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DESIGN, ANALYSIS AND OPTIMIZATION OF PISTON OF 180CC ENGINE USING CAE TOOLS

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Abstract: The stress distribution of two different aluminium alloys (i.e A2618 and Al – GHY1250) piston by using CAE Tools is described in this paper. The specifications used for the study of these pistons belong to four stroke single cylinder engine of Bajaj Pulsar 180cc motorcycle. This paper includes analytical design of two different aluminium alloy pistons and parametric models of Pistons are modelled using PTC Creo Parametric 2.0 software and analysis of that model is carried out by using ANSYS 14.5 Software. The results predict the maximum stress and critical region on the different aluminium alloy pistons using CAE Tools. It is important to locate the critical area of concentrated stress for appropriate modifications. The best aluminium alloy material is selected based on parameters like Von misses Stress and strain, Deformation, Factor of safety and weight reduction for two wheeler piston were done in ANSYS 14.5 software.

Keywords: Innovations, Theoratical Analysis, Finite Element Analysis, Experimental

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INTRODUCTION

A piston is a component of reciprocating IC-engines. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. As an important part in an engine, piston endures the cyclic gas pressure and the inertial forces at work, and this working condition may cause the fatigue damage of piston, such as piston side wear, piston head/crown cracks and so on. The investigations indicate that the greatest stress appears on the upper end of the piston and stress concentration is one of the mainly reason for fatigue failure.

In designing a piston for an engine, the following points should be taken into consideration:

- It should have enormous strength to withstand the high pressure.
- It should have minimum weight to withstand the inertia forces.
- It should form effective oil sealing in the cylinder.
- It should provide sufficient bearing area to prevent undue wear.
- It should have high speed reciprocation without noise.
- It should be of sufficient rigid construction to withstand mechanical distortions.
- It should have sufficient support for the piston pin.

A. *ENGINE SPECIFICATIONS*

The engine used for this work is a single cylinder four stroke air cooled type Bajaj Pulsar 180cc petrol engine. The engine specifications are given in Table 1.1

Table 1.1 Engine Specifications.

PARAMETERS	VALUES
Engine Type	Four stroke, Petrol engine
Induction	Air cooled type
Number of cylinders	Single cylinder
Bore	63.50 mm
Stroke	56.4 mm
Length of connecting rod	112.8 mm

Displacement volume	178.6 cm3
Compression ratio	9.5+/-0.5 : 1
Maximum power	11.77 KW at 8500 rpm
Maximum Torque	14.72 Nm at 6500 rpm
Number of revolutions/cycle	2

B. PROPERTIES OF MATERIALS

The materials chosen for this work are A2618 and Al-GHY1250 for an internal combustion engine piston. The mechanical properties of A2618 and Al-GHY1250 aluminum alloys are listed in the following table 1.2

Table 1.2 Mechanical Properties.

Sr. No.	PARAMETERS	A2618	Al-GHY1250
1	Young's Modulus (GPa)	73.7	83
2	Ultimate Tensile Strength (MPa)	480	1250
3	Possion's Ratio	0.33	0.3
4	Density(Kg/m^3)	2767.99	2880

Methodology

- Analytical design of piston using specification of Bajaj Pulsar 180cc.
- Creation of 3D models of piston using PTC Creo Parametric 2.0 and then imported in ANSYS 14.5
- Mesh of 3D models using ANSYS 14.5
- Analysis of pistons using static stress analysis method.
- Comparative performance of two aluminium alloy pistons under static stress analysis method.
- Select the best aluminium alloy.

Analytical Design

Let,

IP = indicated power produced inside the cylinder (W)

η = mechanical efficiency = 0.8

n = number of working stroke per minute = N/2 (for four stroke engine)

N = engine speed (rpm)

L = length of stroke (mm)A = cross-section area of cylinder (mm^2)

r = crank radius (mm)

l_c = length of connecting rod (mm)

a = acceleration of the reciprocating part (m/s^2)

m_p = mass of the piston (Kg)

V = volume of the piston (mm^3)

t_h = thickness of piston head (mm)

D = cylinder bore (mm)

P_{max} = maximum gas pressure or explosion pressure (MPa)

σ_t = allowable tensile strength (MPa)

σ_{ut} = ultimate tensile strength (MPa)

F.O.S = Factor of Safety = 2.25

K = thermal conductivity (W/m K)

T_c = temperature at the centre of the piston head (K)

T_e = temperature at the edge of the piston head (K)

HCV = Higher Calorific Value of fuel (KJ/Kg) = 47000 KJ/Kg

BP = brake power of the engine per cylinder (KW)

m = mass of fuel used per brake power per second (Kg/KW s)

C = ratio of heat absorbed by the piston to the total heat developed in the cylinder = 5% or 0.05

b = radial width of ring (mm)

Pw = allowable radial pressure on cylinder wall (N/mm^2) = 0.025 MPa

σp = permissible tensile strength for ring material (N/mm^2) = 1110 N/mm^2

h = axial thickness of piston ring (mm)

h_1 = width of top lands (mm)

h_2 = width of ring lands (mm)

t_1 = thickness of piston barrel at the top end (mm)

t_2 = thickness of piston barrel at the open end (mm)

ls = length of skirt (mm)

μ = coefficient of friction (0.01)

l_1 = length of piston pin in the bush of the small end of the connecting rod (mm)

d_o = outer diameter of piston pin (mm)

Mechanical efficiency of the engine (η) = 80 %.

$$\eta = \frac{Brake\ Power\ (B.P)}{Indicated\ Power\ (I.P.)}$$

$$B.P. = \frac{2\pi NT}{60} = \frac{2\pi x 14.72 x 6500}{60} = 10.019KW$$

$$I.P = \frac{Bp}{\eta} = \frac{10.019}{0.8}$$

$$= 12.524\ KW$$

$$I.P = P \times A \times L \times \frac{N}{2}$$

$$I.P = P \times \frac{\pi}{4} \times D^2 \times L \times \frac{N}{2}$$

$$12.524 \times 1000 = P \times \frac{\pi}{4} \times (0.0635)^2 \times (0.0564) \times \frac{6500}{2x60}$$

So, P = 12.94 x 10^5 N/m^2 or P = 1.294 MPa

Maximum Pressure P_{max}=10xP

=10x1.294

=12.94 MPa

ANALYTICAL DESIGN FOR A2618 ALLOY PISTON.

