“Design and Manufacturing of 3-D Printer for Industrial and Educational Use”

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Abstract: Three-dimensional (3D) printing is a crucial technology for rapid prototyping because it allows for simple, quick, and low-cost manufacture. The purpose of this work is to overcome the difficulties faced by the industries in appointing 3-D printers as well as provide this model to the educational settings. This work also focuses on the methods of 3-D printing that businesses may use to save time and money when creating/manufacturing a new product that needs to be launched. We can also identify solutions to minimise the overall cost of manufacturing a 3-D printer. It is intended that the research presented in this paper will provide information on 3-D printers and its uses in industry and education. Making, storing, and delivering spare parts has long been a time-consuming and expensive challenge for spare part providers and their customers. Using 3D printers, several prototypes may be created based on iterative design modifications in a reasonably short timeframe and at a comparatively low cost of manufacture.

***IndexTerms* – Prototyping, 3-D Printing, Manufacturing**

I. INTRODUCTION

The 3D printing craze began a few years ago and has now captivated the general public. The media was instrumental in making "3D printing" the latest buzzword in technological advancement. They began to frequently demonstrate the actual possibilities of this interesting industry. Since then, 3D printing has swept the country. People are enthralled by the prospect of being able to develop a wide range of personalised products as and when they require them. Despite its newness, 3D printing has been around for quite some time. That's for sure, it's been around for much longer than most people realise. This guide's goal is to take you on a journey through the history of 3D printing. We'll begin with the beginning and work our way up to the present day. In a poll of 38 German industrial businesses conducted by Strategy& in late 2015, respondents agreed that 3D printing will save an industry time and money. Making, storing, and delivering spare parts has long been a source of time-consuming and costly challenges for both spare part providers and their consumers. According to a survey done by stratasys, the following are the issues that producers experience when using a 3D printer as a first step in the manufacturing process: Lack of experience and/or training among workforce/employees, Equipment expenses, Limited materials available, Post-processing requirements, Manufacturing costs, Lack of in-house additive manufacturing resources

In the last few years, 3D printing technology has begun to change the way we generate full physical items and pieces. The variety of items generated by 3D printing is wide now, and it continues to expand. We can 3D print anything right now, from basic toys to garments and tools. Technology can also be used to create musical instruments and even human body parts. Yes, you read that correctly. It appears like the potential is limitless. Looking at how a typical inkjet printer works is the easiest method to describe 3D printing. We begin by creating the computerised file, in whatever format it may be. This might be a word processor document, a spreadsheet, an image, or something else entirely. Once our file is ready, we use the computer to send it to the printer, then press the 'PRINT' button. The printer then extrudes (forces) ink onto the paper from a nozzle. The ultimate result of a single print cycle is a two-dimensional representation of the digital information. In a similar way, 3D printing works. The key distinctions are the materials used and the additional print cycles. You must also upload a digital file to the printer when using 3D printing. These files are also known as 3D models, 3D computer graphics, CAD files, and other terms. Whatever they are, a file is required for the 3D printer to print your design. Filaments, which are used in 3D printing, are particular forms of ink. Thermoplastics, metals, glass, paper, and even wood are examples of these materials. Later, we'll go deeper into 3D printing materials. The other major distinction is that 3D printing requires multiple print cycles, or layers, to create a tangible thing. This is where the term "additive manufacturing" comes from. As you can see, inkjet and 3D printing theories are extremely similar.

