iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** XII **Month of publication:** December 2021

DOI: https://doi.org/10.22214/ijraset.2021.39158

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

Vibration Suppression of a Fast Filament Fabrication 3d Printer via Resonance Compensation

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Abstract: ***Additive manufacturing systems especially 3d printers are made by rigid links which provide sufficient stiffness to give motion to 3d printing head system which are moving at very high speed &acceleration. It has been found out that high-speed manipulators generate vibration problem and 3dprinting head is one of them which encounter significant vibration at high speed and acceleration. Therefore, evolution in mathematical control system is necessary for effective vibration suppression and to allow fast motion of 3d printing head at high speed and acceleration. In this paper we develop experiment where we measure the resonance frequency of our bed swinging 3d printer and with graph we optimized it with mathematical system which allows printer to run 140% faster speed and over 600% higher acceleration with same quality and precision.***
Keyword: 1. Additive Manufacturing, 2. Complex system development, 3. Mechatronics, 4. Robotics, 5. Physics. 6. Advanced engineering mathematics 7. High speed manipulators.

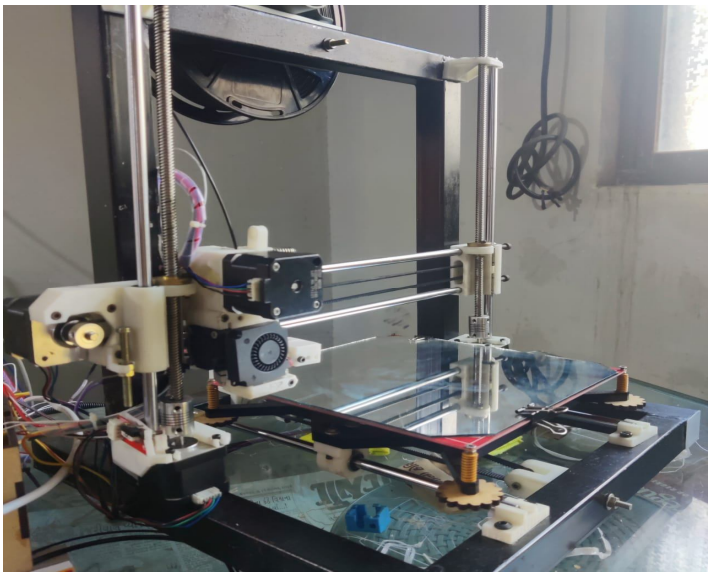
I. INTRODUCTION

3D printing or additive manufacturing in manufacturing, any of several processes for fabricating three-dimensional objects by layering two-dimensional cross sections sequentially, one on top of another. The process is analogous to the fusing of ink or toner onto paper in a printer (hence the term printing) but is actually the solidifying or binding of a liquid or powder at each spot in the horizontal cross section where solid material is desired.

Classification of AM according to ASTM [American society for testing and materials]:

1) VAT PHOTO POLYMERIZATION.
2) MATERIAL JETTING.
3) BINDER JETTING.
4) MATERIAL EXTRUSION.
5) POWDER BED FUSION.
6) DIRECT ENERGY DEPOSITION.

(Low energy to high energy consumption.)



1.] 3DP mini.

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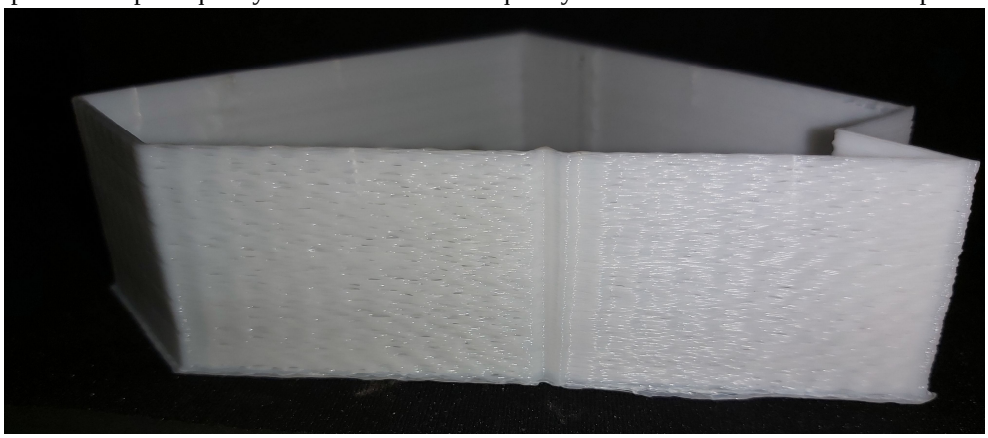
II. MATERIAL EXTRUSION

