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REDESIGNING AND FABRICATION OF EXTRUDER, Z - AXIS DRIVE AND THEIR STRUCTURAL SUPPORTS OF 3D PRINTER

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Abstract:

3D Printing is a new and innovative method used to manufacture solid objects. It allows the user to make the complicated 3D shapes using a method of manufacturing where a part is made by adding layer after layer (ADDITIVE MANUFACTURING) of a heated material that cools and solidifies almost instantly. The 3D shapes are initially created on the computer using the solid modelling software. In order to have a high functioning 3D printer, there are many kind of forces that need to be accounted in the design, so that they don't affect the quality of the produced part. This project report will explain and analyse the problems identified in the existing 3D printer also in addition it will explain how these problems are overcome using the skills in mechanical engineering.

Keywords: 3D printer, Extruder, Buckling forces, , Additive Manufacturing, CURA software.

I. INTRODUCTION

Additive Manufacturing (AM) is used to describe the technologies that build 3D objects by adding layer-upon-layer of material, whether the material is plastic, metal, concrete, ceramic, fluid or anything. The term AM is composed of many technologies including 3D Printing, Rapid Prototyping (RP), Direct Digital Manufacturing (DDM), layered manufacturing and additive fabrication.AM application is limitless. Main use of AM is in the form of Rapid Prototyping focused on preproduction visualization of product models. At present, AM is being used to fabricate end-use products in aircraft, dental restorations, medical implants, automobiles, and fashion products. One of the main advantages of additive manufacture is the speed at which parts can be produced compared to the traditional methods. Complex designs can be uploaded from a CAD model and printed in a few hours. The advantage of this is the rapid verification and development of design ideas. Where in the past it may have taken days or even weeks to receive a prototype, additive manufacturing places a model in the hands of the designer within a few hours.The restrictions imposed by traditional manufacturing on what can be made are generally not relevant for additive manufacturing. Since components are constructed one layer at a time, design requirements such as draft angles, undercuts and tool access do not apply, when designing parts to be 3D printed. While there are some restrictions on the minimum size features that can be accurately printed, most of the limitations of additive manufacturing center around how to optimally orientate a print to reduce support dependency and the likelihood of print failure. This gives designers a large amount of design freedom and enables the easy creation of very complex geometries.Our work will let u know the concepts how the mechanical stability of a machine is important to get a desired output added to the extrusion concept will be briefed and how it can be a problem for 3d printing.Finally a comparative study is done between the existed model before modification and the existing model after modification in order to justify that the changes we made.

II. PROBLEM STATEMENTAND ITS RECTIFICATION SOLUTION.

The main problems identified are: Improper extrusion of the filament through the extruder. Buckling of z axis lead screw. This led to faulty output and the desired output was not obtained, hence we took it up as a challenge and strived to overcome this problem.

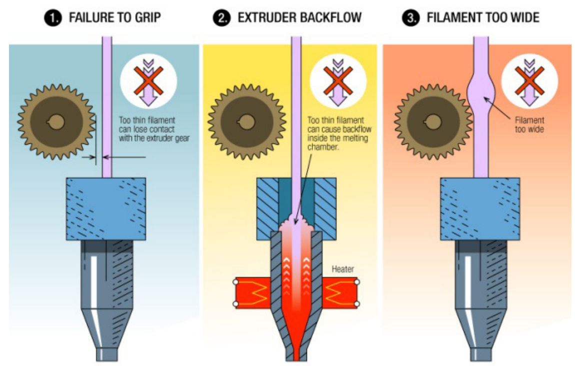

Figure 1. Common Extrusion problems

The Figure 1 explains the different types of extruder problems which can take place in a 3D printer.But none of these were present in the existed design, the problem was that the filament was not tightly held together to the pulley driving it and resulting in improper extrusion.

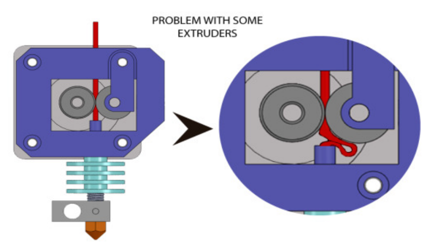

Figure 2. The real problem that existed

The Figure 2 can clearly show how the filament stuck in between the pulley and gear, this is the problem which is made the 3D printer not to extrude properly.

