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MULTI-OBJECTIVE OPTIMIZATION OF ALUMINIUM FOAM MANUFACTURING PARAMETERS

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Abstract

Aluminium foams are a new class of materials with low densities, large specific surface and novel physical and mechanical properties. Their applications are extremely varied: for light weight structural components, for filters and electrodes and for shock or sound absorbing products. Recently, interesting foaming technology developments have proposed metallic foams as a valid commercial chance; foam manufacturing techniques include solid, liquid or vapour state methods. The foams presented in this study are produced by Melt Gas Injection (MGI) process starting from melt aluminium. The objective of this paper is to develop a method for the analysis of the effects of process parameters on the quality of foam parts and to determine their optimal combination. The effects of the foaming parameters are studied by the Taguchi method, applied to design an orthogonal experimental array. A multi-objective optimization approach is then proposed by simultaneously minimizing the relative density and maximizing the absorbed energy efficiency.

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Key Words: Aluminium Foam, Melt Gas Injection Process, Taguchi Method, Multi-Objective Optimization

1. INTRODUCTION

Metal foams are relatively new materials which have attracted the increasing attention of industries, especially of automotive industry, around the world for their novel physical and mechanical properties. A disadvantage of metal foams is the inhomogeneity due to the stochastic nature of manufacturing processes. However the goal of production is not to achieve necessarily homogeneous structure, but predictable properties in a reproducible way. Thus, in order to obtain the desired parts it is necessary to study the influence of foaming parameters.

The melt-foaming process is a continuous, gas injection method developed simultaneously and independently by Alcan [1] and Norsk Hydro [2] in the late 1990s and it is called Melt Gas Injection (MGI). The starting material, usually a metal matrix composite, is molten with conventional foundry equipment and transferred to a tundish where gas is injected in it via a nozzle incorporated into a rotating impeller, thus forming a dispersion of small bubbles. Fig. 1 shows a sketch of the process [2]. The reinforcing particles are typically SiC or Al_2O_3, the volume fraction ranges from 10 to 20 % and the mean particle size from 5 to 20 mm. The ceramic particles trap gas bubbles owing to the favorable interface energy and serve as stabilizer of the cell walls and delay their coalescence. They also reduce the velocity of the rising bubbles by increasing the viscosity of the melt and the relative stabilising mechanisms are discussed in literature [3-5]. The bubbles size can be controlled by adjusting the process parameters: the gas flow rate, the propeller design (number of nozzles and their

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