DESIGN AND ANALYSIS OF DIESEL ENGINE PISTON

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Abstract:Piston is a component of reciprocating engine and reciprocating pumps and other similar mechanisms. Piston is a vital component in an engine. Piston acts as a valve by covering and uncovering ports in the cylinder wall. Piston can be manufactured in two ways: Casting and Forging. The performance of the piston mainly depends upon the design and materials selected for manufacturing it. In this present work piston is designed in CATIA V5R20and further the analysis was carried out in ANSYS workbench. For carrying out the analysis three materials were selected, they are Aluminium, Grey cast iron, Structural steel. Static analysis was carried out and results are tabulated. Total deformation and Von -mises stress are calculated and found out that which materials suits for the assumedconditions.

Keywords: Piston, Aluminium, Grey cast iron, Structural steel.

1.INTRODUCTION

Automobiles consists of various number of parts, out of which piston is one of the most vital component. It is a vital component in cylindrical engine. Basically pistons are moving components which are contained in the cylinder. The main purpose of the piston is to transfer force from e xpanding gas in the cylinder to the crankshaft via piston rod or connecting rod. There are basically four types of pistons: Trunk piston, Crosshead piston, Slipper piston and Deflector piston. The applications of various types of pistons are: Trunk pistons are used in marine diesel engines, Crosshead pistons are used in steam locomotives, Slipper pistons are used in petrol engines like in Formula1 and MotoGP

where high performance is required and Deflector pistons are used where gas flow in cylinder must be carefully directed in order to provide efficient scavenging. In this present work three materials were selected for carrying out analysis, they are Aluminium, Grey Cast iron and Structural steel. The properties of the selected materials are asfollows:

Properties	Aluminium	Grey Cast iron	Structural Steel
Density	2710 Kg/m^3	7200 Kg/m^3	7800 Kg/m^3
Tensile Yield Strength	280 MPa	240 MPa	250 MPa
Ultimate Yield Strength	330 MPa	450 MPa	460 MPa
Young's Modulus	71 GPa	140 GPa	210 GPa

1. METHODOLOGY

Computer-aided design (CAD), also known as computer-aided design and drafting (CADD), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provide the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. The development of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software (construction, manufacturing, etc.) typically uses vector-based (linear) environments whereas graphic-based software utilizes raster-based (pixilated) environments.

CADD environments often involve more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) objects.

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete ENGINE geometry.

The design of geometric models for object shapes, in particular, is often called computer-aidedgeometricdesign (*CAGD*).

Current computer-aided design software packages range from 2D vector-based drafting systems to 3D solid and surface modellers. Modern CAD packages can also frequently allow rotations in three dimensions, allowing viewing of a designed object from any desired angle, even from the inside looking out. Some CAD software is capable of dynamic mathematic modeling, in which case it may be marketed as CADD — computer-aided design and drafting.

CAD is used in the design of tools and machinery and in the drafting and design of all types of buildings, from small residential types (houses) to the largest commercial and industrial structures (hospitals and factories).

CAD is mainly used for detailed engineering of 3D models and/or 2D drawings of physical components, but it is also used throughout the engineering process from conceptual design and layout of products, through strength and dynamic analysis of assemblies to definition of manufacturing methods of components. It can also be used to design objects.

CAD has become an especially important technology within the scope of computer-aided technologies, with benefits such as lower product development costs and a greatly shortened design cycle. CAD enables designers to lay out and develop work on screen, print it out and save it for future editing, saving time on their drawings.

Types of CAD Software

2D CAD

Two-dimensional, or 2D, CAD is used to create flat drawings of products and structures. Objects created in 2D CAD are made up of lines, circles, ovals, slots and curves. 2D CAD programs usually include a library of geometric images; the ability to create Bezier curves, splines and polylines; the ability to define hatching patterns; and the ability to provide a bill of materials generation. Among the most popular 2D CAD programs are AutoCAD, CADkey, CADDS 5, and Medusa.

3D CAD

Three-dimensional (3D) CAD programs come in a wide variety of types, intended for different applications and levels of detail. Overall, 3D CAD programs create a realistic model of what the design object will look like, allowing designers to solve potential problems earlier and with lower production costs. Some 3D CAD programs include Autodesk Inventor, Co Create Solid

Designer, Pro/Engineer Solid Edge, Solid Works, Unigraphics NX and VX CAD, CATIA V5.

3D Wireframe and Surface Modeling

CAD programs that feature 3D wireframe and surface modeling create a skeleton-like inner structure of the object being modeled. A surface is added on later. These types of CAD models are difficult to translate into other software and are therefore rarely used anymore.

