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Design and Analysis of Piston by using Ansys Workbench

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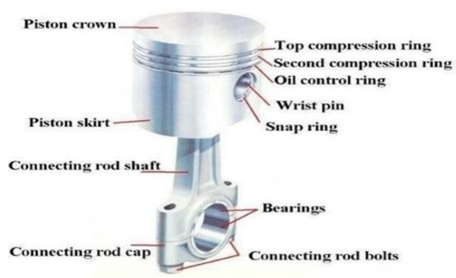
***Abstract:** In this study, structural analysis is investigated on conventional piston made of cast iron. Secondly analysis are performed on piston made of aluminum, titanium alloy , structural steel and fiber glass. The material used for the design of piston should have light weight, low cost, structurally and thermally withstand at very high pressure and temperature condition that will occur in combustion process. In this project, It has been decide to study a particular piston design And its capability for maximum gas pressure. In this work, initial planning is to make piston model using solid modeling software CATIA V5. It has been decided to mesh the geometry analyze using ANSYS. For the analysis of piston input conditions and process of analysis, a lot of literature survey has been done. High combustion gas pressure will act as a mechanical loads and causes major stresses in the critical region of the piston. Detailed static structural analysis is carried out for various loading conditions like maximum gas pressure load.*

***Keywords:** Design calculations, CATIA v5 & ANSYS 19.0*

I. INTRODUCTION

A. Piston

Piston is one of the most important components in internal combustion engine which reciprocates within the cylinder. The main function of the piston is to transfer force from gas in the cylinder to the crank shaft through connecting rod. It is very important to calculate temperature distribution on the piston in order to control thermal stresses and deformation in working condition.



Piston produces stresses and deformation due to periodic load effects which produces from high gas pressure high speed reciprocating motion of inertia force. Lateral force by the chemical reaction ofburning the gas high pressure generates which make the piston expand which generates thermal stresses and thermal deformation.

B. Parts Of Piston

Piston Head or crown: It is flat, convex or concave depending on design of combustion chamber. Itwithstands pressure of gas in the cylinder.

Fig: 1. piston crown

1) *Piston rings:* It is used to seal the cylinder in orderto prevent leakage of gas pressure.

Fig: 2. piston rings

2) *Skirt:* It act as bearing for the side thrust ofconnecting rod on the walls of cylinder.

Fig: 3. piston skirt

II. INTRODUCTION OF CATIA

CATIA (Computer Aided Three-Dimensional Interactive Application) started as a mini house development in 1977 by French aircraft manufacturer Avions Marcel Dassault, at that time customer of the CAD/CAM CAD software to develop Dassault's Mirage fighter jet. It was later adopted in the aerospace, automotive, shipbuilding,and other industries.

A. *Mechanical Engineering*

CATIA enables the creation of 3D parts, from 3D sketches, sheet metal, composites, and molded, forged or tooling parts up to the definition of mechanical assemblies. The software provides advanced technologies for mechanical surfacing & BIW. It provides tools to complete product definition, including functional tolerances as well askinematics definition. CATIA provides a wide range of applications for tooling design, for both generic tooling and mold & die.

Computer aided modeling of piston

Initially, CATIA name is an abbreviation for Computer Aided Three- dimensional Interactive Application the French Dassault Systems is the parent company and IBM participates in the software's and marketing, and CATIA is invades broad industrial sectors, and has been explained in the previous post position of CATIA between 3d modelling software programs A Window will be opened and there are types of design

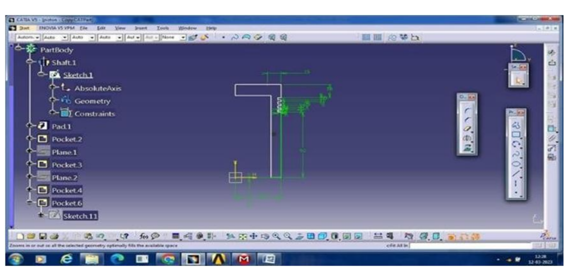


Fig: 4. sketch view of piston

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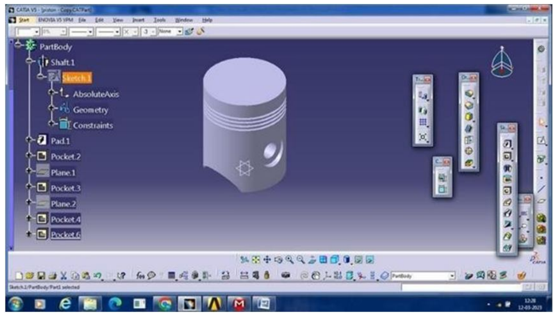

Fig: 5. 3D model of piston

III. FINITE ELEMENT ANALYSIS

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz methodof numerical analysis and minimization of variationcalculus to obtain approximate solutions to vibrationsystems. Shortly thereafter, a paper publishedin1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis.

