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DESIGN AND DEVELOPMENT OF SWIRL CHAMBER TYPE INDUCTION SYSTEM FOR A FOUR STROKE PETROL ENGINE

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ABSTRACT

Conventional spark ignition engine have defects such as high exhaust emission, low power and efficiency due to incomplete combustion which occur during idling & at part load operations conditions. The introduction swirl chamber to the engine allows proper mixing of fuel & air giving complete control on combustion and emissions and thereby increasing power and efficiency. Another significant advantage of using swirl chamber is that it is economical too as it provides a correct estimation of the quality of fuel required at proper time & provides control over combustion. Swirl chamber is becoming an important option to further optimize internal combustion engine. Accordingly a system having swirl chamber type induction system has designed and developed.

KEYWORDS: Induction System, Manifold, Swirl Chamber

INTRODUCTION

It is observed that the quality of air fuel mixture that governs the proper consumption depends upon proper mixing of air and fuel from the transfer port in case of SI. The air intake chamber geometry plays a key role in governing the quality of A/F mixture. The concept is to improve the quality of A/F mixture by introducing swirl chamber design of air intake manifold for the engine.

Most single cylinder engines do not return good fuel efficiency in traffic conditions due to start stop nature of the conditions. It is observed that the increase in compression ratio improves fuel efficiency and power output. The main problem related with the combustion in S.I. engine is to get the homogeneous mixture of fuel and air.

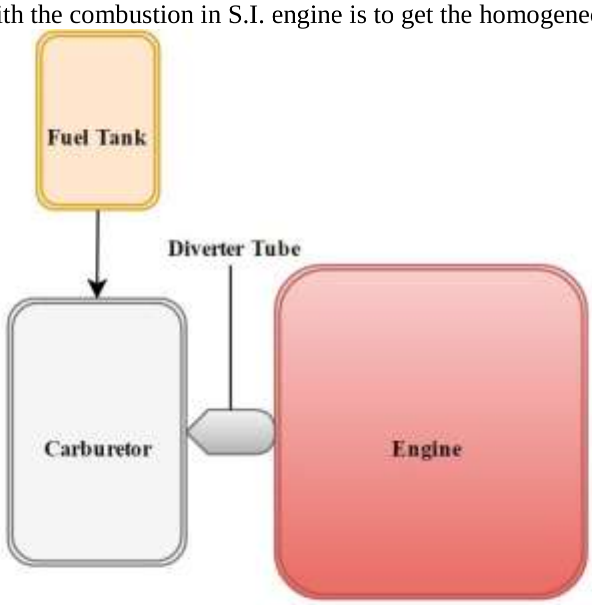

Figure 1: Schematic of layout of modification in intake system

The intake chamber of the engine is modified to achieve better air fuel mixtures the result will be improve fuel economy and less noise and cleaner exhaust. The key to maximum power attained and least pollution is to attain a better air fuel mixture. Air fuel mixture quality is a function of the proper mixing of air with fuel. The motion of air particles in the chamber before the carburettor will be detrimental in achieving a better air fuel mixture. Thus with reference to the schematic, it is proposed to change the intake system of the engine such that it creates an ideal mixing method and helps the carburettor function better.

EXPERIMENTAL SETUP

Test rig set up or testing of four-stroke single cylinder engine:

