PhD Grants from the China Scholarship Council: Co-operation Program with the UTs and INSAs (France), Program 2018

Thesis subject :
Multiphysics computation and phenomenological analysis of SLM additive manufacturing
Keywords :
SLM, computation, transient processes, structural changes, thermomechanical analysis

Description :

<u>Technological context and current issues:</u>
The Additive Manufacturing (AM) method has been extensively explored for decades to develop functionalized components, to produce complex architectures or shapes that are technically unfeasible using conventional machining processes, or to improve techniques of micro-manufacturing with good accuracy. Apart from these major advantages, this innovative method brings potential benefits such as the reduction of both manufacturing cost and material consumption, the variety of material solutions and combinations. The layer-by-layer manufacturing method also enables in-situ monitoring with the possibility of control and optimization. Today, there is a broad range of AM processes which can be classified into various ways depending on the additive procedure, the nature of the added deposit, the material processability or other comparison criterion [1]. Regarding the AM processes for metals, a recent comparison considers the fact that numerous processes use a powder feedstock, and then suggests two main generic techniques: non-powder-based techniques and powder-based techniques, the latter including the powder bed consolidation methods among which Selective Laser Melting is a recent technique that enables the manufacturing of complex structures such as lattice structures and embedded structures. Various studies on feasibility have been achieved and today, a better understanding of materials responses at different scales during each layer consolidation is receiving a growing interest. There are various disciplines to investigate due to the multiphysical and transient behavior of the SLM method. Progresses in this field contribute for an advanced functionalization capability of the SLM method by developing specific or optimized properties via the control of the reaction of the micron sized powders during the consolidation process and particularly the material's response during the interaction with the laser impulse and the subsequent cooling.

<u>Research works:</u>
This PhD work focuses on the predictive simulation of the SLM AM and furthermore, on the computational materials aspect involved by the multiphysical and transient phenomena during this AM process. The research works fall into three major parts, firstly: the simulation of phenomenological interactions between the laser impulse and the powder media, to characterize the thermal kinetics during the formation of a layer due to heat

transfer involved by the fast laser heating and solid/fluid kinematics of the particles. This part investigates temperature gradients, thermal kinetics, transient fluid flow of molten media within the powder bed prior to a solidification, that form the structure during a single layer step. A second part focuses on the metallurgical transformation within powders governed by the thermal kinetics generated by the SLM process. This work package relies on mesoscale thermo-metallurgical simulations that compute the metallurgical zones within individual powders and across the consolidated bed. We will take advantages of the knowledges achieved in fusion welding phenomena and computations [2-4]. This task will include a coupling with a mechanical analysis for investigating structural distortion due to thermal dilatation and metallurgical strain during cooling. The third part deals with the computation of microstructure formation and growth governed by the thermal gradient and kinetics during SLM. The major objective is to analyze the effects of heating and cooling on microstructure orientation. Steel is the material we choose as material of reference. The numerical simulation will be performed using Fluent, Abaqus 6.14 and LS-Dyna packages.

Expected background of the PhD candidate :

Computational material science, Mechanics of materials, Finite element method, Heat transfer, Computational fluid dynamics

Supervision of the research works :

Supervisor: M. Rachik[1]
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References

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