DESIGN AND OPTIMIZATION OF TWO WHEELER PISTON MATERIAL USING ALUMINUM ALLOY 6061 AND ALUMINUM ALLOY 7475-T761

Nampally Saikiran[1], Dr P. SampathRao[2]
[1]*PG Student Department of Mechanical Engineering, Vijay Rural Engineering College,*
[2]*Professor Department of Mechanical Engineering, Vijay Rural Engineering College, Nizamabad, Telangana, India-503003*

Abstract - **A piston is a disc which reciprocates within a cylinder. It is either moved by the fluid or it moves the fluid which enters the cylinder. The main function of the piston of an IC engine is to receive the impulse from the expanding gas and to transmit the energy to the crankshaft through the connecting rod. The piston must also disperse a large amount of heat from the combustion chamber to the cylinder walls. Piston is made of cast aluminum because of its high heat transfer rate. One important thing to take care while using it (cast aluminum) is, because it expands appreciably on heating so right amount of clearance needs to be provided or else it will lead the engine to seize. For avoiding above problem in this project I am going to replace cast aluminum LM25 with Aluminum Alloy 7475-T761 and Aluminum Alloy 6061. These two materials have high strength and Elongation. The aim of project is to design a piston for 150cc engine using Design calculations. 2D drawing is created by using parameters obtained and a 3D model of piston is designed using parametric software Pro/Engineer by using 2D drawings. Couple field Analysis is done on the piston by varying parameters like thickness etc and also by considering materials Aluminum Alloy 7475-761 and Aluminum Alloy 6061. Analysis is done to verify the best combination of parameters and material for two wheeler piston, which is done in Ansys.**

I. INTRODUCTION

A piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that
is contained by a cylinder and is made gas-tight by piston rings. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder wall.

The piston of an internal combustion engine is acted upon by the pressure of the expanding combustion gases in the combustion chamber space at the top of the cylinder. This force then acts downwards through the connecting rod and onto the crankshaft. The connecting rod is attached to the piston by a swiveling gudgeon pin (US: wrist pin). This pin is mounted within the piston: unlike the steam engine, there is no piston rod or crosshead.

The pin itself is of hardened steel and is fixed in the piston, but free to move in the connecting rod. A few designs use a 'fully floating' design that is loose in both components. All pins must be prevented from moving sideways and the ends of the pin digging into the cylinder wall, usually by circlips.

Gas sealing is achieved by the use of piston rings. These are a number of narrow iron rings, fitted loosely into grooves in the piston, just below the crown. The rings are split at a point in the rim, allowing them to press against the cylinder with a light spring pressure. Two types of ring are used: the upper rings have solid faces and provide gas sealing; lower rings have narrow edges and a U-shaped profile, to act as oil scrapers. There are many proprietary and detail design features associated with piston ring

Pistons are cast from aluminium alloys. For better strength and fatigue life, some racing pistons may be forged instead. Early pistons were of cast iron, but there were obvious benefits for engine balancing if a lighter alloy could be used. To produce pistons that could survive engine combustion temperatures, it was necessary to develop new alloys such as Y alloy and Hiduminium, specifically for use as pistons.

A few early gas engines had double-acting cylinders, but otherwise effectively all internal combustion engine pistons are single-acting. During World War II, the US submarine Pompano was fitted with a prototype of the infamously unreliable H.O.R. double-acting two-stroke diesel engine. Although compact, for use in a cramped submarine, this design of engine was not repeated.

II. FINITE ELEMENT METHOD

Finite element analysis is a computer based numerical technique for calculating the strength and behavior of engineering structures. It can be used to calculate deflection, stress, vibration, buckling behavior and many other phenomena. It can analyze elastic deformation or “permanently bent out of shape” deformation. The computer is required because of the astronomical number of calculations needed to analyze a large structure. The power and low cost of modern computers has made finite element analysis available to many disciplines and companies.

With the rapid advancement of technology, the complexity of the problem to be dealt by a design engineer is also increasing. This scenario demand speedy, efficient and optimal design from an engineer. To keep pace with the development and ensure better output, the engineer today resorting to numerical methods. For problems involving complex shapes, material properties and complicated boundary conditions, it is difficult and in many cases interactive to obtain analytical solutions. Numerical methods provide approximate but acceptable solutions to such problems.

Finite element analysis is one of such numerical procedure for analyzing and solving wide range of complex engineering problems (may be structural, heat conduction, flow field...) which are complicated to be solved satisfactorily by any of the available classical analytical methods.

