

# Deterministic Manufacturing Constraints for Optimal Distribution in the Case of Additive Manufacturing

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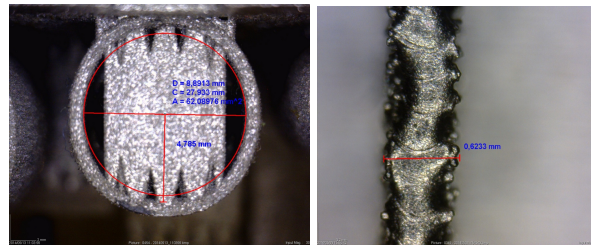
## ABSTRACT

Topology optimization is widely used as a design tool for advanced application mechanical, aerospace and automotive industries. This technique offers an optimal distribution of a pre-determined amount of material in a given design space [1]. In the last years a lot of efforts has been put into the development of high performance methods such as homogenization [2], SIMP [1] or BESO [4]. However as the state of art in manufacturing undergoes evolution a coupling between both is needed.

Additive manufacturing has numerous advantages that fits the characteristics of topology optimized designs [3]. It can manufacture highly complex design without high cost increase and furthermore continuous density material of the SIMP method could be manufacture by lattice structures [3]. With all the opportunities given by the additive manufacturing the urge to bind the last one to topology optimization is heavily required.

However specific constraints related to manufacturing issues have to be taken into account such as the need of support material to ensure a good heat evacuation as well as to hold up overhang section as shown in Fig. 1a. Moreover constraints depending on the manufacturing limitations (LBM, EBM, 3D printing) also must be taken into account such as the minimum size of walls, maximum bridge distance, orientation of the manufactured part, anisotropic behavior of the material, no closed cavities or the surface finishing (Fig. 1b) all those appear when additive manufacturing is used [6]. Some researches have been done to include these new constraints in the optimization formulation. For instance Leary and al. [7] create designs that do not need support structures or Lemaire [5] create a structure without closed cavities. Nevertheless we are far from an optimization formulation that accounts for all of these constraints.

In this work we implement in the optimization formulation some of the manufacturing constraints. Our work is based on the MATLAB optimization code of O. Sigmund [8] and includes some of the limitations caused by the manufacturing method. Those limitations are



(a) Hole support and circle (b) Surface finishing deformation

Figure 1: Exemple

the minimum diameters of holes or channels, the tilt angles of constructions, the definition of cavities, the precision of construction of prismatic volume or the precision and quality of the manufactured part. Thanks to SIRRIS those constraints were quantified for two major additive manufacturing that are LBM and EBM and are implemented in our topopt MATLAB code.

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