CHAPTER –1

1.1 INTRODUCTION

The three dimensional printing or Additive Manufacturing is the technique of making real 3D object with the help of computer without any human envelopment. This is basically automatic manufacturing which can print the object of any shape and of any material. It is different from conventional manufacturing i.e. subtractive manufacturing in which object is manufactured by removing unwanted material in form of chips but here additive manufacturing is used where object is manufactured layer by layer without any wastage in any form like chips etc.. The object is printed from bottom to up in the form of layer in the exact shape and size as required.

This is a very new technology which developed in the last few decades and it is still in developing 11stage. The first RP machine was developed by Charles Hull in 1980s, which was basically a Stereolithography machine 3. It basically uses laser light to cure the liquid raw material i.e. photopolymers in exact shape and size in which we want to manufacture it. They also developed the file format of the RP machine i.e. .STL file format which is most common now a days in almost all the RP machines. After that this technology starts developing and soon many other machines were invented which also works on the basis of additive manufacturing like selective laser sintering (SLS), fused deposition manufacturing (FDM), three dimensional printing (3DP) etc.. The SLS was invented in late 1980s whereas the FDM develops in 19907 and 3DP develops in 1995 by Z Corporation. The 3 D Printers are also known as inkjet printers. A brief classification of different technologies in this field is also shown in figure 1 below.

However the selection of correct machine from all the available machines is also a very critical process which depends upon numbers of parameters and different approaches can be applied to find the best alternative from all. The best machine selection will provide many benefits in terms of cost, flexibility, parameters, processing time etc..

Today rapid prototyping technologies are being used in almost all the industries and they are fast in removing the conventional methods to manufacture any product. These technologies have numerous advantages and they are being successfully used in all over the world. One of the reasons of their world wide application is their ability to manufacture any type of product made up of any material and so these machines have the capability to initiate the next industrial revolution. These days we can print almost all the shapes object without any problem also the printing is not limited to the material as they can print all the materials available in any form say solid, liquid and powder.

In current scenario many researches are being going on this technology and researchers are continuously working to remove the barriers of this technology and to explore the potential of this technology. Some of the recent development in this field shows that it is being used in all the fields like medical field to print bio materials, automobile field to print all the automobile parts, aerospace industry, space industry, food industry, construction industry, manufacturing industry etc. Although this technology have numerous advantages but it has one major problem i.e. cost of the machine. This cost is biggest hurdle for machine’s application in small and medium scale industries and also this cost is greatly linked with the accuracy and reliability of the machine. The cost of machine starts increasing as you go for more accurate and reliable machine 9. So here in our research we tried to manufacture a low cost 3D printer which can print any shape with ABS filament material. As the accuracy of machine is very critical parameter so the accuracy of the machine is also been kept in mind while developing the printer. Here we have designed and modelled the machines structure along with the frame and base parts and at last we have also discussed the use of printer and the printing procedure with a brief overview of different components that are being used for the machine development.

1.2 SCOPE OF THE PROJECT

Includes (list of Deliverables):

- Base electronic and electromechanical components fundamental to 3D axis control. -

3D rendering software communicating with control board controlling axes and extruder.

- Cartesian frame prototype capable of accurate axial motion control using stepper motors.

Includes (list of Deliverables):

- Control Board enclosure
- Board enclosure mounted to Cartesian Frame.
- Material heating bed

Does Not Include:

- 3D rendering software
- Any material extruded from the system that does not resemble a polygonal form.
- Material spool and spool mounting base
- Calibration of the control system

Project Completion Criteria:

- Working three axis control system communicating with software
- Material extrusion in controlled manner with appropriate temperature settings
- Cartesian frame capable of mounting a stepper motor on each axis

Objectives

1. To make a 3D printer at cheapest cost.
2. To make the device customizable using Adriano.
3. To make a 3D Printer that consumes low power.

