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Design and Manufacturing of A 3D Printer

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Abstract:

3D printing, also known as additive manufacturing (AM), refers to various processes used to synthesize a three dimensional object. In 3D printing, successive layers of material are formed under computer control to create an object. These objects can be of almost any shape or geometry and are produced from a 3D model or other electronic data source. A 3D printer is a type of industrial robot. Rapid prototyping is a technique used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing or "additive layer manufacturing" technology3D printers capable of outputting in color and multiple materials already exist and will continue to improve to a point where functional products will be able to be output. With effects on energy use, waste reduction, customization, product availability, medicine, art, construction and sciences, 3D printing will change the manufacturing world.

I. INTRODUCTION

3D printing, also known as additive manufacturing (AM), refers to various processes used to synthesize a three dimensional object. In 3D printing, successive layers of material are formed under computer control to create an object. These objects can be of almost any shape or geometry and are produced from a 3D model or other electronic data source. A 3D printer is a type of industrial robot. It all starts with making a virtual design of the object you want to create. This virtual design is made in a CAD (Computer Aided Design) file using a 3D modeling program (for the creation of a totally new object) or with the use of a 3D scanner (to copy an existing object). A 3D scanner makes a 3D digital copy of an object. To prepare a digital file for printing, the 3D modeling software "slices" the final model into hundreds or thousands of horizontal layers. When the sliced file is uploaded in a 3D printer, the object can be created layer by layer. The 3D printer reads every slice (or 2D image) and creates the object, blending each layer with hardly any

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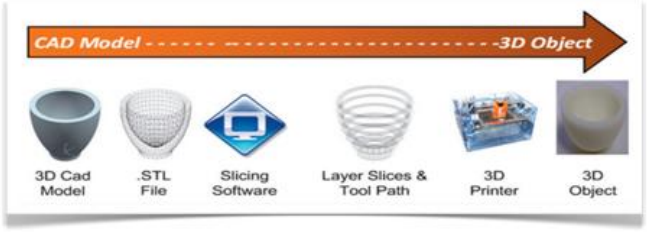
visible sign of the layers, with as a result the three dimensional object.



Examples & Applications of 3D Printing

Applications include rapid prototyping, architectural scale models &maquettes, healthcare (3d printed prosthetics and printing with human tissue) and entertainment (e.g. film props).Other examples of 3D printing would include reconstructing fossils in paleontology, replicating ancient artifacts in archaeology, reconstructing bones and body parts in forensic pathology and reconstructing heavily damaged evidence acquired from crime scene investigations.

3D printing industry

The worldwide 3D printing industry is expected to grow from $3.07B in revenue in 2013 to $12.8B by 2018, and exceed $21B in worldwide revenue by 2020. As it evolves, 3D printing technology is destined to transform almost every major industry and change the way we live, work, and play in the future.

Medical industry

The outlook for medical use of 3D printing is evolving at an extremely rapid pace as specialists are beginning to utilize 3D printing in more advanced ways. Patients around the world are experiencing improved quality of care through 3D printed implants and prosthetics never before seen.

Bio-printing

As of the early two-thousands 3D printing technology has been studied by biotech firms and academia for possible use in tissue engineering applications where organs and body parts are built using inkjet techniques. Layers of living cells are deposited onto a gel medium and slowly built up to form three dimensional structures. We refer to this field of research with the term: bio-printing.

Aerospace & aviation industries

The growth in utilization of 3D printing in the aerospace and aviation industries can, for a large part, be derived from the developments in the metal additive manufacturing sector. NASA for instance prints combustion chamber liners using selective laser melting and as of march 2015 the FAA cleared GE Aviation's first 3D printed jet engine part to fly; a LASER sintered housing for a compressor inlet temperature sensor.

Automotive industry

Although the automotive industry was among the earliest adopters of 3D printing it has for decades relegated 3d printing technology to low volume prototyping applications. Nowadays the use of 3D printing in automotive industry is evolving from relatively simple concept models for fit and finish checks and design verification, to functional parts that are used in test vehicles, engines, and platforms. The expectations are that 3D printing in the automotive industry will generate a combined $1.1 billion dollars by 2019.

Industrial printing

In the last couple of years the term 3D printing has become more known and the technology has reached a broader public. Still, most people haven't even heard of the term while the technology has been in use for decades. Especially manufacturers have long used these printers in their design process to create prototypes for traditional manufacturing and research purposes. Using 3D printers for these purposes is called **rapid prototyping**.