Solid Modeling

Solid modeling in general is useful because the program is often able to calculate the dimensions of the object it is creating. Many sub-types of this exist. Constructive Solid Geometry (CSG) CAD uses the same basic logic as 2D CAD, that is, it uses prepared solid geometric objects to create an object. However, these types of CAD software often cannot be adjusted once they are created. Boundary Representation (Brep) solid modeling takes CSG images and links them together. Hybrid systems mix CSG and Brep to achieve desired designs.

CATIA

Computer Aided Design (CAD) is the use of computer software to design a product or an object.

Computer Aided Manufacturing (CAM) is the use of computer software and hardware to plan, manage and control the operations of a manufacturing plant.

Computer Aided Engineering is the use of computer software to solve engineering problems and analyze products created using CAD.

CATIA is an acronym for Computer **A**ided **T**hree-dimensional **I**nteractive **A**pplication. It is one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products.

CATIA is a multi platform 3D software suite developed by Dassault Systèmes, encompassing CAD, CAM as well as CAE. Dassault is a French engineering giant active in the field of aviation, 3D design, 3D digital mock-ups, and product lifecycle management (PLM) software. CATIA is a solid modelling tool that unites the 3D parametric features with 2D tools and also addresses every design-to-manufacturing process. In addition to creating solid models and assemblies, CATIA also provides generating orthographic, section, auxiliary, isometric or detailed 2D drawing views. It is also possible to generate model dimensions and create reference dimensions in the drawing views. The bi-directionally associative property of CATIA ensures that the modifications made in the model are reflected in the drawing views and vice-versa.

The first release of CATIA was way back in 1977, and the software suite is still going strong more than 30 years later. While CATIA V6 is just being released, the most popular version of CATIA is V5 which was introduced in 1998. That said, it is important to note that each version of CATIA introduces considerable additional functionality. For example, V4 (introduced in 1192) offered enhancements to the Assembly Modeling Product including easy-to-use graphical tree-based assembly management. V5 and V6 saw changes in the way data is handled. Dassault Systemes typically offers new updates, releases and bug fixes for each version. The CATIA software is written in C++. It runs on both Unix and Windows.

What does CATIA do?

CATIA provides the capability to visualize designs in 3D. When it was introduced, this concept was innovative. Since Dassault Systemes did not have an expertise in marketing, they had revenue sharing tie-up with IBM which proved extremely fruitful to both the companies to market CATIA. In the early stages, CATIA was extensively used in the design of the Mirage aircrafts; however the potential of the software soon made it a popular choice in the automotive sector as well. As CATIA was accepted by more and more manufacturing companies, Dassault changed the product classification from CAD / CAM software to Project

Lifecycle Management. The company also expanded the scope of the software.

CATIA can be used at different stages of the design - ideate, draw, test and iterate. The software comes with different workbenches ("modules") that allow CATIA to be used across varied industries – from parts design, surface design and assembly to sheet metal design. CATIA can also be used for CNC.

CATIA offers many workbenches that can be loosely termed as modules. A few of the important workbenches and their brief functionality description is given below:

Part Design: The most essential workbench needed for solid modelling. This CATIA module makes it possible to design precise 3D mechanical parts with an intuitive and flexible user interface, from sketching in an assembly context to iterative detailed design.

Generative Shape Design: allows you to quickly model both simple and complex shapes using wireframe and surface features. It provides a large set of tools for creating and editing shape designs. Though not essential, knowledge of Part Design will be very handy in better utilization of this module.

Assembly: The basics of product structure, constraints, and moving assemblies and parts can be learned quickly. This is the workbench that allows connecting all the parts to form a machine or a component.

2. RESULTS AND DISCUSSION

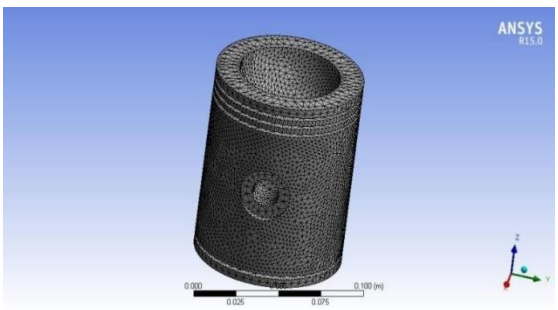

Fig.1 shows meshing of the piston in Ansys.

The component drawn in CATIA is imported to Ansys and then meshing is done for the component. For meshing fine mesh is selected.