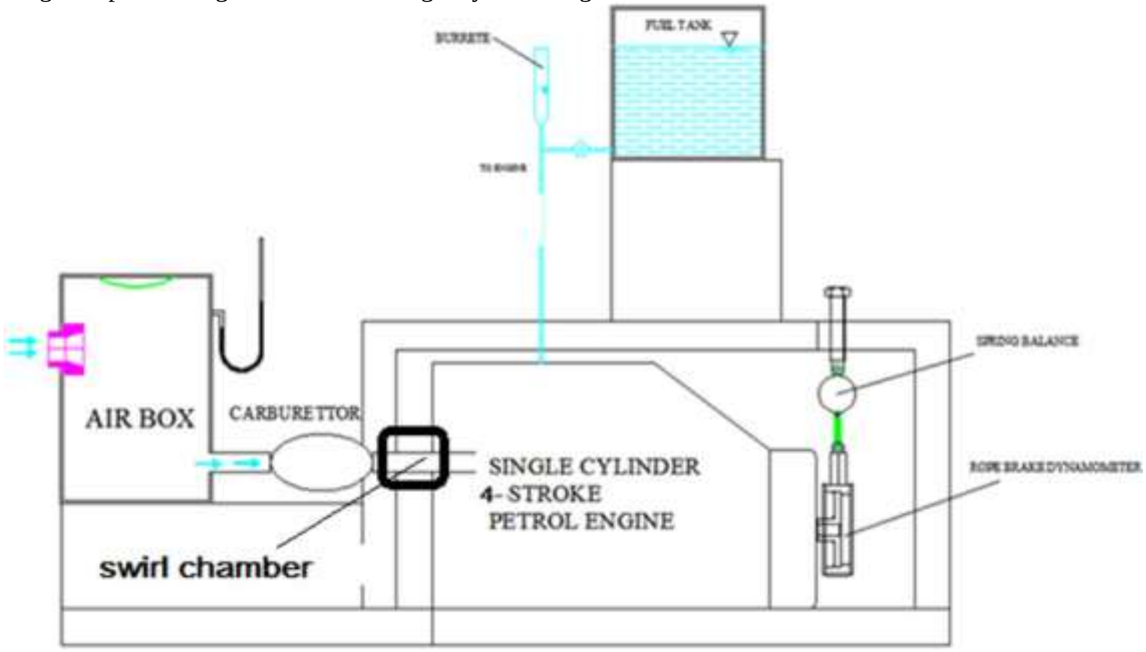

Figure 2: Test Rig Set Up or Testing Of Four-Stroke Single Cylinder Petrol Engine

Engine

We have used four stroke single cylinder petrol engine for experimental setup. Specifications of test engine are given in table 1.

Figure 3: Four Stroke Single Cylinder Petrol Engine

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A four-stroke engine (also known as four cycle) is an internal combustion (IC) engine in which the piston completes four separate strokes while turning a crankshaft. A stroke refers to the full travel of the piston along the cylinder, in either direction. The four separate strokes are termed:

1. Intake: also known as induction or suction. This stroke of the piston begins at top dead center (T.D.C.) and ends at bottom dead center (B.D.C.). In this stroke the intake valve must be in the open position while the piston pulls an air-fuel mixture into the cylinder by producing vacuum pressure into the cylinder through its downward motion.
2. Compression: This stroke begins at B.D.C, or just at the end of the suction stroke, and ends at T.D.C. In this stroke the piston compresses the air-fuel mixture in preparation for ignition during the power stroke (below). Both the intake and exhaust valves are closed during this stage.
3. Combustion: also known as power or ignition. This is the start of the second revolution of the four stroke cycle. At this point the crankshaft has completed a full 360 degree revolution. While the piston is at T.D.C. (the end of the compression stroke) the compressed air-fuel mixture is ignited by a spark plug (in a gasoline engine) or by heat generated by high compression (diesel engines), forcefully returning the piston to B.D.C. This stroke produces mechanical work from the engine to turn the crankshaft.
4. Exhaust: also known as outlet. During the *exhaust* stroke, the piston once again returns from B.D.C. to T.D.C. while the exhaust valve is open. This action expels the spent air-fuel mixture through the exhaust valve.[5]

Table 1. Test Engine Specifications

Engine	
Type	Air Cooled, 4 Stroke Single Cylinder
Bore	50.0 mm
Stroke	49.5 mm
Piston Displacement	97.2
Carburetor	Side Draft , Variable Venturi Type with TCIS
Compression ratio	9.9:1
Transmission	
Clutch	Multiplate wet
Transmission	4 Speed Constant Mesh
Gear shift pattern	All Down, heel-toe shift
Performance	
Max. horsepower	6.15kW (8.36 Ps) @8000 rpm
Max. torque gear	0.82kg - m (8.05 N-m) @5000 rpm

Air Box

The method commonly used in the laboratory for measuring the consumption of air is known as 'Orifice Chamber Method'. The arrangement of the system is shown in figure. It consists of an air-tight chamber fitted with a sharp-edged orifice of known coefficient of discharge. The orifice is located away from the suction connection to the engine.

