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ARCHIVES of FOUNDRY ENGINEERING

DOI: 10.2478/afe-2013-0004

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (2299-2944)
Volume 13
Issue 1/2013

19 – 22

Comparative Analysis of Environmental Impacts of Selected Products

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Received 11.07.2012; accepted in revised form 04.09.2012

Abstract

The purpose of the present study is to demonstrate that environmental impacts exerted by manufactured products throughout their entire life cycle are major aspects to be considered, alongside their functional features and cost-effectiveness. One of the available methods to evaluate environmental impacts is known to as the Life Cycle Assessment (LCA) method.
The study summarises the reports from the literature on the subject of environmental impact assessment. In conclusions, the authors indicate the need for assessing the environmental impact of cast products made from conventional and newly introduced alloys.

Keywords: Ecobalancing analyse, Life cycle assessment, Life cycle costing, Technical object

1. Introduction

In the context of sustainable development, it is required that environmental impacts of products, processes and manufacturing techniques should be thoroughly assessed. Until recently, economic development has been perceived mainly in terms of functional features and cost-effectiveness parameters. Nowadays the concept of economic development has become broader, involving also environmental considerations alongside technical and economic aspects.

Environmental impact assessment procedures typically use eco-development indicators based on information about the quality of environment, also referred to as the level of environmental damage. These include partial factors (having relevance to particular components of the environment) or integrated factors. The selection of indicators to be used usually depends on whether they can be obtained and applied in the given circumstances [9-11].

The Life Cycle Assessment (LCA) approach can be widely employed in applications where either partial or integrated indicators are sought [1-12]. When the Life Cycle Assessment incorporates the Life Cycle Cost (LCC) analysis, the economic and environmental aspects can be effectively combined in the decision-making processes (Fig 1).

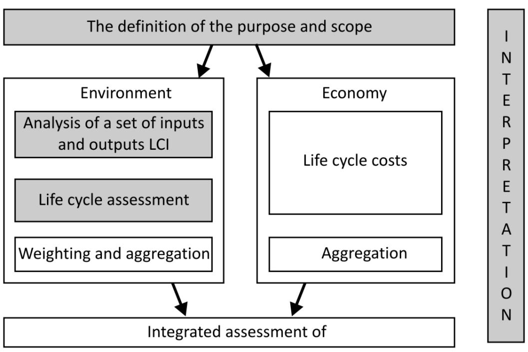

Fig. 1. Schematic diagram of the eco-effectiveness analysis [6], the stages revealed in grey fields represent the elements of the LCA analysis in accordance with the standard PN EN-ISO

The analyses by the LCA method are difficult and time-consuming as the procedures are most complex and a vast body of up-to-date information is required on materials and energy flow (input and output), manufacturing of a given product, the stages of its use and its disposal. These difficulties can be overcome through the use of available databases (Buwal, Ecoinvent) and applicable software supporting LCA analyses (SimaPro, Umberto, BEES, Boustead LCA model [1,4 ,5]. For example, SimaPro package [4,5] enables us to select the calculation procedure, including the estimation of environmental load based on the indicator Eco-indicator 99.

To display the negative environmental impacts and results that are easy to interpret, the number of categories of environmental damage is restricted to three: I- Damage to Mineral and Fossil Resources; II- Damage to Ecosystem Quality, III- Damage to Human Health. The factors to be handled in the subsequent steps of the procedure to compute the Eco-indicator 99 are shown in Fig 2.

