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Performance Assessment of 3d Printed Parts Fabricated By Fdm using Three Different Materails

Harjinder Singh, Harjot gill

***Abstract*: A tremendous research has been notices in the field of three dimensional printing. An experimental study has been carried out for three dimensional printing to analyses the surface roughness and ultimate tensile strength of three different materials. The study has been conducted using Taguchi design of experiment. from the study it has been depicted that the infill percentage has a significant effect on the output.**

Keywords: Infill percentage, Layer thickness, Tensile strength

I. INTRODUCTION

In the recent year a tremendous research has been going in the field of three dimensional printing. This emerging technology has led to a new era of different assembly business because using three dimensional techniques it is helpful in producing fast adjustable components to be utilized practically for prototyping. In three dimensional printing, components are created by means of added substance strategies, which sees last items developed a solitary layer at once from the beginning. This technology has major difference to other available method, in which material is expelled from mass by means of, for instance, processing on a conventional machining such as CNC machine or shaping on a machine. The FDM technique has become a well-known and cost effective type of 3D printing. In this technique, a thermoplastic polymer is deposited on a printing bed, following the created ways in a cut model's G-code. The material mostly polymer based is expelled from a spool kept on a higher temperature using gear drive mechanism.

It comprises a warmer square in thermal harmony with the extruder spout. The material used dissolved in this segment with weight from the drive rigging guaranteeing material is expelled onto the printing bed. At times, this print bed might be warmed. The hot end have a high temperature range of the order of 200 ◦C, with print bed temperatures going from room temperature to 130 ◦C.

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***** Correspondence Author
Harjinder Singh*, Dept. of Mechanical Engineering, Chandigarh University, Chandigarh, India.
Dr.Harjot Gill, Dept. of Mechatronics Engineering, Chandigarh University

The precise temperatures required rely upon the polymer warm properties, explicitly the glass progress temperature and coefficient of warm development related to the equipment of the 3D printer arrangement. The most widely recognized plastics utilized with this innovation are acry-lonitrile butadiene styrene (ABS) and polylactic corrosive (PLA), Polyethylene terephthalate glycol-modified (PETG). These give the most practical and simple to-utilize type of 3D printing. As of late, built variations of these polymers have turned out to be accessible, just as numerous other extraordinary fibers.Independent of the particular strategy, added substance assembling brings about segments with a layered micro structure inside every one of the layers, the mechanical properties of 3D-printed materials rely on bearing. The interfaces between neighboring layers are probably going to have diverse material properties from those of the majority of the layers, and both these interfaces and the layers may contain populaces of various deformities because of blemished assembling forms. The highlights depicted above propose that the mechanical reaction of 3D-printed parts must be an-isotropic and show strain/pressure asymmetry. This is a significant viewpoint in the plan of burden bearing 3D-printed components, independently of the material utilized and of the particular assembling method.

II. METHODOLOGY

The primary aim of conducting experimental study is elaborate and evaluate the dynamics of the process and influence of various controlling factors on the process. Taguchi method is used to minimize the number of experiments in such a way that the entire controllable factor is considered and the cost is minimum. The series of experiments are designed according to Taguchi method so that the number of experiments can be reduced and the most significant controlling factors can be investigated

Various controllable parameters of experimental setup were. Table-1 shows parameters and their levels for conducting experiments. orthogonal array was selected as per Taguchi method full factorial, L’27 orthogonal array is used for experimentation.

Table-1 Input Parameters and Their Levels

Parameters,	Levels		
	I	II	III
A: Infill Percentage	10	30	50
B: Outline Parameter Shell	2	3	4
C: Type of Material	PETG	PLA	AB S

2.1 The Two Way Classification Analysis of variance

In general factorial design there are two factors on which analysis of variance is carried out. There e 'c' level of factor A and 'd' level of factor B are arranged to form a factorial design that is each replicate of experiment contain all 'cd' treatment combination.