CHAPTER – 2

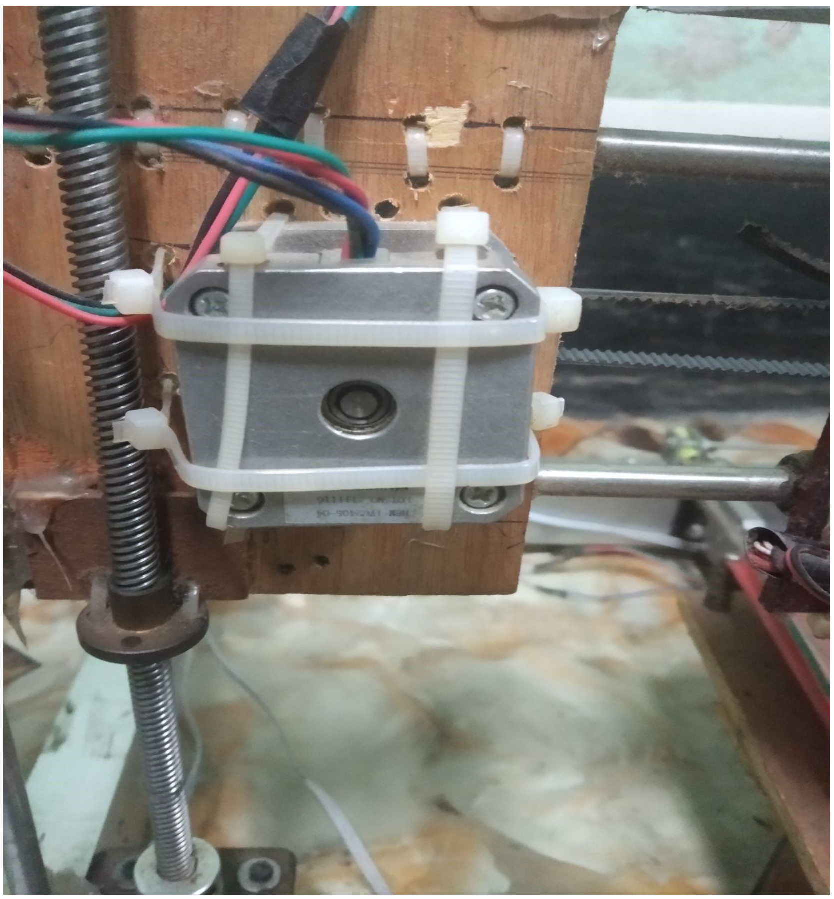
2.1 BACKGROUND

The earliest 3D printing technologies first became visible in the late 1980’s, at which time they were called Rapid Prototyping (RP) technologies. This is because the processes were originally conceived as a fast and more cost-effective method for creating prototypes for product development within industry. As an interesting aside, the very first patent application for RP technology was filed by a Dr Kodama, in Japan, in May 1980. Unfortunately for Dr Kodama, the full patent specification was subsequently not filed before the one year deadline after the application, which is particularly disastrous considering that he was a patent lawyer! In real terms, however, the origins of 3D printing can be traced back to 1986, when the first patent was issued for stereolithography apparatus (SLA). This patent belonged to one Charles (Chuck) Hull, who first invented his SLA machine in 1983. Hull went on to co-found 3D Systems Corporation one of the largest and most prolific organizations operating in the 3D printing sector today. 3D Systems’ first commercial RP system, the SLA-1, was introduced in 1987 and following rigorous testing the first of these systems was sold in 1988. As is fairly typical with new technology, while SLA can claim to be the first past the starting post, it was not the only RP technology in development at this time, for, in 1987, Carl Deckard, who was working at the University of Texas, filed a patent in the US for the Selective Laser Sintering (SLS) RP process. This patent was issued in 1989 and SLS was later licensed to DTM Inc, which was later acquired by 3D Systems. 1989 was also the year that Scott Crump, a co-founder of Stratasys Inc. filed a patent for Fused Deposition Modelling (FDM), the proprietary technology that is still held by the company today, but is also the process used by many of the entry-level machines, based on the open source RepRap model, that are prolific today. The FDM patent was issued to Stratasys in 1992. In Europe, 1989 also saw the formation of EOS GmbH in Germany, founded by Hans Langer. After a dalliance with SL processes, EOS’ R&D focus was placed heavily on the laser sintering (LS) process, which has continued to go from strength to strength. Today, the EOS systems are recognized around the world for their quality output for industrial prototyping and production applications of 3D printing. EOS sold its first ‘Stereos’ system in 1990. The company’s direct metal laser sintering (DMLS) process resulted from an initial project with a division of Electrolux Finland, which was later acquired by EOS. Other 3D printing technologies and processes were also emerging during these years, namely Ballistic Particle Manufacturing (BPM) originally patented by William Masters, Laminated Object Manufacturing (LOM) originally patented by Michael Feygin, Solid Ground Curing (SGC) originally patented by ItzchakPomerantz et al and ‘three dimensional printing’ (3DP) originally patented by Emanuel Sachs et al. And so the early nineties witnessed a growing number of competing companies in the RP market but only three of the originals remain today, 3D Systems, EOS and Stratasys. Throughout the 1990’s and early 2000’s a host of new technologies continued to be introduced, still focused wholly on industrial applications and while they were still largely processes for prototyping applications, R&D was also being conducted by the more advanced technology providers for specific tooling, casting and direct manufacturing applications. This saw the emergence of new terminology, namely Rapid Tooling (RT), Rapid Casting and Rapid Manufacturing (RM) respectively. In terms of commercial operations, Sanders Prototype (later Solidscape) and ZCorporation were set up in 1996, Arcam was established in 1997, Objet Geometries launched in 1998, MCP Technologies (an established vacuum casting OEM) introduced the SLM technology in 2000, EnvisionTec was founded in 2002, ExOne was established in 2005 as a spin-off from the Extrude Hone Corporation and SciakyInc was pioneering its own additive process based on its proprietary electron beam welding technology. These companies all served to swell the ranks of Western companies operating across a global market. The terminology has also evolved with a proliferation of manufacturing applications and the accepted umbrella term for all of the processes was Additive Manufacturing (AM). Notably, there were many parallel developments taking place in the Eastern hemisphere. However, these technologies, while significant in themselves and enjoying some local success, did not really impact the global market at that time.

CHAPTER –3

METHODOLOGY:

3.1 NEMA 17 STEPPER MOTOR:



Figure(3.1): NEMA 17 Stepper Motor

The motors are used to provide the necessary movements to different parts of the printer. We are using four NEMA 17 stepper motors to control the movements. It is a heavy duty motor which provide higher torque with 1.7 x 1.7 inch faceplate. The motor specifications are: •1.4 A to 1.7 A current/phase •15 volts •3 to 7 mH inductance/phase •43 N•cm torque •1.7 or 0.8 degrees/step (200/400 steps/rev)

