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Design and Analysis of Piston Design for 4 Stroke Hero Bike Engine

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***Abstract* – Piston is the part of engine which convert heat and pressure energy liberated by fuel combustion into mechanical works. Engine piston is the most complex component among the automotives. This paper illustrate design procedure for a piston for 4 stroke petrol engine for hero bike and its analysis by its comparison with original piston dimensions used in bike. The design procedure involves determination of various piston dimensions using analytical method under maximum power condition. In this paper the combined effect of mechanical and thermal load is taken into consideration while determining various dimensions. The basic data of the engine are taken from a located engine type of hero bike.**

***Keywords* – Bearing Load, Compression Ratio, Compression Rings, Maximum Pressure, Piston Head.**

I. Introduction

Combustion engines can be classified in two groups, as being follows External combustion (EC) engines and internal combustion(IC) engines.

A. External Combustion (EC) engines: In these engines the substances which are used as working products are separated by a conducting wall. Different fluids are used for combustion such as air, fuel and combustion products. These combustion fluids do not contact at any stage in moving parts of the engine.

B. Internal combustion (IC) engines: In the process of converting this thermal energy into mechanical work, which is performed by increase in pressure which generates forces piston to move with connecting by creating stroke in the cylinder. The fuel combustion occurs inside the cylinder so this process is called internal combustion. The piston engine is known as internal combustion heat engine. it supply air fuel mixture in to the cylinder where it gets compressed and later burnt resulting the power. The internal combustion engine are reciprocating type engines which are either spark ignition (SI) or compression ignition (CI), where the compression engine are called as diesel engines.

C. Reciprocating engines: Two-stroke-engines: This type of two stroke engine where it expansion process the removal of burnt gases at end of each process of expansion and the induction of fresh gas mixture for next cycle. The piston starts at top dead centre (TDC) and it moves downwards in the power stroke and at the bottom of this stroke the exhaust value gets opened or uncovered and so exhaust gases blow down to the exhaust system and at the same time the inlet ports are opened for charging the fuel/air mixture in to case in SI engine and air alone in case of CI engines.

D. Four stroke Engines: The four stroke engine cycle operation takes place in 4 cycles, where the principles partly used are piston, inlet value, exhaust value and the fuel injection nozzle or injector. The inlet value is on the left side and the exhaust value is on the right side.
. Induction 2. Compression 3. Power 4. Exhaust.

Major force acting over piston

1. Due to explosion of fuel gases
2. Due to compression of fuel gases
3. Side wall friction and forces
4. Thermal load
5. Inertia force due to high frequency of reciprocation of piston
6. Friction and forces at crank pin hole

II. Piston Design

By knowing the basic engine specifications like bhp, bore , stroke, compression ratio ,maximum power and maximum torque we find the various dimensions of the piston which are sated below :-

a) Thickness of the piston head
b) Radial thickness of the ring
c) Axial thickness of the ring
d) Height of the first land
e) Thickness of the piston barrel
f) Radial thickness of ring grove
g) Length of piston skirt
h) Length of piston
i) Diameter of piston pin hole
j) Thickness of piston at open end

The various component of the piston are shown in the fig given below. Thickness of the piston head (t_h) can be calculated by using Grashoff's formula. The head is assumed to be flat and fixed at the edges and the gas pressure is considered as uniform over the entire cross sectional area.

$$T_h = \sqrt{3PD^2/16\sigma}$$

$$= \frac{\sqrt{3 \square 91.95 \square 50}}{16 \square 469}$$

$$= 9.58\,mm$$

Where T_h is the thickness of the piston head , P is the maximum pressure or gas explosion pressure ,D is the diameter of piston , while the σ is the allowable stress of the material which is taken as 469 MPa for aluminium alloy.

