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A Design for Additive Manufacturing Strategy for Dimensional and Geometrical Quality Improvement of PolyJet-Manufactured Glossy Cylindrical Features

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Abstract: The dimensional and geometrical quality of additively manufactured parts must be increased to match industrial requirements before they can be incorporated to mass production. Such an objective has a great relevance in the case of features of linear size that are affected by dimensional or geometrical tolerances. This work proposes a design for additive manufacturing strategy that uses the re-parameterization of part design to minimize shape deviations from cylindrical geometries. An analysis of shape deviations in the frequency domain is used to define a re-parameterization strategy, imposing a bi-univocal correspondence between verification parameters and design parameters. Then, the significance of variations in the process and design factors upon part quality is analyzed using design of experiments to determine the appropriate extension for modelling form deviation. Finally, local deviations are mapped for design parameters, and a new part design including local compensations is obtained. This strategy has been evaluated upon glossy surfaces manufactured in a Vero™ material by polymer jetting. The results of the proposed example showed a relevant improvement in dimensional quality, as well as a reduction of geometrical deviations, outperforming the results obtained with a conventional scaling compensation.

Keywords: design for additive manufacturing; quality enhancement; material jetting; features of linear size

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1. Introduction

Additive manufacturing (AM) processes make parts from 3D model data, usually layer upon layer [1]. The theoretical geometry of a three-dimensional object is sliced into bi-dimensional shapes that are later manufactured and stacked vertically. Industrial adoption of AM is still hampered by an insufficient mass production capacity, a limited range of processable materials, and a lower manufacturing quality than achievable through alternative conventional processes [2]. There is a gap between AM specification standards and industrial requirements [3] that demands greater efforts in the fields of standardization, offline verification, on-machine measurement, and process control. In this sense, the evaluation of dimensional and geometrical quality in additive manufacturing of polymeric parts has been the subject of extensive research.

Some research studies [4–6] were focused on characterizing the process capability from a metrological point of view. Different approaches range from using a gage repeatability and reproducibility (G&R) methodology for the capacity evaluation of a polymer jetting system [5], to benchmarking comparisons of dimensional and geometrical accuracy between different polymer AM processes [6]. Other studies [7–15] analyzed the influence of design, process, and production factors on part quality. Part size, location, and orientation are among the most frequent factors [8,9,12,13], whereas inner design factors and process factors also have an influence upon quality results [10,14,15]. These works described part quality in metrological terms by means of the differences between nominal and actual