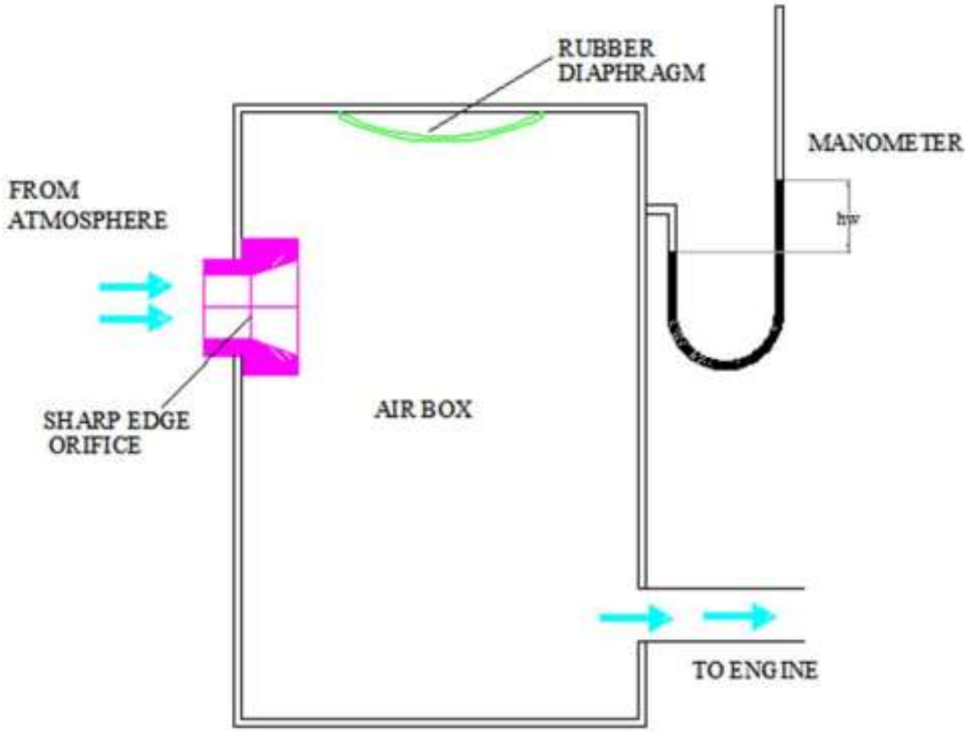

Figure 4: Air Box Method for Measuring Air

The orifice method can be used if pressure pulsation could be damped out by some means. The usual method of damping out pulsation is to fit an air box of suitable volume (500 to 600 times the swept volume in single cylinder engines and less in the case of multi-cylinder engines) to the engine with an orifice placed in the side of the box remote from the engine.[4]

Figure 5: Air Box

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Diverter Tube

The diverter tube is encapsulated in the connector from the carburettor to the engine, with the provision of baffles and passage window cu we ensure that the air is thoroughly mixed with fuel without creating a prominent pressure drop inside the intake chamber. The diverter tube is made of carbon fibre and the baffles are curved inside thereby allowing a streamline air flow inside the tube as well as the passage through the window cuts.

The intermixing of these streams of air fuel mixture will create turbulence in intake chamber and effective best mixing possible of the air and fuel.