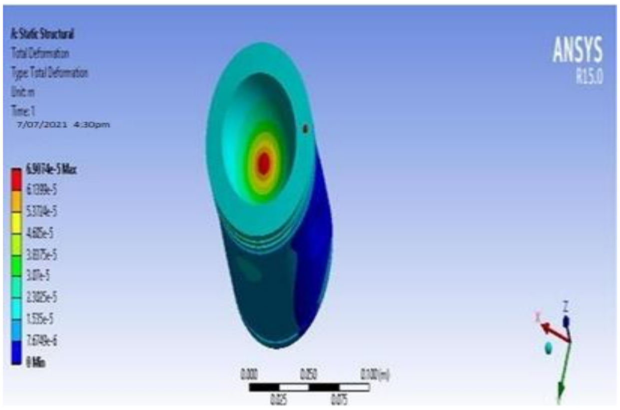

Fig.2 Average cycle pressure on piston head .

A pressure of 6.289 bar is applied at the top of the piston head restraining the piston pin and theaverage cycle pressure is 80 bar for the full load condition which is taken from the open literature will be applied on the piston head.One by one the material was applied on the piston and then the analysis results are shown below. Static analysis was carried out and results are tabulated below. Total deformation and Von- mises stress are calculated and found out that which materials suits for the assumed conditions.

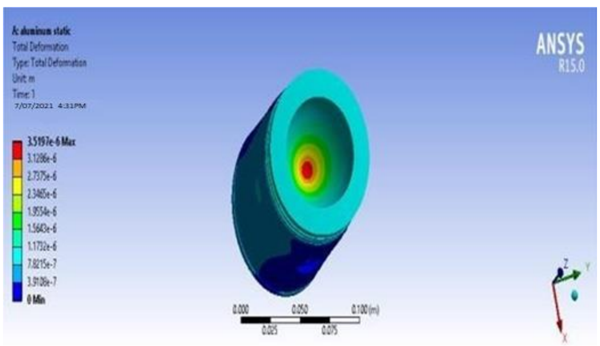

Fig.3 Stress Distribution Structural Steel analysis:

The total deformation is calculated based on Bmep and average cycle pressure applied on piston head. The same is shown depicted below if fig.3

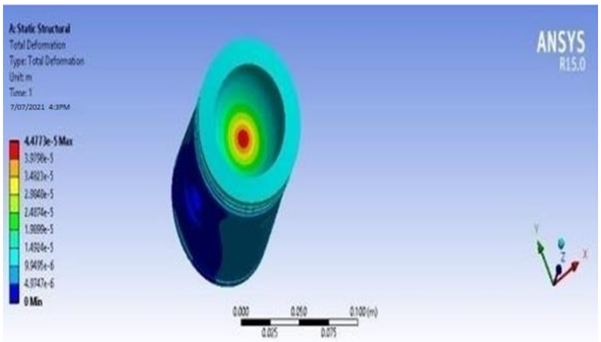

Fig.4 Stress Distribution

Similarly the stress distribution after applying Bmep and average cycle pressure on piston head is shown in fig.4

RESULT TABELS

Materials	Bmep	Average cycle pressure
Aluminium	5.4302e-006 m	6.9074e-005 m
Grey cast iron	3.5197e-006 m	4.4773e-005 m
Structural steel	1.9335e-006 m	2.4595e-005 m

Table-1: Total Deformation

The Total Deformation obtained by applying Bmep and average cycle pressure on piston head is tabulated in Table-1.

Materials	Bmep	Average cycle pressure
Aluminium	1.0089e+007 Pa	1.2841e+008 Pa
Grey cast iron	9.601e+006 Pa	1.222e+008 Pa
Structural steel	9.7935e+006 Pa	1.2465e+008 Pa

Table-2: Stress Distribution

The Stress distribution obtained by applying Bmep and average cycle pressure on piston head is tabulated in Table-2.

STATIC ANALYSIS

MATERIAL	DEFORMATION(mm)	STRESS(N/mm2)	Strain
Steel	0.0059487	67.508	0.00033915
Cast iron	0.01817	67.771	0.00061901
Aluminum alloy	0.016742	67.096	0.00094959

THERMAL ANALYSIS

MATERIAL	Temperature (0C)	Heat flux(W/mm^2)
Steel	**129**	**0.68408**
Cast iron	**129**	**0.65715**
Aluminum alloy	**129**	**0.88043**

5. CONCLUSION

Physically, chemically and mechanically aluminum is ametal like steel, brass, copper, zinc, lead or titanium. Itcan be melted, cast, formed and machined much like thesemetals and it conducts electric current. In fact often theme equipment and fabrication methods are used as forsteel. Aluminum is a very light metal with a specific weight of2.7 g/cm3, about a third that of steel. For example, the useof aluminum in vehicles reduces dead-weight and energy Consumption while increasing load capacity. Its strengthcan be adapted to the application required by modifyingthe composition of its alloys.

By observing the static analysis the stress values are less for aluminum alloy material than steel & cast iron.

By observing the thermal analysis the heat flux values are more for aluminum alloy than steel and cast iron.

So it can be concluded the aluminum alloy is better material for piston.

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