3.2 ARDUINO MEGA 2560:

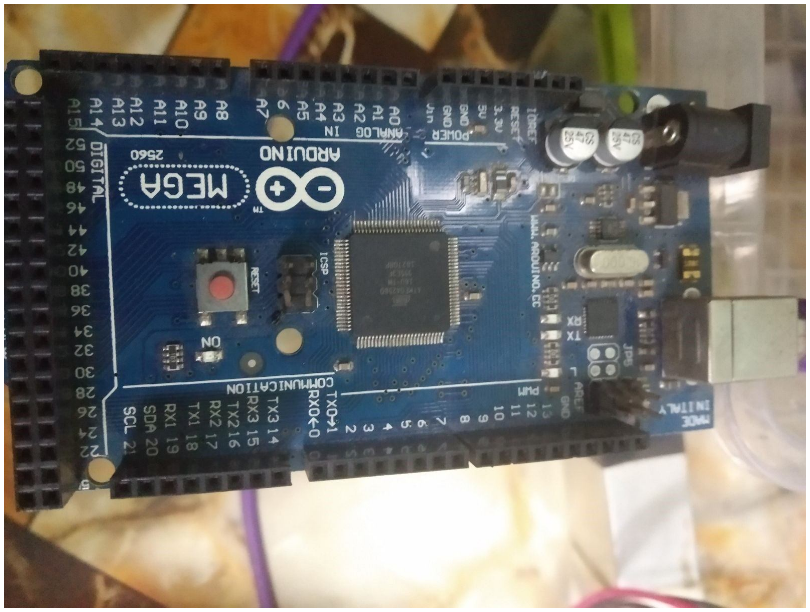


Figure (3.2)**:**Arduino Mega 2560

The MEGA 2560 is designed for more complex projects. With 54 digital I/O pins, 16 analog inputs and a larger space for your sketch it is the recommended board for 3D printers and robotics projects. This gives your projects plenty of room and opportunities.TheArduino Mega 2560 is a microcontroller board based on theATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

3.3 RAMPS 1.4 SHIELD:

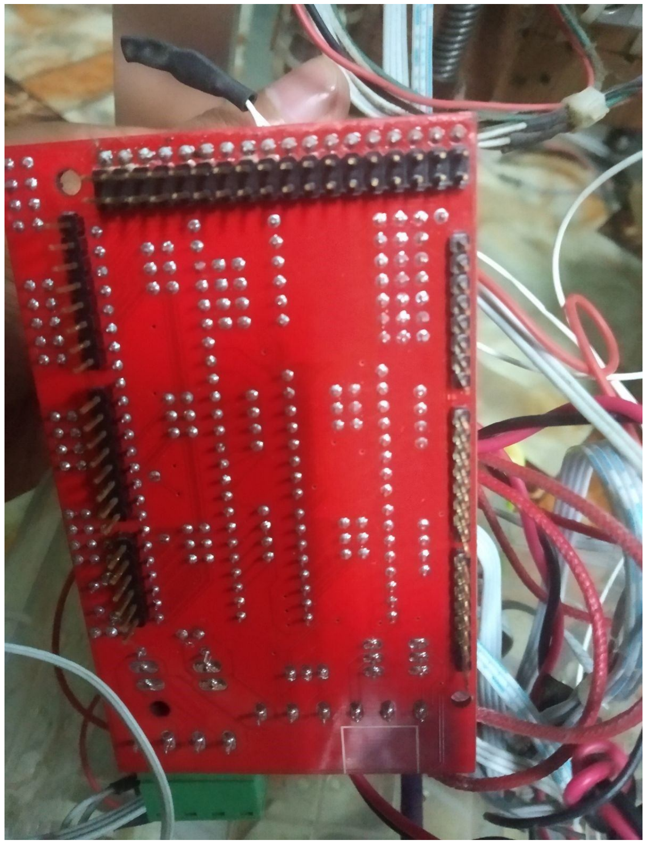
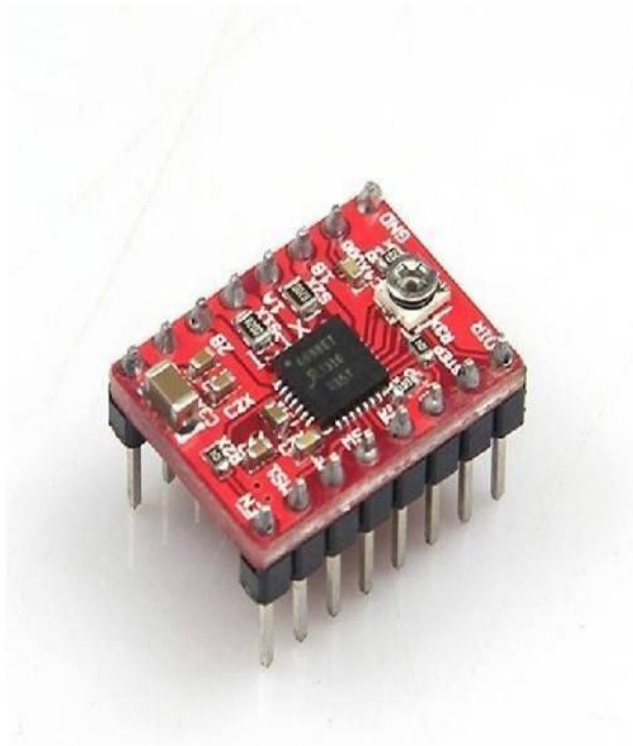


Figure (3.3): Ramps1.4 Shield

Heated bed control with additional 11A fuse. Fits up to 5 stepper driver board. It is designed to fit the entire electronics needed for a RepRap 3D printer in one small package for low cost.The modular design includes plug in stepper drivers and extruder control electronics on an Arduino MEGA shield for easy service, part replacement,Additionally, a number of Arduino expansion boards can be added to the system as long as the main RAMPS board is kept to the top of the stack.

3.4 STEPPER MOTOR DRIVERS WITH HEAT SINK:



Figure(3.4)**:**Stepper motor Drivers with heat sink

The A4988 stepper motor driver carrier is a breakout board for Allegro's easy-to-use A4988 microstepping bipolar stepper motor driver and is a drop-in replacement for the A4983 stepper motor driver carrier. The driver features adjustable current limiting, overcurrent protection, and five different microstep resolutions. It operates from 8 – 35 V and can deliver up to 2 A per coil.