The details of dimensions of the diverter tube to be used in the air intake chamber is as follows:

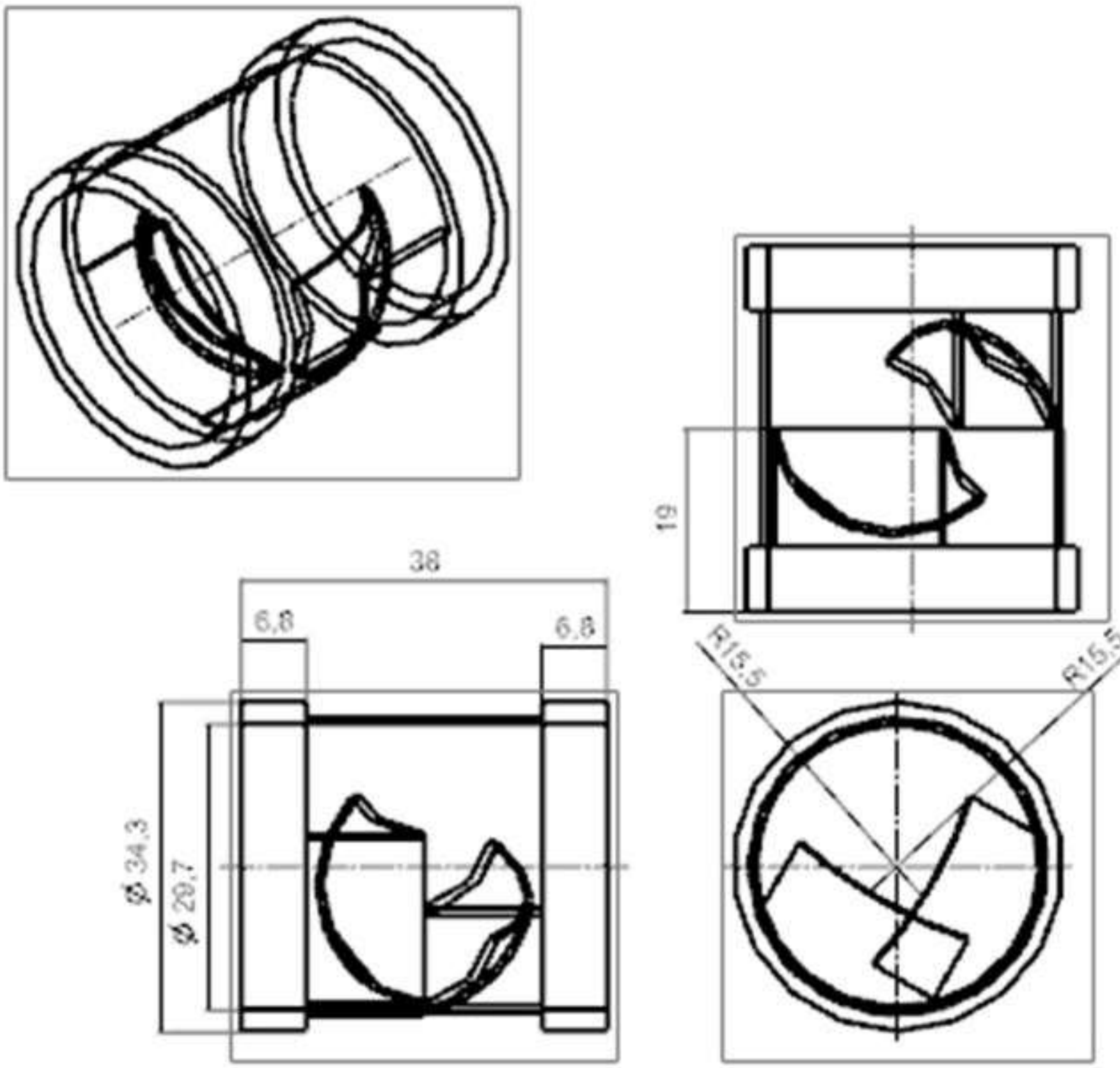

Figure 6: Dimensions of the Diverter Tube

Considering that the maximum pressure encountered inside the air intake chamber is 2.5 bar the design of the diverter tube will be done accordingly for Hoops stress and longitudinal stress.

