Design And Fabrication of Exhaust Manifold Using FDM Technology

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Abstract- *Fused deposition modeling (FDM) is a rapid prototyping technology suited for producing parts with complex geometries, In this paper the FDM process has been used to print an Exhaust manifold and to test the tensile strength properties of the printed sample. This investigation helps to find the optimized size of exhaust pipe system which can be used further designing as well as the manufacturing of exhaust manifold.*

Keywords- Fused Deposition modelling, STL, exhaust Manifold, tensile test specimen, ASTM D638.

I. INTRODUCTION

Additive manufacturing, also known as 3D printing, is a transformative approach to industrial production that enables the creation of lighter, stronger parts and systems.FDM is one of the efficient additive layer-by-layer manufacturing technology capable of delivering or duplicating unsupported modern structures in one piece. Additive manufacturing provides programmed creation of complex shapes with a critical decrease in assembling cost, contrasted with conventional subtractive manufacturing methods. In the most recent years, the utilization of additive manufacturing has developed generously equally in volume and extension. Main principle of FDM technology is to produce parts directly from three-dimensional computer-aided design (CAD) data by using material extrusion process. Three-dimensional CAD model is saved as .stl file configuration and later exported to a 3D printer.The plan is then printed by the FDM printer layer-by-layer structuring a genuine product. 3D printing enables creators and designers to go from level screen to correct part. FDM process has a number of parameters that impact material properties and quality of the product, and also, the mix of these parameters is frequently hard to understand. Printing parameters like layer thickness, feed rate, infill pattern and density, raster width and angle, orientation of the part show a substantial effect on performance and quality of the FDM-printed parts. This paper throws light on printing an exhaust manifold and testing the tensile properties of the printed material.

II. MATERIAL SELECTION

Polylactide (PLA) is a biodegradable, aliphatic polyester derived from lactic acid made from renewable resources, such as corn starch or sugarcane Lactide is the cyclic dimer of lactic acid, and is produced by a combined process of oligomerization and cyclization. PLA has similar mechanical properties to polyethylene terephthalate (PET), but has a significantly lower maximum continuous use temperature. Poly(L-lactide) (PLLA) is the most important PLA. PLA has a larger strength and lower ductility than the traditional acrylonitrile butadiene styrene (ABS) material. PLA is a sustainable thermoplastic alternative which addresses the problem of added waste from end-users manufacturing components at home and has similar characteristics as ABS. PLA parts produced via FDM have also been of high interest to the medical field, due to its biocompatibility in applications such as tissue engineering and custom-made patient-specific implants. Poly lactic acid has been chosen to print the benchmarked component.

III. BENCHMARKING OF THE COMPONENT

A. Exhaust Manifold

Exhaust manifolds are generally simple cast iron or stainless steel units which collect engine exhaust gas from multiple cylinders and deliver it to the exhaust pipe. A vehicle's exhaust manifold plays the leading role in a car or truck's exhaust system. It connects to each exhaust port on the engine's cylinder head, and it funnels the hot exhaust down into one simple exhaust pipe. With the help of the exhaust manifold gaskets, it also prevents the toxic exhaust fumes from sneaking into the vehicle and harming the occupants. Needless to say, it's pretty important to have your exhaust manifold in good working order. Their design usually has to be performed by trial and error method through many experiments and analysis. This designed and analyzed model can be used in different vehicles of designing competition like Supra SAEIndia, FSB, FSG etc. for getting better performance with the same engine.

