Laser path optimization using shape optimization tools for the Laser Powder Bed Fusion (LPBF) process

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ABSTRACT

The building of an object through the Laser Powder Bed Fusion process (LPBF) of Additive Manufacturing (AM) is realized layer by layer: an energy source, moving along a chosen path, melts metallic powder and solidification comes with the cooling. Despite more design's freedom, this technique can create defects, such as thermal expansion or unwanted residual stresses for example [2, 5]. The laser path is of high importance: it impacts directly the thermal distribution and thus the thermal stresses. To our knowledge, the existing paths are mainly based on these well-defined patterns (zig-zag, offsets or spiral for example). Parameters or discrete optimization is then run to design the final path [3]. To get rid of these existent patterns, we propose here to apply shape optimization tools [1, 4] to laser path planning.

To build up this shape optimization approach, only thermal constraints are considered and a two dimensional model, in the layer plane, is set. This model presents many of the difficulties brought by shape optimization and the thermal repartition within the layer is tightly related to the mecanics which allows for a physical interpretation of the results.

The optimization algorithm has been run for the steady case, in which the source is the Dirac-mass corresponding to the while laser path. The results validate the path representation (through front tracking methods [6]) and the hope for interesting results in the unsteady model, which is currently studied.

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