Table 2 Analysis Of Variance For Two- Way Classification Fixed Effect Model:

Parameters	Sum of squar e	D.O.F	M.S (mean of square)	$F_{\text{-Value}}$
A Treatments	$(\text{Sum of Sq})_A$	(c-1)	$MS_A=SS_A/(c-1)$	$F_0 = (MS_A/MS_E)$
B Treatments	$(\text{Sum of Sq})_B$	(d-1)	$MS_B=SS_B/(d-1)$	$F_0 = (MS_B/MS_E)$
Interaction	$(\text{Sum of Sq})_{AB}$	(c-1)(d-1)	$MS_A=SS_{AB}/(c-1)(d-1)$	$F_0 = (MS_{AB}/MS_E)$
Error	$(\text{Sum of Sq})_E$	(c*d) (n-1)	$MS_E=SS_E/(c*d)(n-1)$	
Total	$(\text{Sum of Sq})_T$	(cdn-1)		

2.2 Methodology applied for Optimization of parameters

There are three types of quality characteristic such as Smaller-the better, Normal-the best and Larger-the better.

The Signal to Noise (S/N) ratio is used to measure the quality characteristics such as Smaller-the better, Normal-the best and Larger-the better.

Larger-the-better principle

While performing experiments on the test rig, brake power, brake thermal efficiency and mechanical efficiency are considered as larger-the better principle. The S/N ratio for Larger-the better is as follows:

$$\eta = -10\log_{10}\left[\frac{1}{n}\sum_{i=1}^{n} 1/y_i^{2}\right] \qquad \text{(i)}$$

Where,

η is the S/N ratio,

n is the number of replication for i^{th} experiments,

y_i is the quality characteristics at i^{th} experiments.

Smaller-the-better principle

While performing experiments on the test rig, specific fuel consumption is considered as larger-the better principle is given as follows

$$\eta = -10\log_{10}\left[\frac{1}{n}\sum_{i=1}^{n} y_i^{2}\right] \qquad \text{(ii)}$$

Where,

η is the S/N ratio,

n is the number of replication for i^{th} experiments,

y_i is the quality characteristics at i^{th} experiments.

2.3 Percentage (%) contribution of an input parameter

(iii)

The % contribution for an input parameter using ANOVA results is given below.

$$\%\text{ contribution of input parameter A} = \frac{SSA}{SST} \qquad \text{(iv)}$$

$$\%\text{ contribution of input parameter B} = \frac{SSB}{SST} \qquad \text{(v)}$$

III. EXPERIMENTS RESULTS

Two characteristics namely Ultimate Tensile Strength (UTS) and surface roughness (SR) were measured. Observed machining characteristics are depicted in Table3. In this work all the designs, graphs and analysis in Minitab software.

3.1 S/N Ratio and Parametric Optimization for roughness

A statistical analysis was done for the experimental data obtained which are shown in tables from the L_{27} experiments. The average performance and S/N ratio were calculated for each control factor. Analysis of variance (ANOVA) was performed to identified the most significant control parameter and to quantify their effects on UTS and Surface Roughness

3.2 SN Ratio Graphs

A S/N graph has been plotted for surface roughness. Smaller the better case has been chosen for surface roughness as the minimum value is always desirable for surface roughness.

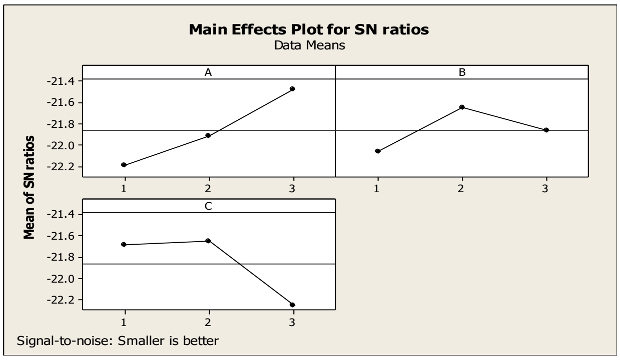

Figure-1 S/N ratio graph for surface roughness

A S/N graph has been plotted for ultimate tensile strength. larger the better case has been chosen ultimate tensile strength as the maximum value is always desirable for surface roughness.