II Design of 3-D Printer

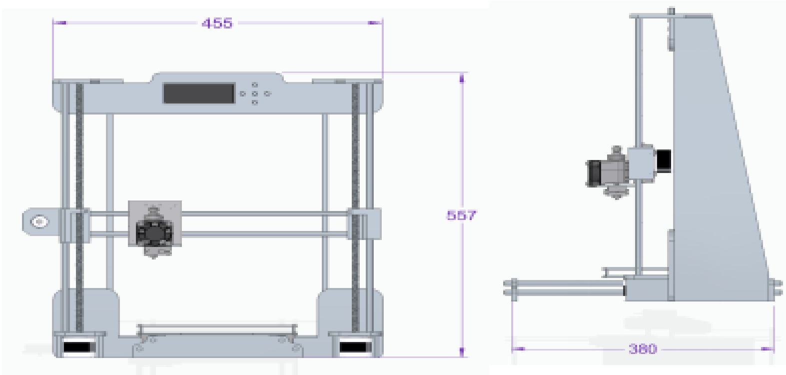

Figure 1- isometric view of 3-d printer Figure 2 Front View and side view of 3-d printer components Used model

1.Hot Bed

The heated bed for 3D printers was created to overcome this issue. The temperature of the printing process and the following cooling phase can be controlled with a heated bed. It lowers the temperature difference between the filament and the bed, which improves adhesion. Circuity boards (PCBs) are commonly used as heating components in heated beds. While such printers are less expensive to purchase, they are not meant to function as heating sources in the intricate process of 3D printing. While such printers are less expensive to purchase, they are not meant to function as heating sources in the intricate process of 3D printing. One disadvantage of utilising these sorts of heated beds is that, because they are heated, they are noisy.

1.1 How Heated Beds Work

When extruded plastic is released from the printer nozzle, it begins to cool. During that cooling process, it also shrinks in size, and it is during shrinking that the part may become uneven and warped, since the cooling may occur at different rates at different points on the part's surface. The heated bed ensures that the printed part stays warm all over during the printing process to allow for more even shrinking once it beings to cool below its melting point. All in all, the heated bed fulfils two tasks: It increases the surface energy of the print bed. This improves the bonding strength at the top layer. It keeps the bottom part hot enough to eliminate the risk of warping for the rest of the print. The bed carries out a delicate balancing act of cooling the plastic without over-cooling it. The extruder part of the printer deposits molten plastic into the receiver bed while supplying a certain degree of heat. The temperature of the heat bed needs to be below the glass point to ensure the print cools into a solid. A lot depends on the temperature sensor of the heat bed to get the required heat that needs to be supplied just right. A certain amount of trial and error needs to be gone through before you can arrive at the correct calibration that matches the setting of the printer and filament.

Fig. 2Hot bed fixed aluminum plate (220mm*220mm*3mm)

2.Extruder

The extruder is one of the most important components on a 3D printer. It is responsible for sending the correct amount of filament to the hot end where it's melted and extruded down in thin layers to make your part. It's important to note that the extruder is not the same as the hot end, though these terms are commonly conflated. The extruder is commonly referred to as the "cold end" because the filament is "cold" when it passes through the extruder on the way to the hot end. There are two basic types of extruders currently available – Bowden and Direct – and there is a lot of conflicting information out there about both. If you've read that "Bowden extruders can't handle flexible filament and they have too much stringing", or "Direct extruders are slow and have too much backlash" and come away confused, we're here to help. We'll walk you through the basics to help understand the differences and decide which option is right for you.

3.Filament Drive Gear:

Something is needed to 'grab' the filament and extrude it through the hot end. Because of the large variety of extruder implementations, these are not all the same. The two most common ones you'll see are small steel gears that have been hobbed, and hobbed bolts. 'Hobbed' just means that splines or teeth have been cut into it. The gears are mounted onto the motor shaft, and the bolts are typically driven by geared extruder motors.

Fig. 3 **Filament Drive Gear**

4. Direct Extruders

Extruders that are directly joined to the hot end are known as direct extruders. This is a Lulzbot Mini hot end and extruder. It's a 3mm filament extruder with a geared direct extruder. It's crucial to understand that a direct extruder and a direct drive extruder are not the same thing. The filament driving mechanism is directly mounted to the motor shaft in a direct drive extruder. Direct drive can be used on both bowden and direct extruders.

