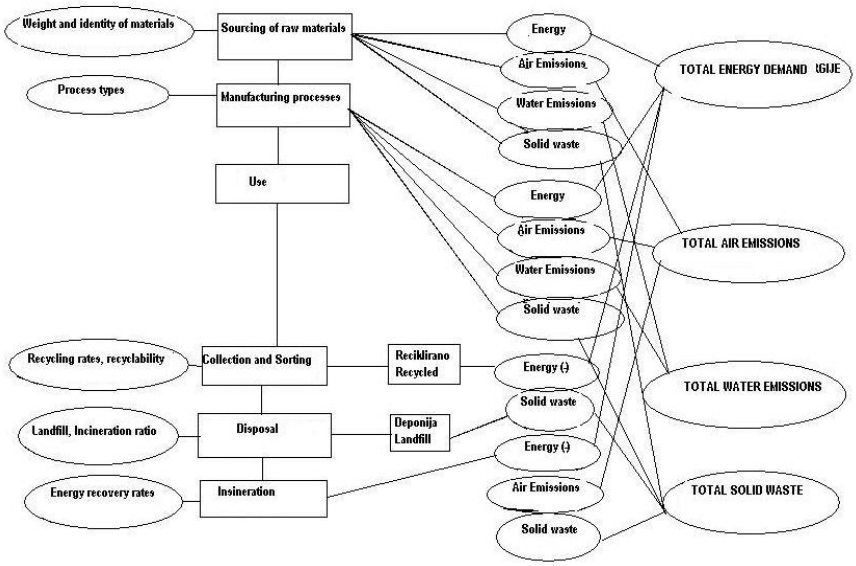

Fig. 2. A shematic showing the working of the lifecycle model

Output analysis of life cycle is inventory, a list of total amount of material and energy consumption and individual materials to be emitted as a waste in air, water or land. Conversion of inventory to environmental impact is required. Evaluation of life cycle inventory includes two inter-related processes (a) merging and (b) the conversion of inventory into effects. The largest number of models for evaluating the impact of packaging lifecycle of on the environment combines the energy consumption, emissions to air, emissions to water and solid waste (*Habersatter, 1991*).

Environmentmental impacts

Environmental impacts are expressed through eco-points and multi-factorial index. Eco points are defined as units of environmental pollution (*Ahbe et al., 1990*). Summary of eco-points shows the extent of environmental burdens. Bigger number of eco-points, the greater the burden.

$$\text{The eco-factor (EF)}=(1/Fk)x(F/Fk)xc \quad (1)$$

where F=excisting emission/energy consumptionlevel, Fk=maximum loading level which does not cause irreversible damage, c=a constant,

Then,

$$\text{Eco-points}=E \times EF \quad (2)$$

For each emission/energy consumption, where E=emission mass/energy consumption calculated for lifecycle.

The second summing principle uses multi-factorial index (*Ryding and Steen, 1991, Ryding,1992*). Here, separate environmental indicesare defined for natural resource use, substance effects (emissions), materials and processes. Indices for natural resource use the effects of substances, each of which consists of several „ecological scores“, multiplied together to give a numerical value for the index. Indices are expressed as environmental load units (ELU) per unit mass (for substances), per square metre (for land) or per megajoule (for energy).

Reducing the negative impact of packaging on the environment is supported by legislation on the management of packaging and packaging waste (*Dulić, 2009, www.ekoplan.gov.rs*).

CONCLUSION

Packaging has a great impact on the quality of our lives, for the implementation of its many features meets our individual needs. Packaging accept the product, transfers it to the consumer, protects it from negative influences, informes the customer, allows easy use of the product, should be economically justified and environmentally suitable. At every stage of its lifecycle packaging has an impact on the environment. From the analysis of life cycle of packaging, relevant information may be obtained, whose carefull interpretation can influence the improvement of the ecological status of packaging and reduced environmental load.

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