Indian Journal of Innovation and Development, Vol 8 (6), June 2019 ISSN (online): 2277 - 5390
ISSN (Print): 2277 - 5382

Design analysis of 4-strokepetrol engine composite cylinder

ART Babu*[1], A Vinutha[2], C H Venkata Anvesh[3]

[1]*Assistant Professor, Mechanical Dept, Welfare College, 530049, India*
[2-3]*Assistant Professor, Mechanical Dept., Sanketika Institute of Technology and Management, PM Palem, 530041, India*
artbabu007@gmail.com[1], ashokanvinutha@gmail.com[2], Chelluri.anvesh@gmail.com[3]

Abstract

Background/Objectives: The work is to optimize the weight to power ratio of an internal combustion engine. So as to achieve the desired result we have considered a composite cylinder.
Methods/Statistical analysis: A cylinder with composite material is assigned as Aluminum alloy LM13 & Magnesium alloy AZ91D by varying thickness of internal cylinder-115x12ox2oomm dimensions. Outer core material is assigned as cast iron with dimensions12ox2oomm with 5mm thickness. Considering HERO SPLENDER PLUS specifications i.e., single cylinder 4 stroke SI engine is considered as standard model for design calculations and dimensional aspects in this project the 3D model of cylinder with varying cross sections is done in CATIA. The 3D model is saved as .igs file and imported to Ansys, thermal analysis module.
Findings: The analysis is carried out. Assuming boundary conditions as 6ooo C at inner surface of internal cylinder, ambient conditions are considered at outer surface and convection coefficient h is 5 watt /mm2 Optimization is done by varying the thickness and material properties of internal cylinder material. Due to which reduce weight to power ratio resulting in producing high specific power and good mileage Aluminum alloy LM13 is best suitable.
Improvements/Applications: The best suitable application is in automotive industry, pressure vessels and hydraulic mechanisms.
***Keywords*:** Composite cylinder, Aluminum alloy LM13, Magnesium alloy AZ91D.

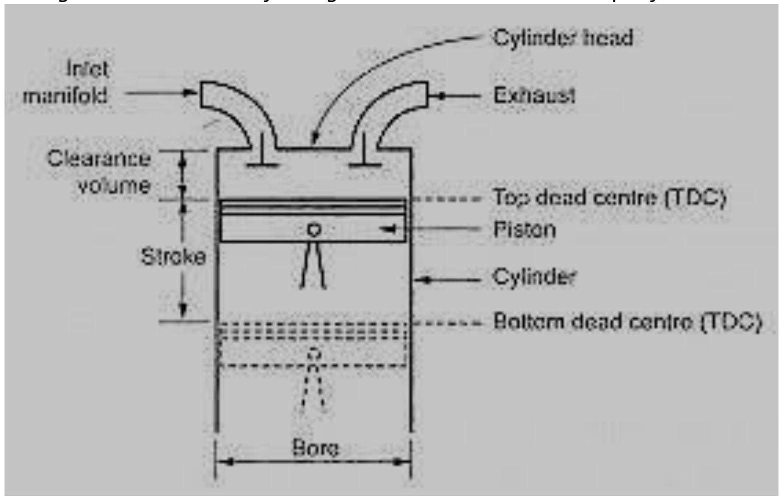
1. Introduction

The following are Nomenclature associated with IC Engines shown in Figure 1.

1. Bore: The ostensible inside width of motor chamber is called bore.
2. Top Dead Centre (TDC): In the event that the cylinder situated next to cylinder clearance volume called top right on target (TDC).
3. Bottom Dead Centre (BDC): In the event that the cylinder situated at the bottom of cylinder is called bottom dead center.
4. Clearance Volume (Vc): The volume contained in cylinder above the top of the piston, when the piston is at top dead Centre is called the clearance volume.
5. Swept Volume (V_s.):The volume contained in barrel over the highest point of the cylinder, when the cylinder is at top right on target is known as the freedom volume. = A x L = DL 2 4 Π
6. A = C/S of the piston in Sq.,
7. L = Stroke length in meters, and Mechanical properties of CI have higher strength, ductility, low melting point and greater fluidity. The strength of CI is what makes it a workable material for various industries.
8. Mach inability CI is easy for machining process. Low cost and durability. TheYieldStress (YS) is about 2%; good creep and fatigue life are also properties of CI.

HIP- Hot Isostatic Processing
CGI- Graphite cast iron
AMC-SC1- Magnesium alloy
YS-Yielding stress
UTS- Ultimate tensile stress

Figure 1. The detailes of IC Engine and there uses are also specified



Cooling System: A cooling system in an internal combustion engine that is used to maintain the various engine components at temperatures conductive to long life and proper functioning [1-2].

