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# 3D printing of polymer composite by varying critical parameter and testing

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***Abstract:*** The main purpose behind this project is "Test the natural frequency of the polymer composite with varying critical parameter'' composites 3D printing also known as additive manufacturing or rapid prototyping, is a popular manufacturing method used for creating prototypes in various industries such as aerospace, defence, medical, and automotive. Fused Deposition Modeling (FDM) is a commonly used 3D printing technique that involves adding melted material layer by layer. FDM has several benefits over traditional manufacturing methods and various parameters such as speed, layer thickness, and nozzle diameter need to be considered while setting 3D printing options.

PLA is widely used filament material for 3D printing, but it has drawbacks such as low toughness and flexibility. To overcome these composites are used, such as wood-PLA. PLA is degradable material hence it is used with other natural fibres.

The 3d printing material is printed into a combination of varying parameters like speed and nozzle as (60, 80, 100) mm/sec and (0.4, 0.6, 0.8) mm respectively. The infill density and temperature is kept at 100% and 2100C respectively. For this we have used Taguchi technique L9 Orthogonal array. Further vibration analysis test is carried out, by this we will find natural frequency. Hence most affecting parameters are finalized and optimum combination parameters are selected.

***Index Terms*** **- Natural frequency, cantilever beam, accelerometer.**

## I. Introduction

In several industries, there has been an upswing in the popularity of Fused Deposition Modeling (FDM) technique in 3D printing for prototyping purposes. The optimization process of this printing method follows a design of experiments approach, where factors such as nozzle diameter, speed and layer thickness are taken into account. This procedure unfolds through three phases: the planning phase, the conducting phase, and finally the analysis phase. Composite materials by means of wood-PLA are utilized to challenge traditional materials' limitations. Varying the printing temperature, experiments were conducted to explore the properties of natural fiber-reinforced filaments. A guide was created based on the results to assist in selecting the most suitable filament for particular applications. To efficiently vary multiple factors, orthogonal arrays were implemented in experimental design. NI Instruments offers a wide range of software and hardware products that enable users to create advanced systems for testing, control, and data acquisition across various industries. The manufacturing industry has undergone a significant transformation due to the implementation of various cutting-edge technologies such as the use of composites, orthogonal arrays, design of experiments process, NI instruments and 3D printing. These innovative processes and resources have revolutionized the entire production procedure.

## II. LITERATURE SURVEY

Sreekanth Sura et. Al.(May 2017) [1]: In this paper, the analysis of cantilever beam is carried out with the NI LABVIEW setup by using the accelerometer to collect the natural frequency data of the beam.

Cany Mendonsa et.al.(2015) [2] The objective of this paper is to study the influence of process parameters like Print speed (A), Layer thickness(B),Infill density(C) on the build time and optimization of these parameters to get Fused Deposition Modeling part in lower lead time using Taguchi and ANOVA approaches. The results show that the build time depend on infill density and the layer thickness. Positively decreasing the layer thickness and negative reducing the infill density can reduce the build time for a given print. In addition, it is concluded that Layer thickness is the most significant factor for Build time in FDM components

Raju Bangalore Singe Gowda et.al.(2014) [3]: In this paper, the influence of the physical build parameters over the part quality are studied. An L9 orthogonal array was designed with the minimum number of experimental runs with desired parameter settings and by analysis tools such as ANOVA (analysis of variance.

Dr M Sumalatha et.al.(2020) [4]: In this paper, the parameters were decided for material selection and taguchi method is used to reduce the variation of process through robust design. The specimen was tested in UTM machine

## III. PROBLEM DEFINITION

In today's world, the non-degradable material is rapidly increasing. As For moving towards sustainability in 3d filament, for this PLA and wood concept is used. Here, composite is used, as a natural fibre for reducing non-degradable content.