Personal printing

Personal 3D printing or domestic 3D printing is mainly for hobbyists and enthusiasts and really started growing in 2011. Because of rapid development within this new market printers are getting cheaper and cheaper, with prices typically in the range of $250 –

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$2,500. This puts 3D printers into more and more hands. The RepRap open source project really ignited this hobbyist market. For about a thousand dollars people could buy the RepRap kit and assemble their own desktop 3D printer. Everybody working on the RepRap shares their knowledge so other people can use it and improve it again.

II. WORKING COMPONENTS OF 3D PRINTER

- EXTRUDER
- HEATER
- HEAT BED
- STEPPER MOTORS
- MKS GEN MOTHERBOARD
- POWER SUPPLY
- X,Y,Z DRIVING AXIS

EXTRUDER

Fused filament fabrication is a 3D printing process that uses a continuous filament of a thermoplastic material. This is fed from a large coil, through a moving, heated printer extruder head. Molten material is forced out of the print head's nozzle and is deposited on the growing work piece. The head is moved, under computer control, to define the printed shape. Usually the head moves in layers, moving in two dimensions to deposit one horizontal plane at a time, before moving slightly upwards to begin a new slice. The speed of the extruder head may also be controlled, to stop and start deposition and form an interrupted plane without stringing or dribbling between sections.

Fused filament printing is now the most popular process (by number of machines) for hobbyist-grade 3D printing. As other techniques, such a photo polymerization and powder sintering, may offer better results at greater cost, they still dominate commercial printing. The 3D printer head or 3D printer extruder is a part in material extrusion-type printing responsible for raw material melting and forming it into a continuous profile.

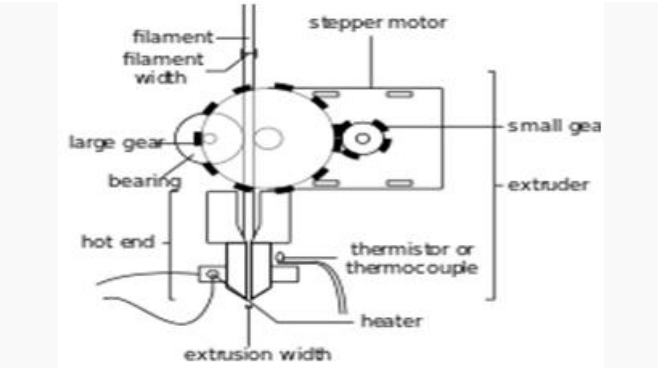

Fig 1: Illustration of an extruder, which shows how all parts are named

A wide variety of materials are extruded, including thermoplastics such as acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), high-impact polystyrene (HIPS), thermoplastic polyurethane (TPU), aliphatic polyamides (nylon), and recently also PEEK. Paste-like materials such as ceramics and chocolate can be extruded using the fused filament process and a paste extruder.

III. DESIGNING STRUCTURE OF 3DPRINTER

AUTO CAD: AutoCAD is a commercial software application for 2D and 3D computer-aided design (CAD) and drafting — available since 1982 as a desktop application and since 2010 as a mobile, web- and cloud-based app marketed as AutoCAD 360.Developed and marketed by Autodesk, AutoCAD was first released in December 1982, running on microcomputers with internal graphics controllers. Prior to the introduction of AutoCAD, most commercial CAD programs ran on mainframe computers or mini computers, with each CAD operator (user) working at a separate graphics terminal. AutoCAD is used across a wide range of industries, by architects, project managers, engineers, graphic designers, and other professionals. It is supported by 750 training centers worldwide as of 1994.As Autodesk's flagship product, by March 1986 AutoCAD had become the most ubiquitous CAD program worldwide.

