Multi-objective Optimization on Surface Roughness of 3D-Printed Parts by Fused Deposition Modelling

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Abstract— **Because of its capacity to make components of complicated designs with less production time and expense, additive manufacturing (AM) technologies like as fused deposition modelling (FDM) have been widely employed in today's manufacturing industries such as transportation, aerospace, and medical. However, in order to get the greatest quality of printed component, careful selection of input process parameters is critical. This study presents unique techniques for figuring out the appropriate parameter settings to enhance surface quality, or the surface roughness of FDM printed objects, such as the response surface methodology. The input variables were extrusion temperature, layer height, and printing speed, while the output response was the roughness of the surface (horizontal, vertical and inclined). The experiment was created using technique known as response surface methodology (RSM). Then, using a regression model, the link between the input parameters and the surface roughness was determined. The statistics show that the surface roughness obtained by RSM rose by 95.69% for horizontal surface, 97.86% for vertical surface, and 97.56% for inclined surface. The predicted surface roughness and the observed values also matched each other well.**

Keywords—FDM, RSM, Surface Roughness, Horizontal, Vertical, Inclined.

INTRODUCTION

Processing both before and after operations should generally be acted upon in additive manufacturing [1]. However, when compared to more established production techniques like machining, the quality of the pieces is insufficient. The staircase effect is one of the major obstacles to achieving acceptable surface quality in additive manufacturing.

According to Strano et al. [1], complicated geometries undermine the benefits of additive manufacturing, therefore often human post-processing activities are required to provide a sufficient surface roughness. The staircase effect, which causes "chordal inaccuracy" between a surface's original location in a CAD model and its matching triangle in a tessellated model, was examined by Pandey et al. [2]. The authors came to the conclusion that two causes of surface errors that must be considered are tessellation and slicing during the manufacturing process. Numerous research have been conducted explicitly on FDM process parameters, examining their impact on outputs including mechanical characteristics and surface topography and quality [1].

For example, Altan et al. [3] investigated how process factors affected the SR and TS of polylactic acid (PLA) samples. The samples were created utilising three parameters layer thickness, deposition head velocity, and nozzle temperature—in accordance with ASTM standards and a Taguchi L16 experimental design. According to the authors, two important factors that greatly affect surface roughness are layer thickness and deposition head velocity. The infill density, layer thickness, and support style process parameters were selected. Changes in the process parameters have been made to investigate built time and surface roughness. According to the ANOVA results, layer thickness has a greater impact on both construction time and surface roughness.

For several materials, Campbell et al. [4] examined surface roughness. The surface roughness values for FDM procedures varied from 9 m to 40 m when the authors used layer thickness of 0.253 mm for ABS material. The ideal process parameters for attaining high surface quality and dimensional accuracy were recently studied. The surface roughness for PLA material ranged between 2.46 µm and 22.48 µm, according to the authors, who used layer heights between 0.25 and 0.5 mm while adjusting the filling density and deposition speed.

Nancharaiah et al. [6] used Taguchi's technique to examine the impact of raster width, raster angle, air gap, and layer thickness on optimum dimensional tolerance and surface quality of FDM parts at three levels of each factor. The results reveal that the raster width and height of the slice have a significant impact on the surface finish and dimensional accuracy of the printed object. On the other hand, raster angle is minor, but air gap has a substantial impact on dimensional accuracy and surface finish of FDM products. Abdullah et al. [7] investigated the topological and mechanical properties of ABS printed objects while taking layer thickness and printing orientation into account. Two levels of printing direction, XY and YZ, as well as three levels of layer thickness, 0.1, 0.2, and 0.3 mm, were used in the mixed design. Both of the study's parameters had a significant effect according to ANOVA.

Nidagundi et al. [8] were able to optimize process parameters using Taguchi's L9 Orthogonal Array (OA). Fill angle, layer thickness, and orientation angle are the chosen process parameters. The output response characteristics chosen were dimensional tolerance, surface roughness, ultimate tensile strength, and build time. S/N ratio was