## IV. METHODOLOGY

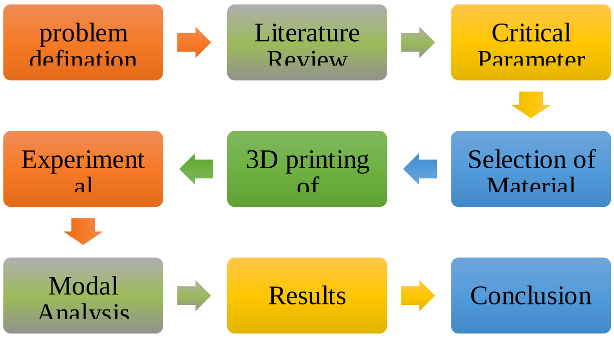


Fig 4.1 Flowchart of process

### 4.1 Identification of critical parameter

- Layer thickness: - The thickness of the layer deposited by the nozzle depends on the nozzle type used.
- Speed of deposition: - It is the rate at which the nozzle deposits the raster.
- Fill Density:-This percentage number determines the amount of plastic infill there will be in an object. Usually a setting of around 0.30 is used.[3]

Table 4.1: Orthogonal array

| Experimentation no. | Speed | Layer thickness | Infill percentage |
|---|---|---|---|
| 1 | 60 | 0.12 | 30 |
| 2 | 60 | 0.16 | 60 |
| 3 | 60 | 0.2 | 100 |
| 4 | 80 | 0.12 | 60 |
| 5 | 80 | 0.16 | 100 |
| 6 | 80 | 0.2 | 30 |
| 7 | 100 | 0.12 | 100 |
| 8 | 100 | 0.16 | 30 |
| 9 | 100 | 0.2 | 60 |

### 4.2 Design of experimentation

- Taguchi method :
  The Taguchi technique uses a unique design of orthogonal arrays to explore the whole parameter space with just a few experiments. Three process parameters are speed, layer thickness, and infill density, with three levels for each parameter. The L9 Orthogonal array should be used for experimentation if three parameters and three levels are employed for each parameter.

- Material selection :
  Wood PLA filament is selected for test. Typically, the term "wood PLA" refers to a kind of 3D printing filament that blends wood fibres or particles with the bio plastic Polylactic acid (PLA). The PLA gives the material its strength and longevity, while the wood particles give the filament a wood-like appearance and texture. Various objects, like as ornamental items, toys, and tiny domestic items, can be made with wood PLA filament. As the wood particles in the filament can take many years to decompose in the environment, it is also crucial to keep in mind that wood PLA filament is not exactly a fully sustainable or biodegradable material. As a result, it's crucial to handle and discard wood PLA artefacts in a responsible manner.

### 4.3 3D printing of polymer composite

A CAD file is created in solidwork.

