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Printing of Mechanical Components by Using 3D Printing Machine

Puli Suresh Kumar
Assistant Professor,
Dept. of Mechanical Engineering,
Thandra Paparaya Institute of Science and Technology,
Bobbili, VZM District, AP.

A Udaya Bhaskar
Assistant Professor,
Dept. of Mechanical Engineering,
Thandra Paparaya Institute of Science and Technology,
Bobbili, VZM District, AP.

ABSTRACT:

3D printers are a new generation of machines that can make everyday things. They're remarkable because they can produce different kinds of objects, in different materials, all from the same machine. A 3D printer can make pretty much anything from ceramic cups to plastic toys, metal machine parts, stoneware vases, fancy chocolate cakes or even (one day soon) human body parts. They replace traditional factory production lines with a single machine; just like home inkjet printers replaced bottles of ink, a printing press, hot metal type and a drying rack.

A materials printer usually performs 3D printing processes using digital technology. The first working 3D printer was created in 1984 by Chuck Hull of 3D Systems Corp.

The 3D printing technology is used for both prototyping and distributed manufacturing with applications in architecture, construction (AEC), industrial design, automotive, aerospace, military, engineering, civil engineering, dental and medical industries, biotech (human tissue replacement), jewelry, education, geographic information systems, food, and many other fields. 3D printing is a type of additive manufacturing technology where a three dimensional object is made by laying down successive layers of material which forms the final object. in this projet few mechanical components such as flange,v-block,journal bearing are printed using 3D printing machine

Keywords: ***3D printing machine,Additive Manufacturing (AM) , Fused Depositoin Modelling,flange,v-block,journal bearing.***

1. INTRODUCTION

3D printing or Additive Manufacturing (AM) is any of various processes for making a three-dimensional object of almost any shape from a 3D model or other electronic data source primarily through additive processes in which successive layers of material are laid down under computer control. A 3D printer is a type of industrial robot.

Early AM equipment and materials were developed in the 1980s. In 1984, Chuck Hull of 3D Systems Corp, invented a process known as stereo lithography employing UV lasers to cure photopolymers. Hull also developed the STL file format widely accepted by 3D printing software, as well as the digital slicing and infill strategies common to many processes today. Also during the 1980s, the metal sintering forms of AM were being developed (such as selective laser sintering and direct metal laser sintering), although they were not yet called 3D printing or AM at the time. In 1990, the plastic extrusion technology most widely associated with the term "3D printing" was commercialized by Stratasys under the name fused deposition modelling (FDM). In 1995, Z Corporation commercialized an MIT-developed additive process under the trademark 3D printing (3DP), referring at that time to a proprietary process inkjet deposition of liquid binder on powder.

AM technologies found applications starting in the 1980s in product development, data visualization, rapid prototyping, and specialized manufacturing. Their expansion into production (job production, mass production, and distributed manufacturing) has been under development in the decades since. Industrial production roles within the metalworking industries achieved significant scale for the first time in the early 2010s. Since the start of the 21st century there has been a large growth in the sales of AM machines, and their price has dropped substantially. According to Wohlers Associates, a consultancy, the market for 3D printers and services was worth $2.2 billion worldwide in 2012, up 29% from 2011. Applications are many, including architecture, construction (AEC), industrial design, automotive, aerospace, military, engineering, dental and medical industries, biotech (human tissue replacement), fashion, footwear, jewellery, eyewear, education, geographic information systems, food, and many other fields.

2. ARCHITECTURE

The picture shows the structure of a typical 3D printer. The print table is the platform where the objects for printing has been situated. It provides the basic support for manufacturing objects layer by layer.

The extruder is the most important part of a 3D-Printer. As the extruders in the normal paper printers, this extruder is also used to pour ink for printing. The movement of extruder in various dimensions create the 3D print. For printing a 3d object, the extruder has to access X, Y and Z coordinates. For achieving this, many techniques are used according to the printer specification required for various applications.

If the 3D-Printer is a desktop printer, the Z axis movement of the extruder can be avoided and that function can be transferred to the print table. This will avoid complexity in 3D printing as well as time consumption.