A. Finite Element Analysis Of Piston

Software which is used to solve structural, thermal and Completion fluid dynamics related problems. The founder of the company is ANSYS pvt limited. This company will release new different version every year. It includes advanced nonlinear topics and releases new version. ANSYS started in 1980'sand from then it released many versions till now. ANSYS 19.0 version is available now. This software is usedin different industries like automobiles, aircrafts,shipyard, spacecraft, manufacturing, education, thermal power stations, fluid problems etc, are used

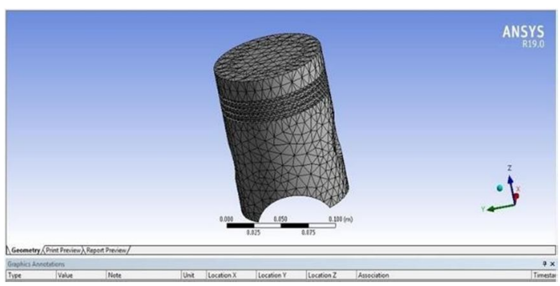

Fig: 6. Finate element model of piston

In the present work, the piston assemblycomponents are divided into 16024 tetrahedron elements and 30343 nodes. In real time, the positionwhere we place the piston pin in its exact location, likewise in ANSYS software same location we applied the boundary condition. Fixed boundary conditions are applied at the piston pin.

