A Model of Heat Transfer in Metal Foaming

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Abstract

Metal foams are interesting materials with many potential applications. Foamed metals or alloys include gas voids in the material structure and therefore the density is introduced as a new variable, with the real possibility to modify ad hoc their physical properties. In the indirect foaming process carried out in a furnace, simultaneous mass, momentum and energy transfer between three phases, solid, liquid and gas, should be taken into account. These mechanisms have major effects on the quality of metal foams, but mostly overlapped and are difficult to analyze.

Computational methods can represent a powerful tool for investigating these phenomena, although the computational work is very challenging. In this work we use COMSOL Multiphysics® software to model the heat transfer process during the foaming of a solid precursor made of a compacted mixture of an aluminium alloy and TiH2 powder as a blowing agent. The precursor is heated in a steel mold (Fig. 1) placed in a furnace. The experimental temperature profiles of the heating process, obtained previously in the laboratory, are used for setting up the model. The geometrical 3D model of precursor and mold has been imported into COMSOL Multiphysics by exploiting the capabilities of the CAD Import module. Transient radiative, convective and conductive heat transfer mechanisms are all taken into account for a metal foaming process carried out in a three dimensional geometry.

In particular to set up the real emissivities of the metal surfaces, experimental thermal data have been used. In our work the turbulence of the fluid flow is represented by using the k-epsilon equations available in the COMSOL CFD Module. The numerical results of the temperature in the system precursor-mold-furnace, obtained by exploiting the Heat Transfer Module features, are compared with the experimental temperature data (Fig. 2) measured by thermocouples in the same simulated conditions. Useful insights from this comparison have been drawn both for tuning the model and for a better comprehension of the precursor foaming process. Then, the computational model has been used to foresee the temperature profiles of the foaming process of a machine tool component, allowing us to optimize the research work.

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Figures used in the abstract

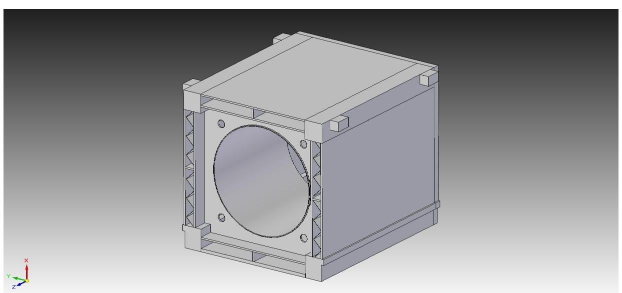

Figure 1: The steel mold filled with the metal foam precursor.

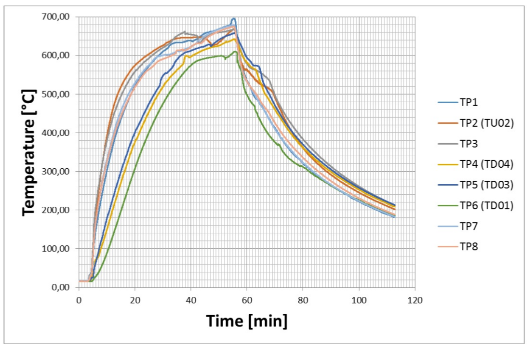

Figure 2: Experimental temperatures data of the steel mold.

Figure 3

Figure 4