Proportional Gradient Method for Minimizing Casting Defects: Numerical and Experimental Application on Aluminum Alloy A356

Kharmanda, G.; Abdalla, M.; Kachit, M.; Verdu, C.*

Faculty of Mechanical Engineering, University of Aleppo, Syria

*Institut National des Sciences Appliquées de Lyon, France

mgk@scs-net.org

Abstract

Mechanical properties such as high corrosion resistance, ductility, and electrical and thermal conductivity of aluminium alloys strongly depend on their microstructure. Relationships between the microstructure and macroscopic properties can be established using a variety of experimental and numerical methods (Kulkarni et al. 2004). The A356 Aluminum alloy is considered as one of the most useful alloys in manufacturing of mechanical parts, especially, in the transportation and spatial industries such as aircraft pump parts, automotive transmission cases, and water-cooled cylinder blocks. In this paper, we propose a Proportional Gradient Method (PGM) based on sensitivity concept for reducing the casting defects for aluminum alloy A356. Here, we seek to minimize the resulting porosity volume considering some casting parameters that leads to overcome defects such as gas and shrinkage porosity and also refinement of microstructure and then to improve the product quality. Therefore, it is the objective to synthesize the optimal microstructure for satisfying user-defined design requirements. A numerical simulation method such as finite element analysis is used to simulate the casting process. A numerical sensitivity study is next carried out to show the influences of different casting parameters. However, in order to obtain precise derivatives, Kharmanda (2003) developed an accurate finite difference model based on Taylor's series. The sensitivity study depending on the developed finite difference model is carried out to find the different parameter influences. We then select three casting parameters: mold temperatures (0-500C°), filling ratios (50-100%) and filling gate sections (600-1600mm²). According to our numerical sensitivity results, we note that the most important parameter is the filling gate section. The proportional gradient of these efficient parameters are considered during the optimization process in order to obtain a good improvement of the studied casting product. The efficacy of the optimization scheme is also evaluated by comparing the experimental results with the numerical optimal values.

Key Words: Sensitivity Concept, Optimization Methods, Aluminum Alloy A356.

References

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