3D-Printing of a Piston Head of 4-Stroke S.I. Engine

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Abstract: In this project, piston head is designed for single cylinder engine and its 3D model is created using modeling software CATIA V5R20. The model created in CATIA V5R20 file is converted in to STL file. The piston head is made by using FDM method with PLA material is a process of prototyping where a structure is synthesized from a 3D model. The 3D model is stored in as a STL format and after that forwarded to a 3D printer. It can use a wide range of materials such ABS, PLA and composites as well. The 3D printer prints the CATIA design layer by layer forming a real object. 3D printing process is derived from inkjet desktop printers in which multiple deposit jets and the printing material, layer by layer derived from the CATIA data. 3D printing significantly challenges mass production processes in the future. This type of printing is predicted to influence industries, like automotive, medical, education, equipment, consumer products industries and various businesses.

Keywords: 3D-Printing

1. Introduction

A. Introduction to 3D Printing Technology

The term additive manufacturing (AM) encompasses many technologies including subsets like 3-D printing, rapid prototyping (RP), direct digital manufacturing (DDM), layered manufacturing and additive fabrication additive manufacturing, the industrial version of 3-D printing is already used to make some niche items in many industries. The terms 3-D printing and additive manufacturing have become interchange-able. The term additive manufacturing refers to the technology or additive process of depositing successive thin layers of material upon each other, producing a final three dimensional product. Each layer is approximately 0.001 to 0.1 inches in thickness. A wide variety of materials can be utilized, namely plastics, resins, rubbers, ceramics, glass, concretes, and metals. Rapid prototyping refers to the application of the technology. This was the first application for AM, which assisted in the increase of time-to-market and innovation. It can be referred to as the process of quickly creating a model/prototype of a part or finished good. This part or finished good will be further tested and scrutinized before mass production occurs. Most commercial 3-D printers have similar functionality. The printer uses a computer-aided design (CAD) to translate the design into a three-dimensional object.

B. 3D Printing Applications

A new technology or invention can be evaluated by considering its applications and positive influence on human life and society. Regarding this, "Maslow's hierarchy of needs" is a good foundation for evaluation. In this pyramid all of the human needs are defined and grouped based on their priority according to the basic necessities and quality of life. Maslow uses the terms Physiological, Safety, Belongingness and Love, Esteem, and Self-actualization to describe the needs that humans generally desire. Maslow's hierarchy of needs is often portrayed in the shape of a pyramid, with the largest and most fundamental levels of needs at the bottom and the need for self-actualization at the top as shown in fig. 1.

Fig. 1. A pyramid of needs by maslow

2. Literature review

A. Review of Journal Papers

Chandra Shekhar Kalnad et. al. 3D printing was known as "rapid prototyping". Chuck Hull, of 3D Systems Corporation, created the first working 3D printer in 1984. [1] Later in the 80's, Selective Laser Sintering (SLS) technology was developed by Dr. Deckard at the University of Texas at Austin during a project sponsored by Defense Advanced Research Projects Agency (DARPA). In the 1990s, the technology was further improved with the development of a method that used ultraviolet light to solidify photopolymer, a viscous liquid material. In the late 20th century, 3D printers were extremely expensive and could only be used to print a limited number of products. The majority of the printers were owned by scientists and electronics enthusiasts for research and display. Consequently, 3D printing began to lead a worldwide

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manufacturing revolution.

Antonio Chaves de Assis Neto et. al. This study introduces an innovative and high-level project of technological development aimed at creating a method for fast production of 3D printed models of bones using 3D scanning and 3D printing technologies. The accuracy and reliability of the printed models was confirmed by visual analysis of their anatomical characteristics, measurements of their structures, and comparisons with the bones. Thus, through future studies involving tests of 3D printed models with students in veterinary anatomy classes, these models may soon be found to be an aid in anatomy lessons and may serve as reliable alternatives in the study of veterinary anatomy. [2]

Cephas Mawere et. al. The 3D printing industry is set on a growth trajectory as evidenced by a growth forecasts. [4] The. applications of 3D printing are increasing as more and more research is carried out. 3D printing will change the way people acquire products as evidenced by the Amazon proposed model. The field is definitely a game changer with lots of prospects to look out for. [3]

3. Experimentation

A. Modeling in CATIA

- STEP1: The part modeling is to be selected first. Then, by selecting one of the three plains, the following 2-d sketch is drawn using appropriate measurements.
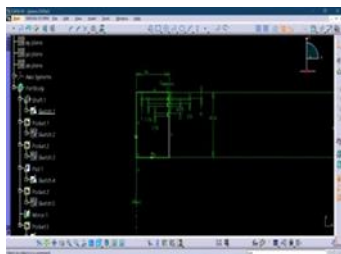

Fig. 2.

