Research Topic for the ParisTech/CSC PhD Program

Field: Materials Science, Mechanics, Fluids

Subfield: Mechanical engineering

Title: Multiscale study of polymer selective laser sintering (SLS) process: from characterization to numerical modeling

ParisTech School: Mines ParisTech

Advisors: Jean-Luc BOUVARD: jean-luc.bouvard@mines-paristech.fr

Yancheng ZHANG: yancheng.zhang@mines-paristech.fr

CEMEF: http://www.cemef.mines-paristech.fr/

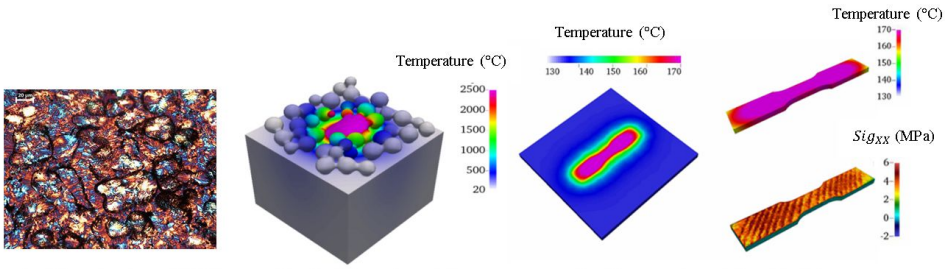
Short description of possible research topics for a PhD:

Additive manufacturing consists in building a part layer by layer directly from the data of a 3D computer-aided design model. Selective laser sintering (SLS) technique has become a viable technique for producing parts of short series and of complex shapes, not only on metals but also on polymers. But SLS process is relatively new and is not yet fully mastered. One of the main challenges is the ability of numerical tools to predict the relationship between the process and the final properties such as residual stress and/or final properties.

The Center of Material Forming (CEMEF), a Mines ParisTech research lab., has a strong expertise in polymer processing from fluid mechanics to solidification/crystallization and induced mechanical properties [1, 2, 3, 4]. The numerical teams have also developed a library based on Level Set methods to model at different scale SLS process. Such library is now applied for metallic component [5]. In this research project, we plan to extend such library to polymer material. In this thesis, a multi-scale study framework is proposed through two main tasks:

i) Studies of the influence of the manufacturing process on the final properties of the polymer and its microstructure (Figure 1 a).

ii) Numerical modeling of the SLS process for a polymer material at particle-scale for predicting the defects like porosities and at macro-scale (Figure 1 b) for predicting the distortion during (Figure 1 c) and post process.



a) Microstructure of PA12 SLS part (scale 20µm) b) Particle-scale model: temperature (IN718) c) Macro-scale model: residual stress (PA12)

Figure 1. Research on additive manufacturing developed at CEMEF

Required background of the student:

The candidate should have a master or engineer degree from mechanical engineering, mechanics or material science. Skills in heat transfer, solid mechanics, modelling and programming are required. Experiences on characterizing mechanical behavior or additive manufacturing are appreciated.

Publications of the group:

[1] A., Maurel-Pantel, E., Baquet, J., Bikard, J.L., Bouvard, N., Billon. A thermo-mechanical large deformation constitutive model for polymers based on material network description: Application to a semi-crystalline polyamide 66, International Journal of Plasticity, 67(2015):102-126.

[2] N. Billon, J.L. Bouvard, Properties and mechanical behavior of thermoplastic polymer, Techniques de l'Ingénieur, 26 p., 2015, Référence AM3115.

[3] J.M. Haudin, S.A.E. Boyer, Crystallization of Polymers in Processing Conditions: An Overview. International Polymer, 32(2016): 545-554.

[4] L. Freire, C. Combeaud, N. Billon, J-M. Haudin, "An analysis of transcrystallinity in polymers", AIP Conf. Proc. 1695, 020010; http://dx.doi.org/10.1063/1.4937288 (2015)

[5] Y. Zhang, G. Guillemot, M. Bernacki, M. Bellet, Macroscopic thermal finite element modelling of additive metal manufacturing by selective laser melting process, Computer Methods in Applied Mechanics and Engineering 331 (2018): 514–535.