MODELING AND STRUCTURAL ANALYSIS OF RADIAL ENGINE ASSEMBLY

G.MAHESH
14R31D0405, M.Tech, Nova College of Engineering and Technology, Jafferguda, Hayatnagar, Hyderabad

B.SWATHI
Assistant Profissor, Nova College of Engineering and Technology, Jafferguda, Hayatnagar, Hyderabad

ABSTRACT

The radial engine is an internal combustion engine, configuration in which the cylinders point outward from a central crankshaft like the spokes on a wheel. This configuration was very commonly used in aircraft engines before being superseded by turbo shaft and turbojet engines. It is a reciprocating engine. The cylinders are connected to the crankshaft with a master-and-articulating-rod assembly. One cylinder has a master rod with a direct attachment to the crankshaft. The remaining cylinder pins their connecting rods attachments ....etc.

The main objective of the project is how to develop the four stroke five cylinder engine assembly using CAD tool PRO-E (Professional Engineer).These Engine assembly consists major components, they are Cylinder head, Hub (master rod), Piston, Radial Connecting Rod Assembly, middle Crank Shaft, Internal system with inlet and outlet valves with required dimensions and also showing the main internal mechanism of Radial engine. These Mechanisms shows the working of engine.

And importing the components which are developed in CAD tool into CAE tool ANSYS for analyze to find out the deformations and stress efficiency of the components, Applying the existing material and another material and showing the comparison between two materials for components when the loads are different.

INTRODUCTION

ENGINE: -

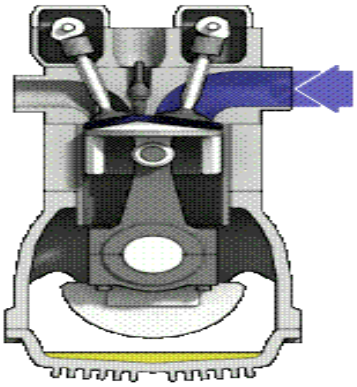
An engine or motor is a machine designed to convert energy into useful mechanical motion. Heat engines, including internal combustion engines and external combustion engines (such as steam engines) burn a fuel to create heat, which then creates motion.

COMBUSTION ENGINE

Combustion engines are heat engines driven by the heat of a combustion process.

INTERNAL COMBUSTION ENGINE: -

The internal combustion engine is an engine in which the combustion of a fuel (generally, fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine the expansion of the high temperature and high pressure gases, which are produced by the combustion, directly applies force to components of the engine, such as the pistons or turbine blades or a nozzle, and by moving it over a distance, generates useful mechanical energy.



Internal Combustion (4-Stroke).

EXTERNAL COMBUSTION ENGINE:

An external combustion engine (EC engine) is a heat engine where an internal working fluid is heated by combustion of an external source, through the engine wall or a heat exchanger. The fluid then, by expanding and acting on the mechanism of the engine produces motion and usable work.

ENGINE CONFIGURATION:-

Engine configuration is an engineering term for the layout of the major components of a reciprocating piston internal combustion engine. These components are the cylinders and crankshafts in particular but also, sometimes, the camshaft(s).

ENGINE SPEED: -

Engine speed is measured in revolutions per minute (RPM). Engines may be classified as low-speed, medium-speed or high-speed but these terms are in exact and depend on the type of engine being described.

LITERATURE REVIEW

HISTORY OF RADIAL ENGINE: -

The very first design of internal combustion aero engine made was that of Charles Manly, who built a five-cylinder radial engine in 1901 for use with Langley`s 'aerodrome' , as the latter inventor decided to call what has since become known as the aero-plane. Manly made a number of experiments, and finally decided on radial design, in which the cylinders are so rayed round a central crank-pin that the pistons act successively upon it. By this arrangement a very short and compact engine is obtained, with a minimum of weight, and a regular crankshaft rotation and perfect balance of inertia forces.

When Manly designed his radial engine, high speed internal combustion engines were in their infancy, and the difficulties in construction can be partly realized when the lack of manufacturing methods for this high-class engine work, and the lack of experimental data on the various materials, are taken into account. During its tests, Manly`s engine developed 52.4 brake horsepower at a speed of 950 revolutions per minute, with the remarkably low weight of only 1.09 kg per horsepower, this latter was increased to 1.64 kg when the engine was completed by the addition of ignition system, radiator, petrol tank, and all accessories, together with the cooling water for the cylinders.

In Manly`s engine, the cylinders were of steel, machined outside and inside to 1.625 of a mm thickness. On the side of the cylinder, at the top end, the valve chamber was brazed, being machined from a solid forging. The casing which formed the water-jacket was of sheet steel, 0.52 of a mm in thickness, and this also was brazed on the cylinder and to the valve chamber. Automatic inlet valves were fitted, and the exhaust 8

valves were operated by a cam which had two points, 180 degrees apart. The cam was rotated in the opposite direction to the engine at one -quarter engine speed. Ignition was obtained by using a one-spark coil and vibrator for all cylinders, with a distributor to select the right cylinder for each spark – this was before the days of the high-tension magneto and the almost perfect ignition systems that makers now employ. The scheme of ignition for this engine was originated by Manly himself, and he also designed the sparking plugs fitted in the tops of the cylinders. Through fear of trouble resulting if the steel pistons worked on the steel cylinders, cast iron liners were introduced in the latter 1.625of a mm thick.