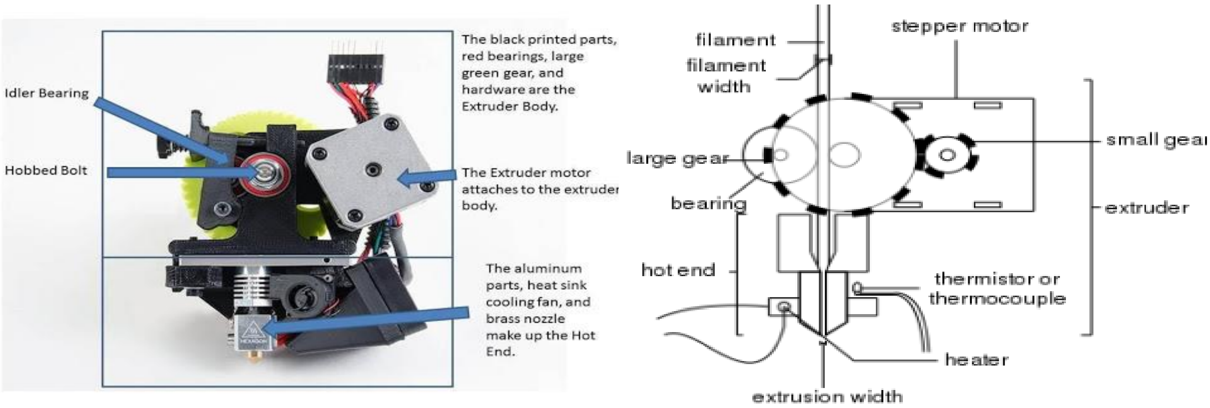

Fig.4 Extruder Assembly and Extruder Mechanism

5. Flexible Filaments

You'll commonly see or hear that bowden extruders can't print flexible. This is demonstrably false. It's also not true that just because direct extruders are direct, they can't print with flexible. While direct extruders are better at printing flexible filaments for the reasons stated above, both types of extruders require the same thing to print flexible filaments: a fully constricted path from the idler/gear pinch point to the hot end. The issue with flexible filaments is depicted in this image of an uncontrolled extruder.

6. Cooling fan

On a PLA 3D printed device, a cooling fan is essential for optimum overhang performance. It may be configured to print at various rates during the printing process, which provides a number of advantages. Continuously running a fan while printing has a negative impact on the final product. Stringing, a fault in which "small threads of plastic are trailed into unwanted locations," can be caused by it. When the machine is unable to remove the force that pulls the thermoplastic filament out of the nozzle quickly enough, stringing develops. The quality of a 3D print is also more consistent and less dependent on the temperature of the environment at the moment when a fan is used at various speeds. When using a PLA cooling fan, there are a few extra things to consider. Because cooling affects adherence to the bed surface, the fan should not be utilised when the item's first few layers are being built up. It must also not be oriented toward the printer's hot end, since this will naturally change the nozzle's temperature, affecting the heated PLA material. Finally, while printing with ABS, another extensively used thermoplastic material in 3D printing, fans should be avoided. This is due to ABS's proclivity for cracking when cooled.

