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Design & 3D Printing of 180cc Engine Connecting Rod

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Abstract: **Connecting rod interconnects piston to crankshaft and it is responsible for transferring power from piston to the crankshaft and sending it to the transmission. Connecting rod are traditionally manufactured using mould casting method which has high moulding cost and requires highly skilled designer to design the mould which is also more costly. So there is a need to optimise the manufacturing process of connecting rod. In this project work, Objective is to use advance manufacturing processes to produces complex Designs using 3d printing methods. Connecting rod of Apache RTR 180cc engine is considered and will use 3D printing technique and different filament materials for customized requirements. Theoretical designing of connecting rod is done as per standard connecting rod design procedure and 3D modelling is done using Solidworks 2015 software. Finite Element analysis software ANSYS 15.0 is used to study the load carrying capacity of connecting rod. Connecting rod is manufactured using 3D printing FDM technique with three different filaments i.e. ABS, Nylon 66 and PC. Experimental testing will be done on the 3D printed connecting Rod using UTM Machine.[1] The results of Finite element analysis shows that 3D Printed Connecting rod made of Acrylonitrile Butadiene Styrene will carry 47 KN load compared with other 3D printed Connecting rod. These types of connecting rod can be used for as per engine specifications and required load carrying capacity with short time of production and complex designs.**

Keywords — **Acrylonitrile Butadiene Styrene, Connecting Rod, CAD Design, 3D Printing, Finite element analysis, NYL 66.**

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.[3] 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 connecting rod using additive manufacturing where there is a requirement for customized order or single product without investing into mold manufacturing cost. Connecting rod is designed using 3 Different filaments i.e. ABS, PC and Nylon.

It consist of three main parts

Pin End (Small End)
Shank Section (Middle)
Crank end (Big End)

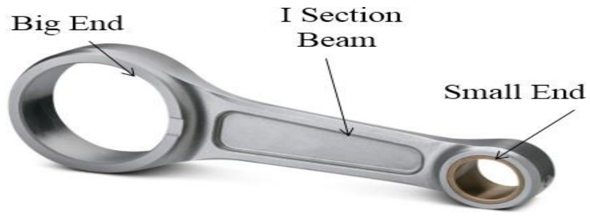

Fig -1: Connecting Rod

Traditionally Connected rods are manufactured using Alloy steel, who's manufacturing cost is high due to mold casting, quenching processes etc. So there is a need to design a 3D printed Connecting rod using advanced 3D printing methods & materials which can be made quickly and easily, with high strength, durability and performance. With following objective we overcome above problem.

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1. To Design the 3D printed connecting rod with different 3D printing materials and to study the behavior at actual loading conditions.
2. To find the stresses and deformation produced on 3D printed connecting rod.
3. To find the strongest 3D printing material to manufacture a connecting rod.

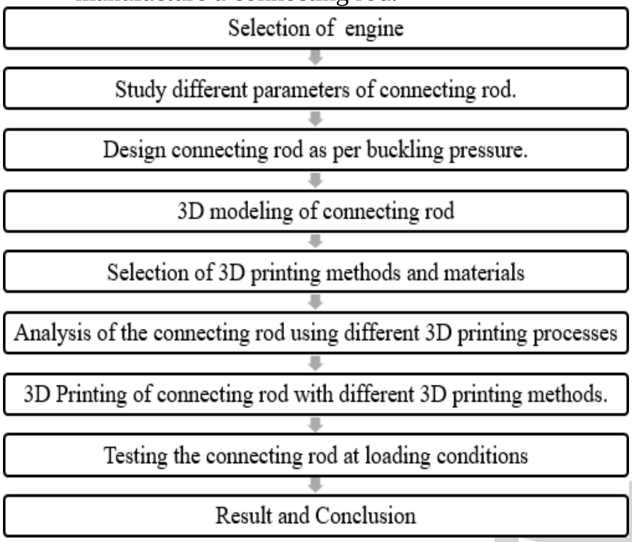


Chart -1: Methodology

II. DESIGN CALCULATION OF ONNECTING ROD SPECIFICATION OF ENGINE

Connecting rod can be used in large number of engine capacities. In this project work, it is restricted to design of two wheeler 180cc engine. Commonly used 180cc Apache RTR Engine is considered whose specifications are as follow

Consider an Apache RTR 180

Engine type =Single-cylinder, 4-stroke air cooled

Bore × Stroke (mm) = 63×56 Displacement = 177.4 cc

Maximum Power = 17.3ps @ 8500 rpm Maximum Torque = 15.5nm @ 6500 rpm Compression Ratio = 9.35/1