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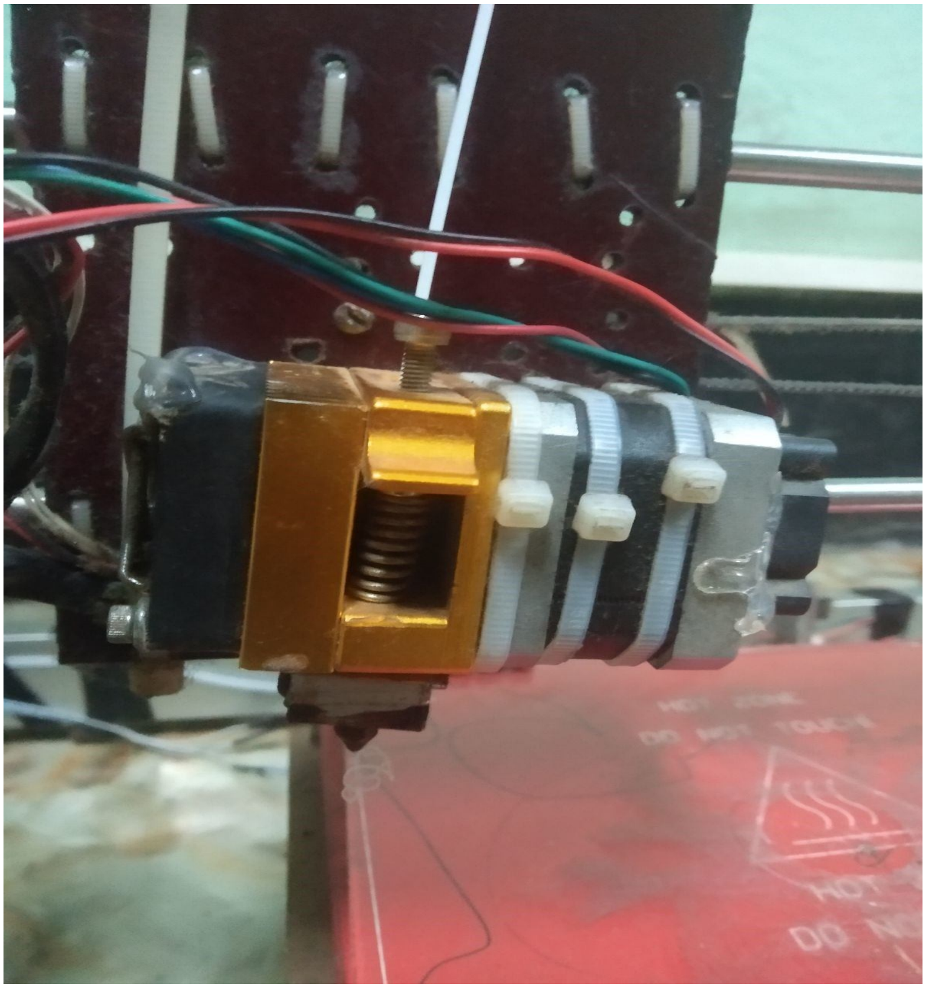
3.5 EXTRUDER FULL SET WITH FAN:



Figure(3.5): Extruder Full set with Fan

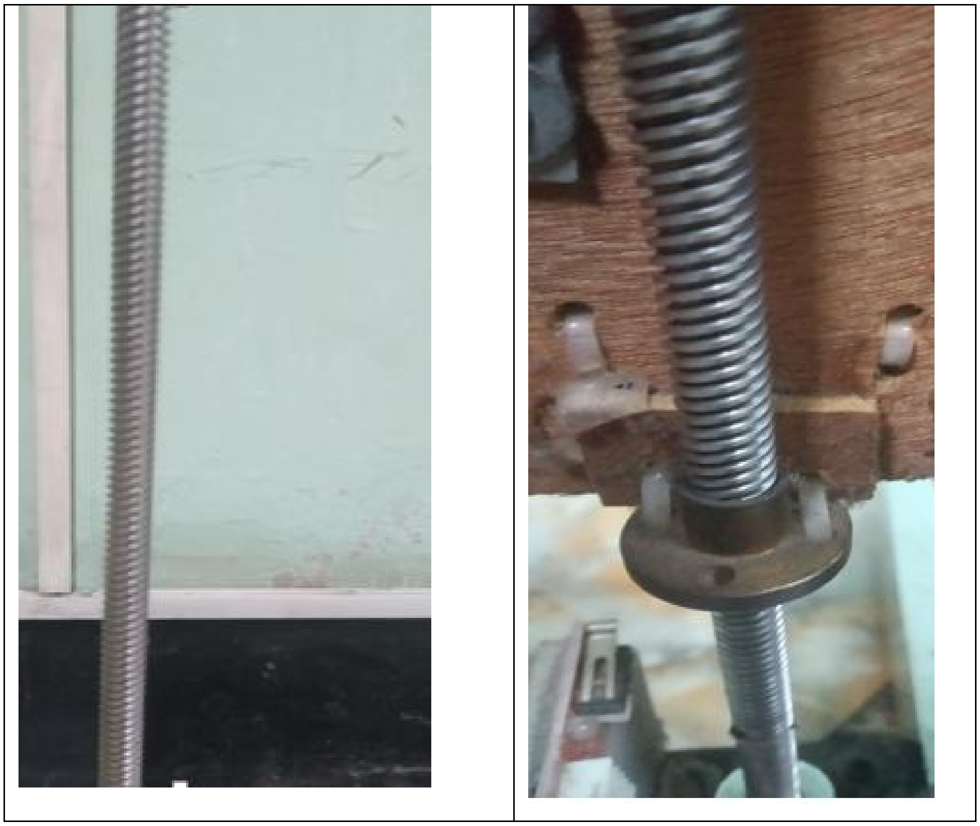
To control the movement of the filament the extruder is used which is basically a feeding system which have a cold top part that feeds the filament with the help of motor and gear and a hot part which is having heating arrangement to heat and melt the filament. The hot part is made up of brass bolt with a hole drilled for the movement of the filament. The drilled hole size varies with the sizes of filament available and here we used 3 mm wide filament.