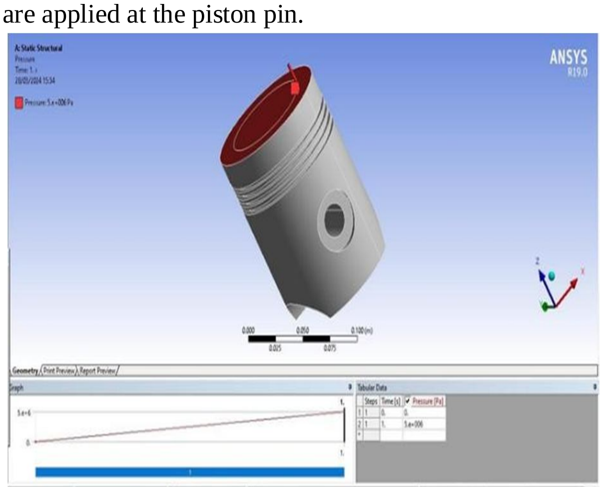

Fig: 7. boundary condition taken for structuralanalysis

B. Analysis Of Piston Using Cast IronMaterial

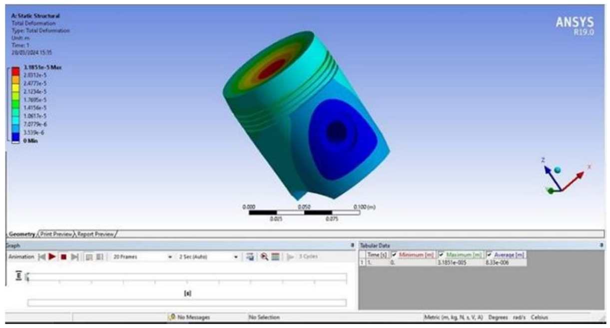

Fig: 8. deformation of cast iron piston

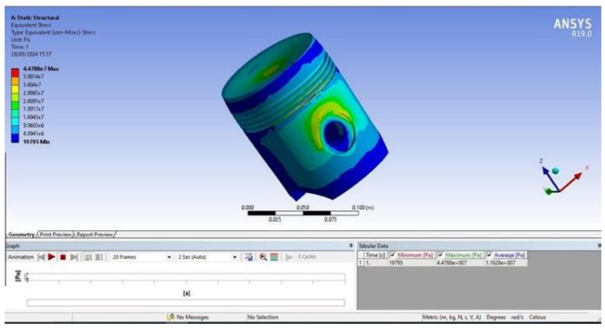

Fig: 10. stress on cast iron piston

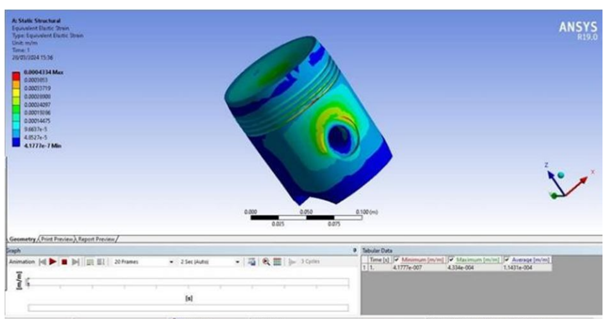

Fig: 11. strain on cast iron piston

C. Analysis Of Piston Using Aluminum Material

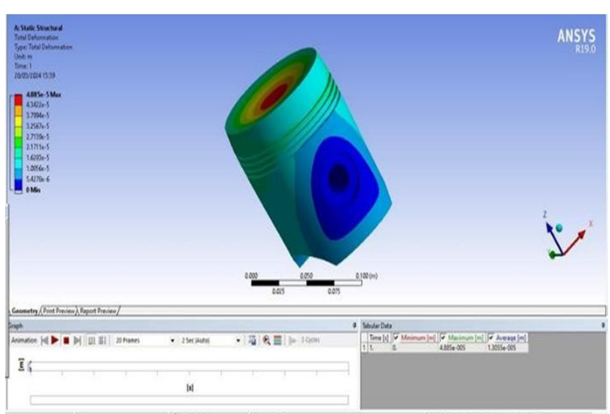

Fig:12. deformation on ALUMINIUM piston

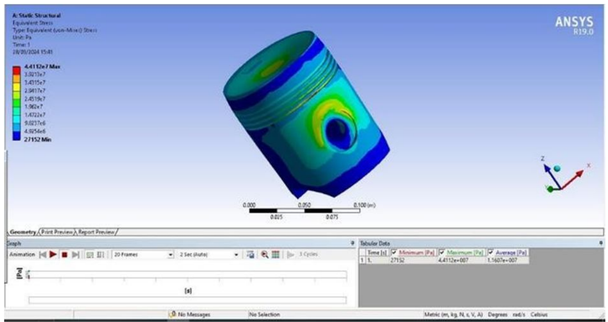

Fig: 13. stress on ALUMINIUM piston

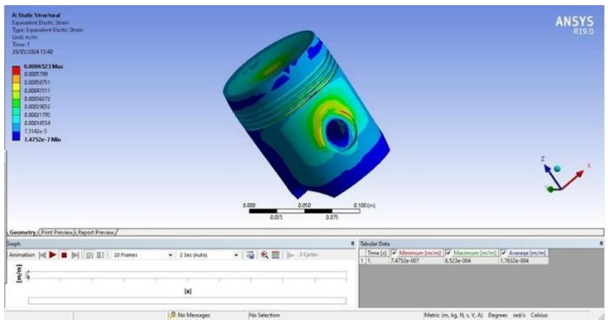

Fig: 14. strain on aluminum piston

D. Analysis Of Piston Using TitaniumAlloy Material

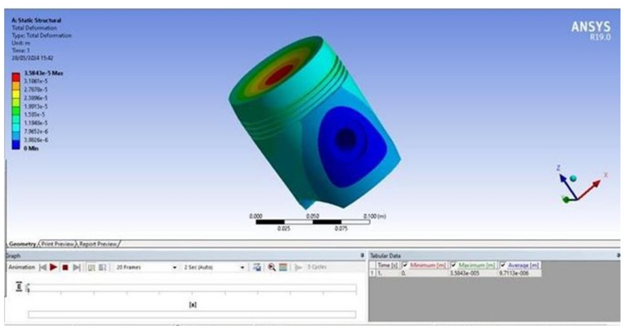

Fig: 15. deformation on titanium alloy piston

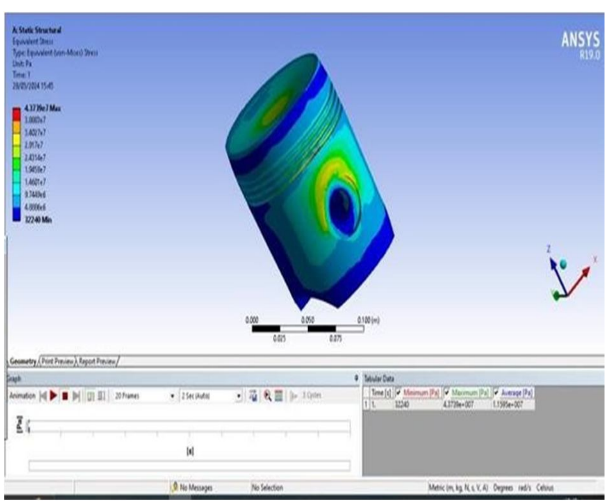

Fig: 16. stress on titanium alloy piston

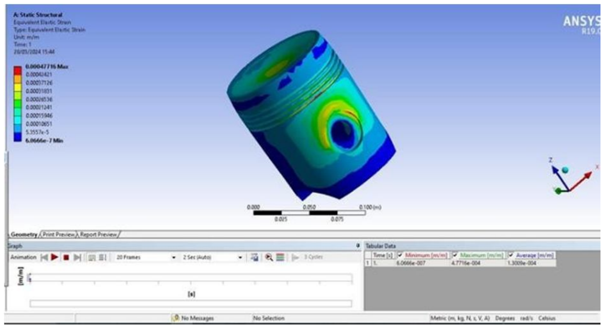

Fig: 17. strain on titanium alloy piston

E. Analysis Of Piston Using StructuralSteel

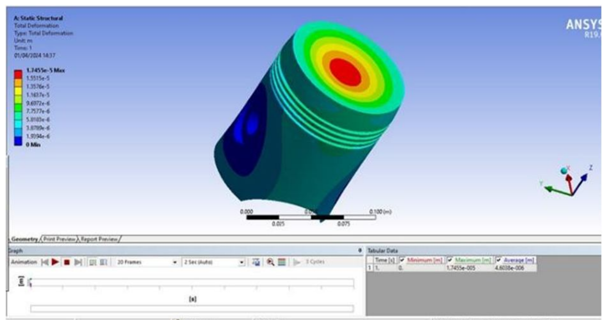

Fig: 18. deformation on structural steel piston

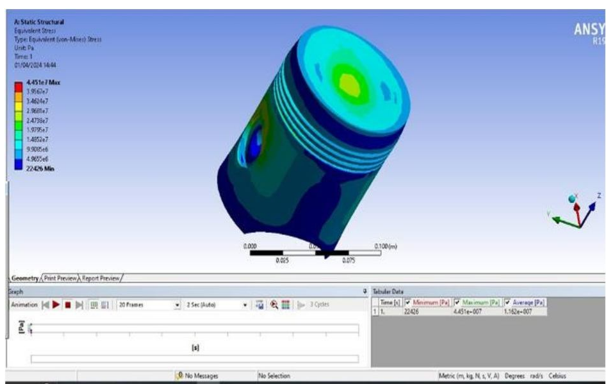

