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A Review on Design and Fabrication of 3D Printing Machine

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***Abstract:** 3D printers are devices which will create a three-dimensional object from a digital model. In this modern world, Fused Deposition Modeling (FDM) based printers are the foremost commonly used printers. They create an object by adding material layer by layer and fusing these layers together. These machines are very costly and have limited print area. Among different types of 3D printers, fused deposition 3D printers are considered to be the cheapest and they are considerably small in size. This is mainly due to its axial movements and type of material used for 3D printing. It's a 4 axis machine whose x, y and z axis make up the first 3 axis, and the extruder is the 4th axis. Our aim is to design and fabricate light weight and chipset 3d printer with available electronic components.*

I. INTRODUCTON

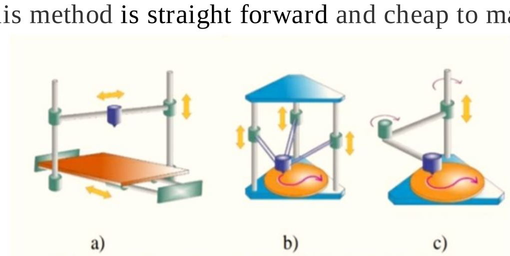
Fused Deposition Modeling (FDM) is that the rapid prototyping technology that forms three-dimensional objects from CAD generated solid or surface models. A temperature- controlled head extrudes ABS plastic wire layer by layer and as a result, the designed object develops as a totally functional three-dimensional part. Rapid prototyping (RP) is employed to save lots of time and cut costs at every stage of merchandise development Process Prototypes can now be produced during a matter of hours that have typically taken weeks or maybe months to form Fused deposition modeling (FDM) and 3D printer are commercial RP processes while neon composite deposition system (NCDS) is an RP test bed system that uses neon composites materials as the part material. "With rapid prototyping, companies are now ready to verify and alter designs with much less investment in time and money", Fused Deposition Modeling (FDM) and 3D printer are commercial RP processes while neon composite deposition system (NCDS) is an RP tested system that uses neon composites materials as the part material.

II. LITERATURE REVIEW

A. *Hardware Improvement of FDM 3D printer*

Hardware Improvement of FDM 3D printer: The FDM 3D printers are classified by the movement system of its head and bed as follow:

1) *Cartesian Method:* Most available 3D printer is using Cartesian method. The movement of the extrusion head and heated bed is linear along the x, y and z axis. In some type, extrusion head is occupation x and y axis while heated bed is moving upward within the z axis. Another type of Cartesian allowed the heated bed to move horizontally in the y axis while the extrusion head move along the x and z axis. This is the straight forward but accurate method during which best for rectangular shaped products. This method is straight forward and cheap to manufacture and operated.



2) *Delta Method:* This method is the most recent hot topic. Movements of delta printer are supported parallel frame of reference by free trajectories generated by articulated axes. It has 3 moving arms where the extrusion head attached and a static bed. This printer works better to produce circular shapes. The printer that using this method has bigger flexibility, higher speed, higher working space and high stability.

3) *SCARA Method:* This is a simplify method of the Selective Compliance Assembly Robot Arm (SCARA). This printer has 3 degree of freedom and driven by 3 stepped motors with a static bed and 2 moving arms (shoulder and elbow) that connected together and attached to a vertically moved bracket. According to Figure 1 SCARA type robotic system has three degrees of freedom and it is actuated by three servo motors to do one vertical and two horizontal motions. This method is more complicated than other methods. Most of SCARA printer still in development phase and no commercial printer available so far.

III. BED LEVELING TOOL INNOVATION

Various leveling tools are available within the market, from the hi-tech automatic leveler to the straightforward with water level tool. But for a RepRap machine those tools are not provided and some printer manufacturer not even introduce those tools that brought difficulties especially for a new user. Current available leveling tools some complaints keep it up arise. This research will attempt to refill the empty space by focusing to seek out an easy and low cost system to level the heated bed that suitable the low cost RepRap FDM 3D printer.