Z axis lead screw was bent and it caused an imbalance to the mechanical stability and the movement of the extruder was not proper due to this problem. This problem led to improper surface finish of the desired output.

III. CHANGES IN EXISTING MODEL PARTS

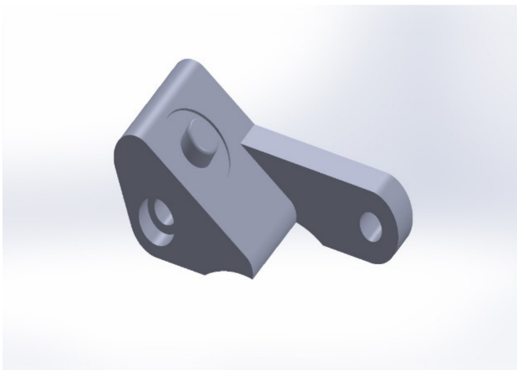

Figure 3. Extruder A

Figure 4. Extruder B

The figure 3 and Figure 4 are the design changes that made to the extruder which will make the filament to properly run through the extruder and pave way for the fine extrusion of the extruder.
Now the X axis motor end and X axis idler end is redesigned.

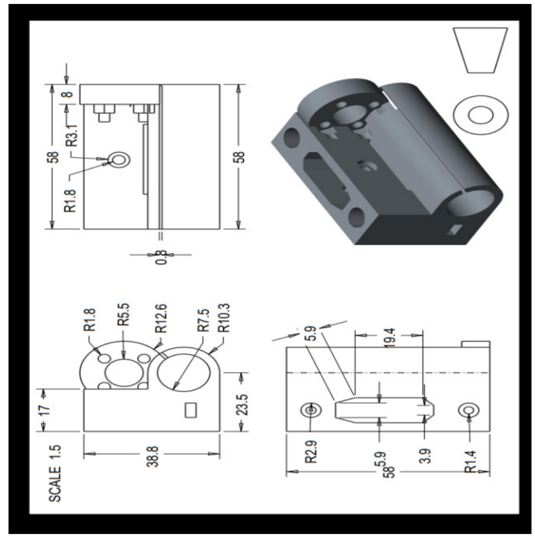

Figure 5. X-end idler

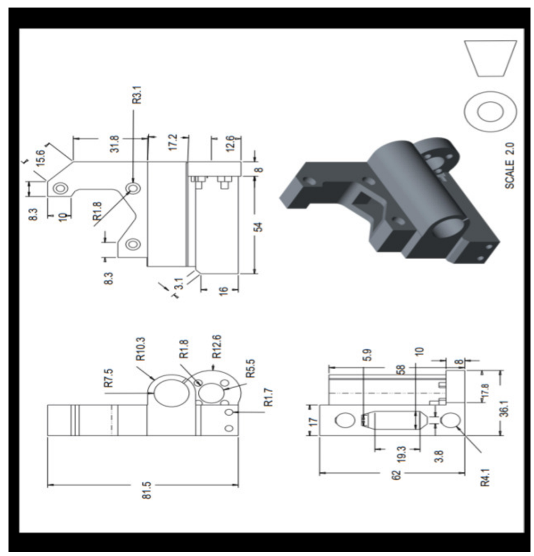

Figure 6. X end motor

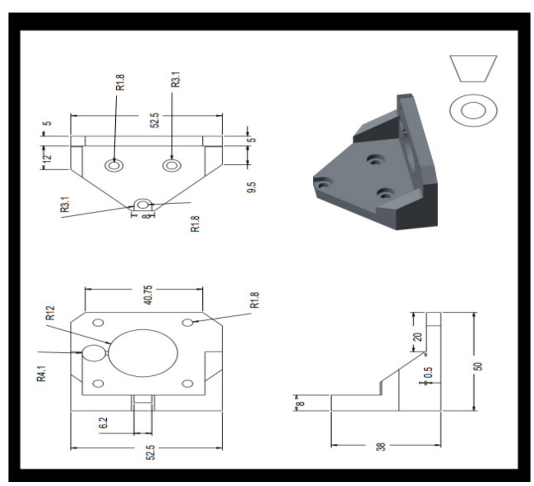

Figure 6. Z axis Bottom left

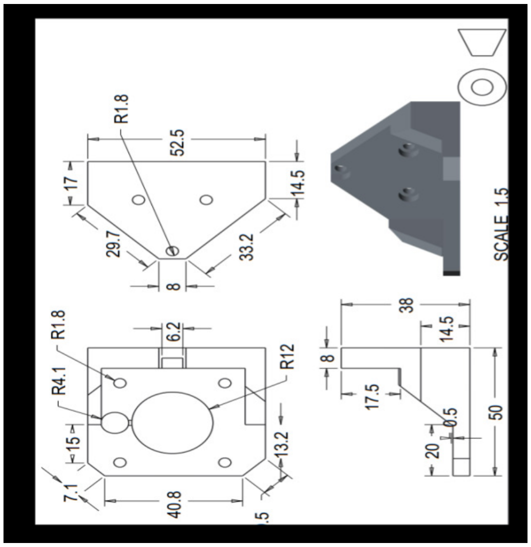

Figure 7. Z axis Bottom right

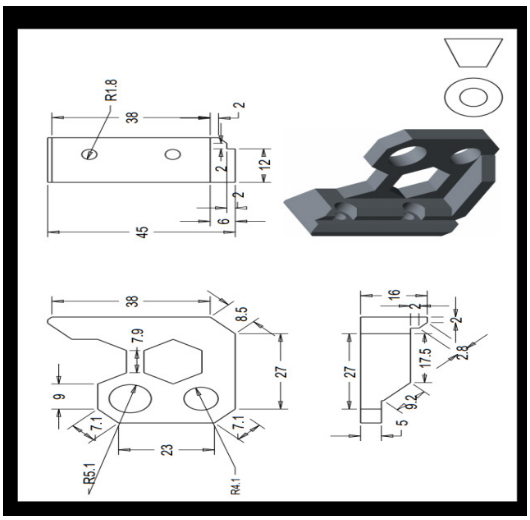

Figure 8. Z axis Top left

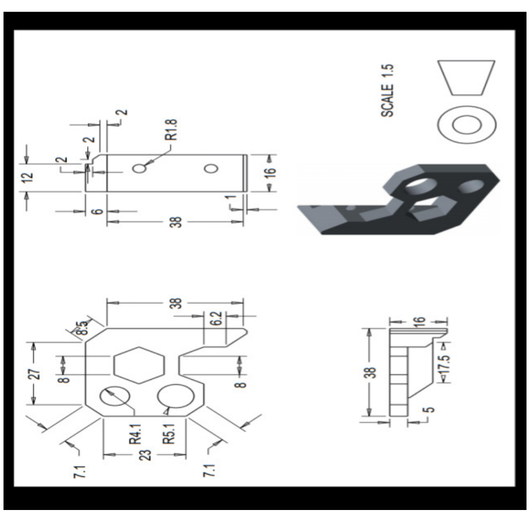

Figure 9. Z axis Top right

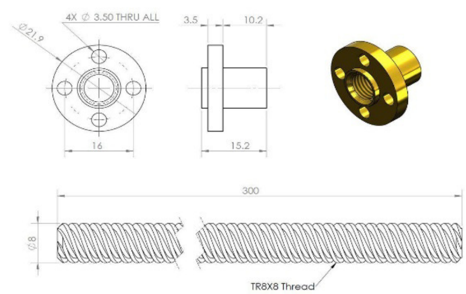

Figure 10. Z-axis screw

These are the design changes made to the existed 3D printer for stabilising the structure of the 3D printer. The Z-axis screw is changed from 4mm diameter to the 8mm diameter thus this is the main change in the structural design and the additional supported structures which are supporting the motor, extruder are redesigned and fabricated by using the 3D printer and the material used for fabrication is ABS.

IV. ANALYSIS

CALCULATION FOR CALIBRATION OF VARIOUS MOTORS (THEORITICAL)

Step = (S*D) / (P*N)

Where,

S, motor steps per revolution

D, steps pot should turn to deliver the current for n revolutions

P, belt pitch (mm)

N, no of teeth on pulley

X- AXIS MOTOR

Steps/mm = (S*D) / (P*N)

= (200 * (1/16)) / (2*20)

= 80

Y- AXIS MOTOR

Steps/mm = (S*D) / (P*N)

= (200 * (1/16)) / (2*20)

= 80steps/mm

Z- AXIS MOTOR

Steps/mm = S*D / T

Where,

T, thread pitch (mm)

S*D = 200*16 steps/rev = 3200steps/rev

S*D/T = 3200steps/rev / 8mm/1rev

= 400steps/mm

EXTRUDER MOTOR

Steps/mm = S*D* / (d * 3.14)