- STEP 2: Using the revolve or shaft command, revolve the selected sketch through 360 degree about the axis.
- STEP3: Now select bottom of the faces and sketch option. Draw the 2 dimensional shape of the object
- STEP 4: Using pocket command, cut the material of the object to a required length.
- STEP 5: Now use the pad option to add the material of the object.
- STEP 6: On the same face draw a 2 dimensional circle
- STEP7: On the same face, use the pocket command and remove the material up to the next of the piston.
- STEP 8: Now select the sketch and select the mirror option of the sketch.
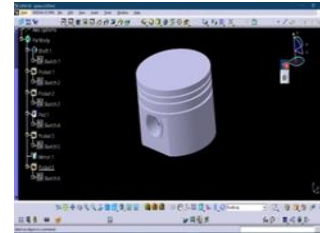- STEP 9: Now the design of the piston is ready.

Fig. 3.

B. 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 counter clockwise 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 counter clockwise 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.

The object (piston, in this case) can be converted to STL format file by the following procedure:

- Open the previously saved design file in the CAD software (CATIA, in this case) and find 'File' on the menu
- Click on the 'File' menu and select 'Save as' as shown in the figure below.
- After selecting 'Save as', the following window appears.
- Now select '. Stl' from the list of options to save the file.

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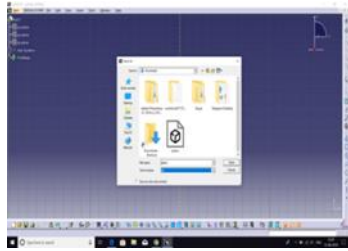- Save the file in the respective folder.

Fig. 4.

The 3d printer should be connected to the pc or the laptop, on which you have been working and the software like CURA from Ultimaker or Ideamaker has to be pre-installed on the computer.

C. Printing 3-D Model

Before printing the 3-D model file, the 3d printer should be connected to the pc or the laptop, on which you have been working and the software like CURA from Ultimaker or Ideamaker has to be pre-installed on the computer.
The filament used to print the 3-D model of piston in this case is PLA.

- The specifications of the PLA filament are:
- Diameter of filament: 1.75 mm
- Certification: Roots approved
- Printing temperature: 190° to 210° C
- Bed temperature: 50° to 60° C
- Colour: White
- Now open the Idea maker software and load the STL file that has been saved using CAD software.

Fig. 5.

Necessary modifications should be done after the file has been loaded, like rotating and scaling (since the maximum printing capacity of most of the printers is 20cm×20cm×20cm, along X, Y and Z axes).

The printing process has to be set to the following settings from the available options, that the software has to offer.

- Layer height: 0.1mm
- Fill density: 10%
- Shell thickness: 2%
- Extruder temperature: 200° C
- Heat bed temperature: 50° C
- Printing speed: 60 mm/s

After the settings have been done, the following information regarding the model to be printed will be displayed:

- Dimension (mm): 24.3×24.3×18.3 (in mm)
- Triangle: 1096
- Edges: 546
- Non-manifold edges: 0
- Error orientation faces: 0
- Layers: 181
- Steps: 280
- Time duration; 56 min 46 sec
- Left filament: ---
- Right filament: 240° C
- Price: $1
- Estimated amount: 3.0 g
- Length: 1.10 m

Now, the processed STL file has to be mounted onto the external storage device like memory card or a pen drive that is compatible with the 3-D printer, and it should be mounted on the printer, where the object would be printed in solid material of the filament.

4. Result

In this project modeling of PISTON HEAD is carried out with the CATIA V5 software by using machine design. After creating model, we save the component in STL file import the component in to 3D printing machine and then we apply the GCODES to the component. And then we get the component.

Fig. 6. Piston head

5. Conclusion

3D printing technology could revolutionize the world. Advances in 3Dprinting technology can significantly change and improve the way we manufacture products and produce goods worldwide. An object is scanned or designed with computer aided design software, then sliced up into thin layers, which can then be printed out to form a solid three-dimensional product. As shown, 3D printing can have an application in almost all of the categories of human needs as described by Maslow.

This project modeling of a piston head is carried out with the CATIA V5 Software by using various commands. And then we apply G-CODES to the component. And then we get the component. Design and 3D printing of Piston Head is done.

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6. Future scope

- NASA engineers are manufacturing 3-D printed parts, which are structurally stronger and more reliable than conventionally crafted parts, for its space launch system.
- 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.
- As noted above, 3D printers may also be used to make future buildings. To this end, a team at Lough Borough University is working on a 3D concrete printing project that could allow large building components to be 3D printed on-site to any design.
- Another possible future application is in the use of 3D printers to create replacement organs for the human body. This is known as bio printing, and is an area of rapid development.

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