Air Cooling System: In this system, heat is carried away by the air flowing over and around the cylinder.

Water Cooling System: In this system, the cylinder walls and heads are provided with jacket through which the cooling liquid can circulate.

A few definitions:

TDC: Top Dead Centre. This is the top most part the piston can reach in a vertical engine.

BDC: Bottom Dead Centre. This is the bottom most part the piston can reach in a vertical engine.

Compression Ratio An engine is basically a pump which squeezes in air/fuel mixture and then ignites it so that it expands back and produces the mechanical energy. The compression ratio is basically tells how much the engine squeezes a certain volume of air that it intakes [3]. So a vehicle with a compression ratio of 12:1 means that for every 12 unit volume of air that is sucked in, the piston squeezes that air to 1 unit volume. The more air that is squeezed into the piston the more energy is produced per engine capacity on the expansion stroke.

One of the limiting factors in increasing the compression ratio is called detonation (known as engine knocking or pinging) where instead of burning in a controlled fashion, the air/fuel mixture explodes, potentially damaging the engine. Also, a higher compression engine tends to have less clearance between the piston at top dead center and the valves fully opened, running at a high rpm can lead to valve float which can leads to contact between the valves and piston [4].

Compression Ratio= (Swept volume + Clearance volume)/Clearance volume

Swept volume= Volume of piston traversed as it completes one full stroke from the TDC to BDC

2. Materials and Methods

1. Material specification

Material properties of three different materials i.e. CI, AL Alloy, Magnesium Alloy are specified in the Table 1 which are used in the construction of composite materials.

Table 1. Material properties

MATERIALS	CI	AL ALLOY	MAGNESIUM ALLOY
DENSITY (kg/m^3)	734o	27oo	181o
YOUNG'SMODULUS (GPa)	124	69	4.5
THERMALCONDUCTIVITY(W/m◦c)	53.3	2o5	72
POSSIONS RATIO	o.26	o.33	o.35

Percentage content of carbon, silicon, magnesium, sulfur and phosphorus are mentioned in the Table 2of the material Grey cast iron used in analysis of composite cylinder.

 ISSN (online): 2277 - 5390
ISSN (Print): 2277 - 5382

Table 2. Material composition of grey CI

S. no	Element	CONTENT %
1.	Carbon	2.5-4.o
2.	Silicon	1.o-3.o
3.	Manganese	o.25-1.o
4.	Sulfur	o.o2-o.25
5.	Phosphorus	o.o5-1.o

Material composition of aluminum is described in detailed as contents in Table 3 and magnesium composites in Table 4.

Table 3. Material composition of AL

S.no	Element	Content %
1.	AL	85.8-91.5
2.	Silicon	5.5-6.5
3.	Copper	3-4
4.	Nickel	o.35
5.	Titanium	o.25
6.	Manganese	o.5
7.	Iron	1
8.	Zinc	1
9.	Magnesium	o.1

Table 4. Material composition of MG

S. no	Element	Content %
1.	Nickel-Cobalt	7o
2.	Chromium	14-17
3.	Iron	5-9
4.	Titanium	2.5-2.75
5.	AL	o.4-1.o
6.	Manganese	o.7-1.2
7.	Silicon	o.5
8.	Sulphur	o.o1
9.	Carbon	o.o8

2. Standard method

Bore and Length of the Cylinder [1]

The bore and length of the cylinder determined as discussed below:

Let pm = indicated mean effective pressure in N/mm2

D Cylinder bore in mm   l = length of stroke in m = 1.5 D

A = Cross-sectional area of the cylinder in mm2

N = Speed of the engine in r.p.m.

n = Number of working strokes per min

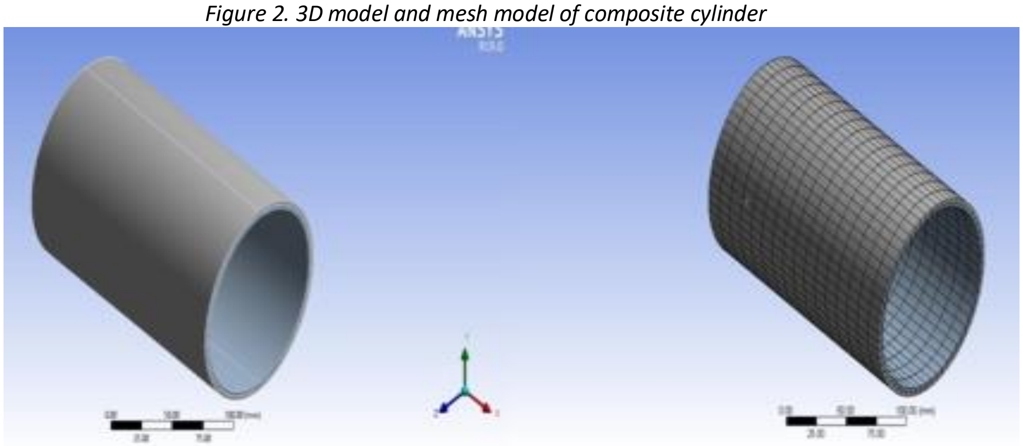
ISSN (online): 2277 - 5390
ISSN (Print): 2277 - 5382

