

Static and Dynamic Analysis of Rapid Prototyping Samples

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ABSTRACT: Rapid prototype/Additive manufacturing technology is being accelerated these years and it plays an important role in manufacturing field and also the vibration plays an important role in engineering components, most of the users are not concerned on vibrational characteristics that may lead failure of the component. A total 8 samples are fabricated using Fused deposition modelling (FDM) process with different part thickness. ABS material was used to print the samples. Tensile test was conducted using a Universal testing machine. Further frequencies of Dynamic analysis are compared with that offrequencies obtained using ANSYS. This paper makes an attempt to find the dynamic analysis of 3D printed rectangular beam under cantilever condition. An Impact hammer is used for modal analysis on the beam to find the natural frequency, deflection of beam and those results are compared in ANSYS WORKBENCH 17.0.

KEYWORDS: Rapid prototyping, 3D printing, Additive manufacturing, Fused Deposition Modelling, Vibration, Frequency, ANSYS WORKBENCH.

I. INTRODUCTION

Rapid prototyping in other words is also said as 3D printing, which refers to a group of technologies that create products of the addition of material rather than by subtraction hence it is also called as Additive Manufacturing. This technology produces the models from 3D CAD model, CT &MRI scan data and model data from 3D object digitizing systems. The fabrication of objects through the deposition of material using a print head, nozzle or other printer technology. Other various types of RP technologies widely used for the prototyping such as Stereo lithography apparatus (SLA), Selective Laser Sintering (SLS), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM) etc. [6, 12]. RP reduces the time and material involving in manufacturing which results in reduction of the costs compared to the conventional manufacturing technology [7]. RP is used in many areas such as Medical, ARTS and Jewellery, Aerospace, Gifts, Trophies, Marketing &Advertising. RP involving many applications such as Prototyping, Tooling, Metal casting, Architectural [2]. As FDM has advantage of chemical free process and no build material storage problem which makes FDM is widely used in prototype parts.

FDM works by extruding a thermoplastic material and depositing it layer by layer fusing it to the material beneath it to form a 3D model. FDM create functional prototypes using a variety of engineering materials like ABS and PLA. In material extrusion is an RP process in which material is selectively dispensed through a nozzle or orifice. In FDM machines head move X-Y direction and build platform moves Z direction which helps in printing the parts in different orientation as shown in fig 1. FDM systems use two spools of material, one for the build material and second for the support material. The build material is supplied in the form of spools and is fed into the extrusion head where the material is heated just above melting point so that it solidifies easily after extrusion. Once the required part is printed completely, it is removed from the printer and the part is separated from its support structure [11]. The finished product exhibits different properties based on its printing orientation and layer thickness [5, 3].

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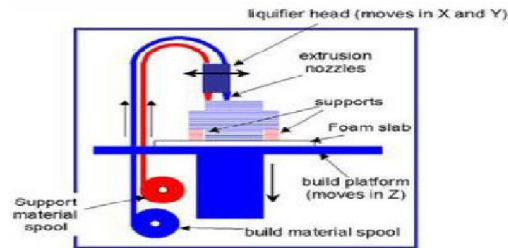


Fig. 1. FDM Process

Fig.1 shows the Fused Depositing modelling process. In FDM process use two spools of material, one for the build material and second for the support material.

Vibration plays an important role in engineering components. In practical situations when the excited frequency of component matches with the natural frequency of the component, resonance condition occurs which leads to failure of component. Hence, it is necessary to find the natural frequency of the component. In this paper, an effort is made to find the vibration properties such as frequency, deflection and it those frequencies are compared in ANSYS.

II. DESIGN AND MANUFACTURING OF SPECIMENS

The material used to print the rectangular beam is ABS (Acrylonitrile butadiene styrene) plastic. FDM based printer (CREAT BOT) was used to print the beam by varying its layer orientation (vertical and horizontal, crisscross) and part thickness. For each orientation, different part thickness of 3mm, 4mm 5mm and 6mm was implemented and for each part thickness two samples were printed. A total of 8 samples were built for all two orientations and part thickness. Figure 2 shows different orientations and isometric view of rectangular beam. Fig. 2 shows the two different orientations of the sample one is Vertical & Horizontal (0/90) and another one is crisscross (+45/-45).

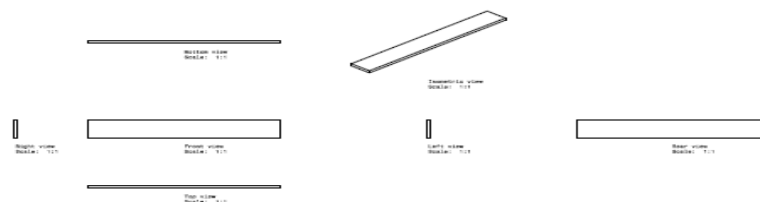


Fig. 2. Two Different Orientations

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The detailed breakups of the number of specimens manufactured for each layer orientation and part thickness is given in Table I.