Fig: 19. stress on structural steel piston

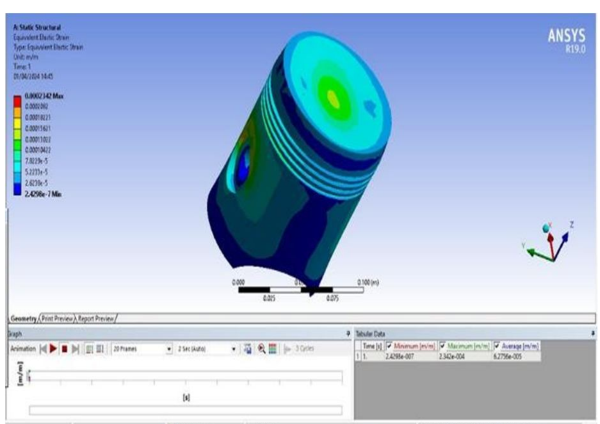

Fig: 20. strain on structural steel piston

F. Analysis Of Piston Using Epoxy GlassMaterial

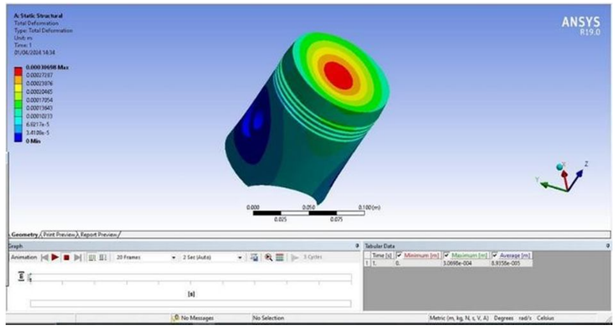

Fig: 21. deformation on epoxy piston

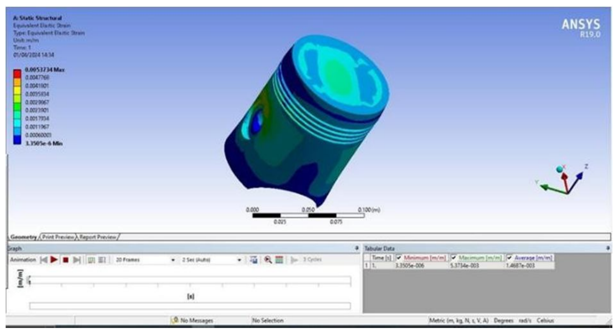

Fig: 22. stress on epoxy piston

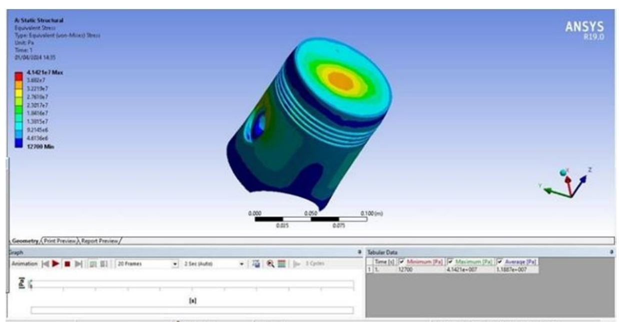

Fig: 23. strain on epoxy piston

IV. RESULTS

The geometry model is designed for 5 MPA gas pressure capacity. And bore Dia is assumed as 50 mm. using design calculations the entire dimensionsare calculated. And model is prepared in the CATIA software. Analysis is performed in the ANSYS workbench. Deformation, stress and strain for five different materials are noted and tabulated below

S No	Parameters	CAST IRON Max	ALUMINIUM Max	TITANIUMA LLOY Max	STRUCTU RAL STEEL Max	EPOXY E GLASS MAX
1	Total Deformation (mm)	0.0318	0.0488	0.0358	0.00074	0.0.0003669 8
2	Equivalent stress(MPa)	44.788	44.112	43.739	44.51	53.73
3	Equivalent strain (MPa)	0.000433	0.000652	0.000477	0.002342	0.000414

Fig: 24. result and comparative analysis ofmaterials