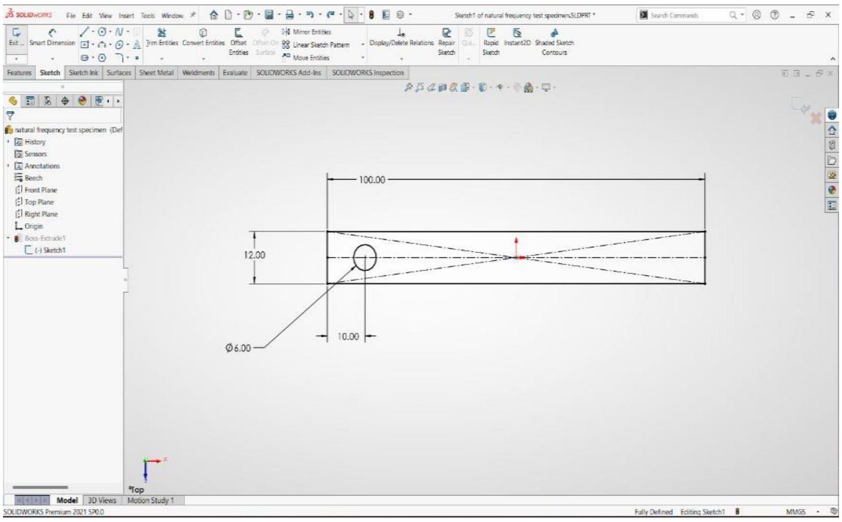


Fig 4.2 2D model in solidwork

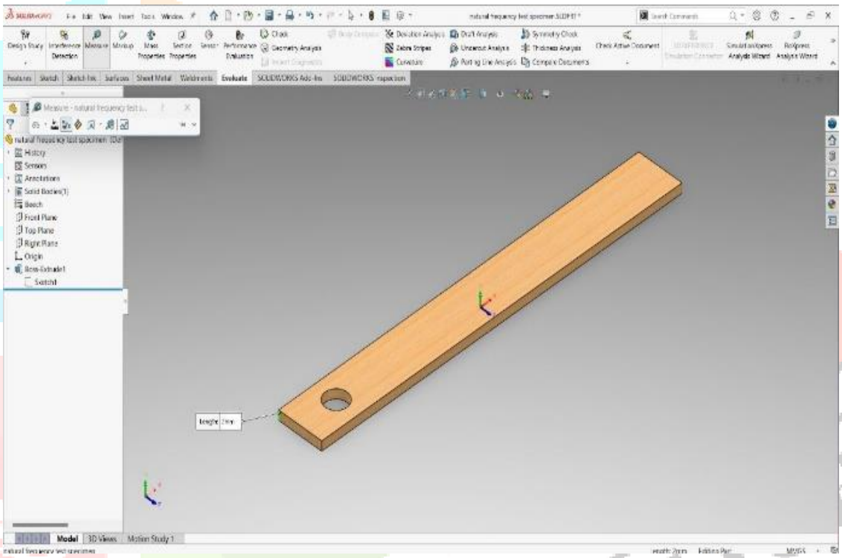

Fig 4.3 3D model in solidwork

### 4.4 vibration test to calculate natural frequency

Figure shows the experimental arrangement used to determine the natural frequency of printed specimens using an accelerometer attached to the free end of a cantilever. The cantilever is connected to a NI data acquisition system. The collected data is analyzed using the sound and vibration toolkit of LABVIEW .[1]

