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Research Paper Engineering

EXPERIMENTAL STUDY ON ANISOTROPIC BEHAVIOUR OF FDM FABRICATED PROTOTYPES

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ABSTRACT

Rapid Prototyping (RP) technologies provide the ability to fabricate initial prototypes from various model materials. Stratasys fused deposition modeling(FDM) is a typical RP process that can fabricate prototypes out of Poly carbonate (PC) plastic. To predict the mechanical behavior of FDM parts, it is critical to understand the material properties of the raw FDM process material, and the effect that FDM built parameters have on anisotropic material properties. This paper characterizes the properties of PC parts fabricated by the FDM 360 machine using a design of experiment(DOE) approach. For the FDM parts the typical tensile strength ranged between 65 to 75 percent of the strength of injection molded PC. Several build rules designing FDM parts were formulated based on experimental results. Experiments were performed to examine the effect of build direction on the FDM part's anisotropic mechanical properties.

Keywords :- Rapid Prototyping (RP),Fused deposition Modeling (FDM),Design of experiment (DOE),Poly carbonate (PC).

INTRODUCTION

The FDM process works as follows; First,a 3D solid model exported to the FDM quick sliceTM Software using the stereolithography (STL) format [5].The software generated the process plan that controls the FDM machine's hardware. The hardware for the FDM machine is represented in Figure 1. The concept is that PC filament is fed throughout a heating element, which heats it to a semi-molten state. the Filament is then fed throughout a nozzle and deposited on to the partially constructed part. since the material is extruded in a semi molten state, the newly deposited material fuses with adjacent material that has already been deposited. the head then moves around in the x-y plane and deposits material according to the part geometry. The platform holding

the part then moves vertically downwards in the z plane to the begin depositing a new layer on the top of previous one. after a period of time the head will have deposited a full physical representation of the original CAD file. The FDM machine possesses a second nozzle that extrudes support material and builds support for any structure. The FDM process produces parts with unique characteristics. The machine deposits material in a directional way that results in part with anisotropic behavior. Experiments were performed in which the effect of several process parameters on the mechanical behavior of FDM parts was examined.

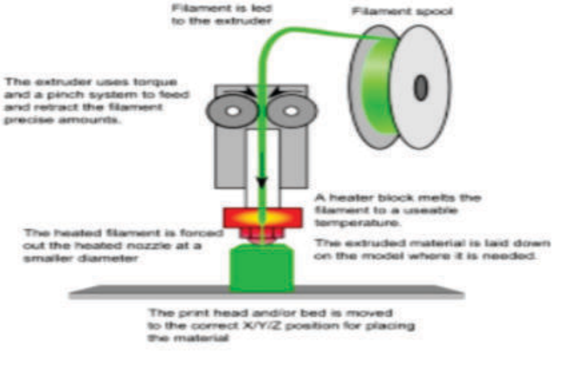

Figure 1: Schematic diagram of FDM

Main process parameters of Fused deposition modeling process are as follows

1.. **Layer thickness:** It is a thickness of layer deposited by nozzle and depends upon the type of nozzle used.

2. Orientation: Part builds orientation or orientation referrers to the inclination of part in a build platform with respect to X, Y, Z axis. Where X and Y-axis are considered parallel to build platform and Z-axis is along the direction of part build.

3. Part raster width (raster width)**:** Width of raster pattern used to fill interior regions of part curves.

4. Raster to raster gap (air gap): It is the gap between two adjacent raster

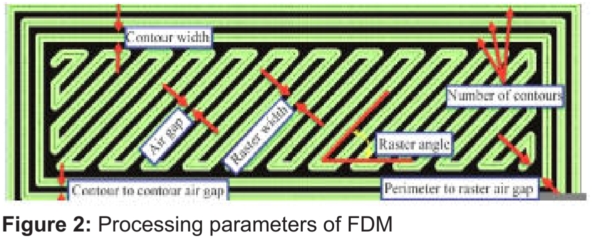

Figure 2: Processing parameters of FDM

LITERATURE REVIEW

Many researchers have worked on effect of process parameters on different strength of ABS prototypes, R. Anitha, S. Arunachalam, P. Radhakrishnan, [1] have pointed out that process parameters such as air gap and raster orientation significantly affect the tensile strength of FDM processed part as compared to other parameters like raster width, model temperature and color through experimental design and analysis.

Khan ZA, Lee BH, Abdullah J.[2] In their study, they have investigated the process parameters in order to achieve optimum elastic performance of a compliant ABS prototype so as to get maximum throwing distance from the prototype. Through this study, not only can the optimal process parameters for FDM process be obtained, but also the main process parameters that affect the performance of the prototype can be found Yizhuo Zhang and Y. Kevin Chou [3] have experimentally demonstrated that among the three parameters road width, scan speed and layer thickness tested, the scan speed is the most significant factor to the residual stresses followed by the layer thickness.

Lee CS, Kim SG, Kim HJ [4] performed experiments on cylindrical parts made from three RP processes such as FDM, 3D printer and nano composite deposition (NCDS) to study the effect of build direction on the compressive strength. Their experimental results show that compressive strength is 11.6% higher for axial FDM specimen as compared to transverse FDM specimen.

EXPERIMENTAL PLAN

In this experimental work, we first identified the process control parameters that were likely to affect the properties of FDM parts. The parameters we selected are listed below. Fixed Factors are shown in Table 1 while Five factors viz., layer thickness (A), part build orientation (B), model temperature (C), raster width (D) and raster to raster gap (air gap) (E) will be varied at two level, as shown in Table 2.

