STUDY AND COMPARISION OF VARIOUS TYPES OF THERMAL SLOTS IN ALUMINIUM PISTON

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Abstract-In this study the aluminium piston is taken into consideration and analysed with the values of peak working condition, in aluminium piston at higher temperature higher expansion rate is achieved. It is also been analysed using different types of thermal slots, by introducing the thermal slots we can reduce the thermal expansion in aluminium piston and also material reduction can achieved in this process. The thermal analysis is been carried out using the Ansys package.

Keywords: Aluminium piston, Thermal expansion, Thermal slots, Weight reduction.

1. INTRODUCTION

This study is mainly focused on comparison of various thermal slots which can be introduced in the aluminium piston, in the present condition in automotive industries performance and life of the product determines the quality and the standard of the product. In aluminium pistons at high temperature conditions the aluminium piston may undergo some thermal expansion; this thermal expansion in piston may affect the performance and the life of the component hence to overcome the effects. The thermal slots are introduced to control the thermal expansion in aluminium piston at higher temperatures, by introducing the thermal slots we can achieve low thermal expansion and weight reduction in piston. By these two advantages the piston's life and the performance can be improved, the thermal slots which are to be introduced in the piston are designed in alphabetic design which is introduced in the shrink of the pistons. By slight weight reduction in piston due to implementation of thermal slots at both sides of the piston shrink can boost up the performance in the engine, lesser the weight of the engine the more performance can be achieved. The piston with thermal slots are been designed using the solidworks and then the pistons are been analysed for the thermal flow in the piston with and without the thermal slots. This advancement leads to better life of the component.

2. LITERATURE REVIEW

Chitthaarth.M.R et al (2013) [2] have done a work on a two wheeler engine piston of hero Honda hunk bike, in which the piston is made up of aluminium alloy. This aluminium piston has high thermal expansion property at higher temperatures, to control the thermal expansion they are introducing thermal slots in which the expansion is been controlled and the piston is redesigned using the Solid Works and analysed in the ANSYS work bench packages. Mainly the temperature flow is been analysed and it found that the inverted E slot has good temperature distribution than the normal piston. Thus by implementing the inverted E slot we could reduce the thermal expansion of the aluminium alloy piston. Chitthaarth.M.R et al (2013) [3] have carried out a work on aluminium piston to control its thermal expansion by introducing two different thermal slots that is the "Y" and "Z" type thermal slots. These slots are been designed using cad package and analysed using Ansys, thermal flow analysis is carried out and the difference in temperature in actual piston and the two different slotted pistons are compared and best one is selected. The topic of control the thermal expansion in piston has been researched extensively. Donald D. Deming [4] U.S. Patent No.2551488 conducted a patent on the Controlled thermal expansion using internal combustion engines and more particularly, to piston constructed of light metals like aluminum, magnesium or various alloy. And we got idea about the slot of the piston which is used to control the thermal expansion in U.S. Patent No 2238087 [5] to Browser et al discloses as done one modification in the well know U-slot piston where in expansion of a cantilever bearing section. Werner Stedile, Bad Freidrichshall [3] conducted studies on Expansion controlled light alloy piston. In which the experiments were conducted on a internal combustion engine. Bhaumik Patel, Ashwin Bhabhor [1] has conducted the study on Thermal analysis of a piston of reciprocating air compressor with different boundary conditions. By reading this journal we got idea and methodology for conducting the thermal analysis and applying the boundary conditions. Zarul Shazwan Bin Zullkafli [7] conducted a study on Failure of piston engine using FEA. Their main aim is to find

and investigate the maximum stress using stress analysis and maximum temperature using thermal analysis.

