Design and Manufacturing of 3D-Printed Structural Components

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ABSTRACT

There is constant demand from several industrial fields for using light-weight components that exhibit high mechanical performance. Although this demand is being traditionally met by employing composite materials, their advantages are limited by the tooling requirements when complex geometries have to be produced. In such cases, 3D-printing technology can be an effective solution for the manufacturing of complex light-weighted shapes, for example coming from a topology optimization process.

The 3D-printing technology, which emerged to address the rapid prototyping needs of the industry, has now outgrown its intended purpose and has potential to be employed for structural applications. In the 3D-printing technology panorama, Fused Deposition Modeling (FDM) has become the most widespread 3D-printing method, thanks to the availability of low-cost machines and materials and to the high level of control of the process: the user can actually tune all the process parameters, like temperatures, velocities, amount of material extruded, etc.

The aim of this work is to develop a computer-based framework that supports the designing of performance-optimized 3D-printed components and translate the design solution to suitable machine instructions to print the component, by means of FDM technology. The designing of components can be done using structural optimization approaches (e.g topology optimization) and suitable constitutive models, that may be obtained through multi-scale techniques based on homogenization. However, for the 3D-printing, there are many impending challenges to be overcome for the produced parts to satisfy the structural requirements. For example, the deposition paths used to fill the geometry to be printed can follow only defined patterns (rectilinear, concentric, honeycomb etc).

This standard-pattern infill is a current limitation when a design solution has to be realized into a 3D-Printed part. Very few preliminary works exist in literature that attempts to solve this problem [1, 2]. A recent work by Khan et al. [1], demonstrated the improvement in the mechanical performance of a 3D-printed open-hole plate when its filaments are oriented to the load paths. However, only an analytical approach was used, in which the curvilinear filament paths were found from the analogy of fluid-flow equations around a cylinder. This necessitates an attempt to develop a robust, generally valid load-oriented deposition technique so that the FDM parts can set its course on becoming structurally viable for practical applications.

REFERENCES

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