Analytical design for A2618 alloy piston is as follows:

Thickness of the Piston Head: t_h = 6.771 mm.

Piston Rings: b = 1.658 mm and h = 1.16 mm.

Width of Top Land: h_1 = 6.771 mm

Ring Lands: h_2 = 0.87 mm

Thickness of piston barrel at the Top end: t_1 = 8.463 mm

Open end: t_2 = 2.115 mm.

Length of the skirt: l_s = 38.1 mm

Length of piston pin in the connecting

rod bushing: l_1 = 28.575 mm

Piston pin diameter: d_o = 17.78 mm

The centre of piston pin should be 0.02D to 0.04D above the centre of skirt.

ANALYTICAL DESIGN FOR AL-GHY1250 ALLOY PISTON.

Analytical design for Al-GHY1250 alloy piston is as follows:

Thickness of the Piston Head: t_h = 4.196 mm.

Piston Rings: b = 1.658 mm and h = 1.16 mm.

Width of Top Land: h_1 = 4.196 mm

Ring Lands: h_2 = 0.87 mm

Thickness of piston barrel at the Top end: t_1 = 8.463 mm

Open end: t_2 = 2.115 mm.

Length of the skirt: l_s = 38.1 mm

Length of piston pin in the connecting

rod bushing: l_1 = 28.575 mm

Piston pin diameter: d_o = 17.78 mm

The centre of piston pin should be 0.02D to 0.04D above the centre of skirt.

RESULT AND DISCUSSION

A. A2618 alloy piston

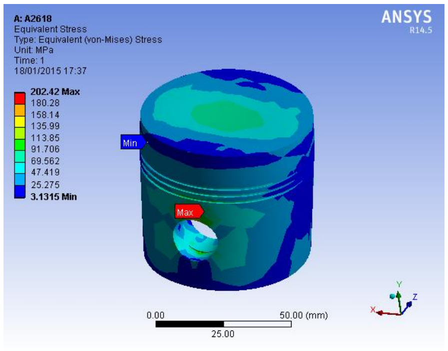

Fig1- Von-misses Stress

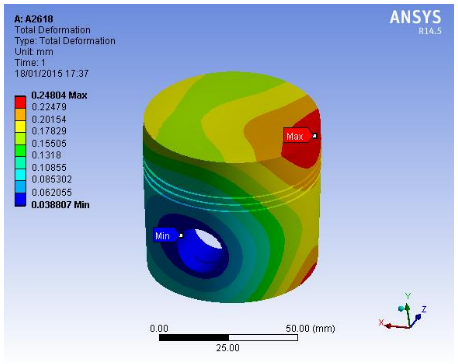

Fig2-Total Deformation

B. Al-GHY1250 alloy piston

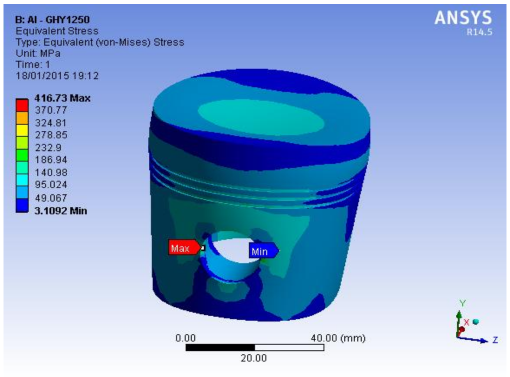

Fig-3 Von -Misses Stress

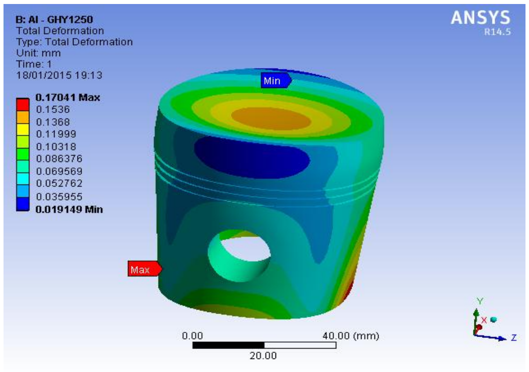

Fig-4 Total deformation

Sr.No.	PARAMETERS	A2618	Al-GHY1250
1	Von-Misses Stress	202.42 MPa	416.73 MPa
2	Total Deformation	0.24804 mm	0.1704 mm
3	Mass	0.2402 kg	0.196 kg
4	Safety Factor	2.4	2.9

From the value of stress and deformation for both materials, we can say that Al-GHY1250 materials are capable of bearing more stress. It is mainly due to following reasons:-

- The addition of Yttrium (atomic No.39) gives high strength and temperature stability.
- The addition of Silicon (Si) to aluminum prevents the changes in mechanical properties of alloy regarding strength, hardness and thermal conductivity.

CONCLUSION

After analyzing the two different alloy pistons of Pulsar 180cc by using CAE Tool, Following conclusion can be drawn :-

- About 18% mass reduction is possible with Al-GHY1250 Alloy.
- Safety factor increased by 17% at same working condition.

Then from this we can conclude that Al-GHY1250 alloy piston is better than conventional alloy piston.

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