$$T_h = \frac{H}{12.56K(tc-te)}$$

$$= 7.37\ mm$$

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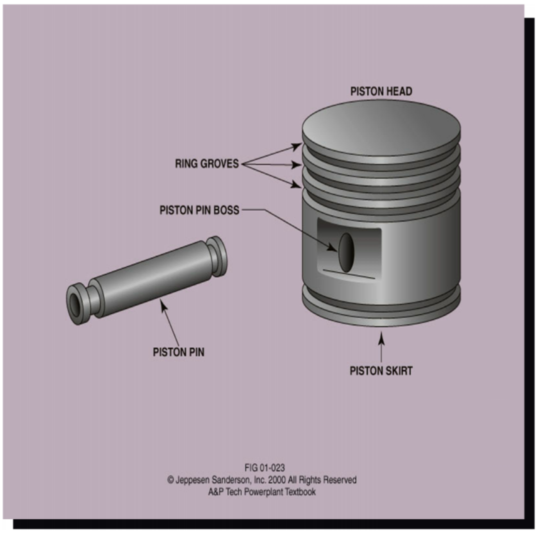
Where H is the heat flowing through the piston head ,K is heat conductivity factor (174.75 W/m/K) for aluminum alloys ,T_c is the temperature at piston center and T_e is temperature at edges ,difference is taken as 75 for aluminum alloy.

The heat flowing through the piston head (H) can be calculated by using

$$H = C \times HCV \times M \times BP$$
$$= 0.05 \times 47000 \times 10^3 \times 0.069 \times 7.5$$
$$= 1216125$$



Where C is the constant representing heat supplied to the engine and taken nearly 0.05 HCV (higher calorific value), HCV of petrol is taken as 47000 KJ/kg , m is mass of fuel used per cycle.

Radial pressure between cylinder wall and ring is consider to find out the radial thickness of ring (t_2) –

$$t_1 = D \times \sqrt{3P_w/\sigma_{t1}}$$

here D is cylinder bore , P_w is pressure of gas on the cylinder wall (nearly taken as 0.025 MPa to 0.042 MPa) and σ_{t1} is allowable bending tensile stress (84 MPa to 112Mpa for cast iron) .The axial thickness can be taken as 0.7 t_1 to t_1 .

The thickness of top land or distance between the rings is taken higher to bear the gas force and high temperature caused due to gas explosion . Its is nearly taken as :-

$$T_L = 0.055 \times D$$
$$= 2.75\ mm$$

While the gap between the other rings are taken less because less force is applied here as compared to the top land .Here gas pressure , inertia of piston rings and friction between the rings and the cylinder wall is taken into consideration . The height of lands goes on decreasing as we go down ward. The width of land between first and second ring is nearly taken equal to **(0.04 D** to **0.05D)**. A small gap is maintain between the rings and the cylinder wall to reduce the friction and piston side thrust.

The depth of ring grove in the piston is taken greater than the width of ring for the reasons as explained above

$$D_r = t_{1\,+}\,0.4$$

A great concern is also taken while determining the thickness of the piston barrel. The thickness of piston barrel goes on decreasing from top to bottom .The maximum thickness is taken towards the top of piston while minimum value is towards the open end of the piston . The thickness of piston is taken as :-

$$T_p = 0.03D + d_r + 4.5$$

At the open end the thickness is taken as *(0.20 to 0.30*T_p*)* . The piston part below the ring section is called as skirt. It helps to bear the side axial thrust. The side thrust is normally taken as 0.1 to 0.3 of maximum pressure.

The length of the piston is the sum of piston skirt ,ring section and top land i.e

$$L_p = L_{ps} + ring\ section$$

Here L_{ps} is taken nearly as 0.5 of the piston diameter (0.5D)

$$L_{p\,=}\,25 + 3 \times 1.62 + 3 \times 2.1$$
$$= 36.16\ mm$$

The outside diameter of the piston pin (do) is obtained

$$P_{Bearing\ Force} = Bearing\ Pressure\ X\ Bearing\ Area$$
$$= P_{b1} \times d \times L$$

Where, d is outside diameter of the piston pin, L is length of the piston pin in the bush of the small end of the connecting rod (0.3D to 0.45D), P_{b1} is bearing pressure at the small end of the connecting rod bushing. The pin diameter is selected up to an optimum of about 40 percent of piston diameter.