Material extrusion is an additive manufacturing technique which uses continuous filament of thermoplastic or composite material to construct 3D parts. The material in the form of plastic filament fed through an extruding nozzle, where it heated and then deposited onto the build platform layer by layer.

III. MATHEMATICAL EVOLUTION

In our 3D printer which we made by ourselves the 3DP mini, we identified the same problem as other printers encounter. The speed was slow. Therefore, we decided to Increase our speed and acceleration through firmware. But by employing it, our print quality diminished. So, we analysed to root cause of the problem. We discovered that manipulators and rigid parts of printer get in vibration when accelerated.

This frequency of resonance when matches with the natural frequency, we get maximum amplitude and thus more vibrations at head. So first we measured frequency of our working head by printing a specimen which change its acceleration incrementally with hight of our object. This specimen A was printed with initial value of 400 mm/sec^2 and increased up to 3,000mm /sec^2. Further than that, acceleration was not possible as print quality was harmed. This frequency was measured with vernier callipers.



2.] Specimen A with no damp compensation and increased acceleration up to 3000mm/sc.

After measuring the natural frequency, we constrained the parts where vibration was dominant. The vibrations were put on to halt. And with this second integration, we once again tested another specimen B so as to see that whether it could achieve more acceleration or not. For finding frequency, we used very simple formulae:

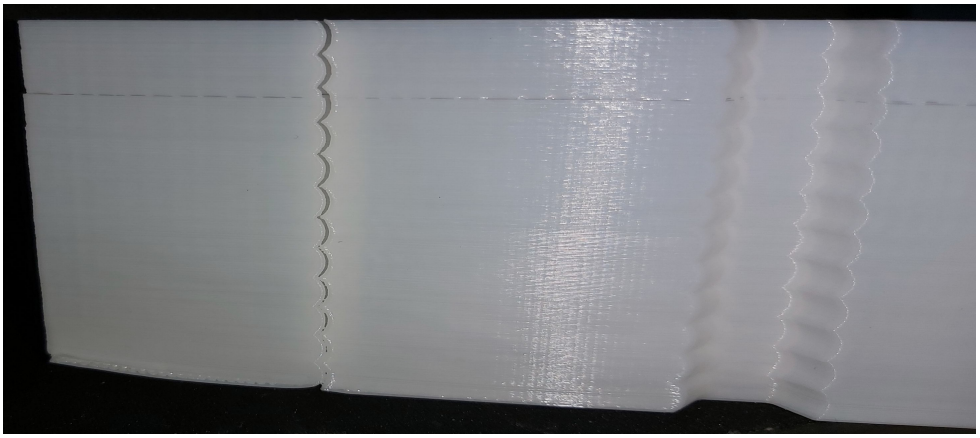
F= v*n/d.(Hz)

Here, F = frequency

V= velocity

N= number of rings.

