DESIGN AND ANALYSIS OF THE PISTON USING THREE MATERIALS

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Abstract - *Piston plays a main role in energy conversation. Failure 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. taking pulsar 220cc piston dimensions different materials (grey castiron, aluminum alloy, AL-NI) have been selected for structural and thermal analysis of piston. Created pressure on piston head 13.65Mpa on these three materials, and applied temperature 400 degress on piston head finally find out the which one is the suitable material on piston in these three materials. Design of the piston is carried out using Solidworks software, static and thermal analysis is performed using Finite Element Analysis (FEA).*

Key Words: Piston, Aluminium alloy, Nickel,

1. INTRODUCTION

An internal combustion engine is defined as an engine in which the chemical energy of the fuel is released inside the engine and used directly for mechanical work, as opposed to an external combustion engine in which a separate combustor is used to burn the fuel. The internal combustion engine was conceived and developed in the late 1800s.

Internal combustion engines can deliver power in the range from 0.01 kW to 20x103 kW, depending on their displacement. The complete in the market place with electric motors, gas turbines and steam engines. The major applications are in the vehicle (automobile and truck), railroad, marine, aircraft, home use and stationary areas. The vast majority of internal combustion engines are produced for vehicular applications, requiring a power output on the order of 102 kW.

1.1 MATERIAL FOR PISTONS

The most commonly used materials for pistons of I.C. engines are cast iron, aluminium alloy (cast aluminium, forged aluminium), cast steel and forged steel.

Here we are using grey cast iron, aluminium alloy and new material aluminium Nickel carbide graphite (Al-Ni Graphite)

1.2 Preparation of Al-Ni graphite's Specimen

Stir Casting technique is a method of producing composite materials, in which a scattered stage (fired particles, short filaments) is blended with a liquid metal by method for mechanical mixing with the help of stirrer. The liquid state composite material is cast by permanent die casting method. In this Stir casting technique has been used to prepare the work-piece samples of Al-Ni-Graphite hybrid metal matrix Composite material and accomplish the required properties of that composite material. The vortex stir casting is best approach to create an accurate mixing of the Nickel carbide and graphite material in the matrix, the aluminium material was stacked in a crucible and it was placed into a resistance furnace at various temperature levels

Preparation of Al-Ni-graphite's Specimen

Nickel carbide and Graphite powder preheated before mixing of aluminium metal melt, the four blades Stirrer was designed in order to produce the sufficient homogenous particle circulation throughout the matrix material. After getting the homogeneous mixing of Nickel carbide, graphite powder and aluminium composite molten metal was poured into the permanent dies. In casting process die are filled with a lubricating material to reducing sticking of the casting metal to the die. The vent holes are provided with the casting for escaping hot gas into the out. The casting was removed from the die; the casting will be too hot, so that casting must be cooled in order to reduce the oxidation process. The casting material is cooled by the water quenching process. This process contains the rapid cooling of the casting. Material by treating with the water. The casting is dipped in to a water to reduce the heat and to get a solid form of the composite specimen.

2. PROPERTIES OF MATERIALS

2.1. GREY CAST IRON:

Resistance to Deformation:

Grey Cast Iron is highly resistant to deformation and provides a rigid frame. However, if there is some construction related problem, then even Grey Cast Iron made structure can breakdown

Resistance to Oxidation:

Grey Cast Iron is highly resistant to rust, which is formed by the reaction of oxygen and Iron. It is a perfect solution to avoid the problem of corrosion.

High Compressive Strength:

This strength is defined by the endurance of any metal or alloy to withstand its compressive forces. Grey Cast Iron has a high compressive strength and that's why, it is widely used in posts and columns of buildings. In addition, their compressive strength can be as high as that of some Mild Steels.

Tensile Strength:

There are different varieties of Grey Cast Iron and their tensile strength varies accordingly. Some varieties show the tensile strength of 5 tons per square inch, some show 19, but on an average their strength is 7 tons per square inch.

2.2. Aluminum alloy

Corrosion Resistance:

When exposed to air, a layer of aluminium oxide forms almost instantaneously on the surface of aluminium. This layer has excellent resistance to corrosion

Thermal Conductivity :

The thermal conductivity of aluminium is about three times greater than that of steel. This makes aluminium an important material for both cooling and heating applications such as heat-exchangers.