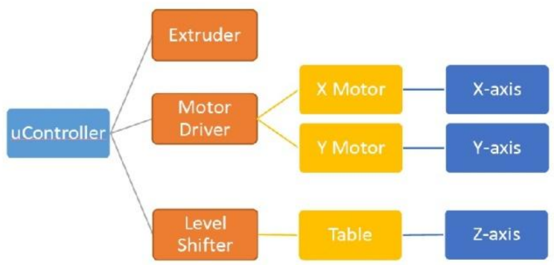

Fig- 3.1: Architecture of 3D Printer

3. ADDITIVE MANUFACTURING

Additive Manufacturing is a truly disruptive technology exploding on the manufacturing scene as leading companies are transitioning from "analog" to "digital" manufacturing. Additive Manufacturing uses three dimensional printing to transform engineering design files into fully functional and durable objects created from sand, metal and glass. The technology creates products layer by layer – after a layer's particles are bound by heat or chemicals the next layer is added and the binding process is repeated. It enables geometries not previously possible to be manufactured. Full-form parts are made directly from computer-aided design (CAD) data for a variety of industrial, commercial and art applications.

Manufacturers across several industries are using this digital manufacturing process to produce a range of products, including: engine components for automotive applications, impellers and blades for aerospace use, pattern less sand moulds for pumps used in the oil and energy industry, and medical prosthetics which require easily adaptable design modifications.

This advanced manufacturing process starts with a CAD file that conveys information about how the finished product is supposed to look. The CAD file is then sent to a specialized printer where the product is created by the repeated laying of finely powdered material (including sand, metal and glass) and binder to gradually build the finished product. Since it works in a similar fashion to an office printer laying ink on paper, this process is often referred to as 3D printing. The 3D printers can create a vast range of products, including parts for use in airplanes and automobiles, to replacing aging or broken industrial equipment, or for precise components for medical needs.

There are tremendous cost advantages to using Additive Manufacturing. There is little to no waste creating objects through Additive Manufacturing, as they are precisely built by adding material layer by layer. In traditional manufacturing, objects are created in a subtractive manner as metals are trimmed and shaped to fit together properly. This process creates substantial waste that can be harmful to the environment. Additive Manufacturing is a very energy efficient and environmentally friendly manufacturing option.

Additive Manufacturing swiftly creates product prototypes – an increasingly critical function that significantly reduces the traditional trial-and-error process – so new products can enter the market more quickly. Likewise, it can promptly create unique or specialized metal products that can replace worn or broken industrial parts. That means companies can avoid costly shut downs and drastically compress the time it takes to machine a replacement part.

With Additive Manufacturing, once a CAD drawing is created the replacement part can be printed. Storage of bulky patterns and tooling is virtually eliminated.

Major global companies, including Ford, Sikorsky and Caterpillar, have recognized that Additive Manufacturing can significantly reduce costs while offering design freedoms not previously possible. They have begun to implement the technology into their manufacturing processes. Additive Manufacturing has robust market capabilities ranging from aerospace to automotive to energy, and it is not uncommon to find 3D printers in use at metal-working factories and in foundries alongside milling machines, presses and plastic injection moulding equipment.

Fig-3.1: Additive Manufacturing

Companies that use Additive Manufacturing reduce costs, lower the risk of trial and error, and create opportunities for design innovation. A serious limitation of subtractive manufacturing is that part designs are often severely comprised to accommodate the constraints of the subtractive process. Additive Manufacturing enables both the design and the materialization of objects by eliminating traditional manufacturing constraints.

A large number of additive processes are now available. They differ in the way layers are deposited to create parts and in the materials that can be used. Some methods melt or soften material to produce the layers, e.g. selective laser melting (SLM) or direct metal laser sintering (DMLS), selective laser sintering (SLS), fused deposition modelling (FDM), while others cure liquid materials using different sophisticated technologies, e.g. stereolithography (SLA). With laminated object manufacturing (LOM), thin layers are cut to shape and joined together (e.g. paper, polymer and metal). Each method has its own advantages and drawbacks, and some companies consequently offer a choice between powder and polymer for the material from which the object is built. Some companies use standard, off-the-shelf business paper as the build material to produce a durable prototype.

