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DESIGN AND STATIC THERMAL ANALYSIS OF PISTON WITH DIFFERENTMATERIAL USING FEM METHOD

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ABSTRACT

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

Key words: FEA, Piston, Stress.etc,.

1.1 INTRODUCTION

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. It has had a significant impact on society, and is considered one of the most significant inventions of the last century. The internal combustion engine has been the foundation for the successful development of many commercial technologies. For example, consider how this type of engine has transformed the transportation industry, allowing the invention and improvement of automobiles, trucks, airplanes and trains. A piston is a component of reciprocating engines, reciprocating pumps, gas compressorsand pneumatic cylinders, among other similar mechanisms. 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. Automobile components are in great demand these days because of increased use of automobiles. The increased demand is due to improved performance and reduced cost of these components. R&D and testing engineers should develop critical components in shortest possible time to minimize launch time for new products. This necessitates understanding of new technologies and quick absorption in the development of new products .A piston is a moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine its purpose is to transfer from expanding gas in the cylinder to the crank shaft via piston rod and or connecting rod. As an important part in an engine piston endures the cyclic gas pressure and inertia forces at work and this working condition may cause the fatigue damage of the piston. The investigations indicate that greatest stress appears on the upper end of the piston and stress concentration is one of the mainly reason for fatigue failureA piston is a component of reciprocating IC engines. It is the moving component with in a cylinder and is made of gas-tight by piston rings. In an engine, piston is used to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod. Piston endures the cyclic gas pressure and the inertial forces at work, and this working condition may cause the fatigue damage of the piston, such as piston side wear, piston head cracks and so on. So there is a need to optimize the design of piston by considering various parameters in this project the parameters selected are analysis of piston by applying pressure force acting at the top of the piston and thermal analysis of piston at various temperatures at the top of the piston in various strokes. This analysis could be useful for design engineers for modification of piston at the time of design.There are significant research works proposing, for engine pistons designs, new geometries, materials and manufacturing techniques, and this evolution has undergone with a continuous improvement over the last decades and required thorough examination of the smallest details. Engine pistons are one of the complex components and its damage mechanisms have different origins and are mainly wear, temperature, and fatigue related. Among the fatigue damages, thermal fatigue and mechanical fatigue, either at room or at high temperature, play a prominent role. For mechanical fatigue analysis we have considered vibration analysis of the piston and used finite element method ANSYS 15.0.The Piston is a 'heart' of an automobile engine. It's one of the key components of the engine and it's working the hard condition. The function of the piston is bearing the gas pressure and making the crankshaft rotation through the piston pin. Piston works in high temperature, high pressure, high speed at poor lubrication conditions. Piston contact with high temperature gas directly, the instantaneous temperature can be up to 2500K. Because of the high temperature and the poor cooling condition, the temperature of the top of the piston can be reach 600~700K when the piston working in the engine and the temperature distribution is uneven. The top of the piston bears the gas pressure, in particular the work pressure.

1.2WORKING CONDITIONS OF PISTON:

Moment of explosion in combustion chamber of engine, the gas temperature can reach around 2000oC– 2200oC,the temperature of the piston head is generally not less than 200oC. Top of the gas under pressure, the pressure for the maximum power stroke, in gasoline engine pressure is up to 3 ~ 5 Mpa and in diesel engine pressure is up to 6 ~ 9 Mpa (standard atmospheric pressure is 0.1 Mpa). High speed of reciprocating motion is about (8 ~ 12 m/s) and the speed is constantly changing.

1.3 PISTON FUNCTION:

The piston is an element of power transmission in engine cylinder, the energy bounded up in fuel is rapidly converted into heat and pressure during combustion process. In short period of time heat and pressure valve increase greatly, the piston has a task of converting released energy in to mechanical work. The usual structure of the piston is a hallow cylinder and closed on one side with the segment piston head with ring belt, pin bas and skirt. The piston head transfers the gas forces (fuel air mixture) from combustion chamber resulting pin boss, piston pin, and connecting rod to crankshaft .