3.6 SMOOTH ROD:

Figure(3.6): Smooth Rod

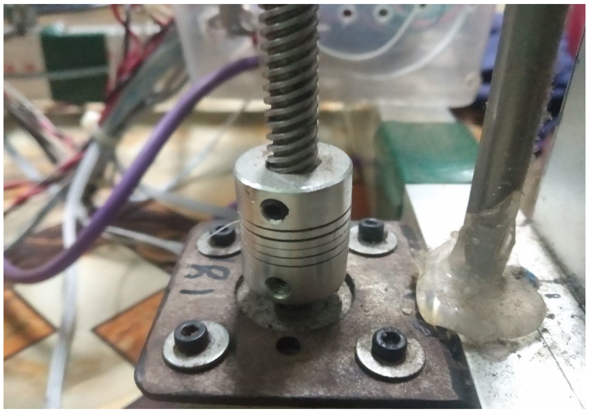
To move the printer bed and the printer head we are using different rods which provides required degree of freedom. To controls the movement of the rods we are using motors, pulleys and belt arrangement. Here the Y-axis provides one degree of freedom by moving the frame back and front with the help of stepper motor and pulley arrangement. The rod used are: • 4x 210 mm M 8 type threads. • 2x 350 mm M 8 type smooth rod. • 2x 375 mm M 10 type threads. The other movements is in Z-axis that is also controlled by another rod. This axis is an integral part of Y-axis construction and it provides the movement to the extruder axis i.e. it moves X-axis (extruder/nozzle) up and down with respect to the printer bed. The rods used are: • 2x 315 mm M 8 type smooth rod. • 2x 310 mm M 5 type threads. The movement of Z-axis is governed with the help of 2 stepper motors for better accuracy. The third axial movement (X-axis) is given to the printer nozzle itself i.e. moving the nozzle left and right with the help of one motor, belt and pulley arrangement. The rods used are:- • 2x 375 mm M 8 type smooth rod.

3.7 TRAPEZOIDAL LEAD SCREW:



Figure(3.7): Trapezoidal Lead Screw

3.8 FLEXIBLE COUPLING COUPLER:



Figure(3.8): Flexible Coupling Coupler

Flexible couplings are used to transmit torque from one shaft to another when the two shafts are slightly misaligned. ... In addition, they can also be used for vibration damping or noise reduction.A coupling designed to allow a limited angular movement between the axes of two waveguides.

3.9 LINEAR BALL BEARING:

Figure(3.9): Linear Ball Bearing

Brand new and excellent quality material.Linear bearing ball cage, hardened coat of both ends ring.Made of carbon chromium bearing steel, safe and reliable. Ball in the cage loop to run a smooth ball guide surface to ensure stability even if high-speed.

3.10 TIMING BELT:

Figure(3.10): Timing Belt

Timing belts are a fantastic way to transfer rotational motion (from a stepper motor) into linear motion (along a rail) and these GT2 belts are excellent for the task. They have a special profile with rounded teeth which reduces backlash. Often used for precision 3D printers and CNC machines.This belt is 1164mm long (582 teeth on a 2mm tooth pitch) and is 6mm wide. It comes in a loop but you can of course cut it down if you need a shorter length.

3.11 TEETH PULLEY:

Figure(3.11): Teeth Pulley

For precise motion control, GT2 belts and pulleys offer excellent precision at a great price. This pulley is meant for use with GT2 6mm wide belts only - MXL belts will slip due to the different tooth profile. This pulley has 20 teeth, and a 5mm inner bore. Two set screws can be used to attach it firmly to any 5mm diameter shaft such as one of our stepper motors. Full aluminum construction means these are very light and very durable.

3.12 PCB HEAT BED:

Figure(3.12): PCB Heat Bed

The PCB heatbed has two sides, one with the copper traces (bottom side) and one without (top). On older versions of the PCB heatbed only the side without traces carried a silkscreen. Currently (as of January 2015) PCB heat beds are silk screened on both sides. Previously, printing on the top side was considered to be safer as the copper traces could be damaged if the print head would collide with the heatbed surface (if for example the Z-min endstop malfunctioned). Obviously if a piece of glass is used as the print surface, it protects the PCB copper traces. However, make sure your heatbed mounting springs are not too strong to prevent damage to the glass in case of an accidental collision. Note that the LED, resistor and wire connections are also liable to accidentally collide with the printhead.

3.13 RADIAL BALL BEARING:

Figure(3.13): RadialBall Bearing

This 608-ZZ miniature radial ball bearing has double shields and a nylon cage, and conforms to ABEC 1 precision standard. This bearing has an 8 mm bore diameter, a 22 mm outside diameter, and a 7 mm width. Its precision is rated at ABEC 1 by the Annular Bearings Engineers Committee (ABEC), allowing higher speeds and creating lower friction than less-precise ball bearings, and its radial internal clearance is C3 for radial slack between the inner and outer rings is greater than CN (normal) to compensate for thermal expansion. This bearing is made of ASTM International 52100 steel and heat treated to increase hardness for optimum wear resistance. Its deep ball grooves in both races support high radial and axial loads, its straight bore fits conventional cylindrical shafts, and its steel cage prevents the balls from coming into contact with each other during use, reducing friction, vibration, and noise. A no-contact steel shield on each side does not add friction or heat build-up during operation and protects against rough contaminants. This ball bearing is suitable for use in skateboarding, inline skating, and other skating applications.

3.14 END STOP SWITCH:

Figure(3.14): End stop switch

To stop the movements of axis when datum position is reached the end stops are used. These switches basically act as a protection to save the machine from striking by cutting off the power when the axis reaches at the end point. The end stops are needed at every axis end & they provide the range and zero position to machine.