N for two stroke engine = N/2, for four stroke engine).
Indicated power, I.P watts = B.P / mechanical efficiency = 5ooo/o.8 = 625o watts.
I.P = (pm*|*A*N)/6o
625o = (o.35*1.5D*3.14D2*6oo)/ (6o*1ooo*4)
D = 115mm l = 1.5D = 1.5*115 = 172.5mm
Length of the cylinder, L = 1.15 x Length of stroke = 1.151 = 1.15*172.5 = 2oomm.
Cylinder Wall Thickness:cylinder wall subjected to gas pressure and piston side thrust. The gas pressure produces following two types of stresses:
Longitudinal stress
Circumferential stress
Since these two stresses act at right angles to each other, therefore, the net stress in each direction is reduced. The piston side thrust tends to bend the cylinder wall, but the stress in the wall due to side thrust is very small and hence it may be neglected.
Let Do= outer diameter of the cylinder in mm
Di = Inner diameter of the cylinder in mm, =115mm
p = Maximum pressure inside the engine cylinder i.e.(3.15 N/mm^2)
t = Thickness of the cylinder wall in mm,
C = Allowance for reboring (o.1), and
σc = Permissible circumferential or hoop stress for the cylinder material in Mpaor N/mm^2.
Its value may be taken from 35 Mpato 1ooMPa depending upon the size and material of the cylinder.
Hence thickness of cylinder is calculated as
T = D ((C*p)/ σc)1/2
= 115((o.1*3.15)/42)1/2 = 1omm.

3. Analysis procedure

Composite cylinder of material CI and Al of thickness 120-125mm is shown if the Figure 2. Keeping the thickness 5mm as constant and varying dimensions of cylinder analysis is carried out.In the above Figure 3 the 3D mesh of the composite cylinder is shown. The no of elements and nodes obtained after meshing are 1952, 13974.Temperature inside the cylinder is considered to be 333K, all the three phase are applied with convection conditions. Convection coefficient for air is assigned to the composite cylinder.

Figure 2. 3D model and mesh model of composite cylinder



3. Results and Discussion

Solution of composite cylinder with various materials is shown in the Figures 3-4 obtained from the analysis. In temperature distribution magnesium is good for composite cylinder. In the heat transfer analysis it can be said that magnesium transfers more heat to the adjacent layer. The analysis carried out for varying cross sections and materials.

Figure 3.Temperature distribution of 3D model with different materials composite cylinder