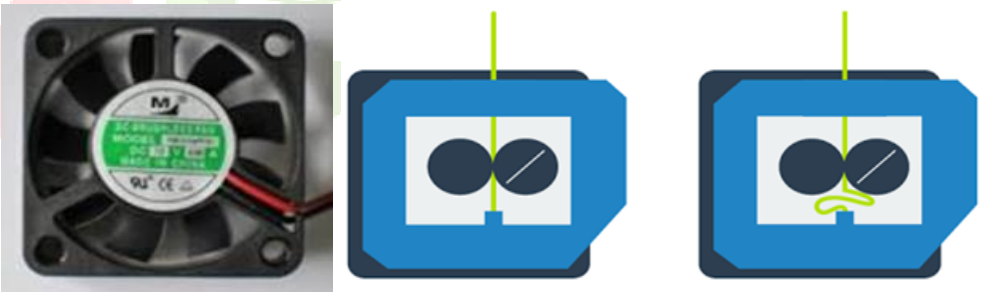

Figure 5 extruder fan filament extruding mechanism

7. Motors

Extruders all have motors. Desktop 3D printers commonly use NEMA 17 stepper motors. "NEMA 17" only refers to the faceplate size, which is 1.7" x 1.7". NEMA 17s aren't all the same. They can be geared at 0.9 degrees every step, 1.8 degrees per step, and so on. They can have a variety of voltage and current ratings, as well as varying lengths and torque capacities. For the time being, those details aren't crucial, but it's worth noting that none of them are necessarily better or worse for usage as an extruder motor. The motor requirements for your extruder's proper operation will be largely determined by the extruder assembly and printer setup. DC motors that move in discrete increments are known as stepper motors.

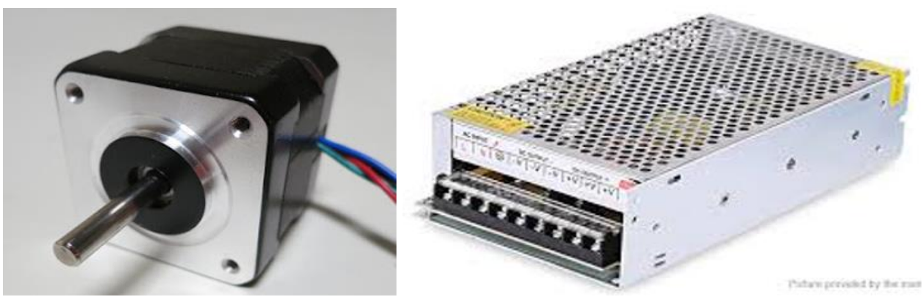

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Figure 6 Stepper Motor and Main power supply

8 Nozzle:

The Nozzle is the tip of the Hot End where the plastics comes out. It needs to be exchangeable when needed. The nozzle size is really important. It usually varies from 0.25mm to 0.75mm. The most common size is 0.5mm. The best practice is to change the nozzle sizes depending on your design and desired results.

9. LCD Display:

The LCD Display controller allows you to 3D print without the need of a computer connected or using a software host such as Cura. It needs a SD card to read the G-code instructions. The display allows more efficient space usage and frees up your computer for other tasks. It's perfect for day-to-day printing and will be used in the majority of your print jobs

Figure 7. Nozzle Of Different Diameters Figure and LCD Display

10 Mainboard:

The Mainboard features On-Board 16-step A4988 Drivers which do just fine for standard build volumes. The nice part about On-Board drivers is you can tune the amps through the firmware and don't have to mess with a millimeter to tune each motor. If the motors are too load for your liking simple add some stepper dampers, these take the noise right out. Its operating voltage is 12V – 24V which makes it a good candidate for swap upgrades of other printers. I find this board to be a better solution over the most commonly used RAMPS Boards. The board has JST-XHP Connectors which are easy to make and stay in place well.

Guide rod:

These are usually used on the printer's Z axis. They rotate, thus forcing nuts to move up and down. Inexpensive printers will use simple threaded steel rods, which are essentially extra-long bolts. Higher quality printers have smooth chrome plated lead screws designed to minimize backlash.