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CHAPTER 2 LITERATURE REVIEW

An optimized piston which is lighter and stronger is coated with zirconium for bio-fuel. In this paper[1], the coated piston undergone a Von misses test by using ANSYS for load applied on the top. Analysis of the stress distribution was done on various parts of the coated piston for finding the stresses due to the gas pressure and thermal variations. Vonmisses stress is increased by 16% and deflection is increased after optimization. But all the parameters are well with in design consideration. Design, Analysis and optimization of piston [2] which is stronger, lighter with minimum cost and with less time. Since the design and weight of the piston influence the engine performance. Analysis of the stress distribution in the various parts of the piston to know the stresses due to the gas pressure and thermal variations using with Ansys. With the definite-element analysis software, a three-dimensional definite-element analysis [3] has been carried out to the gasoline engine piston. Considering the thermal boundary condition, the stress and the deformation distribution conditions of the piston under the coupling effect of the thermal load and explosion pressure have been calculated, thus providing reference for design improvement. Results show that, the main cause of the piston safety, the piston deformation and the great stress is the temperature, so itis feasible to further decrease the piston temperature with structure optimization. This paper [4] involves simulation of a 2-stroke 6S35ME marine diesel engine piston to determine its temperature field, thermal, mechanical and coupled thermal-mechanical stress. The distribution and magnitudes of the afore-mentioned strength parameters are useful in design, failure analysis and optimization of the engine piston. The piston model was developed in solid-works and imported into ANSYS for pre-processing, loading and post processing. Material model chosen was 10-node tetrahedral thermal solid 87. The simulation parameters used in this paper were piston material, combustion pressure, inertial effects and temperature. This work [5] describes the stress distribution of the piston by using finite element method (FEM). FEM is performed by using computer aided engineering (CAE) software. The main objective of this project is to investigate and analyze the stress distribution of piston at the actual engine condition during combustion process.. The report describes the mesh optimization by using FEM technique to predict the higher stress and critical region on the component. The impact of crown thickness, thickness of barrel and piston top land height on stress distribution and total deformation is monitored during the study[6] of actual four stroke engine piston. The entire optimization is carried out based on statistical analysis FEA analysis is carried out using ANSYS for optimum geometry. This paper describes the stress distribution and thermal stresses of three different aluminum alloys piston by using finite element method (FEM). The parameters used for the simulation are operating gas pressure, temperature and material properties of piston. The specifications used for the study of these pistons belong to four stroke single cylinder engine. This topic shows review on design analysis of piston on the basis of improving strength according to the material properties. Vibhandik et. al . (2014), studied that Design analysis and optimization of piston and deformation of its thermal stresses using CAE tools, he had selected I.C. engine piston from TATA motors of diesel engine vehicle. He had performed thermal analysis on conventional diesel piston and secondly on optimized piston made of aluminum alloy and titanium alloy material. Conventional diesel piston made of structural steel. The main objective of this analysis is to reduce the stress concentration on the upper end of the piston so as to increase life of piston. After the analysis he conclude that titanium has better thermal property, it also help us to improve piston qualities but it is expensive for large scale applications, due to which it can be used in some special cases. Ch. Venkata Rajam et. al . (2013), focused on Design analysis and optimization of piston using CATIA and ANSYS. He had optimized with all parameters are within consideration. Target of optimization was to reach a mass reduction of piston. In this analysis a ceramic coating on crown is made. In an optimization of piston, the length is constant because heat flow is not affected the length, diameter is also made constant due to same reason. The volume varied after applying temperature and pressure loads over piston as volume is not only depending on length and diameter but also on thickness which is more affected. The material is removed to reduce the weight of the piston with reduced material. The results obtained by this analysis shows that, by reducing the volume of the piston, thickness of barrel and width of other ring lands, Von mises stress is increased by and Deflection is increased after optimization. But all the parameters are with in design consideration.V. V. Mukkawar et. al . (2015), describes the stress distribution of two different Al alloys by using CAE tools. The piston used for this analysis belongs to four stroke single cylinder engine of Bajaj Pulsar 220 cc motorcycle. He had concluded that deformation is low in AL-GHY 1250 piston as compare to conventional piston. Mass reduction is possible with this alloy. Factor of safety increased up to 27% at same working condition. He used Al-GHY 1250 and conventional material Al-2618 and results were compared, he found that Al-GHY 1250 is better than conventional alloy piston. Manjunatha T. R. et. al. (2013), underlook specification for both high pressure and low pressure stages and analysis is carried out during suction and compression stroke and identify area those are likely to fail due to maximum stress concentration. The material used foe the cylinder is cast-iron and for piston aluminum alloy for both low and high pressure. He concluded that the stress developed during suction and compression stroke is less than the allowable stress. So the design is safe. Swati S. chougule et. al. (2013), focused on the main objective of this paper is to investigate and analyze the stress distribution of piston at actual engine condition during combustion process the parameters used for simulation is operating gas pressure and material properties of piston. She concluded that there is a scope for reduction in a scope for reduction in thickness of piston and therefore 0ptimization of piston is done with mass reduction by 24.319% than non-optimized piston. The static and dynamic analysis is carried out which are well below the permissible stress value. The study of Lokesh Singh et. al . (2015) is related to the material for the piston is aluminumsilicon composites. The high temperature at piston head, due to direct contact with gas, thermal boundary conditions is applied and for maximum pressure mechanical boundary conditions are applied. After all these analysis all values obtained by the analysis is less than permissible value so the design is safe under applied loading condition. The study of R. C. Singh et. al. (2014), discussed about failure of piston in I.C. engines, after all the review, it was found that the function coefficient increases with increasing surface roughness of liner surface and thermal performance of the