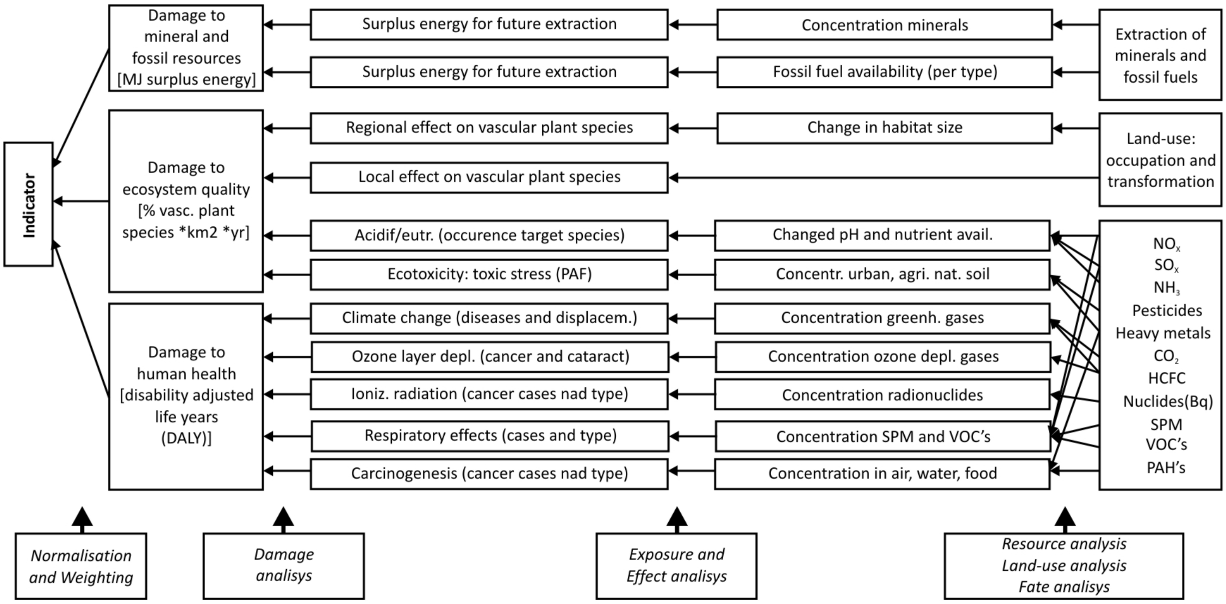

Fig. 2. Procedure for computing the eco-indicator 99 [4, 5]

Evaluation of selected products

Environmental effects of the metal products, including castings are reported in several publications by Polish authors.

The assessment of environmental effects involves the comparative study of:

- products manufactured by selected branches of national industries (Fig 3)
- three groups of materials: aluminium, grey cast iron, ductile cast iron DILIGHT to determine their environmental impacts and to select the optimal material, the optimisation criterion being the energy consumption and contribution to the global greenhouse effect (Fig 4)
- constructional materials for a packaging machine (Fig 5) and its major subassemblies (gear transmission), Fig 6
- materials used for manufacturing water meters (Fig 7)

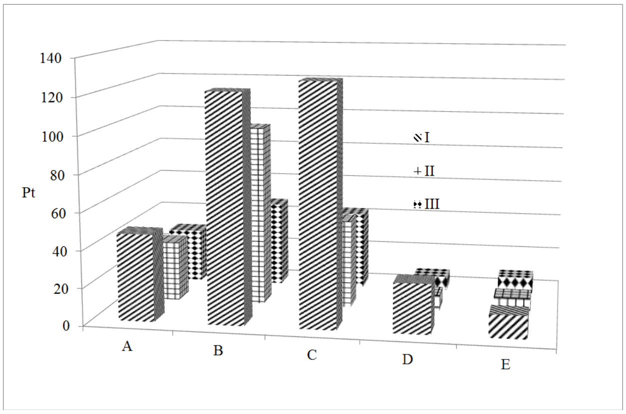

Fig. 3. Results of LCA analysis in the form of a histogram. Source: Central Statistical Office, functional unit 1000 PLN of products [11];

A- production of aluminium and products made of Al, B- production of Pb, Zn, Sn and products made of Pb, Zn, Sn, C- production of artificial fertilisers and nitrogen compounds, D- production of glass and glassware, E- production of salt

I- Damage to Mineral and Fossil Resources,

II- Ecosystem Quality

III- Human Health

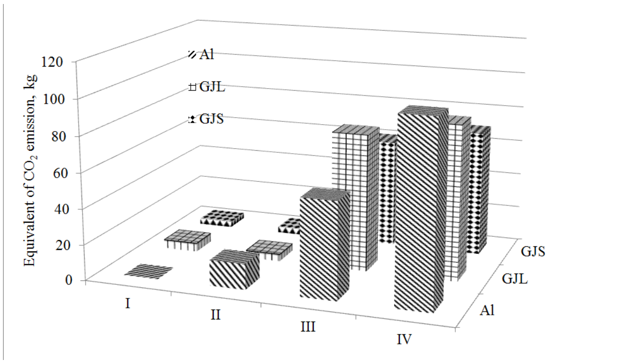

Fig. 4. Comparison of global greenhouse potential (expressed by the equivalent of CO_2 emission) for various stages of life cycle of three types of castings: casting made from aluminium alloy with the mass (3.5 kg), castings made from ductile cast iron (4 kg) and grey cast iron (5 kg); calculation procedure supported by Boustead LCA Model software [1]