A novel leveling tool are going to be proposed for during this research and analyzed in further process research process. The tool are going to be designed to be simple and cheap enough for low cost RepRap FDM 3D printer. The new tool will replace threaded bolts system (Figure 3.) that need another supporting tools in adjusting the leveling. The proposed tools will be pine trees liked pin to assure ease of installation and quick leveling (Fig 4). The new tolls require force to push the bed down that can be done by using hands or with the extruder head to make sure the rings will be move to the same level.

IV. DETAIL DESIGN AND SELECTION OF COMPONENTS

Generally, within the design cycle of a specific product, the aim of the designers is to reduce its costs to the minimum possible value without affecting its performance. One of the efficient approaches to achieve this goal is to determine the source of various components in the system.

In other words, whenever a component is to be used in our 3D printer, it will be obtained from one of the following sources: standard parts (available in the market) or complete design and manufacture of components. Using standard parts would always be the cheapest solution, and having to design and manufacture will be a costly solution.

All components of this project are listed below in Table 5 and further design calculations are done based on the following three categories: a) Design (D), the component will be designed and fabricated using local resources; b) Select (S), the components will be selected and purchased based on technical specifications; c) Design and Select (D&S), the components will be first designed and then selected or manufactured.

V. PRINTER STRUCTURE

The main purpose of the structural component is housing. The function of the housing is to hold all components like the motors, controller and link structure and protect it from dust. The structural part includes two aluminum plates which are the top and bottom plates, steel studs, nuts and washers that connect the two plates, acrylic side plates and the print bed which is made of brass. Aluminum plates were chosen because they were the only locally available material, which was light in weight yet strong. Brass was selected to be the material for the print bed as it is easy to polish and have better surface finish.

VI. AXIS CONFIGURATION (X,Y,Z)

A 3D model of the printer was designed in Sketch up including all the Mechanical and electrical components. When designing the model, all the parts where drawn to exact dimensions and the parts that were to be 3D printed were directly taken from its finished CAD model. Standard parts that where discussed in previous section were also taken into consideration when designing the model. To make a proper movement in different axis, X, Y and Z axis configuration is very important. The following sections will explain about the axis configuration.

A. X Axis Configuration

For getting a print size of 40 x40 the smooth rods on the X axis had to be 50cm long and the belts should have a length for 103 cm. so that enough length are going to be there for it to travel round the pulley and radial bearing. The belt is fixed on to a 3D printed part that is mounted on to these smooth rods using linear bearings. 4 bearings are used to give enough support even when heavier extruders are mounted on to it.

B. Y Axis Configuration

A second linear motion system is designed for the Y axis, unlike the X and Z axis Y axis is independent and moves in its own axis, like shown in the figure above. Since the bottom plate acts because the print surface of the printer, it should be of an equivalent size of the print area along the X and Y axis. Hence a 40x40 ply wood was cut and the bearings attached to its printed parts. The plate is then mounted on to the smooth rods through these linear bearings and the belt is attached to this base plate and the pulley on the motor.

C. Z Axis Configuration

For the Z axis, smooth rods are fixed in situ using printed parts that are mounted on to the frame. And a threaded rod is then threaded into the nut mounted inside the tiny pocket on the X axis idlers. One of end of the thread rod is clamped on to a motor shaft employing a flexible coupling. So that it turns with the motor.

VII. HARDWARE AND ELECTRICALS

A rapid prototyping machine was successfully fabricated with respect to the conception design that was developed. Stepper motors were used for controlling each axis and timer belts were used for X and Y axis since they offer greater speed, for the Z axis threaded rods were used since it required greater precision and higher torque. For X and Y axis the ends of the timer belts were attached to the moving part namely the X carriage and Y carriage so that it moves along with the belt when pulled by the stepper motor. GT2 belts were used as timer belts since they have a tooth profile that works better with linear positioning systems. 5 stepper motors were used for driving the belts pulleys and the extruder gears, of which 2 of the stepper motors are used for two Z axis threaded rods and one stepper each for other axes. The stepper motors are controlled using A4988 stepper driver and the signals needed for the stepper are sent from an Arduino MEGA micro controller.