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piston increases. The stress values obtained from FEA during analysis is compared with material properties of the piston like aluminum alloy zirconium material. If those value obtained are less than allowable stress value of material then the design is safe.

CHAPTER 3 PROJECT OVER VIEW

3.1PISTON 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.

3. 2 OBJECTIVES:

1. Analytical design of piston using Bajaj Kawasaki petrol engine specifications.
2. Obtaining design of piston using catia v5 and then imported in ansys 15.0
3. Meshing of design model using ANSYS 15.
4. Analysis of piston by static analysis and thermal analysis method.
5. Comparing the performance of five different materials aluminum alloys piston under structural and thermal analysis process.
6. Identification of the suitable aluminum alloy material for manufacturing of the piston under specified conditions.

3.3METHODOLOGY:

- Analytical design of piston, using specification of four stroke single cylinder engine of Bajaj Kawasaki motorcycle created.
- Creation of 3D model of piston using CATIA V5 and then imported in ANSYS 14.5.
- Analysis of piston using FEA method.
- Comparative performance of Al alloy piston.
- Select the best Material for piston material

3. 4 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.

3.5 COMMENLY USED MATERIALS: 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. Many researchers stated that for a cast iron piston, the temperature at the centre of the piston head (TC) is about 425°C to 450°C under full load conditions and the temperature at the edges of the piston head (TE) is about 200°C to 225°C. and also for aluminium alloy pistons, TC is about 260°C to 290°C and TE is about 185°C to 215°C. Characterization of Materials: The materials chosen are of pure Aluminium, Al-6061, Al- 6082 and Al-7075 for this work for an internal combustion engine piston. The relevant mechanical and thermal properties of pure Aluminium, Al-6061, Al-6082 and Al-7075 aluminium alloys are listed in the following table

3.6 ENGINE SPECIFICATIONS:

The engine used for this work is a single cylinder four stroke air cooled type Bajaj Kawasaki petrol engine. The engine specifications are given in below tabl