Design Parameter

Thickness of flange & web of the section= t Gas force = Fg

Thickness of the bush = tb = 2

Marginal thickness = tm = 5

Bearing Pressure = Pb = 15

Length of the piston pin = L1 = 1.5 x IDs

Length of the piston pin = L2 = 1 x IDs

Design Calculation

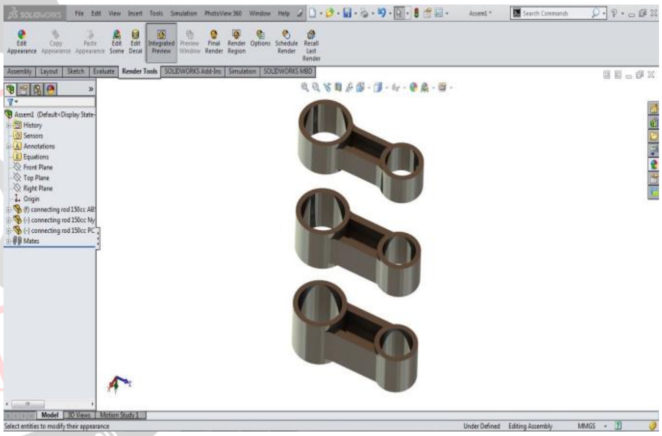
Table -1: Design Parameter & Calculation

Sr. No	Specifications of the Connecting Rod	Parameters	Measurements (mm)		
			ABS + 30% Glass Fiber	Nylon 66	Polycarbonate
1	Thickness of the connecting rod	t	8.86	10.6	11.73
2	Width of the section	B = 4t	35.44	42.4	46.92
3	Height of the section	H = 5t	44.3	53	58.65
4	Height at the big end	H2 = 1.1H	39.87	47.7	52.78
5	Height at the small end	H1 = 0.75H	48.73	58.3	64.51
6	Inner diameter of the small end	IDs = Fg/Pb*L2	50.68	50.68	50.68
7	Outer diameter of the small end	Ods = d2+2tb+2tm	64.68	64.68	64.68
8	Inner diameter of the big end	IDb = Fg/Pb*L1	66.78	66.78	66.78
9	Outer diameter of the big end	Odb = d2+2tb+2tm	80.78	80.78	80.78

CAD Model

Solid works currently markets several versions of the Solid works CAD software in addition to e-drawings, a collaboration tool and a draft sight a 2D CAD product. 3D Modelling of Connecting rods as per Design Calculations in Solidworks

Fig -2: CAD Model of Connecting Rod



3D Printing & Material Selection

Additive Manufacturing (AM) is a term to describe set of technologies that create 3D objects by adding layer-upon-layer of material. Materials can vary from technology to technology. But there are some common features for all Addictive Manufacturing, such as usage of computer together with special 3D modeling software.

Selection of 3D Printing Method

Table -2: Selection of 3D Printing Methods

3D Printing Methods	Strength	Cost	Materials form	Worker Required	Materials
SLA	Low	Low	Liquid	Beginner	Plastics
FDM	High	Low	Solid	Moderate	Thermoplastics, wood, Nylon, ceramics, Carbon fiber, etc
SLS	High	Very High	Powder	Expert	Metals
SLM	Very High	Very High	Powder	Expert	Metals
LOM	Low	High	Sheet	Moderate	Papers, metal sheets etc.

Fused deposition modeling (FDM) 3D printing method is selected because its products have high strength and it is most widely used method for 3D printing. It is compatible with huge variety of filaments such as nylon, wood, carbon fiber etc. FDM method is simple doesn't require an expert

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worker. This Method is used for manufacturing of Connecting Rod.

Table -3: 3D Printing Materials

Materials	Density (g/cc)	Compressive strength (MPa) Yield	Young's modulus (GPa)	Cost of material filament / Kg	3D Printing methods
ABS	1.28	120	8	1625	FDM
NYL 66	1.15	86.18	2.89	7150	FDM
PC	1.20	63.3	2.36	6175	FDM
Stainless steel	7.80	592	198	7280	SLS
Gold & silver	Requirement of high end Printing Machines and Costly				SLS/FDM
Titanium	Requirement of high end Printing Machines and Costly				SLM
Ceramic	3.65	275	Customized FDM machine is required.		

The following 3D printing materials have been shortlisted because of their high tensile strength, durability, availability and low cost which is required for the proper functioning of connecting rod.

Table -4: Mechanical Properties of Material

Materials	Density (g/cc)	Compressive yield strength (MPa)	Young's modulus (GPa)
ABS + 30% glass fiber	1.28	120	8
NYL 66	1.15	86.18	2.89
PC	1.2	7	2

Material Selection is done on the basis of Availability of Printing Machine to print the Component, Cost, and Weight Carrying Capacity and commonly preferred by the industry.

Table -5: 3D Printing Product Cost Estimation

Materials	Density (g/cc)	Cost of Filament per kg	Mass of product (Grams)	Cost of 3d printing per Gram (Rs.)	Total Cost of 3d printed Product (Rs.)
ABS	1.28	1625	219	25	5475
NYL 66	1.15	7150	251	25	6275
PC	1.2	6175	303	25	7575

Printing cost for 3D printed parts in the market varies from Rs. 15/gram to Rs. 35/gram depending upon the machine used for printing and type of filament used. The above said cost is for ABS, it may vary slightly for other materials also. This cost is inclusive of filament and machining cost.