The length is taken less than the piston bore for allowing end clearance of the pin. The material used for piston pin is normally taken steel alloyed with nickel, chromium, molybdenum or vanadium which has very high tensile strength nearly 750MPa to 900MPa

III. Properties of the Material Used

Aluminum 2024-T4; 2024-T351

Component	**Wt. %**
Al	90.7 - 94.7
Cr	Max 0.1
Cu	3.8 - 4.9
Fe	Max 0.5
Mg	1.2 - 1.8
Mn	0.3 - 0.9
Si	Max 0.5
Tn	Max 0.15
Zn	Max 0.25
Density	2.78 g/cc

Physical, Mechanical and thermal properties

Properties	**Metric value**
ultimate tensile stress	469 Mpa
Modulus of elasticity	73.1 Gpa
Poisson’s ratio	.33
Thermal conductivity	121 W/mk
Specific heat capacity	0.875 j/g k
Density	2.78 g/cc

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Engine specification

Content	Value
Bore and stroke	50×49.5 mm
Compression ratio	9:1
Max. power	7.5 Ps @ 8000 rpm
Max torque	7.95 N/m @4500 rpm
Air fuel ratio	12:1
Petrol Density	719.7 kg /m^3
Calorific valve of petrol	47000kj/kg

The dimensions found by the using these specification are displayed in the table below. There might be a small variation in values of different content due to change in working condition of the engine. The values are found out on basis of extreme condition.

IV. Result and Comparison

Parameter	Calculated values	Actual values	Difference
Piston length	36.16 mm	37 mm	0.84 mm
Piston diameter	50 mm	49.5mm	0.5mm
Pin hole external diameter	13mm	12.7mm	0.3 mm
Pin hole internal diameter	8mm	6.6 mm	1.4 mm
Piston ring axial thickness	1.05mm	0.8mm	0.205mm
Radial thickness of ring	1.62 mm	2mm	0.3mm
Depth of ring groove	2.02mm	2.01mm	0.01mm
Gap between the rings	2.75mm	2.6mm	0.15mm
Top land thickness	7.3mm	5.6mm	1.7mm
Thickness of piston at top	7.05mm	6.65mm	0.4mm
Thickness of piston at open end	1.76mm	1.64mm	.12mm

The result given above are first calculated by using the formulas presented in paper and then compared with the dimensions of the actual pistons currently being used in the hero splendor bikes.

V. Conclusion

The fundamental concepts and design methods concerned with single cylinders petrol engine have been studied in this paper the results found by the use of this analytical method are nearly equal to the actual dimensions used now a days. Hence it provides a fast procedure to design a piston which can be further improved by the use of various software and methods. The most important part is that very less time is required to design the piston and only a few basic specification of the engine.

Further Possible Work

The ANSYS analysis of the model designed on the basis of the dimensions found in this paper can be done. This will help to get the idea whether the design is safe or not and what further changes can be made in the design considering into mind the reduction of wt. of the piston i.e work towards the weight minimization. The analysis can be done with change in material of piston can be changed for better strength and light weight.

References

[1] Computer Aided Design and Analysis of Piston Mechanism of Four Stroke S.I. Engine.
[2] Mathur M.L., Sharma, A Course in Internal Combustion EngineR.P. Dhanpat Rai Publication 1997 (i, ii, iii).
[3] Amitabha Ghosh, Ashok Kumar Malik, Theory of Mechanism and Machines, third Edition, Affiliated press pvt limited New De 1998.
[4] Shigley, Joseph Edward, Theory of Machines and Mechanisms, Tata McGraw Hill, New York, 2003.
[5] Khurmi, R.S. and Gupta, J.K., A Textbook of Theory of Machine,4th Edition, Eurasia Publishing House (Pvt.), Ltd, New Delhi, 2003
[6] Dr. P.C. Sharma, Aggarwal, R.D.K, , A Text Book of Machine Design, S. K. Kataraia and sons, New Delhi. 2004
[7] Thermal Analysis And Optimization Of I.C. Engine Piston Using finite Element Method.

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