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EXPERIMENTAL EVALUATION OF THE INFLUENCE OF PROCESS PARAMETERS ON SURFACE ROUGHNESS IN COMPONENTS PRODUCED BY 3- D PRINTING (F D M)

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Abstract— Fused Deposition modeling (F D M) is an Additive Manufacturing Technology in which components are produced by adding of material by layer wise fashion. It is also called as 3- D Printing Technology and Rapid Prototyping process, and it consumes very minimum time for the production of any complex component just by creation of CAD model in the computer. There are numerous practical applications for 3- D Printing Technology in various fields such as Aerospace Technology, Defense sector, Automobile Industry, Ship building factories, etc.,. A B S plus thermoplastic material is used in the Fused Deposition Modelling Technique (FDM), which is supplied in wire forms and squeezed into the required product by the heated nozzle controlled by the CATALYST software. By the combination of process parameters such as model interior, build orientation angle, and direction of rotation using Taguchi L 9 method, a prototype of specimen is modeled using CATIA V 5 and fabricated by Dimension 1200 E S model 3- D Printing machine. The Surface Roughness test is carried out by using Mitutoyo Surface Roughness Tester. Experiments are conducted on 3- D Printing machine by varying the Model Interior, Build Orientation Angle and Direction of Rotation. All the 27 fabricated test specimens are tested for Surface Roughness. The optimum parameters of Model Interior, Direction of Rotation and Build Orientation Angle are obtained after conducting experiments on the 3- D Printing machine.

Keywords—3-D printing;F D M, Model Interior, Direction of Rotation, Build Orientation angle, Catalyst Software, Catia V 5, Surface Roughness.

I. Introduction

For Product development, digital prototyping is widely used by many manufacturing organizations in the recent times, in different areas. The main challenge comes after the product has been digitally prototyped, and tested for the real world, under virtual conditions; and then in the manufacturing of the real prototype. There are many challenges such as maintenance of sufficient levels of the limits, fits, tolerances, time and costs (tooling design and manufacturing), time for producing the component for the first time. For the purpose of prototyping, 3- D Printing technique is being used in the present days. This method is also called as Additive Manufacturing process or Rapid prototyping.

In this process, addition of material is used in order to build the machine component, which is under manufacturing. There is no metal cutting and associated chips production in 3- D Printing process. In this method, the required complex shaped components are modeled using CAD software and stored in .stl file format, which in turn is loaded into the 3- D Printing machine. The required components are fabricated automatically with materials like ABS plastics. In the process of adopting 3- D Printing Technology, Fused Deposition Modeling is one of the important processes that is being currently used by many Industries and Research Institutes for the purpose of developing the prototypes for the first time to ensure their designs, to follow the manufacturing considerations, and to test the components in the laboratory under a large number of conditions.

In this F D M process, one of the important considerations is to evaluate the quality of surface finish of the fabricated components. The process parameters show significant effect on the finished product to meet the market standards. The accuracy of the component is directly dependent on the quality of the surface and also indirectly affects life time of the component in long run. The F D M process is shown in Fig 1.

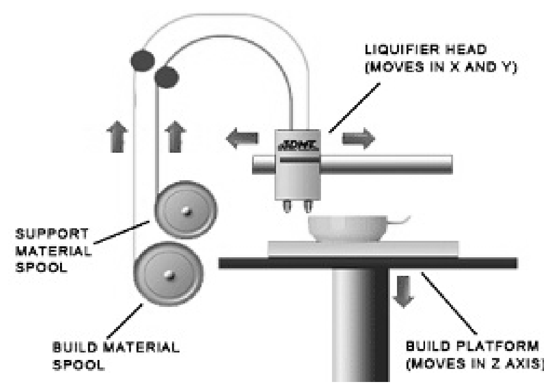

Fig. 1. F D M Working Principle.

.II. Statement Of The Problem

Surface topography of the fabricated component by Fused Deposition Modelling process depends on the process parameters availability at the machine. Optimum selection

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of process parameters is difficult task to achieve the required surface roughness value on the component. Hence, using Taguchi L 9 method, a set of 9 experiments with combination of different process parameters such as Build Orientation Angle, Direction of Rotation and Model Interior have to be carried out. The fabricated components are to be tested for surface roughness values (R_a)

III. Experimental Setup

The test specimen for Surface Roughness measurement is designed using CATIA V 5, as shown in Fig 2. The dimensions of the rectangular specimen are: 32 mm x 12.7 mm x 4 mm.

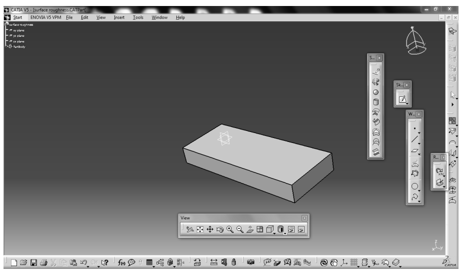

Fig 2. CAD model of Test specimen for Surface Roughness

The CAD model of the Surface roughness specimen is converted into .stl file format. It is loaded into CATALYST V 4.2 interface software of STRATASYS Dimension 1200 ES 3- D Printing (F D M) machine, USA make, as shown in Fig 3. CATALYST software does interface work and it transfers CAD data into the printer readable language by slicing the CAD model into thin slices as per the defined layer thickness. Experiments are conducted on this F D M machine with different combinations of the process parameters using Taguchi L 9 method. A set of 27 test specimens are fabricated and tested for surface topography using Mitutoyo Surf Tester as shown in Fig. 4. The obtained Ra values are tabulated in Table. 1 and plotted to find the optimum combination of process parameters using L 9 orthogonal array.

Fig 3. STRATASYS Dimension 1200 E S 3- D Printing machine (F D M)

Fig 4. Mitutoyo Surf Tester

Table 1: Surface Roughness (R_a) values for the Rectangular specimens.

Expt. No	Surface Roughness value R_a (µm)
1	1.31
2	1.52
3	6.02
4	17.54
5	1.67
6	4.56
7	1.57
8	15.65
9	0.84

A graph is drawn to show the variation of Surface Roughness value R_a (µm) for Rectangular specimen, as shown in Fig 5.

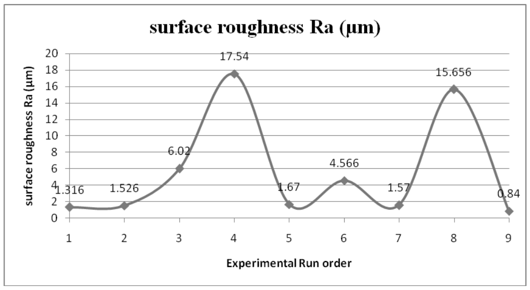

Fig 5. Graph between Experimental Run order and Surface Roughness value R_a (µm)

IV. conclusion

From the experimental investigation after the fabrication of the Rectangular specimens, it is concluded that Expt. No. 9, with combination of process parameters such as model interior is sparse low density, direction of rotation is about Z- axis and Build orientation angle is 45^0 yields least arithmetic mean surface roughness value R_a is 0.84 (µm).

The observed optimum process parameters for the minimum surface roughness for the Rectangular specimen by the Dimension 1200 ES machine is sparse low density model interior, direction of rotation is about Z- axis and Build orientation angle is 45^0.

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