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Title of the Thesis : "Computational and Experimental Analysis of Parts in three Dimensional Printing"

ABSTRACT

Keywords: Additive Manufacturing Processes, Analytic Network Process (ANP), CAD, Computational Fluid Dynamics, Sensitivity, Design and development, Extrusion, Solid freeform fabrication (SFF), FDM, layered Manufacturing,Nozzle offset, RPT, Surface Roughness, Slicing, 3D Printing.

The additive manufacturing process builds near net shape part in which three-dimensional part is built by adding material layer by layer from 3D CAD model, which is designed as per customer specifications. The additive manufacturing process is also known as 3D printing. The additive manufacturing processes are free from geometrical constraints and have many benefits over the conventional or subtractive manufacturing processes. This technology quickly fabricates a physical & scaled model using CAD data which can be developed by cloud point, reverse engineering MRI, and CT Scan, etc. processes. In additive manufacturing process a large number of technologies are available in the market like Laminated Object Manufacturing process (LOM), Selective Laser Sintering (SLS), Stereo Lithography(SLA), Fused Deposition Modeling (FDM) and Three Dimensional Printing (3DP), etc.

The research work demonstrates the development of a frame work based on qualitative and quantitative attributes for SLS, FDM, 3DP alternatives and its analysis is done using analytic network process approach (ANP).This methodology finally gives normalised overall weight indexes for FDM, SLS and 3DP as 0.209770444, 0.249670467 and 0.540559089 respectively. The results show normalised overall weight age index (NOWI) for 3DP is higher than SLS and FDM technology weightage. For its robustness, a sensitivity analysis is also done.

The design, development & fabrication of 3D printer demonstrate its bill of material, cost and process steps to print the part using open source repetition software. The effects of process variables like horizontal and vertical offset on buildup time and material consumption is done using RXP-2200 plus 3D printer. The experimental result shows that as vertical offset increases the build- up time as well as material consumption to build the part decreases. The experiment also shows that the material consumption and build-up time depends on geometry profile orientation on x-y, y-z and z-x plane. The part which is developed by this process has maximum roughness at the face where printing process is completed as compared to bottom and side wall. The experiment shows that part strength, surface roughness, build up time, etc. are depends on feed wire melt behaviour, flow rate, nozzle material and its working temperature, nozzle exit diameter and pressure drop, etc.

The Mathematical and Computational fluid Dynamics (CFD) analysis results show that the pressure drop is more sensitive with exit diameter as compared to nozzle angle. In mathematical as well as CFD analysis results give same trends in pressure drop for nozzle angle 30^0, 60^0, 90^0 and 120^0 with varying exit diameter from 0.2 mm, 0.3 mm and 0.4 mm. At nozzle angle 30^0 with exit diameter 0.2 mm highest resolution is achieved but due to highest pressure drop, the feed force required is more as compared to another nozzle angle. So to optimise the feed force and resolution best combination of pressure drop is considered at 120^0 nozzle angle with an exit diameter of 0.2 mm. The mathematical and Computational Fluid Dynamics results show's that at 0.2 mm nozzle exit diameter pressure drop is highest which offers resistance against the material flow. This is validated by fabricating nozzle with 0.2 mm exit diameter, and it is used in RX2200 plus FDM machine. When nozzle with 0.2 mm exit diameter is used for 3mm Poly-lactic-acid (PLA) feed wire, the wire does not run continuously and material flow regularly interrupt after few seconds, but as the nozzle exit diameter increases from 0.4 mm to 0.6 mm for 3mm feed wire the material flows continuously without any feed wire feeding problem.