International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 01 | Jan - 2022 ISSN: 2582-3930

Design and 3D Printing of Piston Head

K.Vinay Kumar Reddy[1] Mohammed Amer[2] Mohammed Sameer[3] Sachin Gouda[4]

[1,2,3,4]Department of Mechanical Engineering

[1,2,3,4]Guru Nanak Institute of Technology, JNTUH, Hyderabad, India

Abstract— In this project, piston head is designed for single cylinder engine and its 3D model is created using modeling software CATIAV5.The model created in CATIAV5 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 modelis 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 CATIAV5 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 CATIAV5 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 variousbusinesses.

Keywords: 3D Printing Methods, Piston Head, Poly Lactic Acid (PLA)

I. INTRODUCTION

3D printing creates solid parts by building up objects one layer at a time. Producing parts via this method offers many advantages over traditional manufacturing techniques. 3D printing is unlikely to replace many traditional manufacturing methods yet there are many applications where a 3D printer is able to deliver a design quickly, with high accuracy from a functional material. Understanding the advantages of 3D printing allows designers to make better decisions when selecting a manufacturing technique that results delivery of the optimal product. One of the main advantages of additive manufacture is the speed at which parts can be produced compared to traditional manufacturing methods. Complex designs can be uploaded from a CAD model and printed in a few hours. The advantage of this is the rapid verification and development of design ideas. Where in the past it may have taken days or even weeks to receive a prototype, additive manufacturing places a model in the hands of the designer within a few hours. While the more industrial additive manufacturing machines take longer to print and post process a part, the ability to produce functional end parts at low to mid volumes offers a huge time saving advantage when compared to traditional manufacturing techniques. In this paper, an attempt is made to design a new concept of manufacturing Piston head using additive manufacturing where there is a requirement for customized order or single product without investing into mold manufacturing cost. It consists of Piston pin, Compression ring, Oil ringand Piston skirt.

Fig. 1: Piston Head

Piston Head Traditionally Piston Heads are manufactured using Aluminium Alloy, who's manufacturing cost ishigh due to mold casting, quenching processes etc. So there is a need to design a 3D printed Piston Head using advanced 3D printing methods & materials which can be made quickly and easily, with high strength, durability and performance.

II. LITERATURE REVIEW

Elizabeth Matias, Bharat Rao, "3d printing on its historical evolution and the implications for business", 2015 Proceedings of PICMET: Management of the Technology Age.Quite simply, the term "additive manufacturing" refers to the process of building products by adding many very thin layers of material, layer on top of layer. Historically speaking, additive manufacturing can trace its roots back to the 19th century, particularly the fields of topography and photo sculpture. However, in a "Brief History of Additive Manufacturing and the 2009 Roadmap…" by Beaman et al, they cite that in 1972 Ciraud released the first technology that truly represented today's definition of additive manufacturing.

Gabriel Gaala, Melissa Mendesa, Tiago P. de Almeida, "Simplified fabrication of integrated microfluidic devices using fused deposition modeling 3D printing" Science Direct. I have done a research on a 3D printer, its designing, manufacturing and it various operations. This machine is a complete compact CNC machine, which can be used as a 2d plotter, leaser cuter & even milling by changing its tool. It is less costly than any other 3D printer which can function in the way as mentioned above, it is user friendly, and its filaments are easily available in various colors and various materials.To fhis machine is of lowest maintenance. I believe this machine will change the INDIAN manufacturing ways, In future u will see this machine in larger scale of making houses as well. Materials used in 3D printing and their properties will become a notable topic in technological aspects.

3D printing or additive manufacturing (AM) is a process for making a 3D object of any shape from a 3D model or other electronic data sources through additive processes in which successive layers of material are laid down under computer controls. Hideo Kodama of Nayoga Municipal Industrial Research Institute is generally regarded to have printed the first solid object from a digital design. However, the credit forthe first 3D printer generally goes to Charles Hull, who in 1984 designed it while working for the company he founded, 3D Systems Corp. Charles a Hull was a pioneer of the solid imaging process known as stereolithography and the STL (stereo lithographic) file format which is still the most widely used format used today in 3D printing. He is also regarded to have started commercial rapid prototyping that was concurrent with his development of 3D printing. He initially used photopolymers heated by ultraviolet light to achieve the melting and solidification effect. [2]Since 1984, when the first3D printer was designed and realized by Charles W. Hull from 3D Systems Corp., the technology has evolved and these machines have become more and more useful, while their price points lowered, thus becoming more affordable.