3.15 ALUMINUM CHANNEL:

Figure(3.15): Aluminum channel

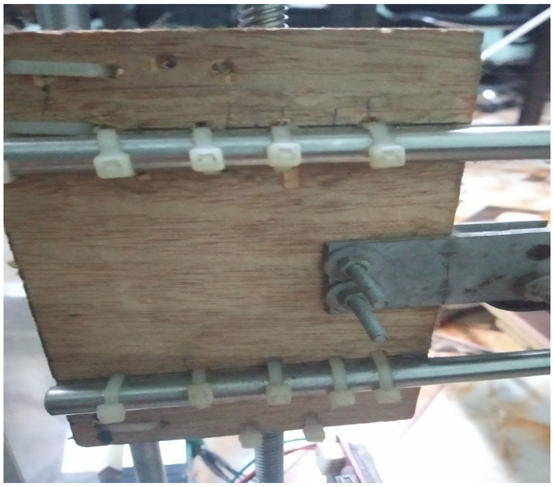
This series aluminum pipe can be used in processing airplane parts, camera parts, couplers, ship parts, hardware, electronic accessories and joints, valves and valve parts, etc. It can also be used in low tension weapons and connectors in airplane. 6061-T6 is one of the most commonly used 6000 series aluminum alloys. 6063 is an aluminum alloy, with magnesium and silicon as the alloying elements. It is typically produced with very smooth surfaces fit for anodizing. It has generally good mechanical properties and is heat treatable and weldable. Bozhong is a professional manufacturer and supplier of 6000 aluminum pipe based in China. We also offer aluminum coil, aluminium slit coil, aluminum sheet, coated aluminum coil, diamond aluminum tread pipe,and more. Whenever you have a need for any of our products, please feel free to contact us.

3.16 GLASS:

Figure(3.16): Glass

Glass is a hard material that can be made in many shapes. It is usually transparent, but it can also be made in colours. Glass is mainly made of silica; glass made of silica only is called silica glass. Coloured glass is made by adding small amounts of metal oxides.

3.17 PLYWOOD:



Figure(3.17): Plywood

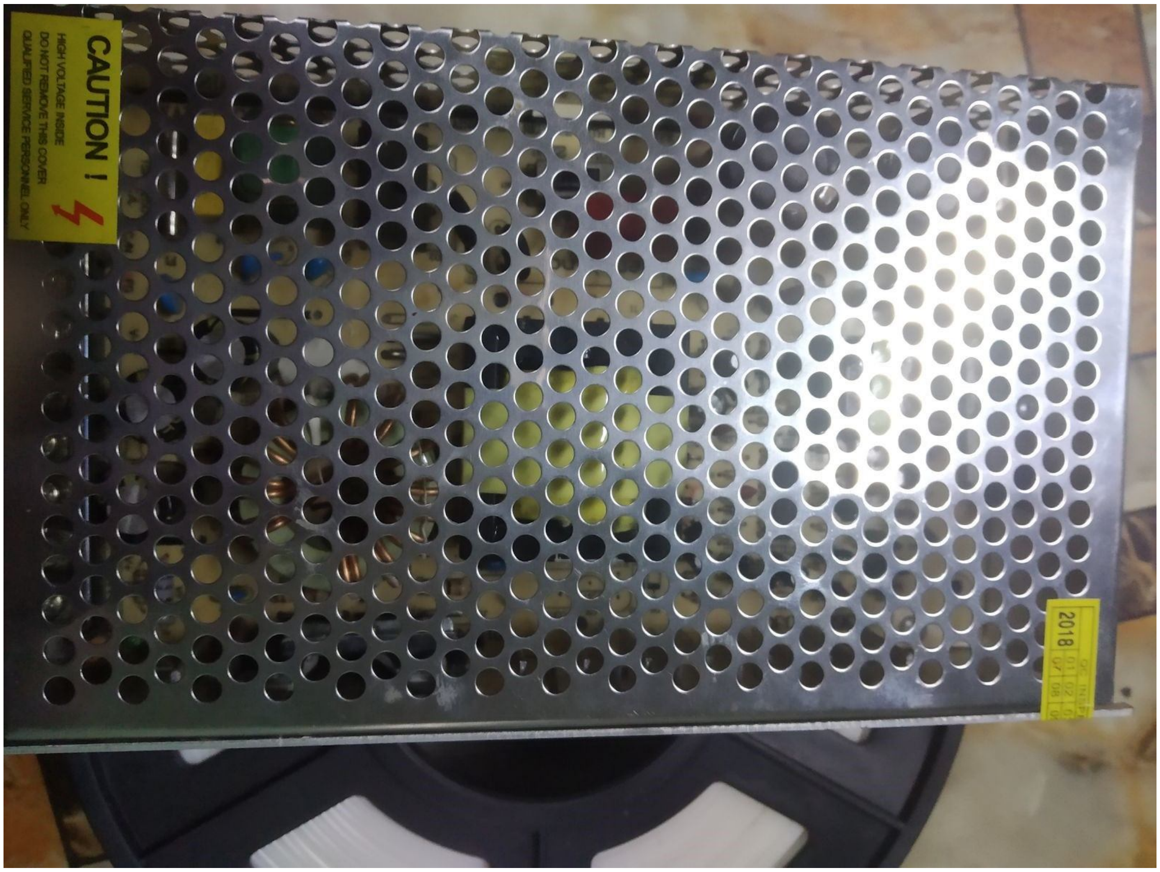
We have used this plywood as mounted the stepper mounted with the frame. also it is used as the mount of heat bed.

3.18ZIP TIE:

Figure(3.18): Zip tie

we have used zip tie to fix motor with the plywood as role of screw.

3.19DC POWER SUPPLY 12 Volt 20 amp:



Figure(3.19): power supply 12 Volt 20 amp

The ATX-12V system is used to supply power to the different parts of the machine. ATX is an advanced technology extended having the motherboard configuration which is manufactured by Intel in 1995. Its specifications basically used to identify its dimensions and it consists of mounting points, input/output panel, power and different connector interfaces between computer and case, a motherboard and a power supply.