V. GRAPHS

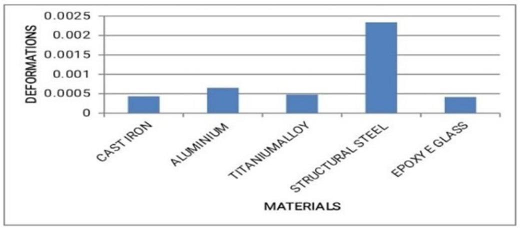

Fig: 25. deformation of piston with differentmaterials

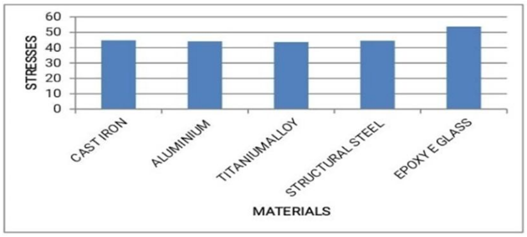

Fig: 26. stress on piston with different materials

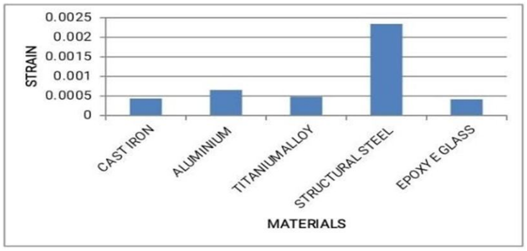

Fig: 27. strain on piston with different materials

VI. CONCLUSION

It is concluded from the above study that using CATIA V5 R20 software design and modeling become easier. Only few steps are needed to make drawing in three dimensions. Same can be imported to ANSYS for analysis. Piston made of five different materials CASTIRON, ALUMINIUM, TITANIUM ALLOY, STRUCTURAL STEEL & EPOXY GLASS are analyzed. Their structural analysis shows that the maximum stress intensity is on the bottom surface of the piston crown in all the materials, but stress intensity is close to the yield strength of alloy piston. Theoretical calculation are performed and is validated with Ansys results. Aluminum material is having minimum stress as well as it is having high safety factor. So finally concluded that Aluminum material is optimum material for piston.

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