High-fidelity numerical simulation of additive manufacturing processes.

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ABSTRACT

In this work the numerical simulation of Additive Manufacturing (AM) processes is addressed [1]. Among the different existing technologies, Laser Engineered Net Shaping (LENS) or Laser Powder Forming (LPF) is an additive manufacturing technology developed for fabricating metal parts directly from a CAD model. Metal powder (titanium, Inconel, steel, among others) is injected into a molten pool created by a focused, high-powered laser beam. A layer of added material is created according to the scanning path specified by the user. As a result a layer-by-layer metal deposition can be carried out to build complex shapes for components such as turbine blades, aircraft stiffeners, cooling systems, medical implants, among others. The advantage of this process consists of a rapid cooling of each deposited layer and, consequentially, a finer grain size compared to other metal forming technology such as casting or forming.

The results obtained through the numerical simulation of the LENS technology will be compared with a similar AM technique such as the Selective Laser Melting (SLM) or Selective Laser Sintering (SLS). In this case the process makes use of a metal powder beds prepared for each layer followed by a laser consolidation (sintering) process according to a pre-defined scanning path.

A fully couple thermo-mechanical analysis is carried out following the real laser scanning pattern employed in the laboratory. Those consist of a complex sequence of polylines, which usually define the (smooth) boundaries of the component, and hatches patterns to fill the inner section. The full sequence is given through Common Layer Interface (CLI) format, which is a standard format for layer-by-layer manufacturing processes such as rapid prototyping, SMD or machining, among others. The same input is adopted for the element activation technology used for the high-fidelity, FE-based simulation analysis.

A thermo-visco-plastic constitutive law is assumed including strain hardening and thermal softening behaviour.

Numerical results are compared with the experimental evidence obtained at SKLSP laboratory.

REFERENCES

[1] Chiumenti M., Cervera M., Salmi A., Agelet de Saracibar C., Dialami N. and Matsui K., "Finite element modeling of multi-pass welding and shaped metal deposition processes", Computer Methods in Applied Mechanics and Engineering, 199 (2010) 2343-2359