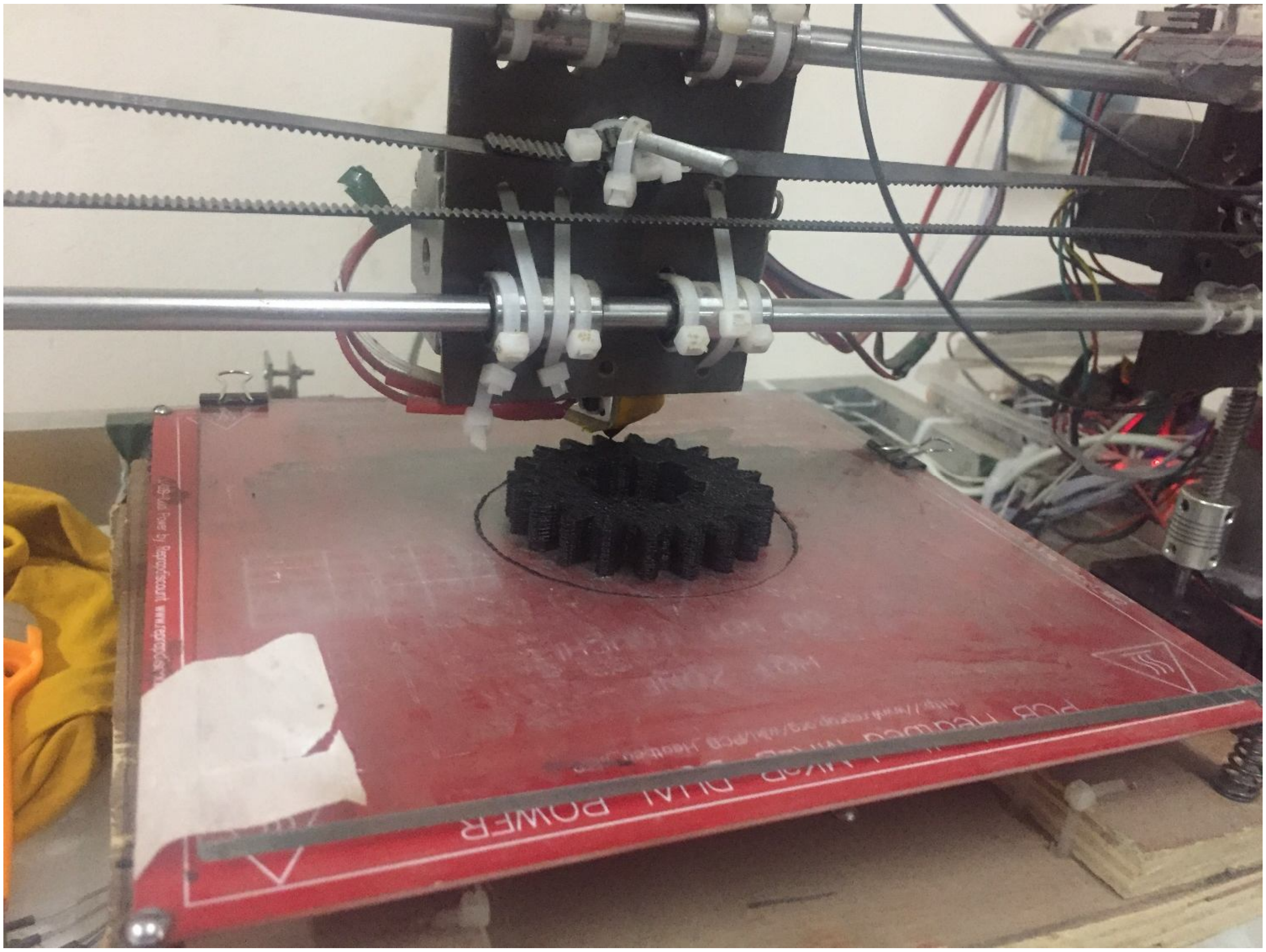
3.20 FILAMENT 1.75 mm:

Figure(3.20): Filament 1.75mm

There are numerous filaments available but here Acrylonitrile Butadiene Styrene (ABS) is used and its chemical formula is (C8H8)x•(C4H6)y•(C3H3N)z. Its glass transition temperature is 108 °C. It is amorphous in nature and made up of polymerizing styrene and acrylonitrile with addition of polybutadiene.

We have used PLA (Polylactic acid) for our 3D printing, its operating temperature is 190-230 degree Celsius and chemical formula is $(C_3H_4O_2)_n$.

3.21 WORKING PRINCIPLE OF 3D PRINTER:



Figure(3.21): Low cost 3D printer

After made the 3D printer we have downloaded the software Marlin Firmware, arduino and pronterface. Then we did the configuration on the Marlin using laptop connected with arduino so that the configuration automatically install in the arduino.Then we did some setting on the Slic3r for printer and filament.

after that we have chosen a prototype product which we want to make and 1st we have made it G-Code in Slic3r . after we open the pronterface and made the setup

1. set up the port and set COMB .
2. then set up the Baud of printer
3. then set up the maximum and minimum speed
4. then set up the heat bed temperature
5. then setup the print speed
6. setup the print flow

after we need to load the prototype product which we have already made G-Code. when the product fully loaded on the pronterface then put the printer USB cable with the laptop and select the connect then the prototype product file automatically loaded on the Arduino. the click on the print then the heat bed temperature will increase up to our selected temperature.

at the same time the extruder will come his working position and we need to put a little glue on the glass otherwise the product can remove from the bed.