The computer intervention is the backbone of the procedure since it involves the solution of many simultaneous algebraic equations, which can be solved easily by the computer. Actually Finite Element Method was originated as a method of stress analysis. But today the applications are numerous. Now days, each and every design is developed through Finite Element Analysis. The numerous applications include the fields of Heat transfer, Fluid flow, Lubrication. Electric and Magnetic fields, Seepage and other flow problems. The various areas of applications include design of buildings and bridges, electric motors, heat engines, aircraft structures, spacecrafts etc. With the advances in Interactive CAD systems complex problems can be modeled with relative ease. Several alternative configurations can be tried out on a computer before the prototype is built.

III. DESIGN CALCULATIONS OF PISTON

Suzuki GS 150 R specifications

Engine type : air cooled 4-stroke SOHC

Bore

Displacement =149.5CC

×( ) = 57 × 58.6

Maximum power = 13.8bhp @8500rpm

Maximum torque = 13.4Nm @ 6000 rpm

Compression ratio =9.35/1

Density of petrol = 0.00073722 kg/cm^3

= 737.22 60

= 0.00000073722 kg/mm^3

T = 60F =288.855K =15.55^{0}C Mass = density ×

m = 0.00000073722× 149500 m = 0.11kg

molecular wt. for petrol 144.2285 g/mole R = Gas constant

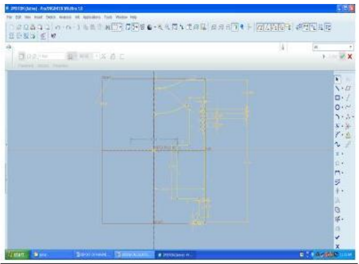
PV = mRT

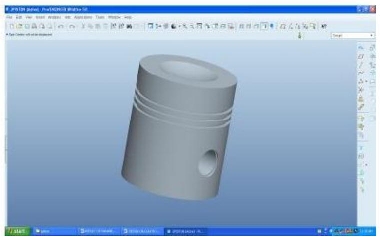
where m = mass/molecular wt. R = Gas constant

P = 15454538.533 j/m^3 = N/m^2

P =15.454 N/mm^2

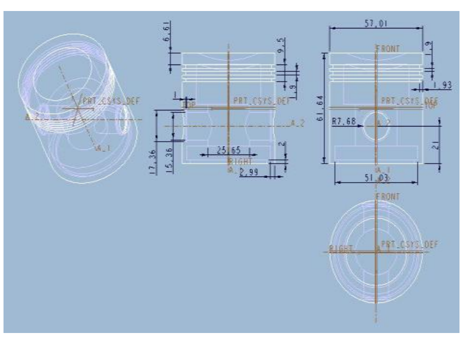
IV MODELS OF PISTON AND MESHING OF PISTON

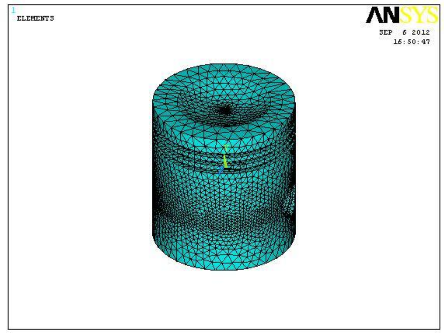




Aluminum alloy 7475-T761

Aluminum alloy 6061





1. Sequence of steps:

Importing the piston model from Pro/Engineer

Defining the Thermal Environment.

Defining the Structural Environment.

Solution phase-assigning loads and solving.

Post processing and viewing the results.

Boundary Conditions

In a piston under static conditions it is supported by the gudgeon pin region. So, the areas corresponding to these have to be constrained in all degrees of freedom.

The working pressure is 15.454 Mpa. Pressures applied at the top of the piston.

2. Importing the piston model:

Utility menu > file > Import > browse >

Pro/Engineer part model

ANSYS Utility menu > plot controls > style >

solid model facets> normal faceting.

Before going into the later part of the analysis a little Meshed model bit of description, regarding

the type of analysis and

the method used appears to be mandatory.