Figure8. Mainboard Guide Rod

III Softwares used in 3D Printing

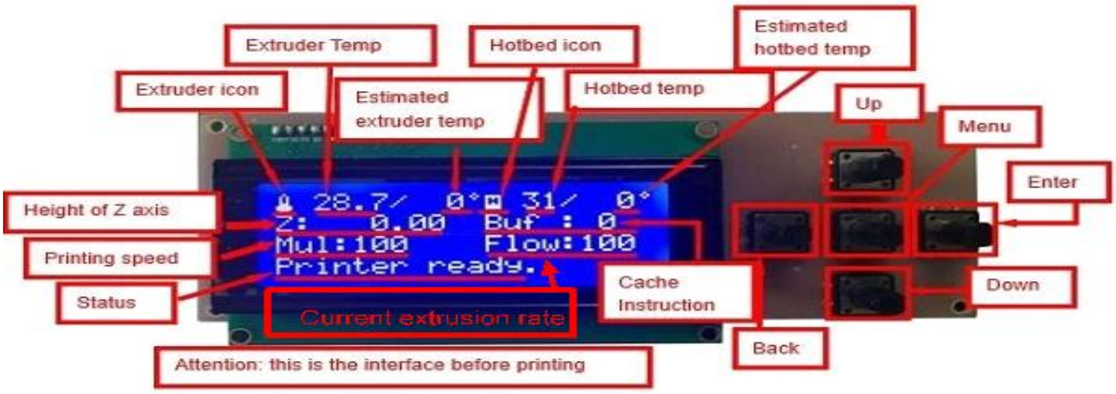
1. 3-D Modeling Software

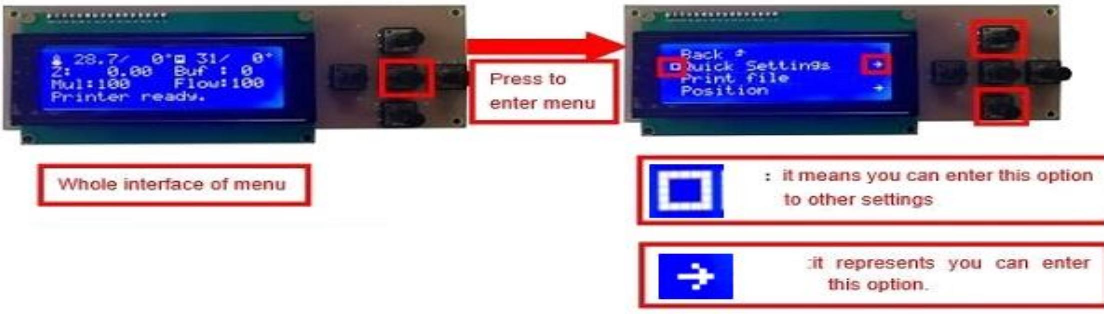
These tools are all about creating models for 3D printing. Some of them are pretty easy to use while other programs are only suitable for professional users with years of experience.

3-D Slash , Tinker CAD, Free CAD, Sketch UP ,Blender ,SolidWorks , Inventor

Printing Operation

Layer thickness：0.1-0.3mm Nozzle diameter: 0.4mm	Machine size： 500*400*450mm
Printing speed：10-120mm/s	Machine weight：7.5KG
X Y axis position accuracy：0.05mm	Packing size：510*345*215mm
Z axis position accuracy：0.015m	Gross weight：9.2KG
Printing material：ABS,PLA	Build size：220*220*240mm
Software： Cura	Working condition： 10-30℃，Humidity 20-50%
Material tendency：PLA	LCD screen：Yes
Filament diameter ：1.75mm	Offline printing：SD CARD
Software language：Multi-Language	File format：STL、G-Code、OBJ
Function of support automatically	OS：windows(linux、mac)





CONCLUSION:

There are numerous possible applications for 3D printers in the future. Designers and engineers can now envision, build, and test prototypes in less time thanks to new 3D printing techniques. However, for 3D printing to catch on in the fast changing industrial industry, it must be viewed by businesses as a daily business choice rather than a fascinating technological advancement. Other applications that we can only dream of today will become available as materials improve and costs fall. The educational field, for the purpose of demonstration, is perhaps the most promising area for 3-D printing to expand.

Hence to make 3-d printer a machine that can be used on daily basis following are the steps taken by us:

1. In this work reduced the overall cost of the 3-d printer by altering the frame design to one with a lower frame cost.
2. We have updated the printing medium to PLA (Polylactic Acid), which is less expensive than other materials and provides good precision.
3. It's also critical to keep costs down by lowering the printer's per-prototype cost, which can be accomplished via slicing using extremely precise software. As a result, we utilised ulimakercura to slice our food. As can be seen in the application of a 3-d printer, the cost of creating a single prototype is approximately (1-2 Rs). This was accomplished using ultimakrecura software to scale and slice the prototype properly.

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