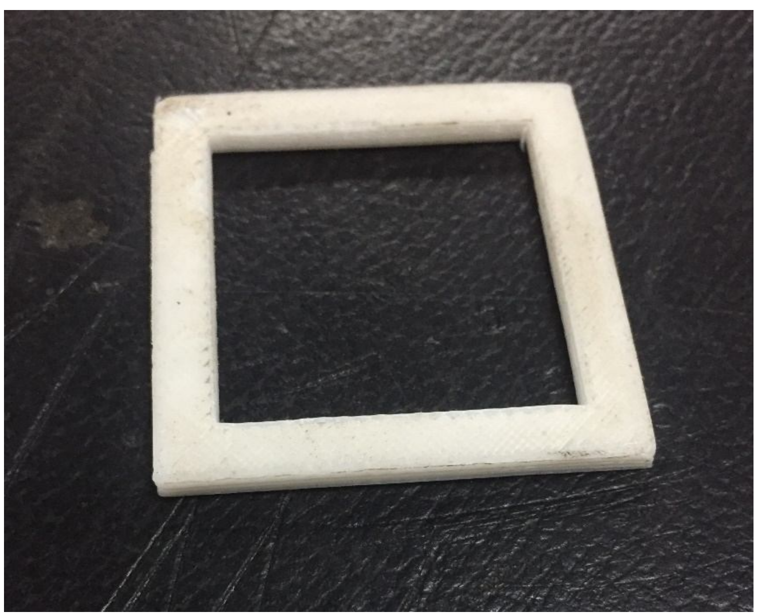
when the bed fully heated then the printing will start.The product making time depend on the product size and speed of printing.

3.22 FINAL PRODUCTS:

The figure 3 below shows some of the samples printed using the printer. The printer can print complicated shapes with ease and also the software develop the support material itself without any human interaction depending upon the configuration of the workpiece. However we can change the support if required. These specimens shown below are further used to study the mechanical & physical properties of the filament used however they results are not discussed here.

Figure(3.23):: Spur Gear

Figure(3.22):: cup



Figure(3.24):: Halo Square Box

CHAPTER-4

DISCUSSION AND CONCLUSION:

4.1 COMPARISON OF OUR 3D PRINTER WITH CONVENTIONAL 3D PRINTER IN MARKET:

Fig (4.1.1): Our Project (Arduino Based) **Fig (4.1.2): anycubicprusa i3**

3D Printer (Arduino based)	3D Printer (anycubicprusa i3)
1) Very low cost, only TK. 16500.	1) High cost, Min TK.40000
2) Electric power consumption is low, used only 120 Watt.	2) Electric power consumption is high, used minimum 220 watt.
3) It can be easily operated.	3) operating process is little hard compared to Arduino based 3D printer

4.2 ADVANTAGE OF LOW COST 3D PRINTER:

Customization – A major advantage in 3d printing. With just a raw material, a blueprint and a 3d printer, one can print any design no matter how complex it might be.

Constant Prototyping and Increased Productivity – It enables quick production with a high number of prototypes or a small-scale version of the real object in less time than using conventional methods. This helps designers to improve their prototypes, for any design flaws that may affect the quality of the product.

Affordability – The initial cost for setting up a 3d printing facility is definitely high; however, it is much cheaper compared to labor costs and manufacturing costs while using the conventional way. Adding to it, is the fact that the cost of producing or manufacturing products using 3d printing technology is equal for small-scale and mass manufacturing.

Storage – Traditional manufacturing produces additional products that you probably know you will eventually need thus storage problems arise. However, 3d printing technology, products can be “printed” when needed thus excess products are eliminated and no storage cost is required.

Health Care – With the advancement of technology, a customizable human body parts and organs can now be manufactured this technology is termed as Bioprinting. Although right now this is still experimental, the potential is huge. This breakthrough will not only address the shortage of organ donors, but also organ rejection since the organs that are built will consist of the patient’s unique characters and DNA.

4.3 LIMITATIONS OF LOW COST 3D PRINTER:

Decrease in Manufacturing Jobs – The decrease in manufacturing jobs will greatly affect the economy of countries that rely on a large number of low skill jobs.

Limited Size – The size of objects created with 3d printers is currently limited however, in the near future; large items such as architectural structures can be created using 3d printing.

Limited Raw Materials – Traditional manufacturing of products has an enormous range of raw materials that can be used. Presently 3d printers can work up to approximately 100 different raw materials and creating products that uses more raw materials are still under development.

Violation of Copyrights – The biggest disadvantage of 3d printing is Counterfeiting. Anyone who gets a hold of a blueprint will be able to counterfeit products easily. It will become more common and tracing the source of the counterfeit items will be nearly impossible. Many copyright holders will have a hard time protecting their rights and businesses producing unique products will suffer.

Production of Dangerous Items – With 3d printers, plastic knives, guns and any other hazardous objects can be created. It makes easier for terrorists and criminals bring a weapon without being detected.

4.4. CONCLUSION:

The 3D printer is a new technology which has lots of potential and its proper analysis based upon its impact on the society, environment, industries etc. is needed to be done. It is having both advantages and limitations and all of them are needed to be kept in mind while selecting and working with 3D printers. Basically this technique is very different from traditional technique in which subtractive approach was used to manufacture a component while here additive approach is used to manufacture any component. It basically creates the object layer by layer and so it reduces the wastage in form of chips etc. Also this technology creates the custom fit objects in least possible time with good accuracy and also it is just in time manufacturing where objects are manufactured just when they needed. It provides flexibility in terms of complicated shapes and in terms of materials as recent development shows that it can use almost all the materials for printing.

The recent developments in the technologies like more accurate lead screws, more accurate motors, good sensor system, more reliable feedback loop etc. shows that the accuracy of 3D printers is improving day by day. The further development in the technologies will removes all the barriers of this technique and soon the day will come when only 3D printers will be used for manufacturing all the parts, components, objects. So we can say that soon the 3D printers will lead the market and it will completely removes the conventional manufacturing systems and it has the potential to create the next industrial revolution where only 3D printers will dominate in each and every field.

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