MATERIALS AND METHODS

Selection of Material

To prepare any machine part, the type of raw material and finished material should be properly selected, considering design, safety and following points:

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- Availability of materials
- Suitability of the material for the required components
- Suitability of the material for the desired working conditions
- Cost of the materials
- In addition to the above factors the other properties to be considered

We have selected the material ABS Polymer FDM Nylon 12 considering the above factors and also as per the availability of the material.
FDM Nylon 12 is the first material in family of nylon offerings, complementing the current portfolio of FDM materials and enabling new applications requiring: repetitive snap fits, high fatigue resistance, strong chemical resistance and press (friction) fit inserts. Nylon 12 is primarily used in aerospace, automotive and consumer goods industries to take on everything from tooling, jigs and fixtures to covers, panels and vibration resistant components. FDM Nylon 12 offers unparalleled toughness and a simple, clean process – free of powders.[6]

Characteristics / Properties of ABS Polymer FDM Nylon 12
- Snap fit and press fit inserts: tough small clips, bosses, posts and holes
- High fatigue resistance: parts exposed to repeat loading cycles, stress and vibration
- Good impact strength: parts resistant to shock from being dropped or abrupt forces
- Moderate temperate resistance: HDT of up to 82° C (after annealing)
- Good chemical resistance: resistant to moderate solvents, alcohols and chemicals
- Strong resistance to cracking under stress, including instances when it encapsulates metal components.
- It provides excellent resistance to abrasion.
- It dampens noise and vibration.
- It is highly processable.[7]

Theoretical Design of the Diverter Tube
Material of diverter tube = ABS Polymer FDM Nylon 12
Hoope's stress due to pressure:
Maximum pressure induced in(P) = 2.5 bar = 0.25 Mpa
$fc_{act} = P \times d / 2t$
$fc_{act} = 0.25 \times 29.7 / 2 \times 0.5$
$fc_{act} = 7.425\ N / mm^2$
As, $fc_{act} < fc_{all}$; Diverter pipe is safe.
Where, fc_{act} = hoop's stress induced actually in material
d = inner diameter of diverter tube
t = thickness of diverter tube
fc_{all} = Allowable stress = Ultimate tensile stress / FOS = 48 /2 = 24Mpa

Longitudinal stress due to pressure:
Maximum pressure induced in system due to exhaust gases = 2.5 bar = 0.25 Mpa
$fc_{l} = P \times d / 4t$
$fcl_{act} = 0.25 \times 29.7 / 4 \times 0.5$
$fcl_{act} = 3.7125\ N / mm$
As, $fcl_{act} < fc_{all}$; Diverter pipe is safe.
Where, fcl_{act} = Actual longitudinal stress
fc_{all} = Allowable longitudinal stress = UTS / FOS = 48 /2 = 24Mpa

Design of the Diverter Tube
NX is used for design of diverter tube. NX, formerly known as NX Unigraphics or usually just UG, is an advanced high-end CAD/CAM/CAE software package. Convergent Modeling in NX and 3D printing enables complex shapes to be designed and manufactured. NX is the only software to offer this ability to work with Facet, Surface and Solid geometry in one environment. Many modern designs that are developed with newer design concepts such as lattice features or via topology optimized facet geometry would be impossible to manufacture with traditional manufacturing techniques. The ability of NX to connect directly to a 3D printer lets the designer print parts directly from NX.

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The details of the diverter tube are as below:

