

“Study of High Speed Steel deposits produced by Laser Cladding: Microstructure - Wear – Thermal Model”

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The thesis aims to understand the correlation between the microstructure of laser clad (LC) High Speed Steel (HSS) thick deposits, the thermal field during fabrication and the wear behaviour. To this goal, various microstructural analyses are performed, investigating the effects of the composition and of the laser cladding process parameters and using the thermal field computed by finite element. The thesis further investigates the influence of microstructural characteristics such as the types, morphologies and amount of carbides present in the different LC HSS deposits on their wear behaviour.

Firstly, the results of the microstructural characterisation, including the chemical composition, grain size, carbides quantification and hardness, of the 3 thick LC HSS deposits are presented. These microstructural characteristics are linked to the process parameters and compared to microstructural features of a conventional cast HSS material. The results show that a specific microstructure is associated with each LC deposit of different compositions. The microstructure of the LC deposits varies significantly as a function of position, from the deposit free surface towards the substrate. Moreover, different types, morphologies and amounts of carbides as well as different grain sizes can be observed in 2 deposits fabricated with the same powder, but under different processing conditions (e.g. with an insulator or steel plate under the substrate, or with different preheating temperatures).

Secondly, Differential Thermal Analysis (DTA) tests are carried out on the LC HSS deposits, in order to reach a better understanding of their phase transformation and carbide solidification. However, due to the much slower cooling rate in DTA (5 °C/min) compared to laser cladding (103 to 107 °C/sec), the DTA and the LC samples exhibit different types and morphologies of carbides, as well as different grain sizes.

Thirdly, the wear behaviour of the 3 thick LC A, B and C deposits and the conventional cast material is investigated at ambient and high temperature (300 °C), with the aim of studying the influence of the microstructural features on the wear mechanism. Oxidation is the main wear mechanism both at ambient temperature and at 300 °C, with oxide debris acting as a third body abrasive. Moreover, adhesive wear also contributes to the wear mechanisms at high temperature. A deep understanding of the effect of the different types, morphologies and amount of carbides on the wear behaviour has thus been reached.

Lastly, a 2D thermal model of laser cladding is presented in order to explain the final microstructure at different deposit depths. The input thermophysical properties are measured experimentally. The correlation between the computed thermal field history and the LC microstructure explains the formation of different carbide types and morphologies at different deposit depths. This allows reaching a deeper understanding of (1) the effect of the melt superheating temperature and of the thermal cyclic history on carbides solidification, and (2) the effect of the cooling rate on carbide growth.