Nowadays, rapid prototyping has a wide range of applications in various fields of human activity: research, engineering, medical industry, military, construction, architecture, fashion, education, the computer industry and many others. In 1990, the plastic extrusion technology most widely associated with the term "3D printing" was invented by Stratasys by name fused deposition modeling (FDM). After the start of the 21st century, there has been a large growth in the sales of 3D printing machines and their price has been dropped gradually. By the early 2010s, the terms 3D printing and additive manufacturing evolved senses in which they were alternate umbrella terms for AM technologies, one being used in popular vernacular by consumer - maker communities and the media, and the other used officially by industrial AM end use part producers, AM machine manufacturers, and global technical standards organizations. Both terms reflect the simple fact that the technologies all share the common theme of sequential-layer material addition/joining throughout a 3D work envelope under automated control.

Other terms that had been used as AM synonyms included desktop manufacturing, rapid manufacturing, and agile tooling on-demand manufacturing. The 2010s were the first decade in which metal end use parts such as engine brackets and large nuts would be grown (either before or instead of machining) in job production rather than obligatory being machined from bar stock or plate.

Dongkeon Lee, Takashi Miyoshi, Yasuhiro Takaya and Taeho Ha, "3D Micro fabrication of Photosensitive Resin Reinforced with Ceramic Nanoparticles Using LCD 3D printing or additive manufacturing (AM) is a process for making a 3D object of any shape from a 3D model or other electronic data sources through additive processes in which successive layers of material are laid down under computer controls. Hideo Kodama of Nayoga Municipal Industrial Research Institute is generally regarded to have printed the first solid object from a digital design. However, the credit for the first 3D printer generally goes to Charles Hull, who in 1984 designed it while working for the company he founded, 3D Systems Corp. Charles a Hull was a pioneer of the solid imaging process known as stereo lithography and the STL (stereo lithographic) file format which is still the most widely used format used today in 3D printing. He is also regarded to have started commercial rapid prototyping that was concurrent with his development of 3D printing. He initially used photopolymers heated by ultraviolet light to achieve the melting and solidification effect. [2]Since 1984, when the first 3D printer was designed and realized by Charles W. Hull from 3D Systems Corp., the technology has evolved and these machines have become more and more useful, while their price points lowered, thus becoming moreaffordable.

Acrylonitrile Butadiene Styrene [ABS] One of the most widely used material since the inception of 3D printing. This material is very durable, slightly flexible, and lightweight and can be easily extruded, which makes it perfect for 3D printing. It requires less force to extrude than when using PLA, which is another popular 3D filament. This fact makes extrusion easier for small parts. The disadvantage of ABS is that it requires higher temperature. Its glass transition temperature is about 105Â°C and temperature about 210 – 250Â°C is usually used for printing with ABS materials. Also another drawback of this material is quite intense fumes during printing that can be dangerous for pets or people withbreathing difficulties. So 3D printers need to be placed in well-ventilated area. Also good advice is to avoid breathing in fumes during printing considering the cost of 3D materials ABS is the cheapest, which makes it favorite in printing communities until now.

Poly Lactic Acid [PLA] Poly lactic acid (PLA) (is derived from corn and is biodegradable) is another well-spread material among 3D printing enthusiasts. It is a biodegradable thermoplastic that is derived from renewable resources. As a result PLA materials are more environmentally friendly among other plastic materials. The other great feature of PLA is its biocompatibility with a human body. The structure of PLA is harder than the one of ABS and material melts at 180 220Â°C which is lower than ABS. PLA glass transition temperature is between 60 65 Â° C, so PLA together with ABS could be some good options for any of your projects

Pshtiwan Shakor, Jay Sanjayan, Ali Nazari, Shami Nejadi, "Modified 3D printed powder to cement-based material and mechanical properties of cement scaffold used in 3D printing", Science Direct. Additive manufacturing is acommon technique used to produce 3D printed structures. These techniques have been used as precise application geometry in different fields such as architecture and medicine,and the food, mechanics and chemical industries. However, in most cases only a limited amount of powder has been used to fabricate scaffold (structure). In this study, a unique mix of cements (calcium aluminate cement passed through a 150 μm sieve and ordinary Portland cement) was developed for Z-Corporation's three-dimensional printing (3DP) process.

