ECOLE DOCTORALE
ED 468
« Mécanique, Energétique, Génie Civil, Procédés »

Thesis proposal for a Doctoral position 2017-2020

Title	**Modeling of residual stress genesis during additive manufacture by selective laser melting (SLM) of the titanium alloy**
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Study context:

The shaping processes of titanium alloys derived from powder metallurgy present a very high potential for aeronautic and energy applications, allowing the development of so-called "Near Net Shape" parts involving less raw material and offering good manufacturing reproducibility.

Among these methods, more particular attention is given to additive manufacture by selective laser melting (SLM). This process is accompanied by large temperature gradients at the origin of a heterogeneous microstructure, and residual stresses that are difficult to control. The mechanical behavior of parts resulting from this process is poorly controlled at present.

Research project description:

The additive manufacturing processes have the ability to create structures with complex geometries. This process makes it possible to manufacture three-dimensional parts from metal powders by melting the material layer by layer in accordance with the CAD model. During this process, many thermal cycles and large thermal gradients occur in the part. These temperature gradients induce heterogeneous deformations and thereby residual stresses. These stresses can stop the manufacture and/or affected the quality of the obtained part.

Indeed, during the SLM process, the energy supplied by the laser beam is absorbed by the powder and converted into heat. The thermal stresses generated by the expansion and contraction cycles of the solidified layers can exceed the yield stress of the studied material, in particular for the bad heat conductor materials such as the titanium alloy TA6V. In addition, the volume changes resulting from the phase transformations, including allotropic phase transformations (crystal structure changes as observed in titanium alloys), induce also residual stresses. The objective of this work is to propose analytical and numerical models (finite elements) in order to study the genesis of these residual stresses during the TA6V selective laser melting process. Then, we will characterize and modeling the influence of various process parameters on the stress levels.

The development of such models will require, firstly, determination of the temperature-dependent mechanical properties of the studied titanium alloy, and secondly, residual stress analysis on validation cases. Experimental characterization tests will be carried out in order to feed these models. Then, different approaches and techniques for analyzing residual stresses will be implemented. Finally, a parameterized model will be developed to analyze the effects of parameter process on the internal stress distribution, and to establish a test / model discussion.