TABLE. I

Part Thickness (mm)	Layer Orientation	
	Vertical & Horizontal(0/90)	Crisscross(+45/-45)
3mm	1	1
4mm	1	1
5mm	1	1
6mm	1	1

Number of Beam Samples

Mechanical properties of ABS filament were obtained in Tensile test is as follows:

TABLE II

MECHANICAL PROPERTIES OF ABS PLASTIC

Yield Stress(Mpa)	Poisson's Ratio	Density (Kg/m ³)	Young Modulus (Mpa)
29	0.3	1040	1635.185

III. EXPERIMENTAL MODEL ANALYSIS

Natural frequency is used to identify the dynamic behaviour of structure. Here, an Impact hammer test was selected for experimentation because it is an easy procedure and costs less. The Accelerometer is used to sense the frequency. The Fig.3 shows the Impact hammer were used to hit the sample at different places for finding the natural frequency and Fig.4 shows the Accelerometer were used to excite the beam and the responses were noted by using Dewesoft 7.1.1.

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Fig. 3. Impact Hammer



Fig. 4. Accelerometer

The Fig. 5 shows the experimental setup for Dynamic analysis. The specimen having dimensions 150mm x 20mm x (3mm, 4mm, 5mm, 6mm) is clamped as a cantilever beam support up to a length of 30mm and the accelerometer was attached to free end of cantilever beam with the help of wax. An impact hammer was used to hit the beam at three places for each sample to obtain frequencies. The data gets directly transferred to computer via data acquisition system where FFT (Fast Fourier Transform) was obtained using Dewesoft 7.1.1 software and those frequencies are compared using ANSYS. The results obtained are shown in below Table III and Fig .6.



Fig. 5. Experiment Setup

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TABLE III

FREQUENCY AND DEFLECTION

Part thickness (mm)	Layer Orientation	Frequency(HZ)	Deflection (mm)
3mm	Horizontal & Vertical (0/90)	40.833	0.05521
	Crisscross(45/-45)	39.1667	0.1225
4mm	Horizontal& Vertical (0/90)	53.33	0.0708
	Crisscross(45/-45)	51.667	0.0659
5mm	Horizontal& Vertical (0/90)	66.667	0.0250
	Crisscross (45/-45)	65	0.05189
6mm	Horizontal& Vertical (0/90)	80	0.019
	Crisscross (45/-45)	78.33	0.0081

The following Frequency graph was obtained from ANSYS WORKBENCH 17.0 for the Rectangular Beam with 3mm thickness. The frequencies of the remaining specimens are driven out of ANSYS as the present one.

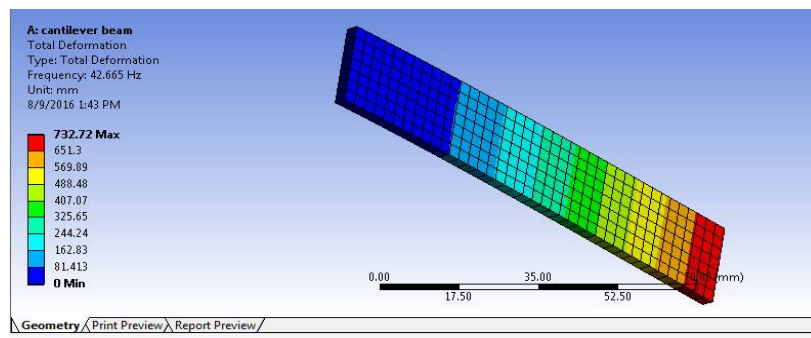


Fig. 6 ANSYS Frequency

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IV. RESULTS AND DISSCUSSION

The natural frequency obtained from the Dynamic analysis when excited using an impact hammer a small difference was observed when compared with calculated ANSYS natural frequencies. Table I shows thenatural frequency of the specimen increases when the part thickness increases and also with change in the layer orientation. TableIVshows the comparison of natural frequency obtained from experiment with that of ANSYS. A small difference in the ANSYS and experimental values were found, this is may be due to the small disturbances while 3D printing of the sample.

TABLEIV

COMPARISIONOFNATURALFREQUENCY

Part Thickness(mm)	Layer Orientation	Natural Frequency (Hz)	
		Experimental	ANSYS
3mm	Horizontal and Vertical (0/90)	40.833	42.665
	Crisscross (+45/-45)	39.1667	
4mm	Horizontal and Vertical (0/90)	53.33	56.753
	Crisscross (+45/-45)	51.667	
5mm	Horizontal and Vertical (0/90)	66.667	70.875
	Crisscross (+45/-45)	65	
6mm	Horizontal and Vertical (0/90)	80	84.964
	Crisscross (+45/-45)	78.33	

V. CONCLUSION

This paper explains the experimental modal analysis done to find the vibrational properties of 3D printed cantilever beam. The results obtained from experimental work were nearer to the ANSYS frequencies. The natural frequency of the beam obtained from experiment on keeping observation indicates the fact that the value changes when the part thickness and layer orientation of the beam changes. This indicates that catastrophic failures may occur if proper layer orientation and part thickness are not selected in real life situations. Further experiments are needed to verify the vibration properties of the RP made components.

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