This cement mix was blended and the resulting composite powders were printed with a water-based binder using a Z-Corporation 3D printer. Moreover, some samples were added lithium carbonate to reduce the setting time for the cement mixture. The aims of the study were to firstly, find the proper cementitious powder close to the targeted powder (Z-powder); and secondly, evaluate the mechanical properties of this material. Cubic specimens of two different batches with varying saturation levels were cast and cured in various scenarios to enhance the best mechanical properties. The samples were characterised by porosity analyses, compression tests, Olympus BX61 Microscope imaging, 3D profiling Veeco (Dektak) and the Scanning Electronic Microscope (SEM). The maximum compressive strength of the cubic specimens for cementitious 3DP was 8.26 MPa at the saturation level of 170% for both the shell and core. The minimum porosity obtained was 49.28% at the saturation level of 170% and 340% for the shell and the core, respectively.

Alexandru Pirjan, Dana-Mihaela Petrosanu, "The Impact of 3D Printing Technology on the society and economy", Journal of Information Systems and Operations Management, Volume 7, Dec 2013

In 1981, Hideo Kodama of the Nagoya Municipal Industrial Research Institute (Nagoya, Japan) has studied and published for the first time the manufacturing of a printed solid model, the starting point of the "additive manufacturing", "rapid prototyping" or "3D printing technology". In the next decades, this technology has been substantially improved and has evolved into a useful tool for researchers, manufacturers, designers, engineers and scientists. As the term suggests, "additive manufacturing" is based on creating materials and objects, starting from a digital model, using an additive process of layering, in a sequential manner. Most of the traditional manufacturing processes are based on subtractive techniques: starting from an object having an initial shape, thematerial is removed (cut, drilled) until the desired shape is obtained. Unlike the above-mentioned technique, the 3D printing is based on adding successive material layers in order to obtain the desired shape. Since 1984, when the first 3D printer was designed and realized by Charles W. Hull from 3D Systems Corp the technology has evolved and these machines have become more and more useful, while their price points lowered, thus becoming more affordable. Nowadays, rapid prototyping has a wide range of applications in various fields of human activity: research, engineering, medical industry, military, construction, architecture, fashion, education, computer industry and many others. The 3D printing technology consists of three main phases - the modeling, the printing and the finishing of the product:

In the modeling phase, in order to obtain the printing model, the machine uses virtual blueprints of the object and processes them in a series of thin cross-sections that are being used successively. The virtual model is identical to the physical one.

- In the printing phase, the 3D printer reads the design (consisting of cross-sections) and deposits the layers of material, in order to build the product. Each layer, based on a virtual cross section, fuses with the previous ones and, finally, after printing all these layers, the desired object has been obtained. Through this technique, one can create different objects of various shapes, built from a variety of materials (thermoplastic, metal, powder, ceramic, paper, photopolymer, liquid).
- The final phase consists in the finishing of the product. In many cases, in order to obtain an increased precision, it is more advantageous to print the object at a higher size than the final desired one, using a standard resolution and toremove then the supplementary material using a subtractive process at a higher resolution.

III. METHODOLOGY AND GENERAL PRINCIPLES

A. *Modeling*

3D printable models can be created with the help of CATIA design packages or via 3D scanner. The manual modeling.

process of preparing geometric data for 3D computer graphics is similar to method sculpting. 3D modeling is a process of analyzing and collecting data on the shape and appearance of an object. Based on this data, 3D models of the scanned object can be produced. Both manual and automatic creations of 3Dprinted models are very difficult for average consumers. That is why several market-places have emerged over the last years among the world. The most popular are shape ways, Thing verse, My Mini Factory, and Threading.

B. *Printing*

Before printing a 3D model from .STL file, it must beprocessed by a piece of software called a "slicer" which converts the 3D model into a series of thin layers and produces a G-code file from .STL file containing instructions to a printer. There are several open source slicer programs exist, including, Slic3r, KISSlicer, and Cura. The 3D printer follows the G-code instructions to put down successive layers of liquid, powder, or sheet material to build a model from a series of cross-sections of a model. These layers, which correspond to the virtual cross sections from the CAD model are joined or fused to create the final shape of a model. The main advantage of this technique is its ability to create almost any shape or geometric model. Construction of a model with existing methods can take anywhere from several hours today's, depending on the method used and the size and complexity of the model. Additive systems can typically reduce this time to very few hours; it varies widely depending on the type of machine used and the size and number of models being produced.