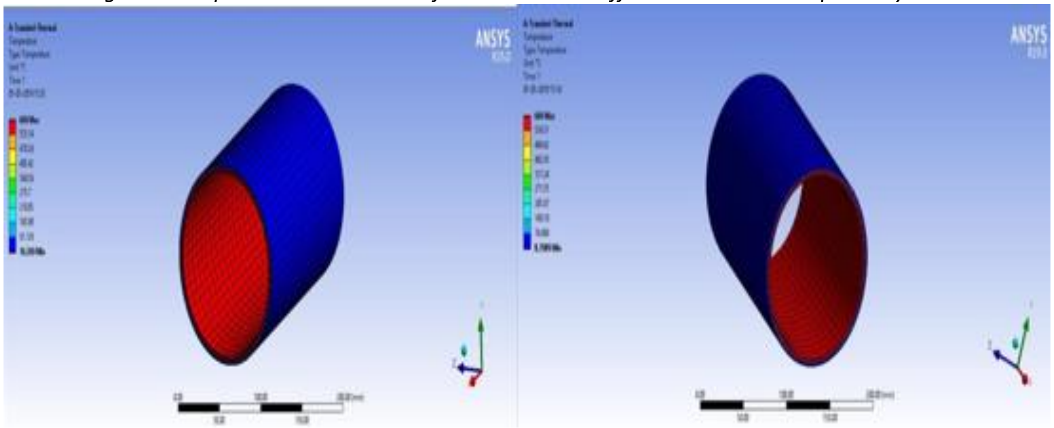
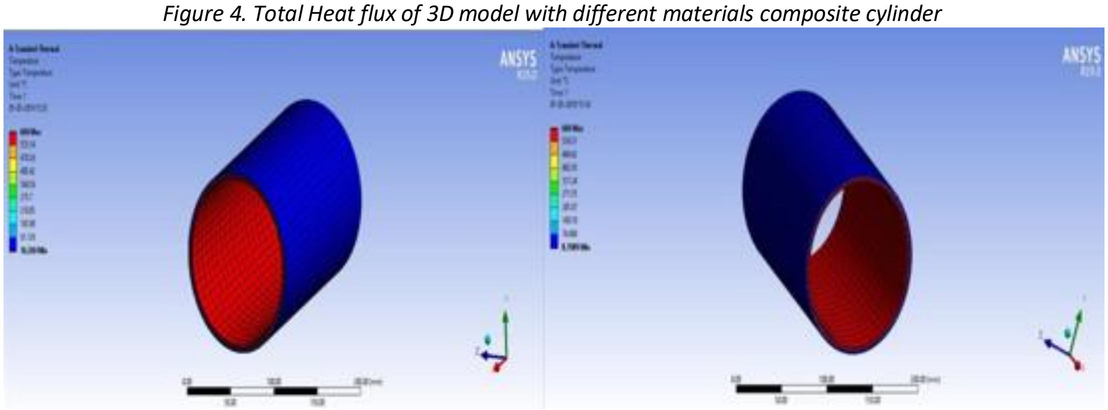
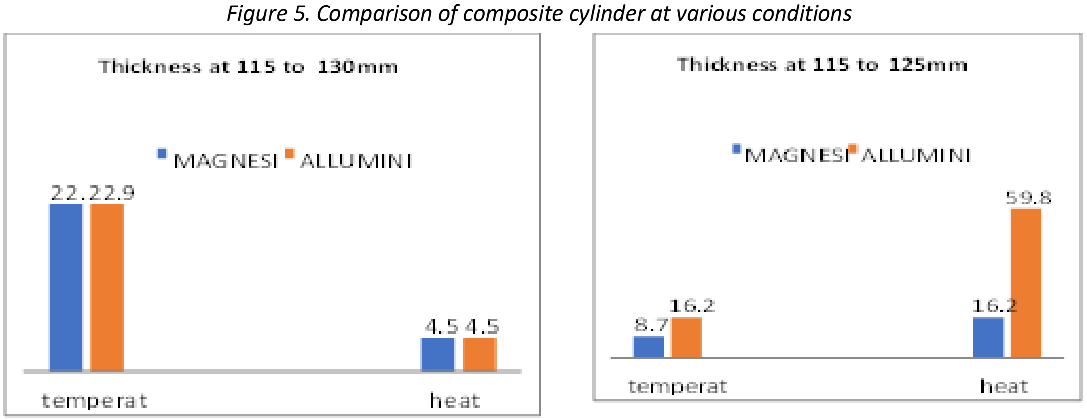


Figure 4. Total Heat flux of 3D model with different materials composite cylinder



Graphical representation of asys result at thickness 15-125mm is described in the Figure 5. Al is the suitable

Figure 5. Comparison of composite cylinder at various conditions



4. Conclusion

Al Alloy is suitable material for Cylinder design than compared to Magnesium. Al alloy is having less density which is about 2700(kg/m3) used for corrosion resistance and prevent oxidation and high strength in order to optimize weight. Al offers excellent resistance to corrosion and has low density and can be mostly used for manufacturing of engine parts which result in wide use and optimization of weight is done which increases the mileage of the vehicle.

ISSN (online): 2277 - 5390
ISSN (Print): 2277 - 5382

5. References

1. N. Lavanya, P. Sampath Rao, M. Pramod Reddy. Design and analysis of suspension coil spring for automotive vehicle. *International Journal of Engineering Research and Applications*. 2014; 4(9), 1-7.
2. R. Takade, C. Patil. Structural and model analysis of shock absorber of vehicle. *International Journal of Engineering Trends and Technology*. 2015; 21(4), 1-14.
3. P.R. Jadhav, N.P. Doshi, U.D. Gulhane. Analysis of helical spring in dual suspension system used in motorcycle. *International Journal on Research in Advent Technology*. 2014; 2(10).
4. M. Bakhshesh, M. Bakhshesh. Optimization of steel helical spring by composite spring. *International Journal of Multidisciplinary Science and Engineering*. 2012; 3(6), 1-5.

The Publication fee is defrayed by Indian Society for Education and Environment (www.iseeadyar.org)
Cite this article as:
ART Babu, A Vinutha, C H Venkata Anvesh. Design analysis of 4-strokepetrol engine composite cylinder. Indian Journal of Innovation and Development. Vol 8 (6), June 2019.