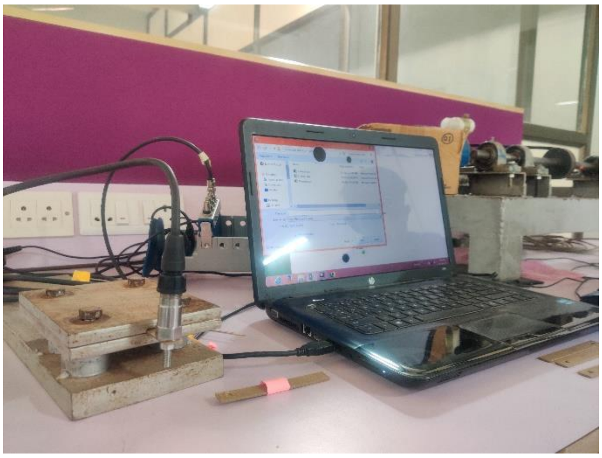

Fig 4.4 Experimental setup for cantilever beam

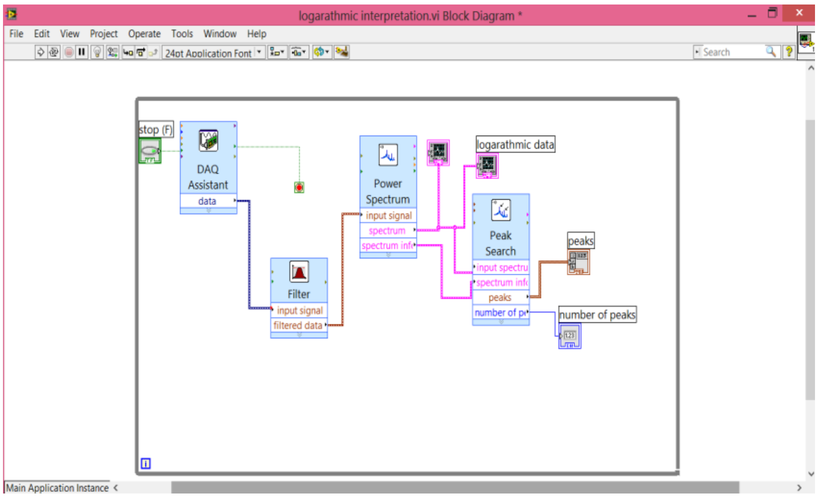


Fig 4.5 Linear and logarithmic block diagram

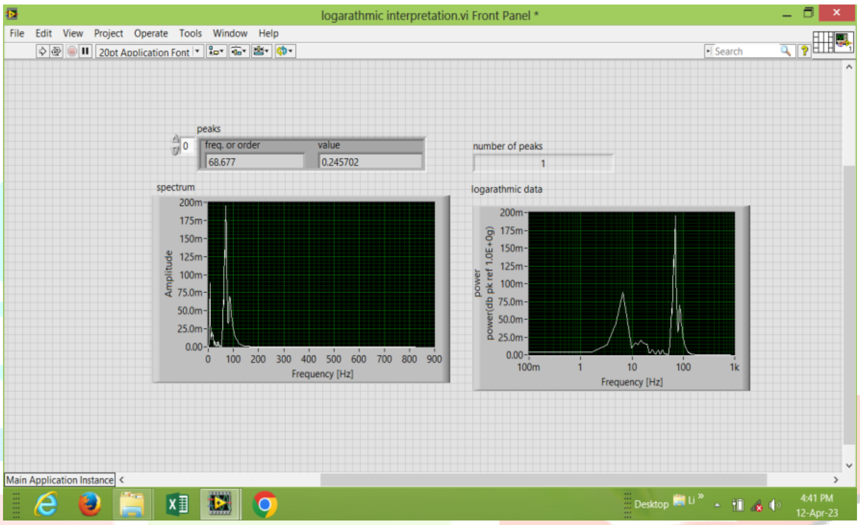


Fig 4.6 Power spectrum and Logarithmic data graph

Frequencies obtained by varying the nozzle diameter of 0.4mm, 0.6mm, 0.8mm are shown in Table no. 4.2, Table no. 4.3, Table no. 4.4 respectively .L9 array is used for each nozzle.

Table 4.2 L9 array for 0.4 mm nozzle

| Experimentation no. | Frequency 1 | Frequency 2 |
|---|---|---|
| 1 | 42.1 | 42.56 |
| 2 | 42.13 | 42.54 |
| 3 | 47.08 | 47.06 |
| 4 | 46.98 | 45.22 |
| 5 | 47.5 | 47 |
| 6 | 45.61 | 49.93 |
| 7 | 49.95 | 50.55 |
| 8 | 48.57 | 45.29 |
| 9 | 47.42 | 47.13 |

Table 4.3 L9 array for 0.6 mm nozzle

| Experimentation no. | Frequency 1 | Frequency 2 |
|---|---|---|
| 1 | 51.96 | 55.34 |
| 2 | 69.1 | 66.86 |
| 3 | 55.24 | 56.96 |
| 4 | 42.02 | 41.08 |
| 5 | 47.04 | 47.19 |
| 6 | 55.32 | 56.96 |
| 7 | 56.99 | 57.01 |
| 8 | 53.68 | 52.13 |
| 9 | 66.77 | 68.67 |