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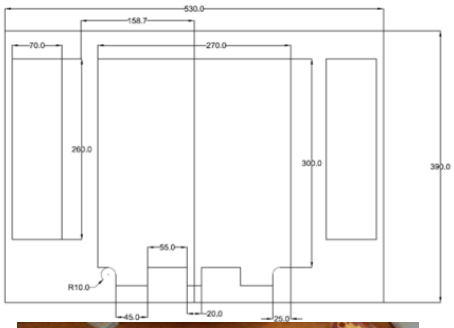
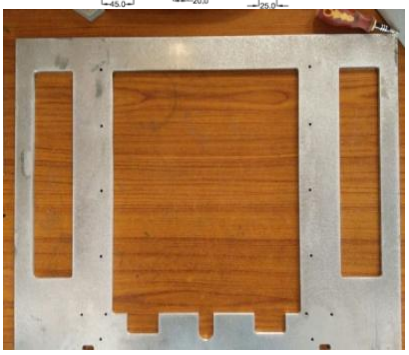
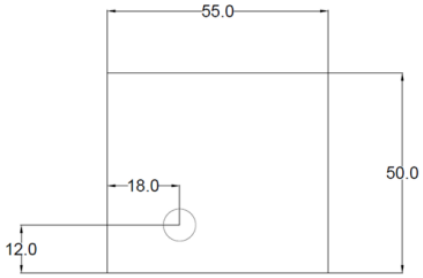
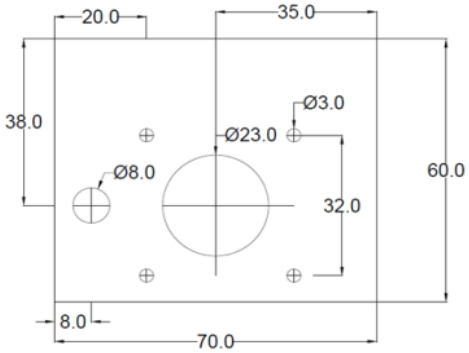
MAIN FRAME

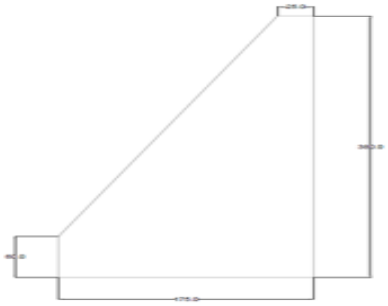




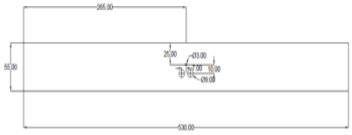




SIDE PLATES



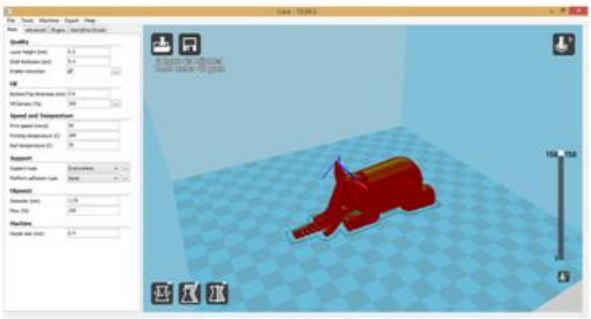
FRONT PLATES



MOTOR PLATES

CURA (Slicing software)

CURA is the 3D model to tool path Slicer by David (David Braam). Cura is free Open Source software released on the AGPLv3 license. It is currently maintained by Ultimaker who employed David to work on it. Cura is well suited for Bowden-extruder machines like the Ultimaker and most Delta-bots. Also you can use it with most of reprap printers. Cura features its own Slicing engine, GCode sender and other tools to provide an "all in one" solution for 3D printing. However all components can be used on their own.



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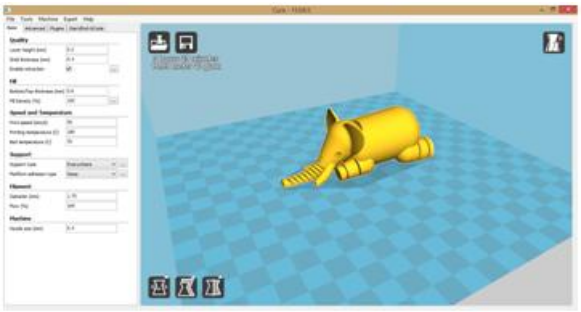

AUTO CAD VARIANT USED:

Formerly marketed as AutoCAD WS, AutoCAD 360 is an account-based mobile and web application enabling registered users to view, edit, and share AutoCAD files via mobile device and web using a limited AutoCAD feature set — and using cloud-stored drawing files. The program, which is an evolution and combination of previous products, uses a premium business model with a free plan and two paid levels — marketed as Pro ($4.99 monthly or $49.99 yearly) and Pro Plus ($99.99 yearly) — including various amounts of storage, tools, and online access to drawings. 360 include new features such as a "Smart Pen" mode and linking to third-party cloud-based storage such as Dropbox. Having evolved from Flash-based software, AutoCAD 360 uses HTML5 browser technology available in newer browsers including Firefox and Google Chrome.