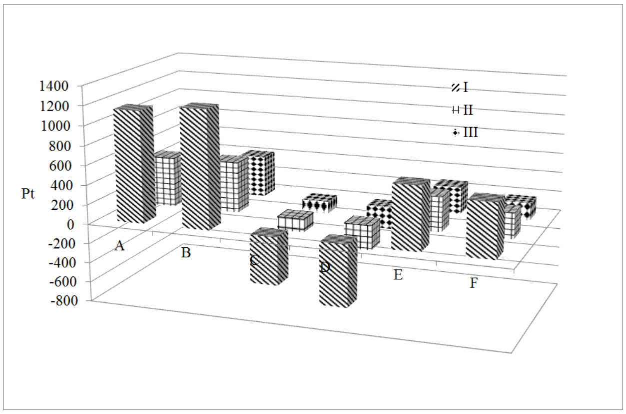

Fig. 5. Comparison of environmental impacts exerted throughout the life cycle of a packaging machine when the proportion of aluminium is increased in machine components [12]; A, B – Production; 15%, 30% Al; C, D – Recycling; 15%, 30% Al; Life cycle; 15%, 30% Al

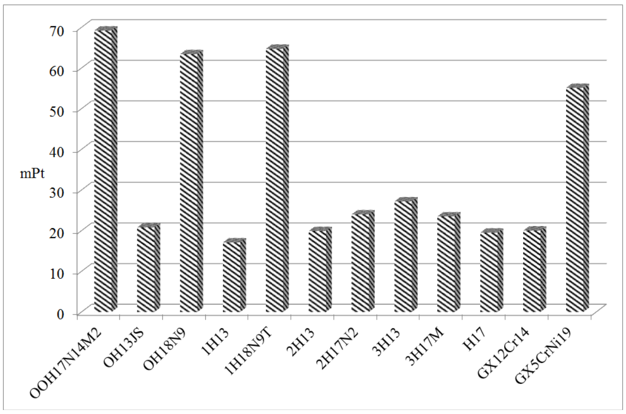

Fig. 6. Environmental impacts exerted by materials for wheels in gear transmissions [7]

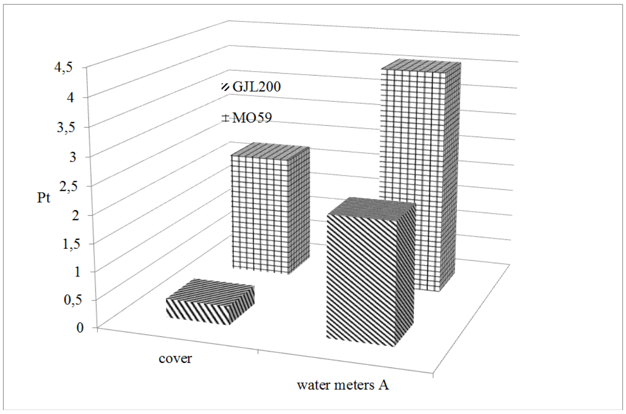

Fig. 7. Suggestions of pro-environmental measures to be put in place following the eco-balance for 8 types of water meters [5]

The data provided in this study should be treated as approximations only as they cannot be fully verified without knowing the applied computational procedure, yet they prove most useful in comparative analyses.

In the case of cast products, the strongest negative impacts are registered at the stage of manufacturing, the environmental effects are becoming more positive at the stage of their operation and recycling.

2. Conclusions

The Life Cycle Assessment approach allows for analysing the impacts that products, machines, installations, manufacturing processes and technologies have on the environment, prompting pro-environmental rationalisation of manufacturing and maintenance procedures. The approach involves the manufacturing processes, technologies and materials, hence the benefits of the LCA methodology applied to products, designs and new technologies are concurrent.

Presentation of results based on one integrated eco-indicator or partial indicators (with no subjective weighing) allows the environmental effects to be compared and the best solution to be selected. Creating the demand for casting products requires comparative environmental analyses of manufacturing materials, both conventional and newly introduced.

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