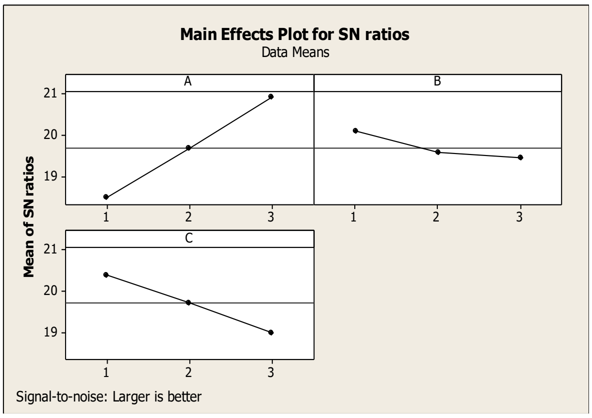

Figure-2 S/N ratio graph for ultimate tensile strength

3.3 Analysis of Variance

Analysis of variance has been carried out for UTS and Surface roughness using the design of experiment teble-4 shows the ANOVA results for UTS.

Table-3 ANOVA for ultimate tensile strength

Source	DF	Seq SS	Adj SS	Adj MS	F- Value	P-Value	%age
A	2	34.7935	34.7935	17.3967	155.12	0	71.20157
B	2	1.6666	1.6666	0.8333	7.43	0.015	3.410537
C	2	11.0821	11.0821	5.5411	49.41	0	22.67846
A*B	4	0.1119	0.1119	0.028	0.25	0.902	0.228993
A*C	4	0.125	0.125	0.0313	0.28	0.884	0.255801
B*C	4	0.1899	0.1899	0.0475	0.42	0.788	0.388612
Error	8	0.8972	0.8972	0.1122			1.836034
Total	26	48.8662					100

Table-4 shows the ANOVA results for Surface roughness

Source	DF	Seq SS	Adj SS	Adj MS	F-Value	P-value	%age
A	2	5.92036	5.92036	2.96018	63.07	0	51.8751
B	2	1.92789	1.92789	0.96394	20.54	0.001	16.89247
C	2	2.51111	2.51111	1.25556	26.75	0	22.00273
A*B	4	0.3177	0.3177	0.07943	1.69	0.244	2.783736
A*C	4	0.22008	0.22008	0.05502	1.17	0.392	1.928375
B*C	4	0.14013	0.14013	0.03503	0.75	0.587	1.227841
Error	8	0.37545	0.37545	0.04693			3.28975
Total	26	11.41272					100

3.4 Regression Analysis

Regression based mathematical model have been developed for surface roughness and ultimate tensile strength.

Surface roughness = 13.6 + 0.491 A - 1.33 B + 0.112 C - 0.195 A*A + 0.232 B*B + 0.0841 C*C - 0.0243 A*B - 0.113 A*C + 0.0741 B*C

Ultimate tensile strength = 8.47 + 1.26 A + 0.190 B - 0.253 C + 0.051 A*A - 0.082 B*B - 0.121 C*C - 0.0483 A*B + 0.0092 A*C - 0.0325 B*C

IV. CONCLUSION

On the basis of the experimental results and discussion from the conducted study the following conclusions are drawn as listed below.

1. The surface roughness and ultimate tensile strength at different levels of control factors such as infill percentage, outline parameter shell and type of material are analyzed through ANOVA (analysis of variance). The ANOVA reveals that the infill percentage is the most significant control factor with 51-71 % contribution.
2. The optimization (maximization / minimization) of the output parameters surface roughness and ultimate tensile strength at different levels of control factors such as infill percentage, outline parameter shell and type of material analyzed through S/N response graphs. The S/N response graphs reveal that minimum surface roughness is achieved at parametric combination **A3 B2 C2** and maximum value of ultimate strength was observed at parametric combination **A3 B1 C1**.

3. Mathematical model based on regression analysis have been developed using input out experimental results.

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AUTHORS PROFILE

Harjinder Singh, Researcher at Chandigarh University, Dept. of Mechanical Engineering, Thermal Engineering. B. Tech from Shaheed bhagat Singh college of engineering and technology, Ferozepur Research area 3d printed material.

Dr. Harjot gill ,Dept. of Mechatronics Engineering, Chandigarh University, Chandigarh, India. Research area Bio medical engineering and 3d printed material. B. TECH from Shaheed bhagat Singh collage of engineering. Master degree from Punjab technical university.