IV. ALUMINUM SHEET METAL FABRICATION

Metal Fabrication

Metal fabrication is the building of metal structures by cutting, bending, and assembling processes. It is a value added process that involves the construction of machines and structures from various raw materials. A fab shop will bid on a job, usually based on the engineering drawings, and if awarded the contract will build the product. Large fab shops will employ a multitude of value added processes in one plant or facility including welding, cutting, forming and machining. These large fab shops offer additional value to their customers by limiting the need for purchasing personnel to locate multiple vendors for different services.

Metal fabrication jobs usually start with shop drawings including precise measurements then move to the fabrication stage and finally to the installation of the final project. Fabrication shops are employed by contractors, OEM's and VAR's. Typical projects include loose parts, structural frames for buildings and heavy equipment, and stairs and hand railings for buildings.

Process of Metal Fabrication:

- **Cutting** of the sheet metal is done by sawing, shearing, or chiseling (all with manual and powdered variants). Torching with hand-held torches (such as oxy-fuel torches or plasma torches) and via numerical control (CNC) cutters (using a LASER, mill bits, torch, or water jet).
- **Bending** of sheet metal is done by hammering (manual or powered) or via press brakes and similar tools. Modern metal fabricators use press brakes to either coin or air-bend metal sheet into form. CNC-controlled press brakes are seamless and very efficient.
- **Assembling** (joining of the pieces) is done by welding, binding with adhesives, riveting, threaded fasteners, or even yet more bending in the form of crimped seam. Structural steel and sheet metal are the usual starting materials for fabrication, along with the welding wire, flux and fasteners that will join the cut pieces. As with other manufacturing processes, both human labor and automation are commonly used. The product resulting from fabrication may be called fabrication; shops that specialize in this type of metal work are called as fab shops. The end products of other common types of metal working such as machining, metal stamping, forging and casting may be similar in shape and function, but those processes are not classified as fabrication.

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Raw materials

The raw materials mostly used in metal fabrications are,

- Plate metal
- Aluminum sheet metal
- Formed and expanded metal
- Tube stock
- Welding wire/Welding rod
- Casting

Cost Analysis

Cost of electronic components = 17,500 INR

Motherboard –7000
LCD Display –800
Stepper motors -2500
Heat bed & base – 2500
Hot end – 1500
Extruder – 1200
End stoppers – 500
Power supply - 1500

Cost of Mechanical components = 6,500 INR

Sheet metal (250*19kg's)
Bearings – 500
MS shaft plain & threaded-500

Cost of filament (Qty-2kg's) = 3,000 INR

Miscellaneous cost = 2,500 INR

Belt dives – 150
Workshop costs – 1500
Stationary cost – 350
Tools and screws - 500

Total cost = 29,500 INR

*a 3D printer of same specifications averagely costs 70,000 INR

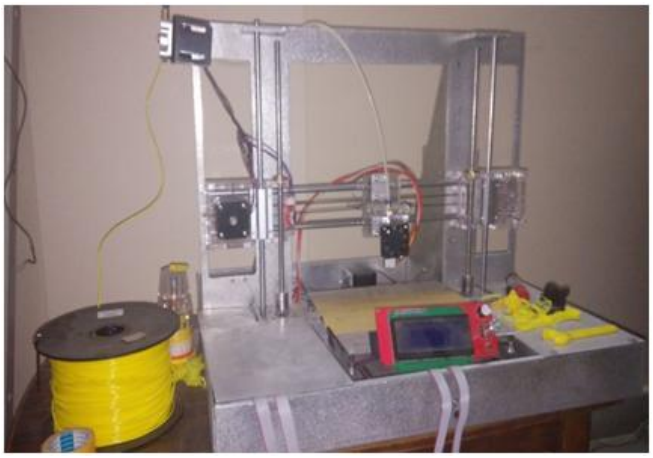

Fig 2: Prototype of 3D printer

V. CONCLUSION:

It is generally believed that 3D printing will be a revolutionary force in manufacturing and prototyping, whether positive or negative. Many Multinational companies have already been using the technology to produce intricate components in various fields. As3D printers become more affordable, they will inevitably be used for local, small scale manufacturing largely eliminating supply chain for many types of product. There will be major challenges for the conventional manufacturing industry to adapt to these changes in technology. The outlook for medical use of 3D printing is evolving at an extremely rapid pace as specialists are beginning to utilize 3D printing in more advanced ways. 3D printing of liver or kidney tissues is better than transplantation of organs. This could be a breakthrough in medical history. 3D printers capable of outputting in color and multiple materials already exist and will continue to improve to a point where functional products will be able to be output. With effects on energy use, waste reduction, customization, product availability, medicine, art, construction and sciences, 3D printing will change the manufacturing world.

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