IV. PROCESS SELECTION

Process selected for the printing of this bench marked component is Fused Deposition modelling. This is one of the cost efficient rapid prototyping processes that can build parts of any geometry by sequential deposition of the material on a layer by layer process. Unlike other Rapid prototyping processes which uses an array of lasers, this process uses thermoplastic filaments which are extruded from the tip of a nozzle in the prescribed manner. The FDM machine used for building this exhaust manifold is shown in Figure 1. Also, the specifications of the FDM machine are as shown in Figure 2

Fig 1Fused Deposition Modelling Machine

Build Volume: 220mm (Dia) X 300 mm (H)
Build Temperature: 180 to 270 deg C
Printing Filament Size: 1.75mm
Layer Resolution: 50-300 Microns
Speed: 200mm/sec
Compatible filament: PLA, ABS
Machine Dimension:500mm X 1000mm
Display : LCD
Rated Power: 100 W
Power Supply: AC 100-240 V

Fig 2 Specifications of the FDM Machine

V. EXPERIMENTAL WORK

The following steps has been done in the printing of the component:

STEP 1: Identification of benchmark component
STEP 2: Prepare Virtual 3D model of benchmark component and covert it in STL file
STEP 3: Print the patterns in selected material on Fused deposition modelling machine
STEP 4: Printing of specimens for tensile and flexural test according to respective ASTM standards
STEP 5:Perform Tensile test
STEP 6: Record and analyse the results in terms of their mechanical properties

The CADD design of the exhaust manifold is drawn in Solid works 2018 software and the design is virtually inspected for any geometrical errors. The CADD file is then saved as STL file. The STL file format has become the Rapid Prototyping industry's defacto standard data transmission format, and is the format required to interact with Quickparts. The designed STL file of the exhaust manifold is as below in Fig 3.

Fig 3 Exhaust Manifold STL File

VI. MECHANICAL TESTS

A. Tensile test

Now the material property of tensile strength is been tested by means of Plastic tensile testing machine, for which the tensile test specimen was built according to the ASTM D638. ASTM D638 standard procedure is adopted for evaluating the tensile behaviour of 3D-printed PLA test specimens. Solidworks software is used for modelling the geometry of the specimens as per the dimensions specified in ASTM D638 standard as shown in Fig. 4. Models are then saved in .stl file format as shown in Fig. 5 and then imported to the 3D printing software. The printed and tested tensile samples are as shown in Fig 6 and Fig 7.

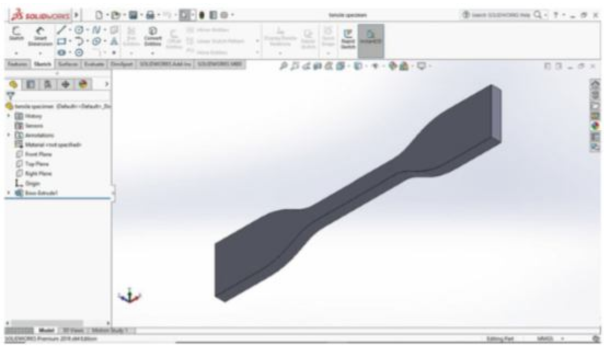

Fig 4 Modelled Tensile Test specimen

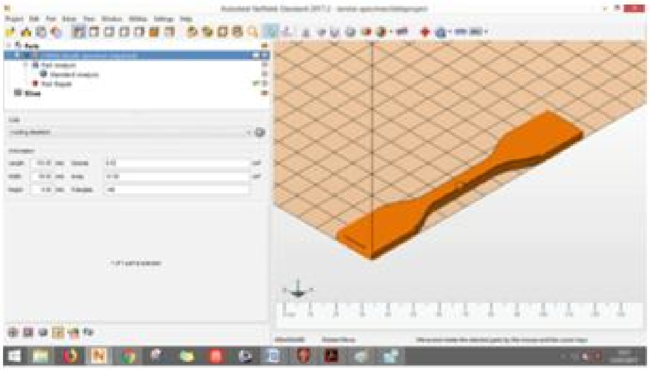

Fig 5 Tensile Specimen STL File

Fig 6 Printed tensile test specimen (Before testing)

Fig 7 Tensile tested Sample

The test result showed that the tensile strength of PLA printed sample was 45 N/mm^2.

VII. CONCLUSION

In this paper Exhaust manifold has been printed according to the required dimensions and the Fused deposition modelling process has been selected for printing it. Tensile test has been done on the sample built according to ASTM D638 standard. Future works can be done to use this printed parts as wax patterns in investment casting process, by neglecting the making of separate wax patterns, tool and die making charges in investment casting.

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