Modeling of high temperature- and diffusion-controlled die soldering in aluminum high pressure die casting - DTU Orbit (04/12/2018)

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Soldering of cast alloys to the dies has been a continuing source of die surface damage in the aluminum die-casting industry. To reduce the repair and maintenance costs, an approach to modeling the damage and predicting the die lifetime is required. The aim of the present study is the estimation of the die lifetime based on a quantitative analysis of die soldering in the framework of the numerical simulations of the die-casting process. Full 3D simulations of the process, including the filling, solidification, and the die cooling, are carried out using the casting simulation software MAGMASoft. The resulting transient temperature fields on the die surface and in the casting are then post-processed to estimate the die soldering. The present work deals only with the metallurgical/chemical kind of soldering which occurs at high temperatures and involves formation and growth of intermetallic layers. The die-soldering model combines two approaches available in literature, describing the two aspects of die soldering: the growth of the intermetallic layer, and the thermal and metallurgical conditions in the layer that lead to the die soldering. The theoretical model is then extended with the treatment of the intermetallic layer growth controlled by the idealized effective diffusivity and with the treatment of solder strength dependent on the temperature and liquid fraction within the layer. The solder strength locally on the die surface is calculated as a function of the number of die-casting cycles. This also provides the estimation of the die lifetime defined as the number of cycles until the critical solder strength level is reached. Proper validation of the model is required, and the model parameters (the critical solder strength value, among others) need to be calibrated by measurements and data from the die-casting industry. As an example, the model is applied to several cases of high pressure die casting (HPDC) where A380 alloy parts are cast in the H13 steel die. The predicted locations of the higher strength of soldering appear in the "hot spot" areas of the die surface in agreement with the reports in literature. The influence of several casting process parameters such as cooling/spraying efficiency and other parameters that control the thermal history of the die and the casting is in agreement with the expected behavior.

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