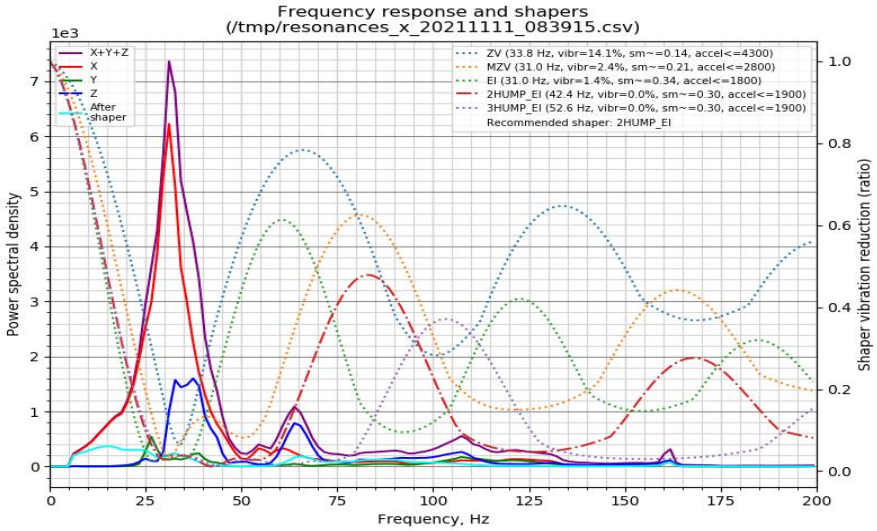
D =distance between two consecutive rings



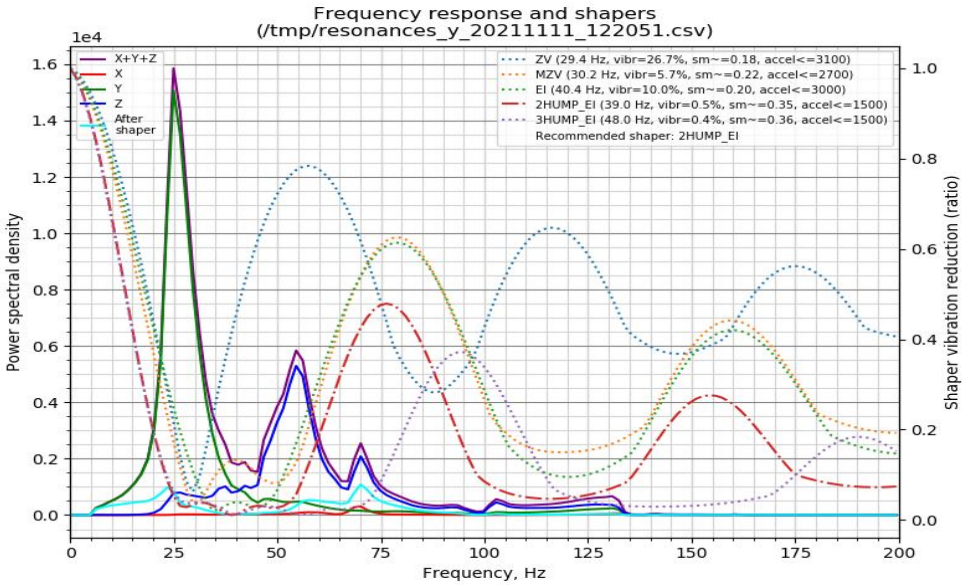
3] Specimen B with 1500mm /sc to 7500mm /sc acceleration.

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In specimen B, results were very promising as we got splendid increase in acceleration up to 7,500mm /sc. And this too without ghosting or ringing problem hence no compromise in quality at such high speed. This holds immense potential in 3D printing technology as it addresses the root drawback of 3D printing which is slow printing. Now we can print very fast and with good quality. For second specimen, we measured resonance frequency with the help of accelerometer (ADXL345) Which given us values of vibration frequency at Different time interval. With the help of this values, we Plotted graph in MATLAB. We uploaded whole script in Raspberry pi and thus generated two graphs for X & Y axis respectively.



4] Frequency graph for X axis in MATLAB.