3.1 Types of Additive Manufacturing:

- Extrusion deposition
- Granular material binding
- Photopolymeriszation
- Lamination

4. PROCEDURES FOR PRINTING

There are some procedures for printing. First you must create a computer model for printing the object. For creating that, you can use Computer Aided Design Software like AutoCAD, 3DS Max etc. After the object file is created, the file need to be modified. The object file contains numerous amount of curves. Curves cannot be printed by the printer directly. The curves has to be converted to STL (Stereo lithography) file format.

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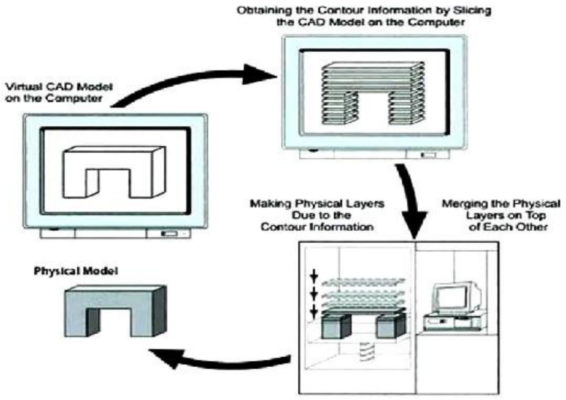

Fig-4.1:Procedures For Printing

The STL file format conversion removes all the curves and it is replaced with linear shapes. Then the file need to be sliced into layer by layer. The layer thickness is so chosen to meet the resolution of the 3D printer we are using. If you are unable to draw objects in CAD software, there are many websites available which are hosted by the 3D printing companies to ease the creation of 3D object. The sliced file is processed and generates the special coordinates. These coordinates can be processed by a controller to generate required signal to the motor for driving extruder. This layer by layer process generate a complete object.

4.1 Designing Using CAD:

Computer-aided design (CAD) is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.

CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space. CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation.

The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

The design of geometric models for object shapes, in particular, is occasionally called computer-aided geometric design (CAGD). Unexpected capabilities of these associative relationships have led to a new form of prototyping called digital prototyping. In contrast to physical prototypes, which entail manufacturing time in the design. That said, CAD models can be generated by a computer after the physical prototype has been scanned using an industrial CT scanning machine. Depending on the nature of the business, digital or physical prototypes can be initially chosen according to specific needs.

Today, CAD systems exist for all the major platforms (Windows, Linux, UNIX and Mac OS X); some packages even support multiple platforms which enhances the capabilities of 3D printing into a new level.

4.2 CONVERSION TO STL FILE FORMAT:

An STL file is a triangular representation of a 3D surface geometry. The surface is tessellated logically into a set of oriented triangles (facets). Each facet is described by the unit outward normal and three points listed in counterclockwise order representing the vertices of the triangle. While the aspect ratio and orientation of individual facets is governed by the surface curvature, the size of the facets is driven by the tolerance controlling the quality of the surface representation in terms of the distance of the facets from the surface. The choice of the tolerance is strongly dependent on the target application of the produced STL file.

In industrial processing, where stereolithography machines perform a computer controlled layer by layer laser curing of a photo-sensitive resin, the tolerance may be in order of 0.1 mm to make the produced 3D part precise with highly worked out details. However much larger values are typically used in pre-production STL prototypes, for example for visualization purposes.
The native STL format has to fulfill the following specifications:
(i) The normal and each vertex of every facet are specified by three coordinates each, so there is a total of 12 numbers stored for each facet.
(ii) Each facet is part of the boundary between the interior and the exterior of the object. The orientation of the facets (which way is ``out'' and which way is ``in'') is specified redundantly in two ways which must be consistent. First, the direction of the normal is outward. Second, the vertices are listed in counterclockwise order when looking at the object from the outside (right-hand rule).
(iii) Each triangle must share two vertices with each of its adjacent triangles. This is known as vertex-to-vertex rule.
(iv) The object represented must be located in the all-positive octant (all vertex coordinates must be positive).

However, for non-native STL applications, the STL format can be generalized. The normal, if not specified (three zeroes might be used instead), can be easily computed from the coordinates of the vertices using the right-hand rule.

Moreover, the vertices can be located in any octant. And finally, the facet can even be on the interface between two objects (or two parts of the same object). This makes the generalized STL format suitable for modelling of 3D non-manifolds objects.

