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A Review on Prediction Of Piston Performance Using Two Varience Anova Method

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Abstract.– Piston plays a main role in energy conversion. Failure occurred of piston due to various thermal and mechanical stresses. The working condition of the piston is so worst in comparison of other parts of the internal combustion engine. The main objective of this work is to investigate and analyze the stress distribution of piston. Design and analysis of an IC engine piston using three different materials that are used in this project.

Keywords- Piston ring, Structural Analysis, Stress, CAD, FEA.

I. INTRODUCTION

Today, the pistons designed by the suppliers based on load data determined by the engine performance targets. From this data the supplier estimates the temperatures of the piston and recommends a design that is suitable for the application. This procedure is successful for the design of the piston, but gives no knowledge of the thermal interaction between the piston and its surrounding parts. The current trend in car engine development is to make smaller engines with higher specie power outputs to meet the demands for lower fuel consumption and emissions.

This leads to higher thermal loads on the engine and an increasing need to understand the heat balance of the complete engine in order to optimize the different engine parts and systems. A substantial part of the heat generated by the combustion is transported to the coolant through the piston and to the surrounding structure. It is therefore important to get an accurate description of these interactions. The goal of Volvo Cars future combustion engine development is to increase power and efficiency and decrease fuel consumption while still maintaining reliability and durability of the highest possible level. As such, it is necessary to have a complete image of the thermal effect. In the recent time automobile industry is growing with very rapid rate. The engine is one of the most important and crucial parts of any automobiles which are used for generating the power.

II. MODELLING PISTON DESIGN

Modelling Criteria

The piston is designed according to the procedure and specification which are given in machine design and data hand books. The dimensions are calculated in terms of SI Units. The pressure applied on piston head, temperatures of various areas of the piston, stresses, strains, length, diameter of piston and hole, thicknesses, etc., parameters are taken into consideration Design Considerations for a Piston. 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.

1. It should have minimum weight to withstand the inertia forces.
2. It should form effective oil sealing in the cylinder.
3. It should provide sufficient bearing area to prevent undue wear.
4. It should have high speed reciprocation without noise.
5. It should be of sufficient rigid construction to withstand thermal and mechanical distortions.
6. It should have sufficient support for the piston pin.

Forces Effects

The major forces acting on the piston are as follows: Inertia force caused by the high frequency of reciprocating motion of piston Friction between the cylinder walls and the piston rings Forces due to expansion of gases.

III. MATERIAL BASED PISTON DESIGN FEATURES

1. Have sufficient mechanical strength and stiffness.
2. Can effectively block the heat reached the piston head.
3. High temperature corrosion resistance.
4. Dimensions as compact as possible, in order to reduce the weight of the piston

IV. MATERIAL ORIENTED FUNCTIONS OF PISTON

- To receive the thrust force generated by the action of fuel in the cylinder and transmits to connecting rod.
- To reciprocate in the cylinder provide seal connecting force generator.
- Piston crown is a cylindrical part which tapers to a thinner section.

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- Piston skirt is a cylindrical part of the piston below the pressure rings, keeping the piston in alignment with the cylinder. It can contain a scraper ring.

1. Piston Materials Selection Features

The functions of the piston and the loads that act on it present a very special set of requirements for the piston material. If low piston weight is the goal, then a low-density material is preferred. Besides its design shape, the strength of the material is the deciding factor for the load capacity of the piston. The change in loads over time requires both good static and dynamic strength. Temperature resistance is likewise important, due to the loads.

A material with good machining properties supports cost-effective production in large quantities. The manufacture of the raw part should be as near to net shape as possible, and should contribute to high material quality. Suitable processes include gravity die casting and forging. The sliding and sealing surfaces demand high-precision finishing, which requires suitable machinability of the material.

As a light alloy with high conductivity, aluminum is particularly predestined to be used as a piston material. In the unalloyed state, however, its strength and wear resistance are too low. With the discovery of precipitation hardening by Wilm in 1906, aluminum alloys became well suited for technical purposes. Metals have a mutual solubility that varies with temperature, which is very low for certain metals at low temperatures in the solid state [1]. Phase diagrams, derived from cooling curves from the liquid range, depict these relationships particularly clearly. In order to increase better functionality, the piston material should satisfy the following requirements:

- Light weight
- Good wear resistance
- High strength to weight ratio
- Free from rust
- Easy to cast
- Easy to machine
- Non magnetic
- Non toxic

Piston should be designed and fabricated with such features to satisfy the above requirements. Generally pistons are made of Al alloy and cast iron. But the Al alloy is more preferable in comparison of cast iron because of its light weight which suitable for the reciprocating part. There are some drawbacks of Al alloys in comparison to cast iron that are the Al alloys are less in strength and in wearing qualities. The heat conductivity of Al is about of thrice of the cast iron. Al pistons are made thicker which is necessary for strength in order to give proper cooling.