Arduino gets its instructions needed for controlling these stepper drivers through a serial port that is connected to a computer. A serial data transferring software is run on PC that uses slicing software to slice the model into layers and convert those vector data into G-code.

A firmware is burned into Arduino's memory that can intercept the G-codes that are received and generate instructions based on it. It also uses analog data from thermistors for sensing the temperature of the hot end and uses it for regulating the current to the heater. Other sensors include mechanical end stops that are used for sensing the absolute positions of the carriages on each axis. The entire system runs on 12V and requires up to 20A current that is provided by an OEM power supply. Appropriate calculations and required assumptions were made when choosing the power supply.

Once the printer was completed multiple tests were performed which proved some flaws in the extruder design and assembly. Some of these problems were corrected and a few of them were beyond the scope or changing, since it required redesigning of the whole extruder assembly. It also had some advantages to its design, which enabled it to work as a plotter as well as a CNC machine.

This design can further be modified by changing the frame with a laser cut birch plywood, that greatly helps in damping the vibrations from the motor and it also helps in reducing the bulkiness of the frame. Other features such as SD card or wireless printing can eliminate the need of any physical connection to the computer for printing. Automatic calibration can also be added using laser sensors or opto sensors eliminating the need of calibrating the printer every time.

VIII. BASIC PRINCIPLES OF 3D PRINTING

A 3D Printer Works on different technologies are

1) *Stereo Lithography:* It was invented by Charles Hull in 1986. In this method UV rays are concentrated on the surface of the object to be replicated which is made of photopolymer. As the rays strike the object, the required model is created.
2) *Fused Deposition Modeling (FDM):* It was patented by Stratasys. In this process, filament of plastic modeling material and soluble support material are fed from auto-loading carries in the material bay up to the extrusion head. There, the materials are heated to a semi-liquid state, forced through dual up to the extrusion tips and precisely deposited onto the modeling in extremely fine layers. The print head moves in X-Y direction and the modeling base moves in the Z-axis.
3) *Selective Laser Sintering:* In this technology powdered material is used instead of liquid resin. Nylon, ceramics, glass, aluminum, steel or silver.
4) *Selective Laser Melting:* In this process the powder material used in the printer is melted instead of combining them.
5) Electronic Beam Melting: 3D printers use the electron beam instead of UV rays.

IX. SELECTION OF PRINTING PROCESS

Currently, with the rapid growth of AM technology, there are a large number of 3D printing methods in the market. Selection of an appropriate method for a printed object is a difficult decision in consideration of interactions between the qualities, properties, cost, build envelope, build time and so on. In the literature, the knowledge based systems have been proposed to have fast response to users which 3D printing method is suitable for a specific application. To carry out this research, materials, printing method, and printing machine ability are analyzed and classified for developing the knowledge system. Materials used for printing are classified into groups such as polymers, metals, ceramics, and cermet's. In each group, materials are classified into types such as powder, solid, and liquid. For applications with plastic materials such as ABS, PLA in filament form, FDM is a suitable 3D printing method.

In consideration of the printed part's quality with FDM technique, evaluation of open source as well as material properties have been carried out. One of important applications of the FDM technique is for education field with graphic design and rapid prototyping courses.

X. CONCLUSION

Thus the establishment of movement of bed using belt drive causes tension and slag on the belt. We are going with the lead screw on behalf of belt drive, so that we are expecting to achieve good performance and more accuracy. Designing and fabricating the 3D Printing Machine by using aluminium material for reducing the weight and cost by changing the belt drive with lead screw.

