Life Cycle Inventory Analysis – A Case Study of Steel Used in Brazilian Automobiles

Cássia M.L. Ugaya1* and Arnaldo C.S. Walter2

1 Centro Federal de Educação Tecnológica do Paraná (CEFET-PR), Av. Sete de Setembro, 3165, Curitiba, Paraná, Brazil
2 Universidade Estadual de Campinas (Unicamp), Campinas, São Paulo, Brazil

* Corresponding author (cassia@cefetpr.br)

Abstract

DOI: http://dx.doi.org/10.1065/Ica2004.09.180.5

Data acquisition to perform LCA is time and capital consuming. There is already international data about environmental aspects in several processes. This study aims to verify the possibility of adapting international data to Brazilian conditions. Therefore, a Life Cycle Inventory was conducted to compare the use of national and international data for steel used in automobiles. This was done in three steps: objective and scope definition, inventory analysis and interpretation. LCI is a simplification of Life Cycle Assessment (LCA) as impact assessment is not taken into account. Even so, LCI takes into account all life cycle stages of a product, that is, from its extraction through its deposition. In this study, three phases of the life cycle were considered: steel manufacturing, automobile use and disposal. In the case studied, the amount of steel evaluated was 263 kg, which would be possible to be replaced by other materials in a 1,300 kg automobile. Resources and energy consumption, atmospheric emissions and solid residues production were taken into account within the analysis done. Results show that automobile use and materials manufacturing are responsible for the bulk of energy and resources consumption. Solid residues occur mainly in the discard phase, due to the low level of recycling. Several differences were also achieved between national and international data, which implies the need of environmental databases development.

Keywords: Automobile; life cycle assessment; steel, recycling

Introduction

Life Cycle Assessment (LCA) is a tool to evaluate environmental impacts through the life cycle of a product, that is, from resources extraction to final product disposition [1]. Several studies divide this methodology in four interrelated steps: aim and scope definition, inventory analysis, impact analysis and improvement analysis [1–3]. The latter is known by ISO [4] as an interpretation step and is linked to all the other steps.

Data acquisition to perform LCA is time and capital consuming. There is already international data about environmental aspects in several processes. Therefore, the aim of this study is to verify the possibility of adapting basic international data to Brazilian conditions. In order to achieve this aim, it was performed a Life Cycle Inventory comparison between the use of national and international data for steel used in automobiles.

Due to the large amount of data necessary to develop an LCA, a preliminary evaluation (PE) was performed as shown in Fig. 1 to help define the scope of the study. The goals of the PE were to identify environmental impacts in the life cycle of automobiles and evolution in automobile production, mainly those related to new materials and fuels.

In the course of this evaluation it was found out that, worldwide, the automobile industry is responsible for the consumption of 20% of steel, 10% of aluminium [7], 7% of plastics [8] and 75% of casted magnesium [9]. Additionally, it was observed that from 1978 to 2001 there was a 5.2% decrease on the automobile weight in average in the USA [7]. The same authors reported that in 2001 the share of steel in an average US car was 40.8% of conventional steel, 10.6% of high-strength steel, and 2.4% of other steels. Despite a decreasing tendency during this period, on a mass basis steel is still the most used material in automobiles.
Table 1: Environmental aspects and impacts in automobile life cycle

<table>
<thead>
<tr>
<th>Life Cycle Steps</th>
<th>Environmental aspects or impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Resources consumption</td>
</tr>
<tr>
<td>Resources extraction and transportation</td>
<td>Surface</td>
</tr>
<tr>
<td></td>
<td>Underground</td>
</tr>
<tr>
<td></td>
<td>Materials processing</td>
</tr>
<tr>
<td></td>
<td>Automobile assembly</td>
</tr>
<tr>
<td></td>
<td>Use</td>
</tr>
<tr>
<td></td>
<td>Discard*</td>
</tr>
</tbody>
</table>

Regarding environmental aspects and environmental impacts of the automobile life cycle, Table 1 presents a summary of information gathered from several studies [10–35]. Results suggest that the most important issues are water and energy consumption (mainly in materials processing and use stages), solid residues (mostly caused by automobile discard) and atmospheric emissions (mainly during the combustion process).

1 Case Study – Steel Used in Automobiles Produced in Brazil

1.1 Aim and scope definition

Based on average US figures, previously presented, it was assumed that a typical automobile of 1,300 kg has 878 kg of steel and that 30 per cent of this material, i.e., 263 kg, can be substitute by other materials.

Regarding the life-cycle assessment, three phases were considered, as shown in Fig. 2. The materials production (either primary or secondary), the use of the automobile and its discard. The analysis was restricted to Brazil and the collected data were from the year 1998.

The Brazilian motor vehicle and automotive parts industry consumed respectively 1,567 and 2,024 thousands of tons of steel in 1996 and 2002, which accounted for 12.4% and 12.8% of the national production, respectively [36–37].

![Fig. 2: Life cycle stages](image-url)