Table 4.4 L9 array for 0.8 mm nozzle

| Experimentation no. | Frequency 1 | Frequency 2 |
|---|---|---|
| 1 | 60.28 | 56.91 |
| 2 | 56.48 | 57.37 |
| 3 | 59.51 | 58.62 |
| 4 | 53.93 | 54.27 |
| 5 | 45.54 | 43.95 |
| 6 | 43.47 | 40.44 |
| 7 | 65.27 | 65.24 |
| 8 | 53.67 | 53.7 |
| 9 | 48.83 | 48.67 |

**4.5 Modal analysis**

It is a process for determining the inherent dynamic characteristics such as Natural frequency, mode shapes, damping factor. In this project, was to find natural frequency for this we did modal analysis on Ansys.[1]

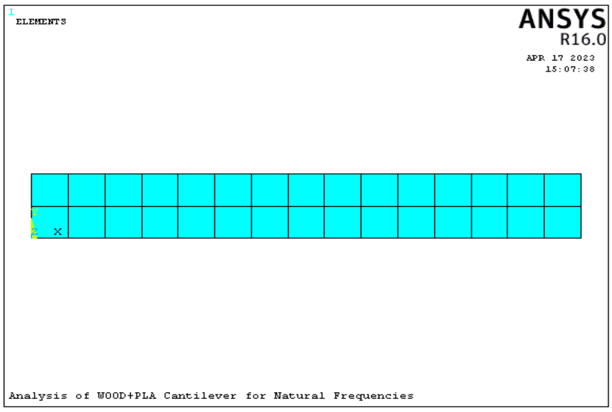


Fig 4.7 Crossectional area of cantilever beam

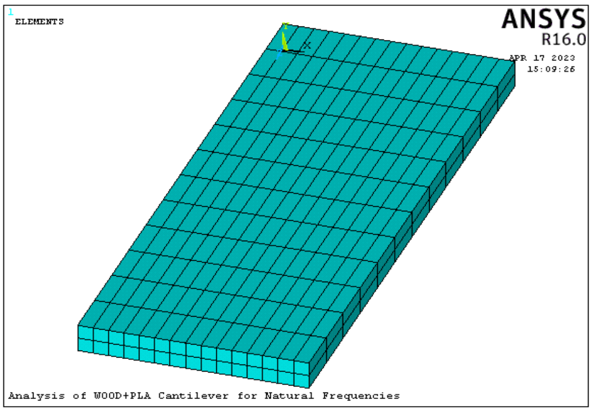


Fig 4.8 FEA mesh

- Nodal solution

The nodal solution in ANSYS provides a detailed understanding of the behavior of the structure under different loading and boundary conditions. It is a powerful tool for analyzing complex structures, and it is widely used in many industries, such as aerospace, automotive, and civil engineering.[1]

Analytical values:

Extracted & frequencies of cantilever beam

Table 4.5 Analytical value of frequencies obtain from simulation

| SET | TIME/FREQ |
|---|---|
| 1 | 16.667 |
| **2** | **68.198** |
| 3 | 79.588 |
| 4 | 104.36 |
| 5 | 221.96 |
| 6 | 293.43 |
| 7 | 355.78 |