4.3 CHOOSING PRINTING INKS:

Printing inks are chosen according to the need and kind of object that has to print. Different types of inks are available according to the size, type, resolution and function of the object.

- Colloidal Inks
- Fugitive Ink
- Nanoparticle Ink
- Polyelectrolyte Ink
- Sol-Gel Ink

5. APPLICATIONS

Three-dimensional printing makes it as cheap to create single items as it is to produce thousands and thus undermines economies of scale. It may have as profound an impact on the world as the coming of the factory did....Just as nobody could have predicted the impact of the steam engine in 1750 or the printing press in 1450, or the transistor in 1950 . It is impossible to foresee the long-term impact of 3D printing. But the technology is coming, and it is likely to disrupt every field it touches.

Additive Manufacturing's earliest applications have been on the tool room end of the manufacturing spectrum. For example, rapid prototyping was one of the earliest additive variants, and its mission was to reduce the lead time and cost of developing prototypes of new parts and devices, which was earlier only done with subtractive tool room methods (typically slowly and expensively). With technological advances in Additive Manufacturing, however, and the dissemination of those advances into the business world, additive methods are moving ever further into the production end of manufacturing in creative and sometimes unexpected ways. Parts that were formerly the sole province of subtractive methods can now in some cases be made more profitably via additive ones.

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Standard applications include design visualization, prototyping/CAD, metal casting, architecture, education, geospatial, healthcare, and entertainment/retail.

3D printer came with immense number of applications. All the traditional methods of printing causes wastage of resources. But 3D printer only uses the exact amount of material for printing. This enhances the efficiency. If the material is very costly, 3d printing techniques can be used to reduce the wastage of material.

Consider printing of a complex geometry like combustion chamber of a rocket engine. The 3D printing will enhances the strength and accuracy of the object. Conventional methods uses parts by parts alignment. This will cause weak points in structures. But in the case of 3D printed object, the whole structure is a single piece.

3D printer has numerous application in every field it touches. Since it is a product development device, rate of production, customization and prototyping capabilities need to be considered.

5.1 TYPES OF APPLICATIONS:

- Rapid prototyping
- Mass customization
- Automobiles
- Wearables
- 3d bio-printing.

6. 3D PRINTING OPERATION

Dia 2mm filament material melts 205ºc. Which drops through brass nozzle due to gravity as dia 0.5mm filament. At this temperature the moving nozzle settles the filament on the PLA bed at 70ºc and thus the printing starts. This moving brass nozzle controlled by servo motor and monitored by the Ardunio controller on board the printer.

6.1FUSED DEPOSITION MODELING:

Fused deposition modeling is an additive manufacturing technology commonly used for modeling, prototyping, and production applications. It is one of the techniques used for 3D printing.

FDM works on an "additive" principle by laying down material in layers; a plastic filament or metal wire is unwound from a coil and supplies material to produce a part.

The technology was developed by S. Scott Crump in the late 1980s and was commercialized in 1990. The term fused deposition modeling and its abbreviation to FDM are trademarked by Stratasys Inc. The exactly equivalent term, fused filament fabrication (FFF), was coined by the members of the RepRap project to give a phrase that would be legally unconstrained in its use. It is also sometimes called Plastic Jet Printing (PJP).

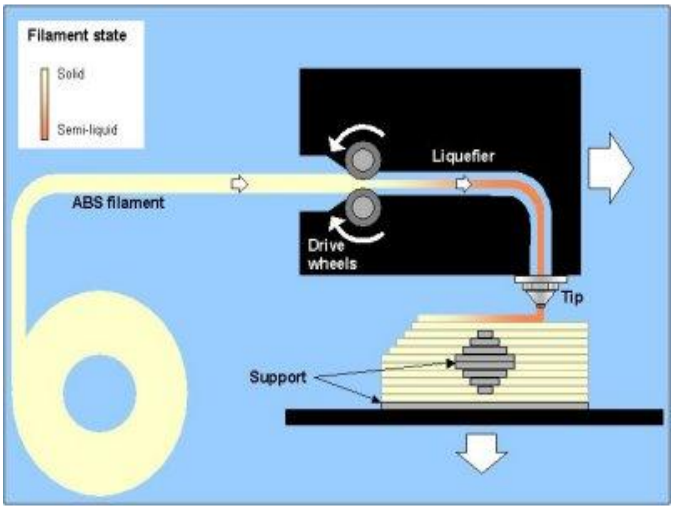

Fig-6.1: Fused deposition modeling

6.1.1 WORKING OF FUSED DEPOSITION MODELING

FDM begins with a software process which processes an STL file (stereolithography file format), mathematically slicing and orienting the model for the build process. If required, support structures may be generated. The machine may dispense multiple materials to achieve different goals: For example, one may use one material to build up the model and use another as a soluble support structure, or one could use multiple colors of the same type of thermoplastic on the same model.