Table 1 ENGINE SPECIFICATIONS

S.NO	parameters	values
1	Engine type	Four stroke, petrol engine
2	No. of cylinder	Single cylinder engine
3	Maximum pressure	$18N/mm^2$
4	Bore	50mm
5	Stroke length	81.25 mm
6	Speed	5000rpm
7	Brake power	8Bhp
8	Compression ratio	8.4
9	Maximum torque	8.05Nm at 5500
10	Maximum horse power	6.0. kw at 7500 rpm

3.7. ANALYTICAL DESIGN:

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 (mm2)

r = crank radius (mm)

lc = length of connecting rod (mm)

a = acceleration of the reciprocating part (m/s2)

mp = mass of the piston (Kg)

V = volume of the piston (mm3)

th = thickness of piston head (mm)

D = cylinder bore (mm)

pmax = maximum gas pressure or explosion pressure (MPa)

σt = allowable tensile strength (MPa)

σut = ultimate tensile strength (MPa)

F.O.S = Factor of Safety = 2.25

K = thermal conductivity (W/m K)

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

Te = 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/mm2) = 0.025 Mpa

σp = permissible tensile strength for ring material (N/mm2) = 1110 N/mm2

h = axial thickness of piston ring (mm)

h1 = width of top lands (mm)

h2 = width of ring lands (mm)

t1 = thickness of piston barrel at the top end (mm)

t2 = thickness of piston barrel at the open end (mm)

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ls = length of skirt (mm)

μ = coefficient of friction (0.01)

l1 = length of piston pin in the bush of the small end of the connecting rod (mm)

do = outer diameter of piston pin (mm)

Mechanical efficiency of the engine (η) = 80 %

$$\eta = \frac{\text{Brake power (B.P)}}{\text{Indicating power (I.P)}}$$

$$\text{Therefore, I.P} = \frac{\text{Brake power (B.P)}}{0.8} \quad \text{I.P} = \frac{6.2}{\eta}$$

I.P = 7.75 KW

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

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

Substituting the values from Table

$$\text{We have } 7.75 \times 1000 = P \times \frac{\pi}{4} (0.051)^2 \times (\quad \frac{5000}{2 \times 60}$$

$$\text{So, } P = 18.66 \times 10^5 \frac{N}{m^2}$$

Or P = 1.866 MPa Maximum Pressure pmax = 10 1.866 = 18.66 MPa

From above calculations

3.7.1. Analytical design considerations for alloy piston:

Thickness of the Piston Head: th = 7.3 mm.

Piston Rings: b = 1.33 mm and h = 1 mm.

Width of Top Land: h1 = 7.3 mm.

Ring Lands: h2 = 0.75 mm Thickness of piston barrel at the Top end: t1 = 7.76 mm

Open end: t2 = 2 mm.

Length of the skirt: ls = 30.6 mm

Length of piston pin in the connecting rod bushing: l1 = 22.95 mm.

Piston pin diameter: do = 14.2

3.8 PROPERTIES OF MATERIALS

Al 4032:

Aluminium/Aluminum alloys are known for strong corrosion resistance. These alloys are sensitive to high temperatures ranging between 200 and 250°C (392 and 482°F), and tend to lose some of its strength. However, the strength of Aluminium/Aluminum alloys can be enhanced at subzero temperatures, making them ideal low-temperature alloys.

Aluminium/Aluminum 4032 alloy is a wrought alloy type. The following datasheet will provide more details about Aluminium/Aluminum 4032 alloy.4032 aluminum is an alloy of aluminum, further classified within the AA 4000 series (aluminum-silicon wrought alloy). It is typically furnished in the T6 temper. 4032 is the Aluminum Association (AA) designation for this material. In European standards, it will typically be given as EN AW-4032. Additionally, the EN chemical designation is AlSi12,5MgCuNi. And the British Standard (BS) designation is DTD324B.

