Towards process monitoring and numerical simulation for metallic AM processes

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Abstract. Additive Manufacturing (AM) is a promising manufacturing technology compared to subtractive processes, in terms of cost and freedom of manufacturing, depending on the component type. Among all the AM techniques, Direct Energy Deposition (DED) processes are dedicated to functional metallic parts manufacturing (Kerninon, 2008). Process monitoring and numerical simulation are the most widely used solutions to improve DED processes performances. To date, most monitoring strategies have focused on only one aspect of manufacturing, mainly thermal or geometrical, using single-sensor control systems. Nevertheless, as DED are complex processes with coupled phenomena, single monitoring systems cannot provide a comprehensive control over a wide range of manufacturing conditions. Few multi-sensor monitoring strategies have also been proposed (Xu 2016), but were hardly developed and adapted to several cases and processes. In the GeM institute, a novel multiple monitoring methodology dedicated to DED processes has been developed, coupling both thermal and geometrical in-situ controls (Hascoët, 2017). Concerning simulation, some numerical models focused on specific physical aspects of DED process, such as particles movement (Muller 2013), in order to improve the understanding of the occurring phenomena during manufacturing, but they hardly enabled to simulate a manufacturing of real parts. Thermo-mechanical Finite Element (FE) models have been applied to DED processes, but their predictions are currently limited to the manufacturing of walls with few layers (Block 2018), model complexity and calculation time being major obstacles to simulate more complex parts. The present works propose to use both monitoring and numerical simulation solutions to enhance DED processes performances. More precisely, this paper highlights the necessity to perform process monitoring aside from numerical simulation in order to guarantee a correct manufacturing; this necessity is illustrated on thermal considerations.

Keywords. Additive Manufacturing, DED processes, numerical simulation, process monitoring, temperature.

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