The model or part is produced by extruding small flattened strings of molten material to form layers as the material hardens immediately after extrusion from the nozzle

A plastic filament or metal wire is unwound from a coil and supplies material to an extrusion nozzle which can turn the flow on and off. There is typically a worm-drive that pushes the filament into the nozzle at a controlled rate.

The nozzle is heated to melt the material. The thermoplastics are heated past their glass transition temperature and are then deposited by an extrusion head.

The nozzle can be moved in both horizontal and vertical directions by a numerically controlled mechanism. The nozzle follows a tool-path controlled by a computer-aided manufacturing (CAM) software package, and the part is built from the bottom up, one layer at a time. Stepper motors or servo motors are typically employed to move the extrusion head. The mechanism used is often an X-Y-Z rectilinear design, although other mechanical designs such as deltabot have been employed.

Although as a printing technology FDM is very flexible, and it is capable of dealing with small overhangs by the support from lower layers, FDM generally has some restrictions on the slope of the overhang, and cannot produce unsupported stalactites.

Myriad materials are available, such as Acrylonitrile Butadiene Styrene ABS, Polylactic acid PLA, Polycarbonate PC, Polyamide PA, Polystyrene PS, lignin, rubber, among many others, with different trade-offs between strength and temperature properties. In addition, even the color of a given thermoplastic material may affect the strength of the printed object. Recently a German company demonstrated for the first time the technical possibility of processing granular PEEK into filament form and 3D printing parts from the filament material using FDM-technology.

During FDM, the hot molten polymer is exposed to air.

Operating the FDM process within an inert gas atmosphere such as nitrogen or argon can significantly increase the layer adhesion and leads to improved mechanical properties of the 3D printed objects. An inert gas is routinely used to prevent oxidation during selective laser sintering.

6.2 INTRODUCTION TO AUTO CAD

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

Its use in designing electronic systems is known as electronic design automation, or EDA. In mechanical design it is known as mechanical design automation (MDA) or computer-aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software.

CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information,suchas materials, processes, dimensions,and tolerances, according to application-specific conventions.

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The design of geometric models for object shapes, in particular, is occasionally called computer-aided geometric design (CAGD).

6.3 PARTS DESIGNED AND PRINTED BY 3D PRINTER

- Flange
- Journal Bearing
- V-Block

6.3.1 FLANGE

Flange designed by using auto cad

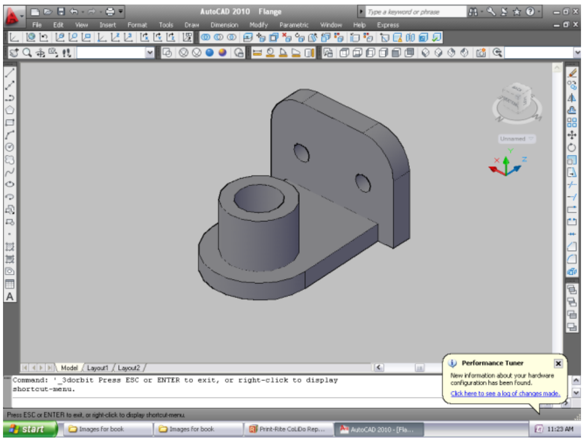

Fig-6.2: Auto cad design of flange.

SCALED OBJECT BY USING PRINT-RITE

After completion of designing in the auto cad. The file is exported to the PrintriteRepetier Host software as .stl format file and then manipulated sing object placement tab where it is rotated or scaled,etc as per the work space of the printer.