6082 aluminium alloy

6082 aluminium alloy is an alloy in the wrought aluminium-magnesium-silicon family (6000 or 6xxx series). It is one of the more popular alloys in its series (alongside alloys 6005, 6061, and 6063), although it is not strongly featured in ASTM (North American) standards. It is typically formed by extrusion and rolling, but as a wrought alloy it is not used in casting. It can also be forged and clad, but that is not common practice with this alloy. It cannot be work hardened, but is commonly heat treated to produce tempers with a higher strength but lower ductility

Aluminum alloy 7075:

Aluminum alloy 7075 is an aluminum alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than many other Al alloys, but has significantly better corrosion resistance than the 2000 alloys. Its relatively high cost limits its use to applications where cheaper alloys are not suitable.

7075 aluminum alloy's composition roughly includes 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper, and less than a half percent of silicon, iron, manganese, titanium, chromium, and other metals. It is produced in many tempers, some of which are **7075-0**, **7075-T6**, **7075-T651**

AL-SIC graphite material:

PREPARATION OF AL-SICGRAPHITES 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-Sic-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 silicon 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. Silicon carbide and Graphite powder preheated before mixing of aluminium metal molt, the four blades Stirrer was designed in order to produce the sufficient homogenous particle circulation throughout the matrix material[5]. After getting the homogeneous mixing of silicon 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.

hardness of the composite specimen and decrease the deformation. The brinnel hardness number is increases in the Al-Sic-Graphite sample compared to the pure aluminium. The impact strength value has been increased by adding the graphite in the metal matrix. Impact strength is decrease with increase graphite more than 30 grams. In this metal matrix percentage of elongation decreases with addition of graphite. Tensile strength has been increases by adding the Sic and graphite in composite material. The Young's modulus value of the hybrid metal matrix is higher compared to the aluminium. This demonstrates the Al-Sic-Graphite is better in all the perspectives when compared to the pure Aluminium.

S.NO	Parameters	Al-sic graphite	A7075	A6082	A4032	AL-ghy 1250
1	Density(Kg/m^3)	2711.4	2761.9	2700	2684.95	2880
2	Poisons ratio(μ)	0.34	0.33	0.33	0.33	0.3
3	Young's modulus(Gpa)	74	73	71	82	83
4	Ultimate Tensile strength(Mpa)	193.38	512	330	380	1250
5	Thermal conductivity (k)(W/m°C)	147	130	180	154	130
6	Specific heat (J/Kg°c)	826	860	890	870	880

Aluminum alloy Al-GHY1250:

It is an ultra high strength Aluminum alloy processed via mechanically alloying route. The high strength and temperature stability comes from the Yttrium and Oxides. This alloy even outperforms most of the new amorphous Aluminium alloys. Due to the very stable and small Oxides it shows outstanding strength at elevated temperatures. It is the Excellent temperature stability.

3.8 PROBLEM IDENTIFICATION:

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. 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 cracks and so on working condition of the piston of an internal combustion engine is so worst are high chances of failure of piston due to wear and tear. So there is necessary to analyze area of maximum stress concentration, strain, deformation and temperature distribution and heat flux on piston. The objective of the present work is to design and analysis of piston made UP of A4032, Al-GHY1250,AL6082,AL7075, ALSIC GRAPHITE.

CHAPTER 4 INTRODUCTION TO CATIA V5R20

4.1 INTRODUCTION :

Welcome to **CATIA (Computer Aided Three Dimensional Interactive Application)**. As anew user of this software package, you will join hands with thousands of users of this high-end CAD/CAM/CAE tool worldwide. If you are already familiar with the previous releases, you can upgrade your designing skills with the tremendous improvement in this latest release.

CATIA V5, developed by Dasssault Systems, France, is a completely re-engineered, Next-generation family of CAD/CAM/CAE software solutions for Product Lifecycle Management. Through its exceptionally easy-to-use and state-of-the-art user interface, CATIA V5 delivers innovative technologies for maximum productivity and creativity, from the inception concept to the final product. CATIA V5 reduces the learning curve, as it allows the flexibility of using feature-based and parametric designs.