C. *Finishing*

Although the printer-produced resolution is sufficient for many applications, printing a slightly oversized version of the object in standard resolution and then removing material with a higher-resolution process can achieve greater precision. As with the AccurateiD-20 and other machines Press Release. International Manufacturing Technology shows some additive manufacturing techniques are capable of using multiple materials in the course of constructing parts.

IV. 3D PRINTING TECHNIQUE

A. Fused Deposition Modelling

Fused deposition modeling (FDM) method was developed by S. Scott Crump in the late 1980s and was designed in 1990 by Stratasys. After the patent on this technology expired, a large open source development community developed and commercial variants utilizing this type of 3D printer appeared. As a result, the price of FDM technology has dropped by two orders of magnitude since its creation. In this technique, the model is produced by extruding small beads of material which harden to form layers. A thermoplastic filament or wire that is wound into a coil is unwinding to supply material to an extrusion nozzle head. The nozzle head heats the material up to the certain temperature and turns the flow on and off. Typically the stepper motors are employed to move the extrusion head in the z-direction and adjust the flow according to the requirements. The head can be moved in both horizontal and vertical directions, and control of the mechanism is done by a computer-aided manufacturing (CAM) software package running on amicrocontroller.

V. MATERIAL USED

A. Poly Lactic Acid (PLA)

Poly lactic acid (PLA) (is derived from corn and is biodegradable) is another well-spread material among 3Dprinting enthusiasts. It is a biodegradable thermoplastic that is derived from renewable resources. As a result PLA materials are more environmentally friendly among other plastic materials. The other great feature of PLA is its Bio compatibility with a human body. The structure of PLA is harder than the one of ABS and material melts at 180 – 220°C which is lower than ABS. PLA glass transition temperature is between 60 – 65°C, so PLA together with ABS could be some good options for any of your projects

VI. PROCEDURE FOR SLICING AND 3D PRINTING

A. Adding and repairing your model

To add your model, click on the plus icon in the middle. Choose your file and it will be loaded onto the screen. Use the "Pan", "Move" and "Rotate" tools to look around. You can also use the shortcuts. One thing you might notice is an orange warning sign. This means your models are "Invalid" and that they need to be repaired. If you unselect them, they will be colored red. Repairing is a very smooth and efficientprocess in Idea Maker. Here's how to do it:

1) Select the model.
2) Click "Repair" on the toolbar.

VII. RESULT

Piston Head is designed and 3D printed by using Fused Deposition Modeling.

Fig. 2: 3D Printed Piston Head

The final 3D printed object is a prototype of Piston Head made by 3D printing to identify the minute errors and solve them to manufacture a perfect model of Piston Head.

VIII.CONCLUSION

In this journal modeling of a PISTON HEAD is carried out with the of CATIA V5 Software by using of machine design.After creating model we save the component in STL file. Import the component into the 3D Printing machine. And then we apply the G-CODES to the component. And then weget the component.

REFERENCES

Elizabeth Matias, Bharat Rao, "3d printing on its historical evolution and the implications for business", 2015 Proceedings of PICMET: Management of the Technology Age.
Gabriel Gaala, Melissa Mendesa, Tiago P. de Almeida, "Simplified fabrication of integrated microfluidic devices using fused deposition modeling 3D printing" Science Direct.
Dongkeon Lee, Takashi Miyoshi, Yasuhiro Takaya and Taeho Ha, "3D Micro fabrication of Photosensitive Resin Reinforced with Ceramic Nanoparticles Using LCD Microstreolithography", Journal of Laser Micro/Nano engineering Vol.1, No.2, 2006.
Pshtiwan Shakor, Jay Sanjayan, Ali Nazari, Shami Nejadi, "Modified 3D printed powder to cement-based material and mechanical properties of cement scaffold used in 3D printing", Science Direct.
Alexandru Pirjan, Dana-Mihaela Petrosanu, "The Impact of 3D Printing Technology on the society and economy", Journal of Information Systems and Operations Management, Volume 7, Dec 2013.

•