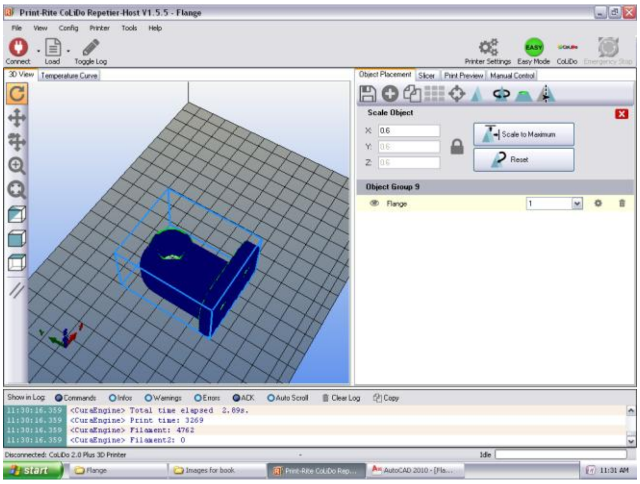

Fig-6.3: Flange during scaling.

SLICING THE OBJECT BY USING PRINTRITE

Afterworking in the object placement tab we now slice the object (generate a grid,discretizie the design) using either Slicer or CuraEngine as the below fig-6.4

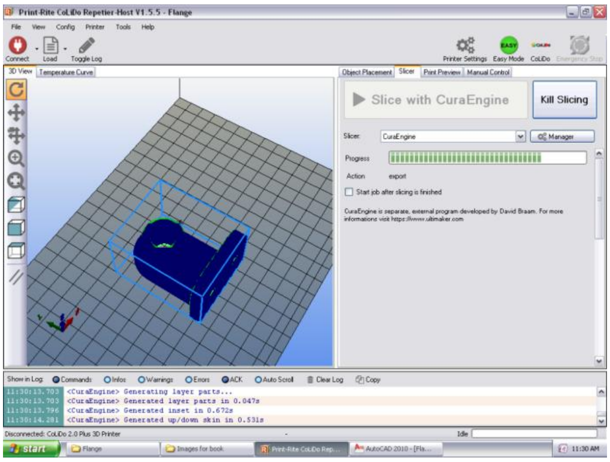

Fig-6.4 : Flange during slicing.

SLICED FLANGE

After the completion of slicing operation the result obtained represents the total time for the printer to complete the work and approximate amount of filament needed for it.

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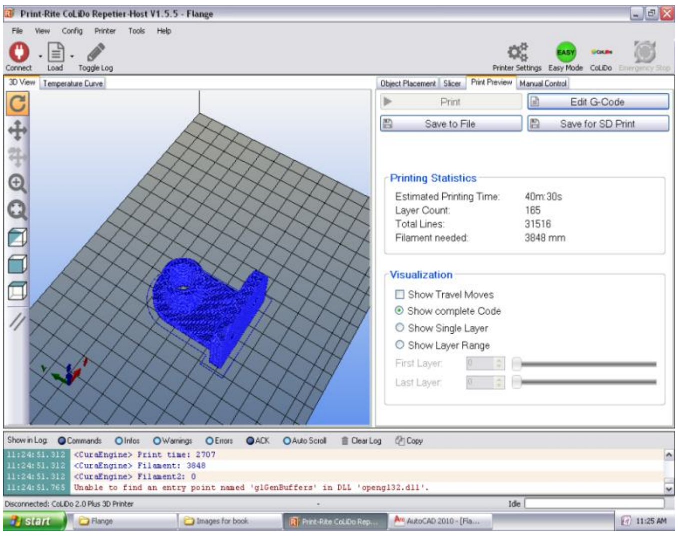

Fig-6.5: Sliced flange.

6.3.2 JOURNAL BEARING

SLICED JOURNAL BEARING

After the completion of slicing operation the result obtained represents the total time for the printer to complete the work and approximate amount of filament needed for it.