V. PISTON MATERIALS SELECTION FEATURES

The functions of the piston and the loads that act on it present a very special set of requirements for the piston material. If low piston weight is the goal, then a low-density material is preferred. Besides its design shape, the strength of the material is the deciding factor for the load capacity of the piston. The change in loads over time requires both good static and dynamic strength. Temperature resistance is likewise important, due to the loads.

1. Cast Iron

Cast iron is a group of iron-carbon alloys with a carbon content more than 2%.[1] Its usefulness derives from its relatively low melting temperature. The alloy constituents affect its colour when fractured: white cast iron has carbide impurities which allow cracks to pass straight through, grey cast iron has graphite flakes which deflect a passing crack and initiate countless new cracks as the material breaks, and ductile cast iron has spherical graphite "nodules" which stop the crack from further progressing.

Carbon (C) ranging from 1.8 to 4 wt%, and silicon (Si) 1–3 wt%, are the main alloying elements of cast iron. Iron alloys with lower carbon content are known as steel. Cast iron tends to be brittle, except for malleable cast irons. With its relatively low melting point, good fluidity, castability, excellent machinability, resistance to deformation and wear resistance, cast irons have become an engineering material with a wide range of applications and are used in pipes, machines and automotive industry parts, such as cylinder heads, cylinder blocks and gearbox cases. It is resistant to damage by oxidation.

2. Aluminium

Aluminium (aluminum in American and Canadian English) is a chemical element with the symbol Al and atomic number 13. It is a silvery-white, soft, non-magnetic and ductile metal in the boron group. By mass, aluminium makes up about 8% of the Earth's crust, where it is the third most abundant element (after oxygen and silicon) and also the most abundant metal. Occurrence of aluminium decreases in the Earth's mantle below, however. The chief ore of aluminium is bauxite. Aluminium metal is highly reactive, such that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals.[2]

Aluminium is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation. Aluminium and its alloys are vital to the aerospace industry[3] and important in transportation and building industries, such as building facades and window frames.[4] The oxides and sulfates are the most useful compounds of aluminium.[5]

3. Steel

Steel is an alloy of iron with typically a few percent of carbon to improve its strength and fracture resistance compared to iron. Many other additional elements may be present or added. Stainless steels are corrosion and oxidation resistant need typically an additional 11% chromium. Because of its high tensile strength and low cost, steel is best used in buildings, infrastructure, tools, ships, trains, cars, machines, electrical appliances, and weapons. Iron is the base metal of steel and it can take on two crystalline forms (allotropic forms): body centred cubic and face-centred cubic. These forms depend on temperature. In the body-centred cubic arrangement, there is an iron atom in the centre and eight atoms at the vertices of each cubic unit cell; in the face-centred cubic, there is one atom at the centre of each of the six faces of the cubic unit cell and eight atoms at its vertices. It is the interaction of the allotropes of iron with the alloying elements, primarily carbon, that gives steel and cast iron their range of unique properties.

4. Ductile Iron

Ductile iron, also known as ductile cast iron, nodular cast iron, spheroidal graphite iron, spheroidal graphite cast iron[1] and SG iron, is a type of graphite-rich cast iron discovered in 1943 by Keith Millis.[2] While most varieties of cast iron are weak in tension and brittle, ductile iron has much more impact and fatigue resistance, due to its nodular graphite inclusions. On October 25, 1949, Keith Dwight Millis, Albert Paul Gagnebin and Norman Boden Pilling received US patent 2,485,760 on a Cast Ferrous Alloy for ductile iron production via magnesium treatment.[3]

Augustus F. Meehan was awarded a patent in January 1931 for inoculating iron with calcium silicide to produce ductile iron subsequently licensed as Meehanite, still produced in 2017. Ductile iron is not a single material but part of a group of materials which can be produced with a wide range of properties through control of their microstructure. The common defining characteristic of this group of materials is the shape of the graphite. In ductile irons, graphite is in the form of nodules rather than flakes as in grey iron. Whereas sharp graphite flakes create stress concentration points within the metal matrix, rounded nodules inhibit the creation of cracks, thus providing the enhanced ductility that gives the alloy its name.

[5] Nodule formation is achieved by adding nodulizing elements, most commonly magnesium (magnesium boils at 1100 °C and iron melts at 1500 °C) and, less often now, cerium (usually in the form of mischmetal).[6] Tellurium has also been used. Yttrium, often a component of mischmetal, has also been studied as a possible nodulizer.

5. Tungsten

Tungsten, or **wolfram**,[7][8] is a chemical element with the symbol **W** and atomic number 74. Tungsten is a rare metal found naturally on Earth almost exclusively as compounds with other elements. It was identified as a new element in 1781 and first isolated as a metal in 1783. Its important ores include scheelite and wolframite, the latter lending the element its alternate name.