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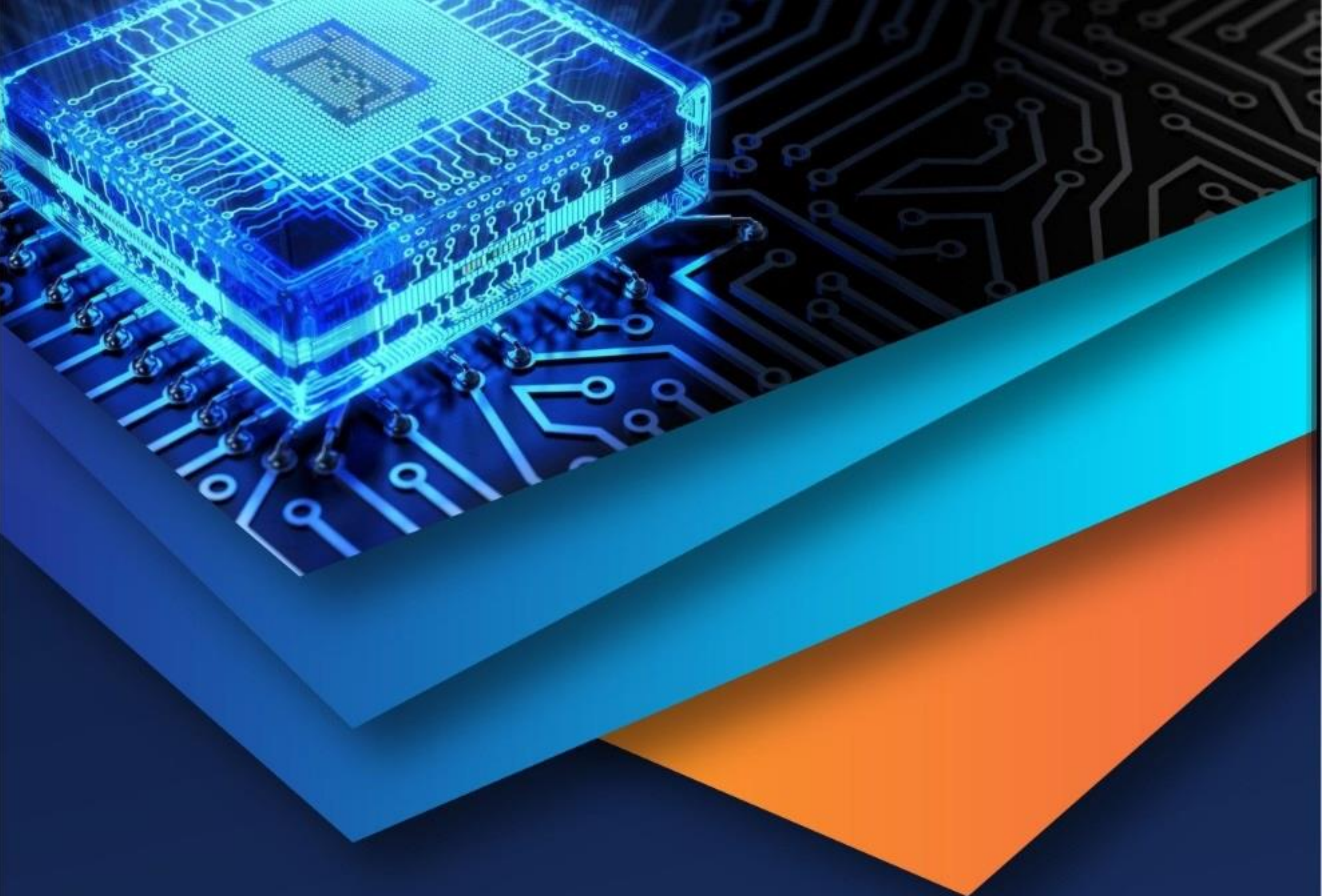

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