Electrical Conductivity:

Along with copper, aluminium has an electrical conductivity high enough for use as an electrical conductor. Although the conductivity of the commonly used conducting alloy (1350) is only around 62% of annealed copper, it is only one third the weight and can therefore conduct twice as much electricity when compared with copper of the same weight.

Reflectivity of Aluminium:

From UV to infra-red, aluminium is an excellent reflector of radiant energy. Visible light reflectivity of around 80% means it is widely used in light fixtures. The same properties of reflectivity makes aluminium ideal as an insulating material to protect against the sun's rays in summer, while insulating against heat loss in winter.

2.3. Al-Ni Graphite

- High resistance to corrosion in water or air
- Low deformation
- To resist high pressures and temperatures

3. ANALYTICAL CALCULATION FOR PISTON

Analytical calculations are done for cast iron piston. For doing analytical calculation material properties and dimensional information should be known and so all the parameters consider for design of piston are calculated by using one analytical problem. 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.

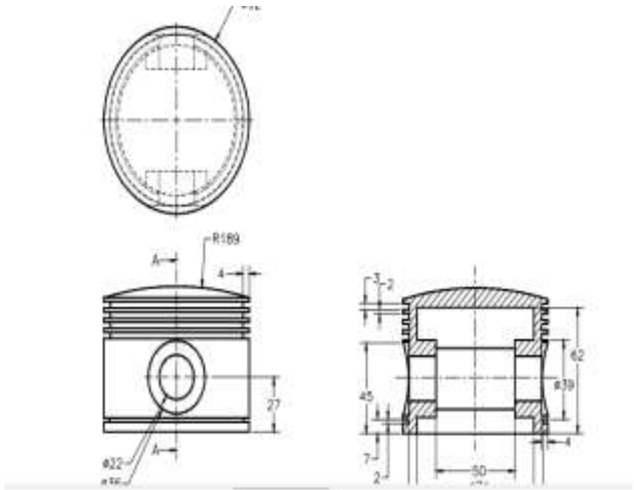
- It should have minimum weight to withstand the inertia forces.
- It should form effective oil sealing in the cylinder.
- It should provide sufficient bearing area to prevent undue wear.
- It should have high speed reciprocation without noise.
- It should be of sufficient rigid construction to withstand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

4. METHODOLOGY:

- Analytical design of piston using specification¬ of Bajaj Pulsar 220CC.
- Creation of 3D models of piston using solid works and then imported in ANSYS 14.5
- Mesh of 3D models using ANSYS 14.5
- Analysis of pistons using static analysis-thermal¬ method.
- Comparative performance of grey cast iron - aluminium alloy piston and composite material under static and thermal analysis method.
- Select the best one aluminium alloy and composite material al-Ni

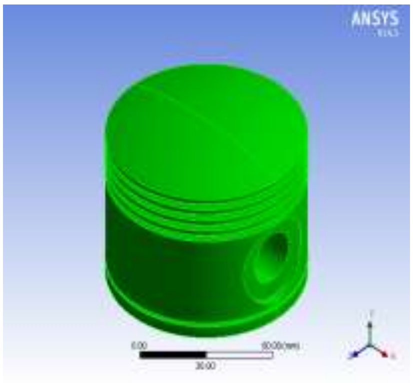
5. MODELING OF PISTON

Sketch with dimensions of a piston:



6. ANSYS ANALYSIS ON PISTON:

The static and thermal analysis for the piston was done by finite elements method using ANSYS software. For ANSYS simulation the solidworks geometry is separated into elements. In this elements are interlinked to one another at a point called as Node. In present examination work we have used FEA for the Thermal and Structural analysis of piston. The solidworks software is used to prepare the piston. After completing solidworks modeling, the model is saved in IGES file then IGES file is imported to ANSYS software for the finite element analysis.