4.2 DESIGNING OF THE MODEL: DESIGN PROCEDURE IN CATIA WORK BENCH:

1Create the half piston profile in sketcher workbench next go to exist work bench (part design) now go to the sketched based features and go to shaft option apply angle 360 after create the planes offset to xy planes create the circles and apply pocket around the up to surface now go to mirror option apply mirror finally as shown the figure below:

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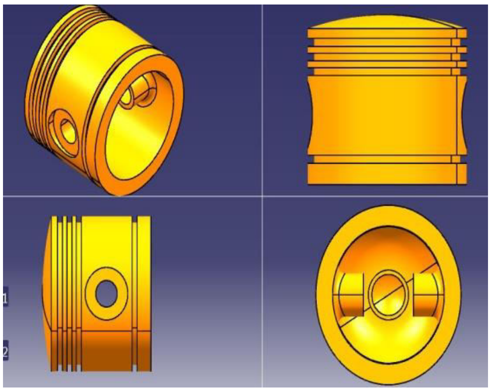

Figure 1 piston in catia work bench

CHAPTER 5 INTRODUCTION TO ANSYS

ANSYS is a large-scale multipurpose finite element program developed and maintained by ANSYS Inc. to analyze a wide spectrum of problems encountered in engineering mechanics**.**

5.1 PROGRAM ORGANIZATION:

The ANSYS program is organized into two basic levels:

- Begin level
- Processor (or Routine) level

The Begin level acts as a gateway into and out of the ANSYS program. It is also used for certain global program controls such as changing the job name, clearing (zeroing out) the database, and copying binary files. When you first enter the program, you are at the Begin level.

At the Processor level, several processors are available. Each processor is a set of functions that perform a specific analysis task. For example, the general pre-processor (PREP7) is where you build the model, the solution processor (SOLUTION) is where you apply loads and obtain the solution, and the general postprocessor (POST1) is where you evaluate the results of a solution. An additional postprocessor, POST26, enables you to evaluate solution results at specific points in the model as a function of time.

6.CHAPTER ANALYSIS

6.1 STRUCTURAL STATIC ANALYSIS:

A static analysis calculates the effects of study loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time varying loads. A static analysis can however include steady inertia loads and time varying loads that can be approximated as static equivalent loads. Static analysis is used to determine the displacements, stresses, strains and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed, i.e. the loads and the structure's responses are assumed to vary slowly with respect to time. The kinds of loading that can be applied in static analysis include:

- Externally applied forces and pressures.
- Steady state inertial forces
- Imposed displacement
- Temperatures

  Fluences (for nuclear swelling)
- Imposed displacement

6.2 PROCEDURE OF STATIC ANALYSIS & THERMAL ANALYSIS:

Create the geomentry in catia workbench and save the file in igs format and open ansys workbench apply engineering data(material properties), create or import the geomentry, apply model(meshing),apply boundary conditions(setup) shown the results(stress,deformation,heat flux).

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Analysis of Piston:
Frictionless support at pin bore areas and fixed all degree of freedom. Downward pressure (18.66 MPa) due to gas load acting on piston head. The piston is analyzed by giving the constraints they are Pressure or structural analysis and Thermal analysis.
Structural Analysis of Piston: Combustion of gases in the combustion chamber exerts pressure on the head of the piston during power stroke. The pressure force will be taken as boundary condition in structural analysis. Fixed support has given at surface of pin hole. Due to the piston will move from TDC to BDC with the help of fixed support at pin hole. So whatever the load is applying on piston due to gas explosion that force causes to

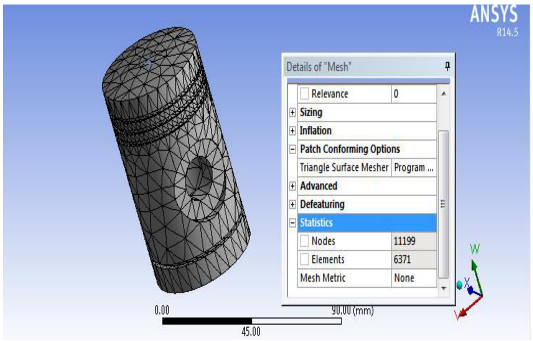

Figure 2 Mesh body

MESH BODY,NODES:11199,ELEMENTS :6371

6.3 BOUDARY CONDITIONS AT STATIC ANDTHERMAL ANALYSIS
Boudary conditions and in static analysis
1. Maximum pressure load at the top surface of the piston crown 18.66 Mpa
2. Temperature at the top surface of the piston crown 800^0C
3. Piston pin holes are fixed DX = DY = DZ = 0