The free element is remarkable for its robustness, especially the fact that it has the highest melting point of all known elements barring carbon (which sublimes at normal pressure), melting at 3,422 °C (6,192 °F; 3,695 K). It also has the highest boiling point, at 5,930 °C (10,710 °F; 6,200 K).[9] Its density is 19.25 grams per cubic centimetre,[10] comparable with that of uranium and gold, and much higher (about 1.7 times) than that of lead.[3] Polycrystalline tungsten is an intrinsically brittle[4][5] and hard material (under standard conditions, when uncombined), making it difficult to work. However, pure single-crystalline tungsten is more ductile and can be cut with a hard-steel hacksaw.[6]

VI. LITERATURE REVIEW

L. R. Pachpande, Review on Design and Comparative Analysis of Piston by Ansys: The modern trend is to develop IC Engine of increased power capacity. One of the design criteria is the endeavor to reduce the structures weight and thus to reduce fuel consumption. This has been made possible by improved engine design. These improvements include increased use of lightweight materials, such as advanced ultra-high tensile strength steels, aluminum and magnesium alloys, polymers, and carbon-fiber reinforced composite materials.

The integration of lighter weight materials is especially important if more complex parts can be manufactured as a single unit. In the next 10–20 years, an additional 20–40% reduction in overall weight, without sacrificing safety, seems to be possible. Cuddy et al (1997) have reported that for every 10% weight reduction of the vehicle, an improvement in fuel consumption of 6–8% is expected. Improved engine design requires optimized engine components. Therefore sophisticated tools are needed to analyze engine components. Engine piston is one of the most analyzed components among all automotive or other industry field components.

The engine can be called the heart of an automobile and the piston may be considered the most important part of an engine. Many sophisticated Aluminum piston analysis methods have been reported in the past years. Silva 2006 has analyzed fatigue damaged piston. Damages initiated at the crown, ring grooves, pin holes and skirt are assessed. An analysis of both thermal fatigue and mechanical fatigue damages is presented and analyzed in this work. A linear static stress analysis, using ‘‘cosmos works’’, is used to determine the stress distribution during the combustion. Stresses at the piston crown and pin holes, as well as stresses at the grooves and skirt as a function of land clearances are also presented. We almost take our Internal Combustion Engines for granted don't we. All we do is buy our vehicles, hop in and drive around. There is, however, a history of development to know about.

S. Manavalan, Impact of Modified Piston - A Review: The piston could be a heart of the engine and its operating condition is that the most passing unhealthy one amongst the key elements of the engine within the work. A piston could be a section of responding piston responding pumps gas compressors and gas chambers among alternative comparative systems. It's the moving half that's contained by a barrel and is formed air-tight by piston rings. During a piston, its motivation is to exchange force from growing gas within the barrel to the rotating shaft through a piston bar and in addition associating pole rod. the most objective is to analyze and analyze the behavior stress and structural analysis of changed piston at the $64000 engine condition throughout the combustion method. This work advancement by utilizing finite component analysis to anticipate the upper stress and significant space is on the part.

A.nandha kumar, review paper on design and analysis of ic engine piston with different material: in the present work describes the stress distribution and thermal stresses of five different materials for piston by using finite element method (fem), testing of mechanical properties. the parameters used for the simulation are operating gas pressure, temperature and material properties of piston. the specifications used for this study of these pistons belong to four stroke single cylinder engine of bajaj kawasaki motorcycle. the results predict the maximum stress and critical region on the different materials piston using fea.. design by using catia v5 software and analysis by using ansys software in ansys 15 static and thermal analysis is performed. the suitable material is selected based on results of structural and thermal analysis on these al-sic graphite, a7075, a6082, a4032, al-ghy 1250 materials.

anand bhatt, a review paper on redesigned piston rings to improve engine performance: the usage of internal combustion engines is increasing day by day to satisfy human thirst, which has led to consumption of fossil fuel at a drastic level contributing more than 80% human co2 emission. as we know that the government norms are becoming stringent day by day due to increase in percentage of co2 in the atmosphere. reducing the global emissions of the internal combustion engines is a prime focus of this paper by decreasing fuel consumption.

Friction in internal combustion engines is mainly due to constantly abrading parts like piston, piston rings, cylinder liner and other engine auxiliaries. fuel consumption can scaled down by reducing friction between piston ring assembly and cylinder liner, which nearly accounts for approximately 20% of engine losses. the friction in the ring assembly is mainly due to top ring (compression) friction which is maximum at t.d.c and b.d.c. positions. friction can be reduced by analysing and experimenting various materials, shapes, sizes, coatings of the piston rings for internal combustion engine. model prediction indicated that by employing skewed barrel profile with a positive twist, taper napier profile with negative twist and tapered ring with negative twist in the first, second and third piston rings grooves respectively reduces a considerable amount of friction of piston rings assembly, ultimately reducing the consumption of fuel and thereby reducing the emissions from internal combustion engines.

VII. CONCLUSION

1) Piston Rings Of Reciprocating Engines Have Several Functions Apart From Sealing The Gas Pressure Which Affect Performance Of Engine. 2) From Lierature It Appears That Piston Ring Can Be Designed Using Experimental, Analytical And Numerical Techniques. 3) Structural Design Of Piston Rings Using FEA Is Not Studied Adequetly. Hence, Design Validation Can Be Caried Out Using Commercial FEA Tools Such Asabaqus Etc.

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