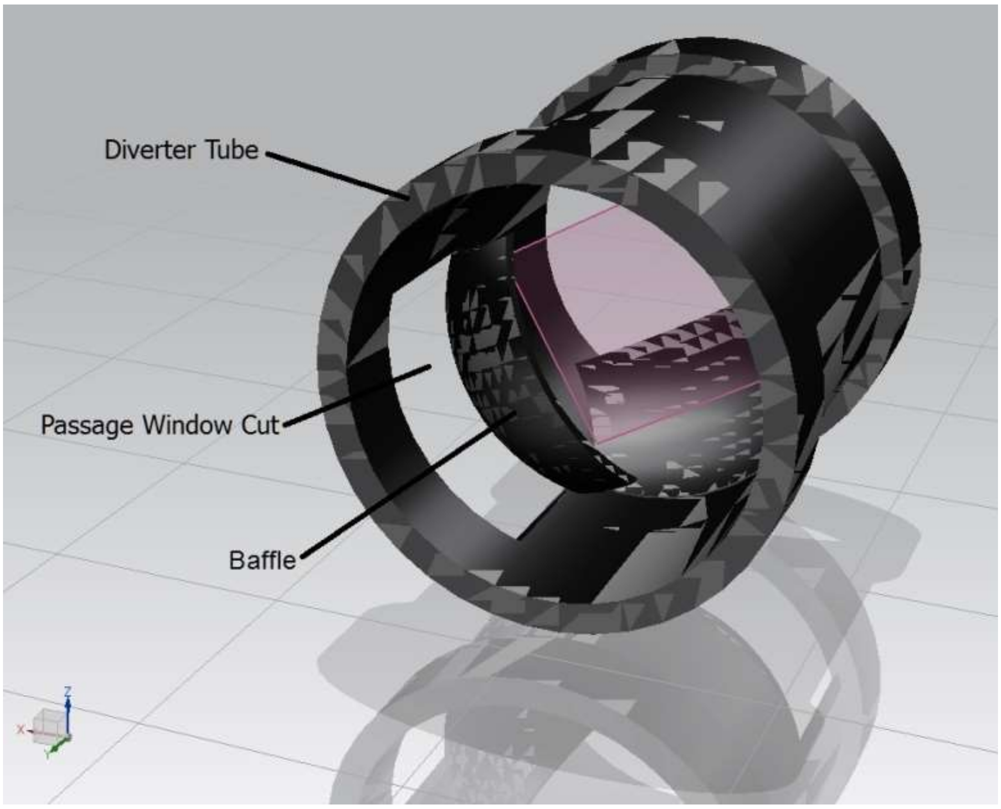

Figure 7: Details of Diverter Tube

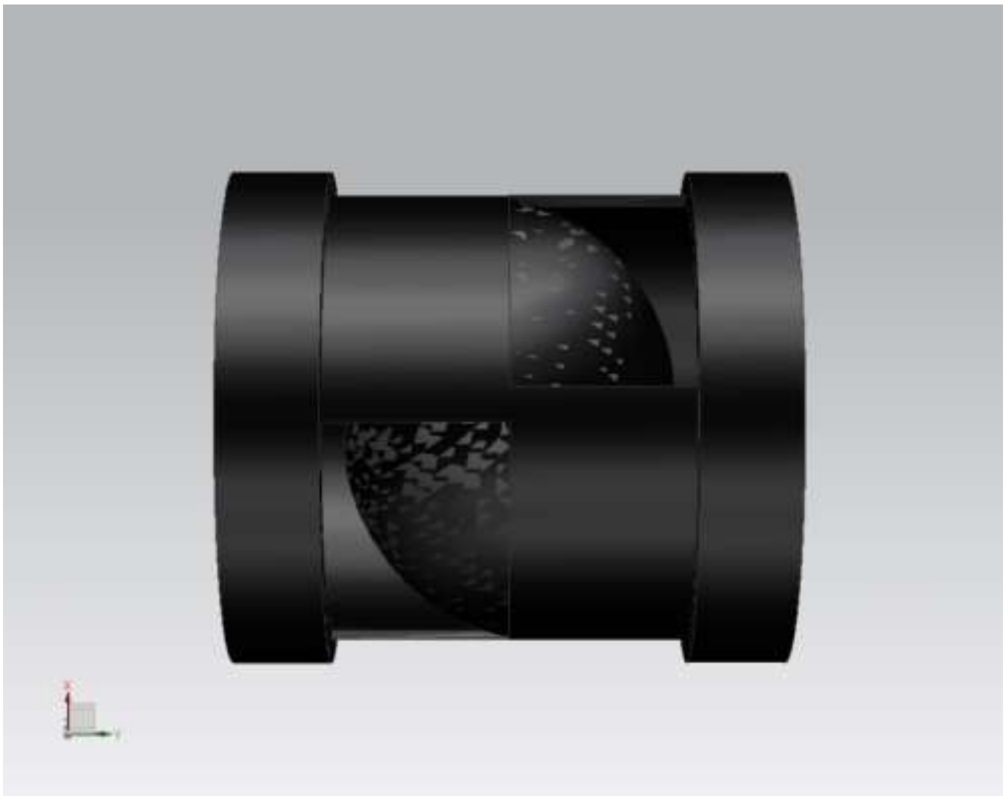

Figure 8: 3D Model of Diverter Tube using NX

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Specification Details of Diverter Pipe

Measurement Mass Properties

Material:	ABS polymer
Volume:	4766.924215081 mm^3
Area:	8567.797401862 mm^2
Mass:	0.005005270 kg
Weight :	0.049084980 N
Radius of Gyration:	20.450860460 mm
Centroid:	-0.084344229, -18.999979010, -0.084299351 mm

Detailed Mass Properties

Analysis calculated using accuracy of 0.990000000

Information Units kg - mm

Density:	0.000001050
Volume:	4766.924215081
Area:	8567.797401862
Mass:	0.005005270

Experiment Methodology

Model of diverter tube is developed using 3D printing. 3D printing, also known as additive manufacturing (AM), refers to processes used to create a three-dimensional object in which layers of material are formed under computer control to create an object. Object can be of almost any shape or geometry and are produced using digital model data from a 3D model or another electronic data source.

3D printers work like inkjet printers. Instead of ink, 3D printers deposit the desired material in successive layers to create a physical object from a digital file.

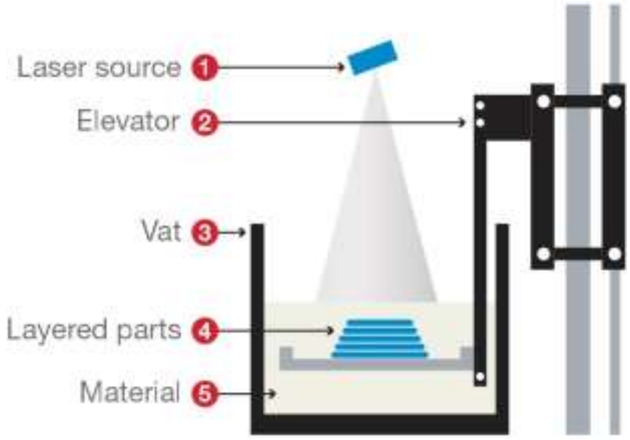

Figure 9: 3D Printing

1. A laser source sends a laser beam to solidify the material.
2. The elevator raises and lowers the platform to help lay the layers.
3. The vat contains the material used to create the 3D object.
4. The 3D object is created as parts are layered on top of each other.
5. Advanced 3D printers use one or more materials including plastic, resin, titanium, polymers and even gold and silver.[8]

Unique Advantages of 3d Printing

• Affordable customization
• Allows manufacture of more efficient designs — lighter, stronger, less assembly required
• One machine, unlimited product lines
• Very small objects(nano)
• Efficient use of raw materials (less waste)
• Pay by weight — complexity is free
• Batches of one, created on demand

• Print at point of assembly/consumption
• Manufacturing accessible to all — lower entry [9]

Figure 10: Diverter Tube

CONCLUSION

This work has presented a powerful method of enhancement of four stroke petrol engine by designing the swirl chamber. Due to the swirl chamber the mixture of air fuel from the carburetor to engine is properly mix and due to this the proper combustion of fuel take place and exhaust of engine is reduces. Performance of engine is increases as well as the power and efficiency is also increases. The main problem of SI engine is improper supply of air and fuel mixture to the engine is reduces due to the swirl chamber. The results will improve fuel economy and less noise and cleaner exhaust.

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