3. PISTON – A GLANCE

The engine main purpose is to converts the thermal energy into mechanical form of energy. The piston reciprocates due to the combustion process takes place in the combustion chamber, when the piston reciprocates the power is been transferred from the piston the crank shaft by means of a connecting rod. The piston reciprocating motion will be converted into a rotary motion through means of the crank shaft. The connecting rod connecting the piston and crank shaft is connected in the piston by means of a gudgeon pin, the piston two more components to achieve a good working process they are the combustion rings and the oil rings here these rings are used a seal between the combustion chamber and the crankcase. The main purposes of the rings are to seal the gap between the piston and the piston liner, the combustion rings are used to seal the fuel mixture and increase the combustion pressure in the engine. The oil rings are used as the oil seal that prevents the oil entering into the combustion chamber from the crank case. The piston are commonly made of the aluminium alloys which are weight less and has high thermal expansion at high temperatures, the piston are made up of casting method and the forging method. The casting piston is used commercial vehicles but the forged pistons are used in the racing and high performance application. The piston can be differentiated into four types they are

- Trunk pistons
- Crosshead pistons
- Slipper pistons
- Deflector pistons

4. WORK DONE

In this study the comparison of various type of thermal slots are been carried out, the two wheeler piston is taken into consideration and designed using cad package. The slots are obtained from the literature survey and a comparative study is been done. The two wheeler piston is been redesigned with the help of the design data's which are been obtained from the literature survey. These thermal slots are mainly introduced to control the thermal expansion in the aluminium alloy two wheeler pistons and thus by the weight reduction also take place in the piston, by controlling the thermal expansion and achieving a weight reduction the performance and the life of the component might be improved.

The five thermal slots are been designed as shown in the figure below then the designed slots are been analysed using the Ansys software for the temperature flow in the piston. The input data's such as temperature and the other boundary condition are been taken from the literature review, the temperature of the aluminium alloy goes to maximum of 550^{o} -- 600^{o}c and the minimum of 260^{o}-- 300^{o}c, the minimum temperature must be maintained so that the efficiency of the piston is not affected. The pressure developed during the combustion process, the thermal conductivity and thermal expansion values are also obtained for the analysis. The pressure developed during the combustion is to be from 350-450 Mpa. The boundary conditions are applied at the gudgeon pin guide hole as the cylindrical support and the pressure and the temperature are applied from the top of the piston. First the thermal analysis is been done on the piston of all types and then the structural analysis is been carried out. The design consideration of analysis is shown below.

5. DESIGN PARAMETERS

LENGTH OF THE PISTON	: 36mm
DIA OF THE PISTON	: 57mm
OUTER THICKNESS OF PISTON	: 3mm
INNER TOP THICKNESS OF PISTON	: 7mm
GUDGEON PIN DIAMETER	: 13mm
LENGTH OF THE THERMAL SLOTS	: 25mm
HEIGHT OF THE THERMAL SLOTS	: 15mm
DAM DIAMETER	: 3mm
ALUMINIUM ALLOY USED	: A356 alloy