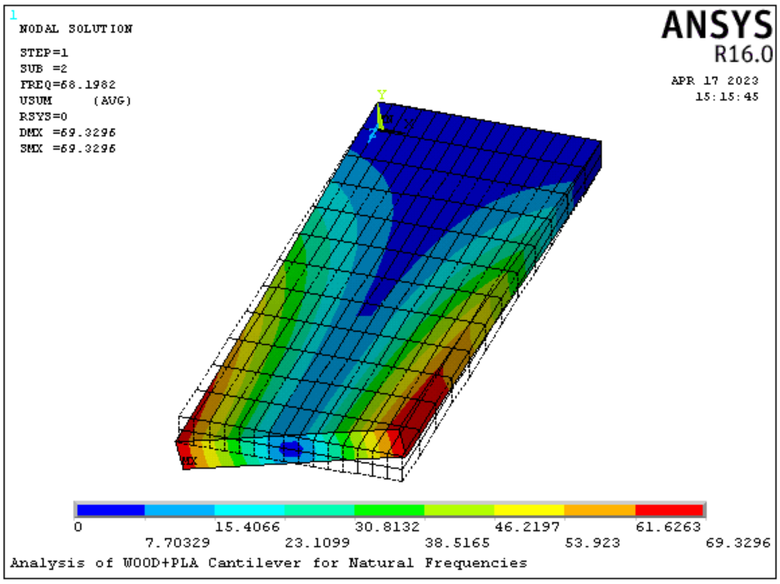


Fig 4.9 Mode shape 2 $\dot{\omega}_2$-68.19 Hz

## V. RESULTS AND DISCUSSION

### 5.1 Frequency comparison

Table 5.1: Natural frequency obtained by varying three different nozzle

| Nozzle in min | 0.8 | 0.6 | 0.4 |
|---|---|---|---|
| Experiment No. | 7 | 9 | 7 |
| Practical Frequency in HZ | 65.26 | 66.72 | 50.5 |
| Analytical Frequency in HZ | | 68.198 | |

Referring to Table no.4.1 the Analytical and practical data can be compared, where the data obtained from the nozzle of 0.6 mm with carrying experiment no.9 is more close to that of the analytical data found. Thus the best properties of the material can be obtained by taking parameters as speed is 100 mm/sec, Layer thickness of 0.2 mm and Infill percentage of 60.

Referring to Table no.5.1 the Analytical and practical data can be compared, where the data obtained from the nozzle of 0.6 mm with carrying experiment no.9 is more close to the that of the analytical data found. Thus the best properties of the material can be obtained by taking parameters as speed is 100 mm/sec, Layer thickness of 0.2 mm and Infill percentage of 60.