3. Defining the thermal environment: Give the analysis title:

Utility menu > file >change title>optimization of piston

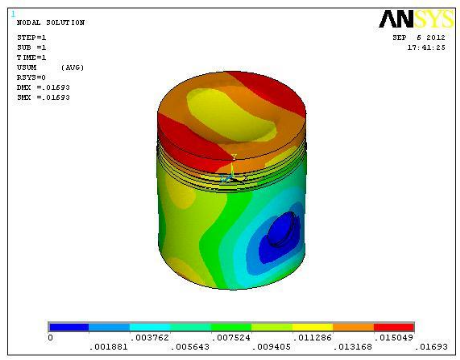
4. Define the type of Element:

Preprocessor > element type > add/edit/delete > add element > add > solid > solid 20 node 90.

The element type that has been selected for the thermal parts of the coupled field analysis is 20 node 90.It is a ten nodded tetrahedron element.

5. Define the element material properties:
Preprocessor> material props> material models> thermal conductivity> isotropic.
In the window that appears, enter the following geometric properties for 6061.
Thermal conductivity (kxx) =180W/mK
Specific heat(c) = 0.896KJ/KgK Density
– 0.0000027Kg/mm3

6. Meshing:



Giving element length:

Preprocessor > meshing > size controls > manual size

> lines > all lines > element edge length > 5 > ok. Write environment: Preprocessor>physics>environment>writ e.

In the window that appears, enter the title thermal and click ok.
Meshing:
Preprocessor > Meshing > Mesh > Volumes

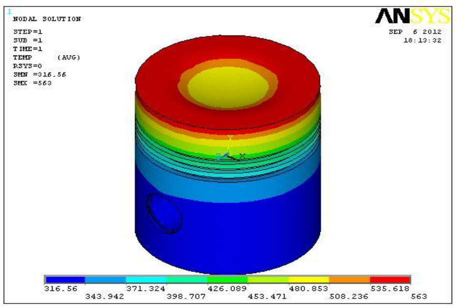
> free > pick all > ok

V. RESULS AND DISSCUSSIONS

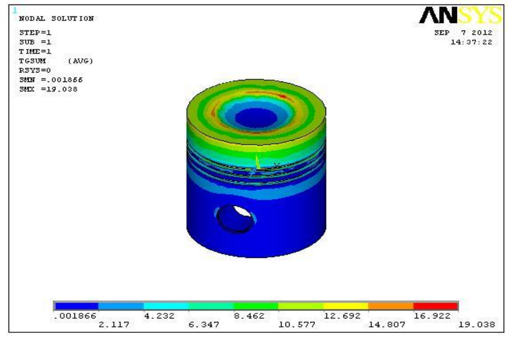
Displacement

ALUMINUM 7675 T761 PISTON MODEL-

Nodal temperature



Thermal Gradient



LM25 PISTON MODEL-1

Thermal conductivity (kxx) =134w/mk
Specific heat(c) = 0.963 kj/kgk

Youngs Modulus (EX) : 70000N/mm^2
Poissons Ratio (PRXY) : 0.32
Density :2680kg/m^3

	Displacement (mm)	Von Mises Stress (N/mm²)	Nodal Temperature (K)	Thermal Gradient (K/mm)	Thermal Flux (W/mm²)
Aluminum alloy 7475-T761	0.016734	123.092	563	20.988	3.085
Aluminum Alloy 6061	0.01707	127.174	563	19.038	3.427
LM25	0.01602	127.174	563	21.681	2.905
	Displacement (mm)	Von Mises Stress (N/mm²)	Nodal Temperature (K)	Thermal Gradient (K/mm)	Thermal Flux (W/mm²)
Aluminum alloy	0.0016593	123.902	563	21.601	3.175

VI. RESULTS

As per the analysis images for Model1 Permissible Yield Stress Values

LM25 – 180N/mm^2

7475-T761 – 448 N/mm^2
6061 – 310 N/mm^2

As per the analysis images for Model2

VII. CONCLUSION

In my project I have designed a piston used in a two wheeler. The present used material for piston is Aluminum alloy LM25. I am replacing with different aluminum alloys 7475-T761 and 6061. I am replacing with above materials, since they have more strength than the Aluminum alloy LM25.

Two models of piston are designed for two materials aluminum alloys 7475-T761 and 6061. Coupled field analysis is done on the models to validate structural and thermal properties like displacement, stress, thermal gradient, thermal flux.

By observing the analysis results, stress values are gradient is more when compared to 6061 and LM25. This material also has high yield strength value.

The main disadvantage of this material 7475-T761 when compared to 6061 and LM25 is that it is more denser so weight of the piston increase

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