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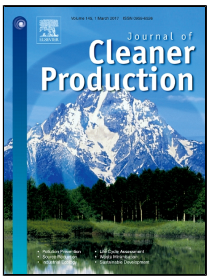


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# A New Lightweight Design Method Integrating Shape Optimization with Life Cycle Assessment for Extrusion Dies

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## Abstract

Extrusion dies, in which melted raw materials are forced continuously into a profile to produce various plastic products, are often empirically designed leading to overweight and waste in materials, energy and emissions. Lightweight design method has been applied to reduce weight and increase material efficiency of extrusion dies at design stage. However, the research work was often focused on weight reduction with function requirements as the design constricts. Environmental impacts (EIs) over the entire life cycle of dies are not considered, as a result, it may result in environmental burdens being shifted from design stage to other stages of life cycle of products. Aiming at it, a new lightweight design method is proposed to integrate life cycle assessment (LCA) with shape optimization. The optimization mathematic models for the proposed method are developed, in which the EIs of extrusion dies are modeled as a function of shape variables and processing parameters. An example of extrusion dies for plastic pipe was presented to illustrate the effectiveness of the proposed method. The results showed that 13% weight reduction whist achieving reduction in EIs over the life cycle of dies in comparison with 18% weight reduction yet 29% increase in EIs at manufacturing stage and resultant increase in EIs over the life cycle using conventional lightweight design method in which EIs are not taken into account. It indicated that the proposed lightweight method could have great potentials to reduce weight and prevent environmental burdens shift problem.

**Key words:** Lightweight design; shape optimization; environmental impact; LCA

## 1 Introduction

Extrusion dies in which melted raw material is forced continuously into a profile are widely used for production of various plastic products. Traditionally, extrusion dies are often over engineered due to lack of advanced numerical simulations, which has directly led to overweight of dies and its associated waste in materials and excessive energy for material extraction, operation and recycling. Some studies on the numerical simulation have been carried out to improve products quality, extrusion performance