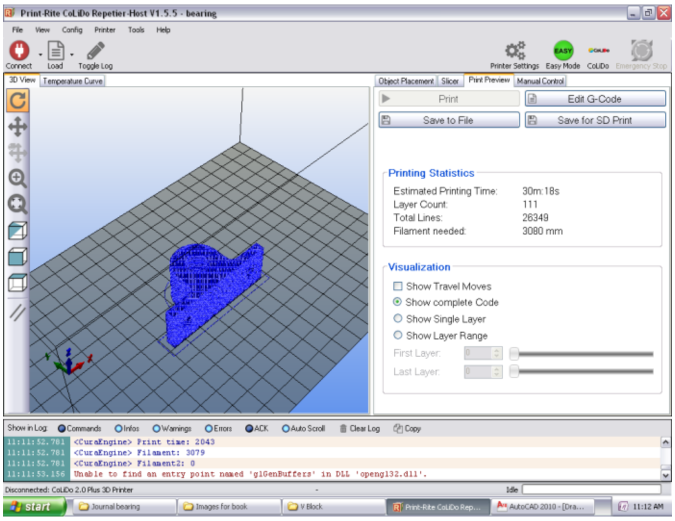

Fig-6.6: Sliced Journal bearing.

6.3.3 V-BLOCK

SLICED V-BLOCK

After the completion of slicing operation the result obtained represents the total time for the printer to complete the work and approximate amount of filament needed for it.

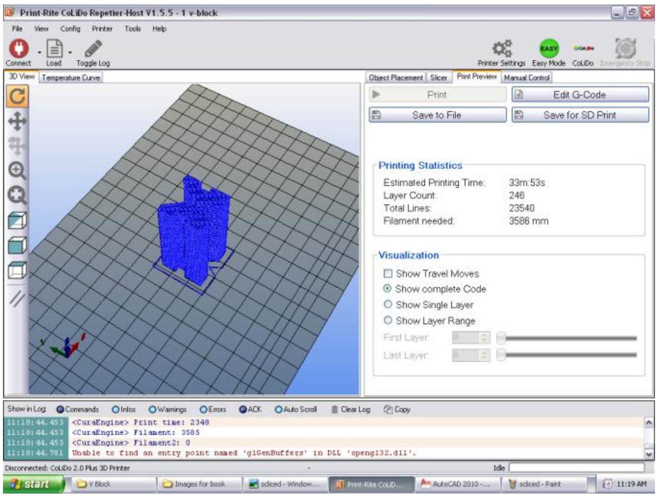

Fig-6.7: Sliced v-block.

7. CONCLUSION

3D printing is the ultimate just-in-time method of manufacturing. No longer do you need a warehouse full of inventory waiting for customers. Just have a 3D printer waiting to print your next order. On top of that, you can also offer almost infinite design options and custom products. It doesn't cost more to add a company logo to every product you have or let your customers pick every feature on their next order, the sky is the limit with Additive Manufacturing.

Whether you are designing tennis shoes or space shuttles, you can't just design whatever you feel like, a good designer always take into account whether or not his design can be manufactured cost effectively.

Additive Manufacturing open up your designs to a whole new level. Because undercuts, complex geometry and thin walled parts are difficult to manufacture using traditional methods, but are sometimes a piece of cake with 3D printing. In addition, the mathematics behind 3D printing are simpler than subtractive methods. For instance, the blades on a centrifugal supercharger would require very difficult path planning using a 5-axis CNC machine. The same geometry using Additive Manufacturing techniques is very simple to calculate, since each layer is analysed separately and 2D information is always simpler than 3D. This mathematical difference, while hard to explain is the

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fundamental reason why 3D printing is superior to other manufacturing techniques. It almost always better to keep things simple and Additive Manufacturing is simple by its very nature.

With so many potential benefits of 3D printing, there's no surprise that this method is making its way through a diverse number of industries and quickly becoming a favourite tool of progressive marketers.

Comparing the numerous advantages, applications and future scope, we can conclude that the 3D printer and its technology is able to create next industrial revolution.

8. FUTURE SCOPE

NASA engineers are 3-D printing parts, which are structurally stronger and more reliable than conventionally crafted parts, for its space launch system. The Mars Rover comprises some 70 3-D-printed custom parts. Scientists are also exploring the use of 3-D printers at the International Space Station to make spare parts on the spot. What once was the province of science fiction has now become a reality.

Medicine is perhaps one of the most exciting areas of application. Beyond the use of 3-D printing in producing prosthetics and hearing aids, it is being deployed to treat challenging medical conditions, and to advance medical research, including in the area of regenerative medicine. The breakthroughs in this area are rapid and awe-inspiring.

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