6.1 GREY CAST IRON

For the pressure load applied is 13.65MPa

Gray Cast Iron

Gray Cast Iron > Constants

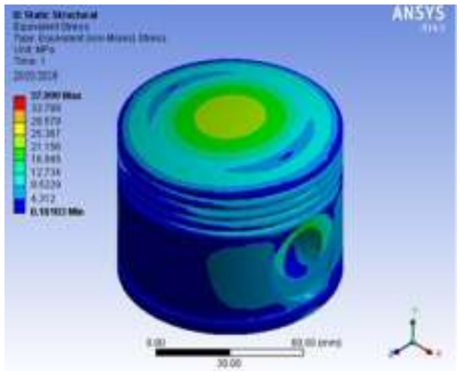
Density	7.2e-009 tonne mm^-3
Coefficient of Thermal Expansion	1.1e-005 C^-1
Specific Heat	4.47e+008 mJ tonne^-1 C^-1
Thermal Conductivity	5.2e-002 W mm^-1 C^-1
Resistivity	9.6e-005 ohm mm

Gray Cast Iron > Compressive Ultimate& Tensile Ultimate Strength

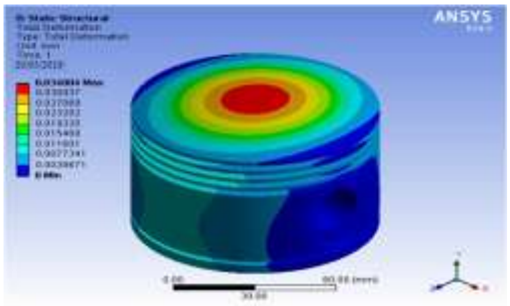
Compressive Ultimate Strength MPa	Tensile Ultimate Strength MPa
820	240

Gray Cast Iron > Isotropic Elasticity

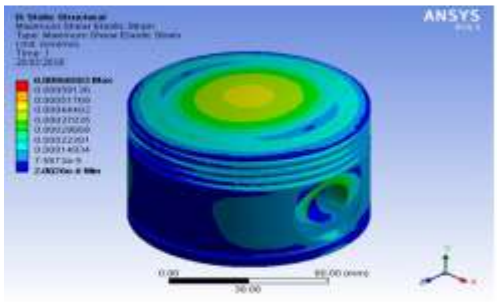
Maximum Stress:



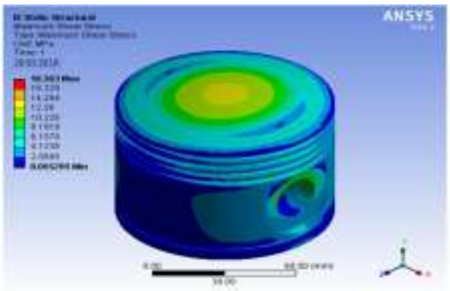
Total Deformation:



Maximum strain:



Maximum shear stress:



Similarly, the max stress, total deformation, max strain, and max shear stress for the other two materials such as ALUMINIUM ALLOY and AL-NI GRAPHITE are as follows.

6.2 ALUMINIUM ALLOY (AL 2024-T361)

For Aluminium Alloy at 13.65Mpa Pressure

Material Data

Aluminium Alloy > Constants

Density	2.77e-009 tonne mm^-3
Coefficient of Thermal Expansion	2.3e-005 C^-1
Specific Heat	8.75e+008 mJ tonne^-1 C^-1

Aluminium Alloy > Compressive Yield & Tensile Yield Strength

Compressive Yield Strength MPa	Tensile Yield Strength
280	280

Aluminium Alloy > Isotropic Elasticity

Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
400	71000	0.33	69608	26692

6.3 Al-Ni-GRAPHITE

Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
400	1.1e+005	0.28	83333	42969

For Aluminium Nickel Carbide Graphite (Al-Ni Graphite) at 13.65 pressure

Material Data

al-Ni-graphite > Constants

Density	2.7114e-009 tonne mm^-3

al-Ni-graphite > Isotropic Elasticity

Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
400	74000	0.34	77083	27612

Al-Ni-graphite > Tensile Yield Strength

Tensile Yield Strength MPa
193.38

RESULTS

Comparision of results for grey cast iron, aluminium alloy, al-Ni-graphite

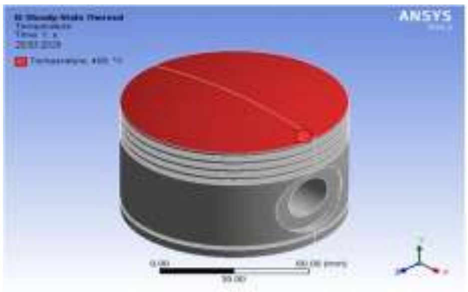
Material	Maximum stress	Total deformation	Maximum strain	Maximum shear stress
Grey cast iron	37.999	0.034804	0.00066503	18.363
Aluminium alloy	35.905	0.036491	0.00069221	18.476
Al-Ni-graphite	35.499	0.024202	0.00046895	20.15