Where,

d, hob effective diameter (mm)

Steps/mm = 200*8 / 7 * 3.14

= 70

PRACTICAL VALUES (USED FOR CALIBRATION)

X- AXIS MOTOR : 80mm/steps

Y- AXIS MOTOR : 80mm/steps

Z- AXIS MOTOR : 401mm/steps

EXTRUDER MOTOR: 100mm/steps

V. PERCENTAGE INCREASE IN FORCE TO CAUSE BUCKLING IN Z AXIS LEAD SCREW

$P_E = \pi^2 E I / L^2$

P_E, force required to cause buckling (N)

E, young's modulus (N/mm^2)

I, area moment of inertia (mm^4)

L, equivalent length (mm)

ONE END FIXED

So the equivalent length = 2L

BEFORE MODIFICATION

L = 300mm

2L = 600mm

E = $180 \times 10^3\ N/mm^2$

I = $(\pi / 64) \times d^4\ mm^4$

Where d is the diameter of the rod (4mm)

I = $12.566\ mm^4$

$P_E = \pi^2 E I / L^2$

$P_E = 3.14^2 \times (180 \times 10^3) \times (12.566)^4 / 600^2$

$P_E = 62.01$ N

AFTER MODIFICATION

L = 300mm

$2L = 600mm$

$E = 180 \times 10^3 N/mm^2$

$I = (\pi / 64) \times d^4 mm^4$

Where d is the diameter of the rod (8mm)

$I = 201.061 mm^4$

$P_E = \pi^2 E I / L^2$

$P_E = 3.14^2 \times (180 \times 10^3) \times (201.061)^4 / 600^2$

$P_E = 992.1962 N$

PERCENTAGE INCREASE IN FORCE TO CAUSE BUCKLING IN Z AXIS LEAD SCREW:

$= \{P_E \text{ (After Modification)} - P_E \text{ (Before Modification)} / P_E \text{ (After Modification)}\} \times 100$

$= \{(992.1962 - 62.01) / 992.1962\} \times 100$

$= 0.9375 \times 100$

$= 93.75\ \%$

There's a 93.75% increase in the force to cause buckling in z axis lead screw.

VI.CONCLUSION

We faced many difficulties such as sourcing of parts, delivery delays, the time constrain and many other challenges during the execution of our project.

We were in a very different scenario, we had the 3d printer in our hand and it was not in the working condition so it was like to analyse the printer first and then work on it to make it run again effectively. Hence we took it up as a challenge and strived to overcome each and every obstacle that hindered proper execution of the machine

Some technical problems were disturbing the performance of the machine, finally after a lot of trial and error exercises we managed to point out the causes for each and every problem and came out with solutions that improved the performance and quality of the printed object.

The main problems identified are

1. Improper extrusion of the filament through the extruder

2. Buckling of z axis lead screw

We added a spring which was missing in the extruder setup to provide tension between the pulley and the filament, so that the filament properly flows through the extruder and this leads to proper extrusion of the plastic material added to that it gives a proper finish to the product we print.

We changed the Z axis lead screw from 4mm to 8mm to increase the percentage in force that causes buckling and we achieved a 93.12% increase in buckling load.

The final product before the modification in design and after the modification of the design is shown in the Figure.11 and Figure 12.

Figure 11. Nut design extruded before modification.

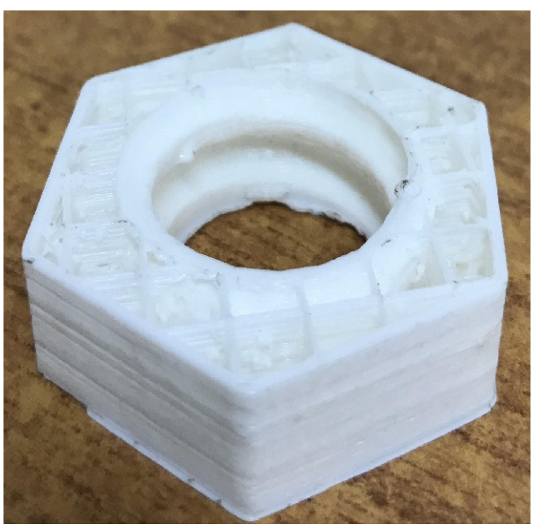

Figure 12. Nut design extruded after modification.