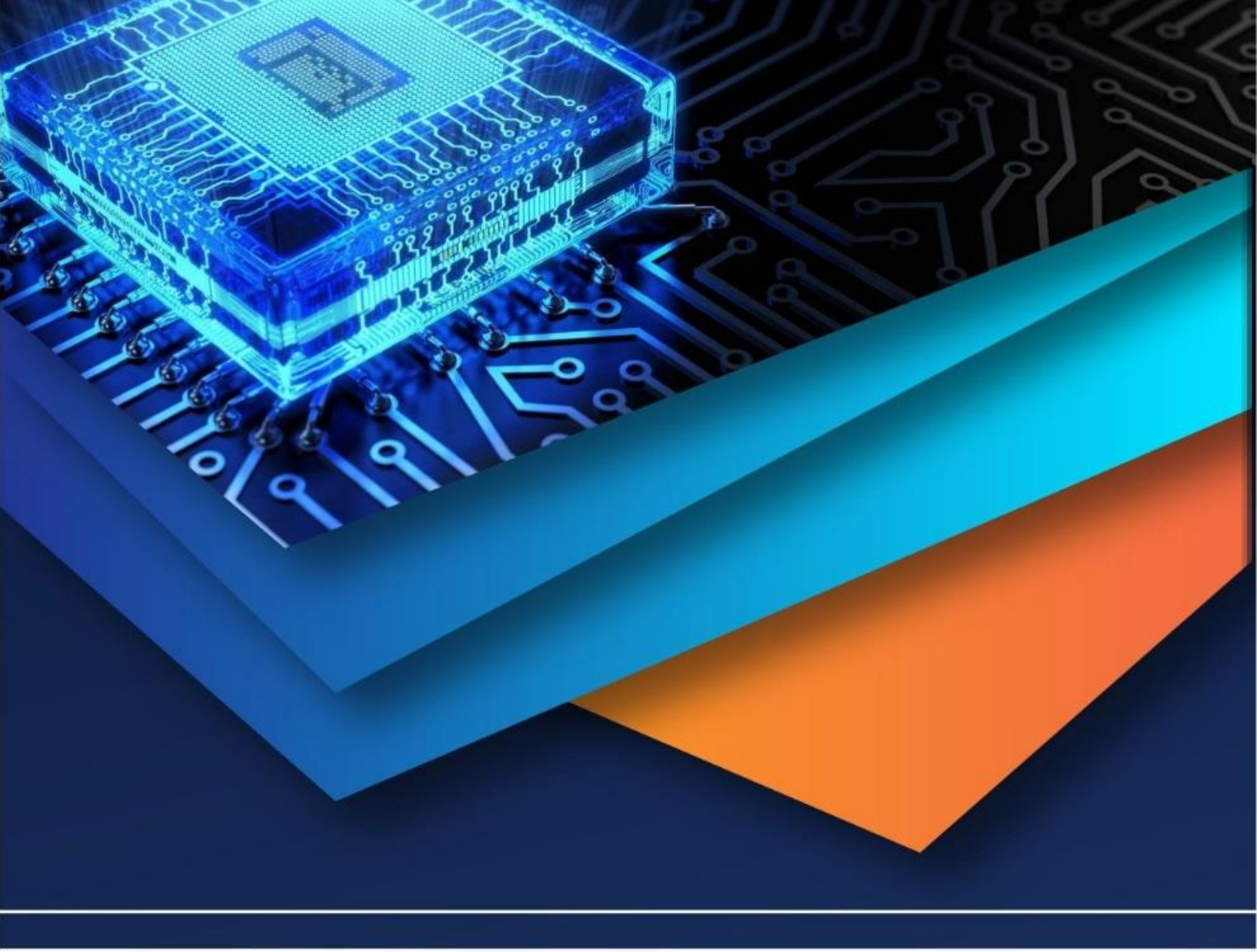


5] Frequency graph for Y axis in MATLAB.

IV. CONCLUSION

It can be concluded that with new evaluated model of mathematical control system, our 3D printer now has increased speed by 140% and acceleration by 600% more than traditional extrusion 3d printer. Additionally, to this, quality and precision were kept intact with the speed and acceleration change. The oscillations damping helps greatly in the making the 3D printing process rapid and giving Rapid prototyping it's true nature to be rapid.

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