An efficient approach based on geometrical analysis to optimize AM process

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ABSTRACT

New methodologies of Design for Additive Manufacturing (DFAM) and relative CAx tools are the key enabling technologies allowing to get the major benefits from AM. It is evident that an increased integration of all CAx phases would lead to a more efficient design and engineering workflow. One of the major bottlenecks of such a holistic approach, which affects AM product time-to-market and restricts its commercial exploitation, is the need of a high amount of time and human resources for simulation, modelling and postprocessing of all the engineering activities. It is not always manageable, especially during a preliminary stage of concept design or feasibility analysis.

Modern mathematical approaches are facing, with the ambition to contribute to solve some of the most challenging engineering tasks to fulfil strict requirements of structural resistance, lightness, noise, static and dynamic stiffness. The effectiveness of analytical and geometrical tools and methods for the study and the optimization of shapes were already demonstrated. As an example, it is well known that small fillet radius are stress concentrators and must be avoided for a robust design of structural parts. In the same way, we can demonstrate that poorly uniform temperature distribution of the material during additive layer manufacturing can be correlated with geometrical section areas and variations along the growing axis, as well as with supports shape configurations.

In this paper, a novel approach is presented which identifies optimal orientation and support configurations, uniquely based on geometrical criteria. The benefits are avoiding long structures to minimise the amount of waste material, accounting for the distribution of the piece weight, effectively draining the thermal field from all the areas of the piece to the build platform. With FE based macroscale process simulations, it is possible to evidence improved thermal strain distributions of optimised configurations, compared to the minimum support volume criterion.

As part of the R&D activity within the “STAMP” project financed by Regione Piemonte, an innovative function was developed and successfully applied to minimize distortions and residual stresses of SLM parts. Within the same project, ITACAe developed a software interface for setting user parameters and individual jobs. The software provides detailed information of the laser path and physical variables, which can be used for off-line or in-line monitoring and control, or for the definition of a model for process simulation. It is also possible to view the entire laser path and the detail of each individual trait, and to generate a file containing structured data as a FEM model, for setting boundary conditions and process parameters.

The algorithms following this approach are included in the integrated platform for AM developed by ITACAe, named AMTOP®. Starting from geometrical, functional and structural product specifications, the platform includes a topological optimization phase, new geometry construction, FEM discretization, FEA validation, optimal orientation and supports creation, so representing a fully integrated product & process engineering workflow.

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