Chapter 12
Multi-Perspective Eco-Efficiency Assessment to Foster Sustainability in Plastic Parts Production: An Integrated Tool for Industrial Use

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ABSTRACT

The eco-efficiency assessment is a powerful metric to introduce two components of sustainability assessment in the industrial companies’ decisions making: the concurrent consideration of economic and environmental performance. The application of the eco-efficiency concept and of the normative documents is not an easy task, mainly because there are myriad environmental related indicator to consider and acquire. This barrier is higher in the realm of plastic injection molding, where each mold is unique, requiring a recurrent effort of data retrieving for such one-of-a-kind molds. To overcome this barrier, an integrated framework to support the eco-efficiency calculation on a life cycle perspective for a specific type of products, injection molds, is proposed in this chapter. It retrieves a small but representative selected set of eco-efficiency performance indicators. A tool was developed to apply the proposed framework and the results of its application to four real industrial case studies is discussed.

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INTRODUCTION

Plastic is one of the most common and versatile materials used worldwide, being used to produce a wide variety of products (Ribeiro et al., 2013; Ribeiro et al., 2014) and bringing extensive economic benefits due to their combination of low cost, durability and light weight, among other important characteristics (Ellen MacArthur Foundation, 2016). Most of these plastic products are manufactured through the use of moulds in the injection moulding process, which is a significant cost driver in the plastic industry and simultaneously regulates the injection moulding process efficiency (Ribeiro et al., 2009). Any change in the mould design can affect significantly the injection moulding efficiency and effectiveness, the investment and the production costs and also the resources consumed, emissions, i.e. the environmental impact.

In the injection moulding industry there is an increasing competiveness, even in countries with low production costs. As such, new and innovative technologies and adaptable business models are likely to be developed in order to increase value and decrease cost, without compromising on process efficiency and without increasing environmental impacts (Folgado et al, 2010; Pecas et al, 2009; Ribeiro et al., 2016). To accomplish that in the mould’s use phase (injection moulding), it is crucial to improve the plastic part’s material requirements and the consumed energy because these are considered as the most relevant factors for the economic and environmental performance in this process. The performance in those two aspects, depends on the mould design (which determines the cycle time and the amount of material wasted in the process) and also depends on the injection machine type and power (Thiriez & Gutowski, 2006; Ribeiro et al, 2012, Ribeiro et al., 2013). In the realm of the injection mould industry, moulds with better performance in their use phase require more complex and high embedded engineering, as well as more effort in the manufacturing phase of the mould. As such, this may lead to higher production costs as well as higher energy and material consumption in manufacturing – yet, by assuming that a single mould can produce up to a few million parts, the significance of the economic and environmental impacts of the manufacturing phase in the plastic part overall performance may be considered as residual (Noble et al., 2014; Esteves et al., 2014). As such, a life cycle perspective should be adopted when selecting the most adequate mould design, considering the environmental and cost impacts of mould manufacturing, use and end-of-life phases. So, the evaluation of all life cycle phases is necessary to allow an informed and sustainability conscious decision making process.

A few analyses comprising life cycle of injection moulds have already been developed (Pecas et al., 2009;Ribeiro et al., 2013;Esteves et al., 2014; Pun et al., 20033). These studies focus mainly the comparison of mould design alternatives on a technological scope considering life cycle cost (LCC) and life cycle assessment (LCA) methods. These publications focus on the selection of the most appropriated mould design for a specific application or part geometry and materials. Nevertheless, those analyses do not include the business specificity and the industrial company context. As such, very important aspect to help the industrial decision-making like added-value and profit, as well as significance of the environmental impact to the society are not taken into account in that type of analysis. The inclusion of these aspects within a life cycle analysis (of the alternative mould design) can bring comparison strategy more close to the decision-making processes currently used in industrial companies. There is a concept of the realm of sustainable manufacturing that can help on this analysis: the Eco-Efficiency.

Consequently, the aim of this chapter is to present a tool for industrial use allowing for the operationalization of the practice of Eco-Efficiency in the part and mould design decision-making processes. Broadening the discussion, one can say that understanding the sustainable development definition is the starting point to develop an approach to assess Eco-Efficiency for the specificities of the sector of moulds.