III. FEA SIMULATION

ANSYS Workbench 15.0 is used for FEA. Connecting rod is assumed to be fixed at small end and subjected to compressive bearing load at the Big end. Mesh size is 2 mm.[2] Patch confirming method with tetrahedron mesh is done. ANSYS simulation is done for four materials.

Appling boundary conditions cylindrical support 0 and bearing load 47000N.

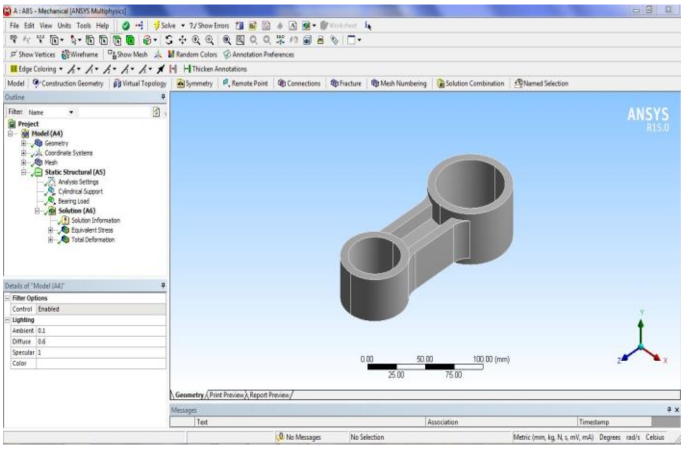

Fig 3: Geometry of connecting rod in ANSYS.

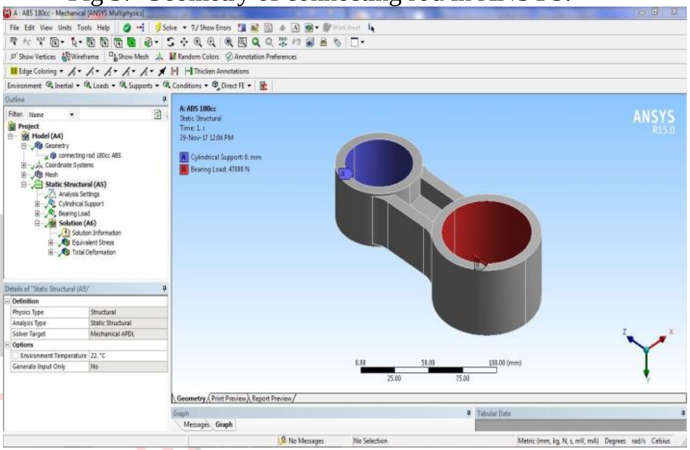

Fig -4: Boundary Condition

Analyze connecting rod for ABS, NYL 66 & PC Material for Stress and Deformation

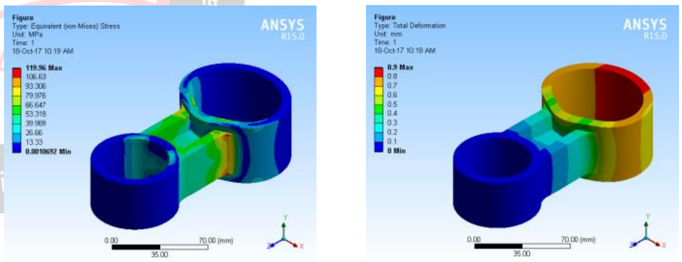

Fig -4: Equivalent Stress & Deformation

IV. RESULTS

Table -6: FEA Results

Sr. no.	Materials	Weight (Kg)	Stress (MPa)	Deformation (mm)	Compressive Load (KN)
1	ABS + 30% Glass Fiber	0.219	119.96	0.9	47
2	NYL 66	0.251	84.87	1.76	40
3	PC	0.303	6.94	0.20	3

A. FEA results shows that Acrylonitrile Butadiene Styrene is strong when subjected to tensile or

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compressive loading. These types of 3D printed components can be used when there is customized requirement.

B. This will results into reducing the time of Production, complex designs can be manufactured and avoids the cost of molding.

C. This concept of Advance manufacturing can be used for different mechanical parts manufacturing like gears and Mold manufacturing for composite materials.

D. These types of manufacturing can be used in Biology where 3D printed body parts can significantly enhance learning. Feeling the texture of a brain is different from seeing it in a book or on screen. Complex structures of protein molecules in DNA can be very easily appreciated with 3d prints.

V. CONCLUSIONS

It was concluded that Acrylonitrile Butadiene Styrene is the strongest 3D printing material which can carry a load of 47 KN up to Yield stress.FEA results shows that Acrylonitrile Butadiene Styrene is strong when subjected to tensile or compressive loading. These types of 3D printed components can be used when there is customized requirement. This will results into reducing the time of Production, complex designs can be manufactured and avoids the cost of molding. This concept of Advance manufacturing can be used for different mechanical parts manufacturing like gears and Mold manufacturing for composite materials. These types of manufacturing can be used in Biology where 3D printed body parts can significantly enhance learning. Feeling the texture of a brain is different from seeing it in a book or on screen. Complex structures of protein molecules in DNA can be very easily appreciated with 3d prints.

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