From the above results shown in the table it found that

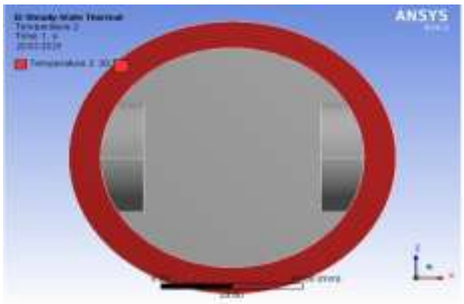
- Static structural analysis is carried out on piston at 13.65MPa pressure with three different materials, such as grey cast iron, aluminium alloy and al-Ni graphite in ansys workbench.
- Maximum stress, deformation, maximum strain and maximum shear stress are noted and tabulated
- From the tables it is concluded that the aluminium Nickel carbide graphite (Al-Ni Graphite) is showing efficient results

7. THERMAL ANALYSIS ON PISTON:

Maximum temperature given at piston crown 400deg

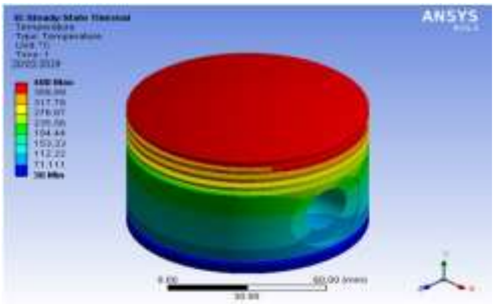


Minimum temperature given at bottom face 30deg

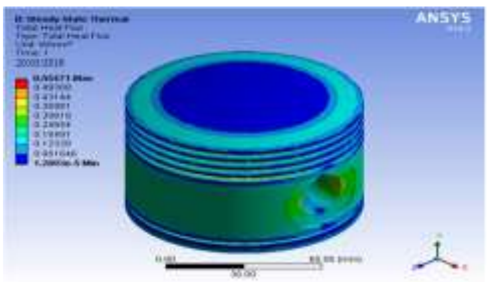


Grey Cast Iron:

Temperature distribution:



Heat flux



Similarly, the heat flux and temperature distribution for the other two materials such as ALUMINIUM ALLOY and AL-NI GRAPHITE are shown in the following results.

RESULTS:

Comparision of results for grey cast iron, aluminium alloy, al-Ni-graphite

Material	Heat flux
Grey cast iron	0.55471 W/mm
Aluminium alloy	1.8145 W/mm
Al-Ni-graphite	1.9201 W/mm

From the above results shown in the table it found that

- Steady state thermal analysis is carried out at maximum temperature 400deg and minimum temperature 30deg for the above three various materials.
- Temperature distribution and heat flux are noted for three different materials and tabulated.
- From the tables it is concluded that the aluminium Nickel carbide graphite (Al-Ni Graphite) is showing efficient results

CONCLUSIONS:

- Modeling and analysis of piston is done
- Modeling of piston is done in solid works 2016 design software by using various commands
- The solidworks part file is converted into IGS file and imported to ansys workbench.
- First Static structural analysis is carried out on piston at 13.65MPa pressure with three different materials, such as grey cast iron, aluminium alloy and al-Ni graphite in ansys workbench.
- Maximum stress, deformation, maximum strain and maximum shear stress are noted and tabulated
- Then steady state thermal analysis is carried out at maximum temperature 400deg and minimum temperature 30deg for the above three various materials.
- Temperature distribution and heat flux are noted for three different materials and tabulated.
- From the tables it is concluded that the aluminium Nickel carbide graphite (Al-Ni Graphite) is showing efficient results
- Hence Al-Ni-Graphite is preferable among the three applied materials.

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