6.3.1BOUNDARY CONDITIONS AND IN STATIC ANALYSIS :

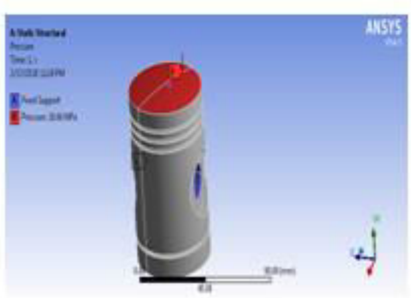

Figure 3 Boundary condition of static analysis

6.3.2Boundary conditions and loads at thermal analysis:

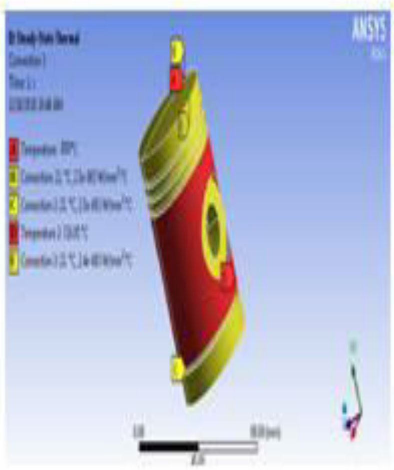

Figure 4 Boundary conditions of thermal analysis

7.CHAPTER RESULTS AND DISCUSSIONS
The constructed piston in catia is analyzed using ANSYS V15.0 and the results are depicted below. Combustion of gases in the combustion chamber exerts pressure on the head of the piston during power stroke. Fixed support has given at surface of pinhole. Because the piston will move from top dead

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center to bottom dead centre with the help of fixed support at pinhole.

7.1EQUIVALENT STRAIN

From figure 0-27, we can observe that in case of equivalent strain , piston made of Al-sic graphite is found to have least strain of 0.0013 in comparison with remaining materials including the present material. Highest strain of 0.00016021 is observed in piston made of A6082. Maximum equivalent strain on A4032 was found to be 0.0014 that of AL-ghy 1250 was found to be 0.00152 and A7075 was found to be0.00146

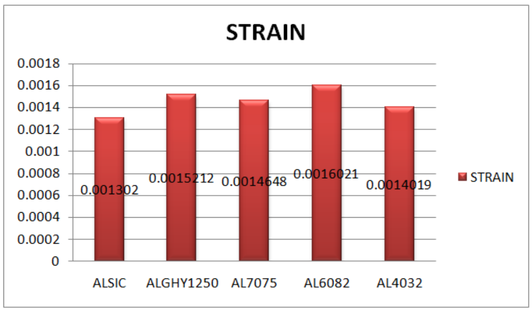

Figure 5 Equivalent strain graph

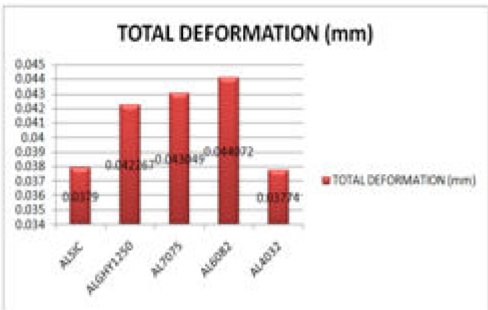

Figure 6 Total deformation graph

7.11.1.3 Total deformation

From figure 0-28, we can observe that in case of total deformation , piston made of Al-sic graphite is found to have least total deformation of 0.0379mm in comparison with remaining materials including the present material. Highest total deformation of 0.044072mmis observed in piston made of A6082. Maximum total deformation on A4032 was found to be 0.037 mm, that of AL-ghy 1250 was found to be 0.0422 mm and A7075 was found to be 0.0430mm.