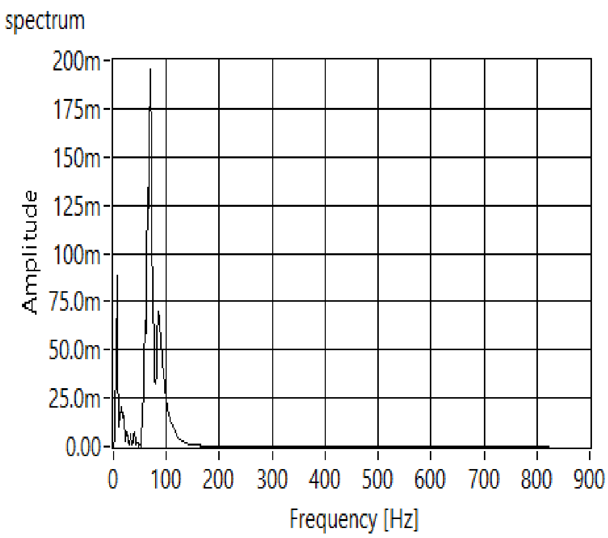


Fig 5.1 spectrum graph for nozzle 0.6 mm

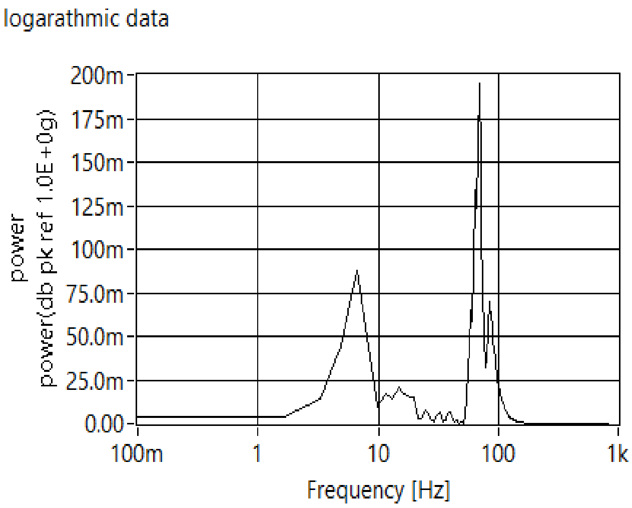


Fig 5.2 Logarithmic data graph for nozzle 0.6 mm

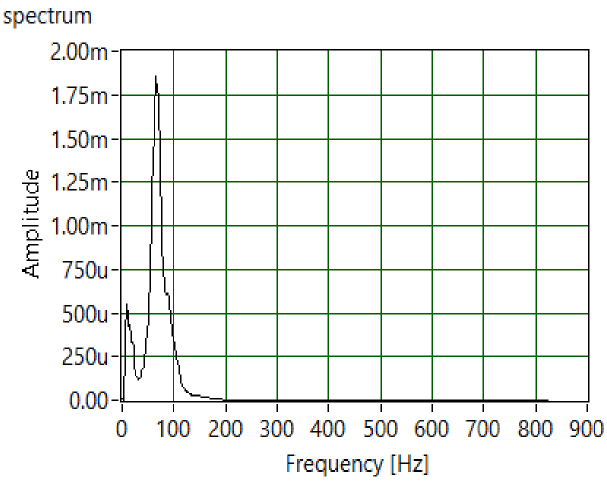


Fig 5.3 spectrum graph for nozzle 0.8 mm

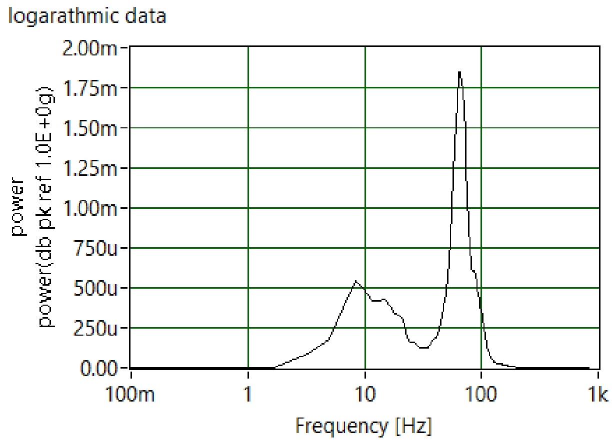


Fig 5.4 Logarithmic data graph for nozzle 0.8 mm

## VI. CONCLUSION

A free vibration analysis of wood PLA 3d printing filament is analyzed by using finite element methods in ANSYS. Comparison of theoretical, numerical and experimental results obtained with smaller differences only less than 10%. The raw acceleration plot and further filtered acceleration, velocity and displacement plots of the cantilever are captured and analyzed by using FFT in association with LabVIEW software (National Instruments) the accelerometer.

## VII. FUTURE SCOPE

- Carrying out the Acoustic test, Thermal TAG test, Pin on disk test, Tribology test on the material and comparing them.
- The technology currently being researched for building construction
- Printing the sturdy toys and the articles.
- Using the Wood PLA for furniture purpose which has same texture instead of use of real wood.

## REFERENCE

**[1]** Sreekanth Sura et.al. “Dynamic Analysis of Cantilever Beam. International Journal of Mechanical Engineering and Technology”, 8(5), 2017, pp. 1167–1173.

**[2]** Cany Mendonsa et.al.(2015)

**[3]** Raju Bangalore Singe Gowda et.al.(2014) “Studies on the Process Parameters of Rapid Prototyping Technique” Article ID 804705

**[4]** M Sumalatha et. al. (2021) IOP Conf. Ser.: Mater. Sci. Eng. 1112 012009

**[5]** Ossi Martikka et. al. “Mechanical Properties of 3D-Printed Wood-Plastic Composites”. (2018) vol. 777.499

**[6]** Lingxiao Liu et.al. “Mechanical Properties of 3D-Printed Wood-Plastic Composites”. June 12,2019

**[7]** Additive manufacturing technologies book by lan Gibson, David w. Rosen, Brent Stucker.

**[8]** vibration analysis by S.S. Grover