BOUNDARY CONDITIONS: cylindrical support, pressure & temperature in – axis

5.1 Diagram of piston

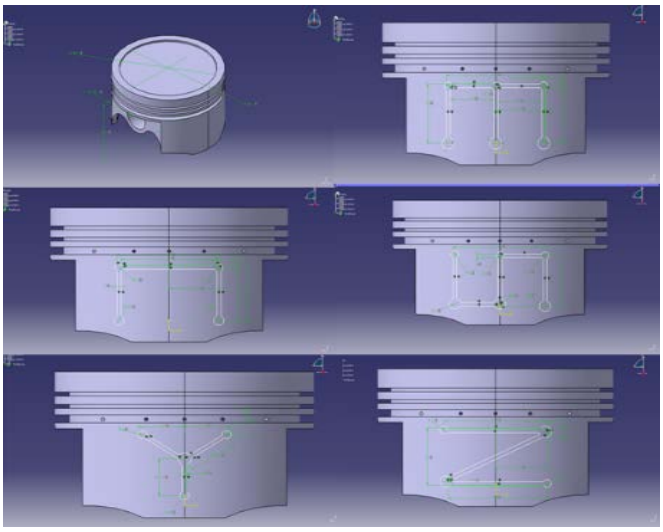

Fig. 1. Design of actual piston and slotted pistons

5.2 Analysis using Ansys software

Temperature distribution in pistons

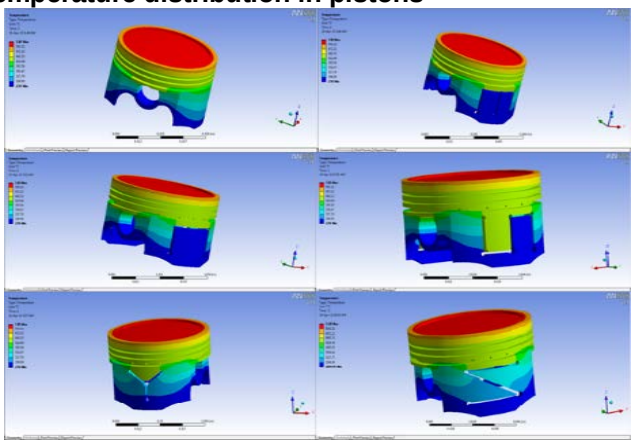

Fig. 2. Thermal analysis of actual piston and slotted piston

Total heat flux in piston

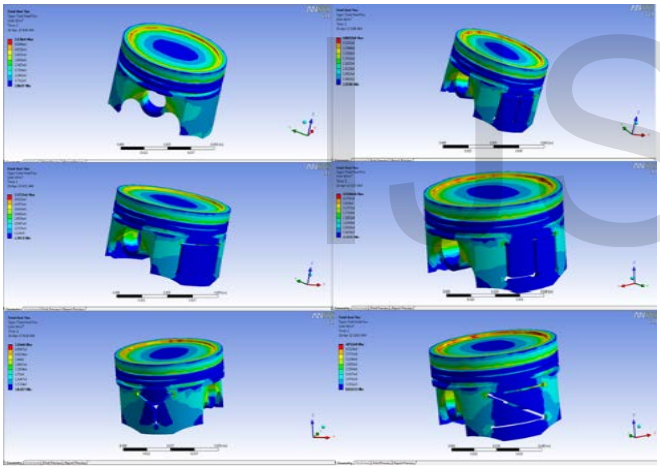

Fig. 3. Heat flux of actual piston and slotted piton

6. RESULTS AND DISSCUSSION:

The temperature distribution in the actual piston and the temperature distribution in the piston with the thermal slot values are been compared in the table below. From the table we can choose that the inverted E slot and Z slot has the normal maximum temperature and the least average minimum temperature.

TABLE 1. Thermal Analysis values

	ACTUAL	INVERTED E SLOT	INVERTED PA SLOT	INVERTED S SLOT	Y SLOT	Z SLOT
THERMAL MAXIMUM	342.92	359.2	396.62	380.73	370.5	385.49
THERMAL MINIMUM	163.3	123.4	121.28	120.97	152.14	136.27

TABLE 2. Heat flux Analysis values

	ACTUAL	INVERTED E SLOT	INVERTED PA SLOT	INVERTED S SLOT	Y SLOT	Z SLOT
HEAT FLUX MAXIMUM	2.8647	2.9196	1.3923	3.3131	3.6107	0.01633
HEAT FLUX MINIMUM	$5.158e^{6}$	$4.8657e^{6}$	$5.5251e^{6}$	$4.9166e^{6}$	$5.16e^{6}$	$4.852e^{6}$

From the heat flux table we can find out the inverted E slot and Z slot has the least average heat flux compared to other five thermal slotted pistons and the actual piston.

From the results and the analysis the inverted E slot has the more and the Z slot has moderate rate efficiency of effective thermal expansion than any other slots designed. Thus we can implement these two types of slots in piston to control the thermal expansion. It has a large quantity of material reduction also takes place due to the slots on the both sides of the piston, this design gives much effective controlled thermal expansion and material reduction which leads to high performance of the piston which gradually increases the engine performance and increase the life of the piston.

FUTURE SCOPE

In future the piston can be analysed by applying the pressure acting on the piston, which is generated during the combustion process can be used to find out the stress strain distribution in the piston. It can also be analysed using the mechanical methods like the FEM methods etc, and the various process to get another deformation which help in further improvement of the piston to get the better performance and material life.

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