Tensile test specimen having dimensions 150 mm x 20 mm x 5 mm. The part are modeled in PROE software and exported as STL file. STL file is imported to FDM software (Insight). [5] Here, factors are set as per experiment plan. Three parts per experiment run are fabricated using Stratasys FDM 360mc machine at Indo German Tool Room-Ahmedabad. The material used for part fabrication is Polycarbonate.

Table 1
Fixed Factors and their level

Part fill style	Perimeter/raster
Contour width	0.3564 mm
Part interior style	Solid normal
Visible surface	Normal raster
XY &Z shrink factor	1.007
Perimeter to raster air gap	0.0000 mm

Table 2
Factors to be varies at their level

Factors/Level	Low	High	Units
Layer thickness(A)	0.1778	0.3302	mm
Orientation(B)	Axial	Transverse	---
Model temperature(C)	270	280	°c
Raster width (D)	0.457	0.679	mm
Air gap (E)	-0.004	0.00	mm

Manufacturing of Poly carbonate specimen by injection molding

In order to measure the reference strength of the PC material tensile specimen were manufactured by Injection molding. This process yields more isotropic than FDM process. The same material was used for specimen produced by both FDM and injection molding. The injection molded specimen were created by cutting strands of PC into 3 to 5mm long piece for use in Morgan Press G100T injection molding machine. The nozzle temperature of injection press was 270^{0}C.The clamping force was 71KN and injection pressure was 41MPa.

RESULTS

Dozen of specimens were produced by FDM for comparison with the samples produced by injection molding .For each type of specimen three to five replication were fabricated and tested.

Figure 3 shows resulting tensile strength of values for the specimen with zero air gap The Injection molded PC failed at 52 MPa and FDM specimen failed between 10 to 75% of the injection molded strength

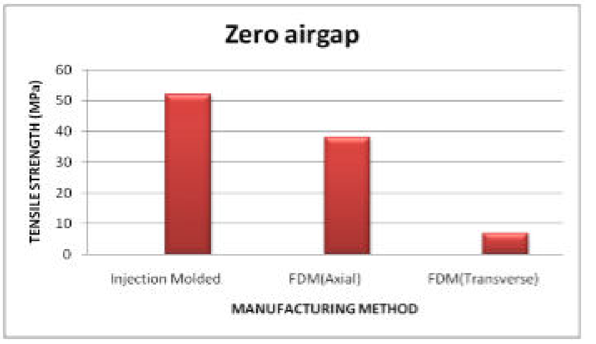

Figure 3 Comparison of Tensile strength of injection molded parts with FDM (axial) and FDM(transverse) for zero air gap

Figure 4, shows the effect of negative air gap which makes the specimen more dense and strong. The strength of axial specimen was not increased much with negative air gap but transverse orientation specimen exhibited a large increase in tensile strength.

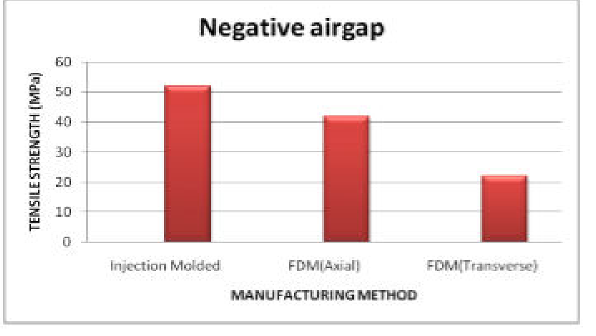

Figure:4 Comparison of Tensile strength of injection molded parts with FDM (axial) and FDM(transverse) for negative air gap.

Following build rules can be obtained from study.

1.Build the parts such that tensile load will be carried axially along the fibers.

2.The stress concentrations occur at radiused corners. This is because the FDM roads exhibits discontinuities at such transitions.

3.Use negative air gap to increase both strength and stiffness.

4.Small raster width increases build time but the same improves surface quality.

5.The effect of part orientation on part accuracy should be considered.

CONCLUSION

From the experiments it was found that the air gap and raster orientation affects the tensile strength of the FDM part greatly. Raster width, layer thickness and model temperature have a little effect. The measured material properties showed that parts made by FDM have anisotropic characteristics. Measured tensile strength of of axial and transverse oriented parts with -0.04mm negative air gap were between 65 to 75% of measured strength of injection molded parts. Because of the anisotropic behavior of the parts made by FDM process, the strength of a local area in the part depends on the raster direction.

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REFERENCES

1. R. Anitha, S. Arunachalam, P. Radhakrishnan, Critical parameter influencing the quality of prototype in fused deposition modelling, Journal of Material Processing Technology 118 (2001) 385–388 |2. Khan ZA, Lee BH, Abdullah J. Optimization of rapid prototyping parameters for production of flexible ABS object. Journal of Material Processing Technology 2005;169:54–61.|3. Yizhuo Zhang and Y. Kevin Chou Mechanical Engineering Department, The University of Alabama, Tuscaloosa, 2006 AL 35487 |4. Lee CS, Kim SG, Kim HJ, Ahn SH. Measurement of anisotropic compressive strength of rapid prototyping parts. Journal of Material Processing Technology 2007;187–188:630–7. |5.Fortus3D Production System,Material Properties and machine user guide. (www.stratasys.com)

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