Accepted Manuscript

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

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PII: S0959-6526(17)30412-2

DOI: 10.1016/j.jclepro.2017.02.186

Reference: JCLP 9112

To appear in: Journal of Cleaner Production

Received Date: 02 March 2016

Revised Date: 02 February 2017

Accepted Date: 25 February 2017

Please cite this article as: Yan He, Tao Huang, Yan Wang, Yi Nie, YuFeng Li, Yulin Wang, A New Lightweight Design Method Integrating Shape Optimization with Life Cycle Assessment for Extrusion Dies, *Journal of Cleaner Production* (2017), doi: 10.1016/j.jclepro.2017.02.186

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ACCEPTED MANUSCRIPT

1	A New Lightweight Design Method Integrating Shape Optimization with Life
2	Cycle Assessment for Extrusion Dies
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8	
9	Abstract
10	Extrusion dies, in which melted raw materials are forced continuously into a profile to produce various
11	plastic products, are often empirically designed leading to overweight and waste in materials, energy
12	and emissions. Lightweight design method has been applied to reduce weight and increase material
13	efficiency of extrusion dies at design stage. However, the research work was often focused on weight
14	reduction with function requirements as the design constricts. Environmental impacts (EIs) over the
15	entire life cycle of dies are not considered, as a result, it may result in environmental burdens being
16	shifted from design stage to other stages of life cycle of products. Aiming at it, a new lightweight
17	design method is proposed to integrate life cycle assessment (LCA) with shape optimization. The
18	optimization mathematic models for the proposed method are developed, in which the EIs of extrusion
19	dies are modeled as a function of shape variables and processing parameters. An example of extrusion
20	dies for plastic pipe was presented to illustrate the effectiveness of the proposed method. The results
21	showed that 13% weight reduction whist achieving reduction in EIs over the life cycle of dies in
22	comparison with 18% weight reduction yet 29% increase in EIs at manufacturing stage and resultant
23	increase in EIs over the life cycle using conventional lightweight design method in which EIs are not
24	taken into account. It indicated that the proposed lightweight method could have great potentials to
25	reduce weight and prevent environmental burdens shift problem.
26	Key words: Lightweight design; shape optimization; environmental impact; LCA
27	
28	1 Introduction
29	Extrusion dies in which melted raw material is forced continuously into a profile are widely used for
30	production of various plastic products. Traditionally, extrusion dies are often over engineered due to
31	lack of advanced numerical simulations, which has directly led to overweight of dies and its associated
32	waste in materials and excessive energy for material extraction, operation and recycling. Some studies
33	on the numerical simulation have been carried out to improve products quality, extrusion performance

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