MACRO- AND MICROSCOPIC SIMULATION OF ADDITIVE MANUFACTURING PROCESSES

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ABSTRACT

Additive Manufacturing (AM) is taking off in many industrial processes. In particular, powder bed fusion for metal manufacturing has definitively changed the way of prototyping metal parts: in fact it allows geometries and resolution precision that were unthinkable just not too long ago. However, AM is a very complex process that involves different phenomena, e.g., heat conduction, phase change, surface change and residual stress rising; accordingly, it is a complex coupled thermo-mechanical problem and simulation is fundamental to predict temperature distribution and stresses during and after the printing process.

The first part of the presentation focuses on microscopic simulations, involving three physical problems: powder melting/solidification, melt pool fluid motion, geometry surface change. The problem has been approached with Lattice Boltzmann Method, able to manage different fluid and different phases, making it ideal to describe the time evolution of the powder bed after melting. Preliminary results of fluid and thermo-dynamic problems are presented.

The second part of the presentation focuses on a macroscopic simulation performed using the commercial code ABAQUS (Dassault Systèmes). Once defined number of layers and the laser path, the thermo-mechanical analysis is divided in two steps. First the heat transfer analysis is carried out modeling both the powder bed properties (absorption, diffusion, etc.) and heat source specifics (spot diameter, power, penetration depth, etc.). Then the mechanical analysis is performed including the temperature distribution obtained from the mechanical one. It is then possible to evaluate temperature distribution and residual stresses on the printed part.