7.2THERMAL ANALYSIS

Heat flux

From figure 0-29, we can observe that in case of heat flux, piston made of A4032 is found to have least heat flux of 9.7878 w/mm^2 in comparison with remaining materials including the present material. Highest heat flux of 12.633 is observed in piston made of Al-sic graphite. Maximum heat flux on AL-ghy 1250 was found to be 10.88 w/mm^2, that of A6081was found to be 10.171 w/mm^2 and A7075was found to be 11.318 w/mm^2

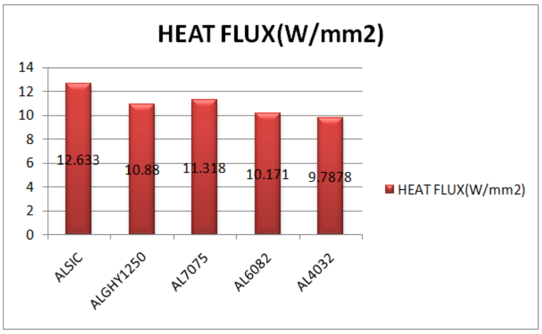

Figure 7 Heat flux

7.3Temperature distribution :

From figure 0-30, we can observe that in case of temperature distribution , piston made of Al-sic graphite is found to have least temperature distribution of 355.96 ^{0}C in comparison with remaining materials including the present material. Highest temperature distribution of 451.3^{0}C is observed in piston made of A4032. Minimum temperature distribution on A7075 was found to be 389.01^{0}C, that of A6082 was found to be 358.48^{0}C and Al-ghy1250 was found to be 357.99^{0}C

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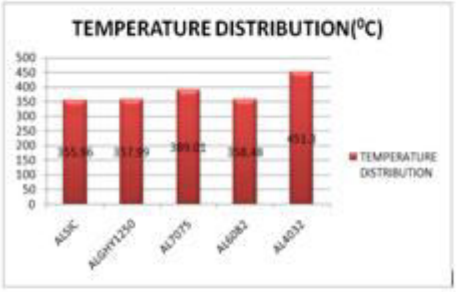

Figure 8 Temperature distribution graph

7.CONCLUSION

Pistons made of different aluminum alloys like Al-sic graphite, A7075, A6082, A4032, AL-GHY 1250 were designed and analyzed successfully. In structural analysis, and in thermal analysis the pistons were analyzed to find out the equivalent (von-mises) stress, equivalent elastic strain, total deformation heat flux and temperature distribution . The results show that in case of equivalent (von-misses) stress, piston of Al-sic graphite is found to have least stress of 104.21Mpa in comparison with remaining materials. Highest stress of 113.702 MPa is observed in material of A4032, followed by A6082, AL-ghy 1250 and A7075.From the strain analysis figures, it can be observed that maximum strain is near pistion pin area in all the materials. The results show that in case of equivalent (von-misses) strain, piston of Al-sic graphite is found to have least strain of 0.001302 in comparison with remaining materials. Highest strain s of 0.00016 is observed in material of A6082, followed by A4032, AL-ghy 1250 and A7075. The results show that in case of Total deformation, piston of Al-sic graphite is found to have least strain of 0.037 in comparison with remaining materials. Highest strain s of 0.044 is observed in material of A6082, followed by A4032, AL-ghy 1250 and A7075. The results show that in case of temperature distribution , piston of Al-sic graphite is found to have minimum temperature 355.96 .The results show that in case of heat flux , piston of Al-sic graphite is found to have highest heat flux of 12.633 in comparison with remaining materials. Least heat flux of 10.171 is observed in material of A6082, followed by A7075, A4032, and Al-ghy 1250.finally suitable material for piston is al-sic graphite material.

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