The connecting rods of this engine were of virtually the same type as is employed on nearly all modern radial engines. The rod for one cylinder had a bearing along the whole

of the crank pin, and its end enclosed the pin. The other four rods had bearings upon the end of the firs rod, and did not touch the crank pin. The bearings of these rods did not receive any of the rubbing effect due to the rotation of the crank pin, the rubbing on them being only that of the small angular displacement of the rods during each revolution, thus there was no difficulty experienced with the lubrication.

Another early example of the radial type of engine was French Anzani, of which type one was fitted to the machine with which Bleriot first crossed the English Channel—this was of 25 horse-powers. The earliest Anzani engines were of three-cylinder fan type, one cylinder being vertical, and the other two placed at an angle of 72 degrees on each side, as the possibility of over lubrication of the bottom cylinders was feared if a regular radial construction were adopted. In order to overcome the unequal dial Engine

DESIGN AND ANALYSIS

Introduction to Pro/E

Pro-e is a suite of programs that are used in the design, analysis, and manufacturing of a virtually unlimited range of product. In PRO-E we will be dealing only with the major front –end module used for pan and assembly design and model creation, and production of engineering drawings Schamtickoo(4) . There are wide ranges of additional modules available to handle tasks ranging from sheet metal operations, piping layout mold design, wiring harness design, NC machining and other operations.

In a nutshell, PRO-ENGINEER is a parametric, feature-based solid modeling system, "Feature based" means that you can create part and assembly by defining feature like extrusions, sweep, cuts, holes, slots, rounds, and so on, instead of specifying low-level geometry like lines, arcs, and circle& features are specifying by setting values and attributes of element such as reference planes or surfaces direction of creation, pattern parameters, shape, dimensions and others.

"Parametric" means that the physical shape of the part or assembly is driven by the values assigned to the attributes (primarily dimensions) of its features. Parametric may define or modify a feature's dimensions or other attributes at any time.

For example, if your design intent is such that a hole is centered on a block, you can relate the dimensional location of the hole to the block dimensions using a numerical formula; if the block dimensions change, the centered hole position will be recomputed automatically.

"Solid Modeling" means that the computer model to create it able to contain all the information that a real solid object would have. The most useful thing about the solid modeling is that it is impossible to create a computer model that is ambiguous or physically non-realizable.

PTC was founded in 1985, by Samuel Peisakhovich Ginsberg, who previously worked at Prime Computer, Computer vision (CV) and Application. Pro/ENGINEER (a.k.a. Pro/E), the company's first product, shipped in 1988.

John Deere became PTC's first customer. Once an initial version of Pro/ENGINEER was developed, the company received venture capital funding from Charles River Associates and Steve Walske became the CEO. Pro/ENGINEER was the first commercially successful

parametric feature based solid modeler. Through a combination of innovative technology, and no-holds-barred sales tactics, PTC quickly became a major force in the CAD industry. Its strong ascent continued unabated until the mid-1990s, when the introduction of Microsoft Windows NT, and the availability of commercial geometric modeling libraries opened the door to a new generation of low-cost competitors and PTC's reputation for overly aggressive sales tactics alienated many of its customers.

These competitors, symbolized by Solid works, squeezed PTC from the bottom, while more established companies like Unigraphics and IBM held the 'high ground' in automotive and aerospace industries. PTC's sales began a multi-year decline from which it took years to recover. It took a new CAD product (Pro/ENGINEER Wildfire) and an expanded product line, but PTC has been able to transform itself over the past 10 years into the third largest provider of Product Lifecycle Management software.

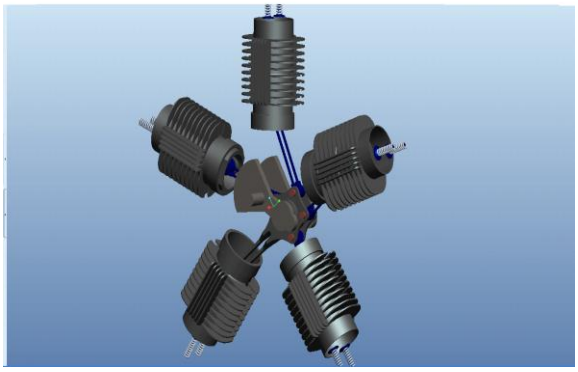
On December 29, 2006 Standard & Poor's bumped PTC off its S&P 500 Index, and replaced it instead with the newly spun-off natural gas company Spectra Energy Corp. (NYSE: SE). Parametric then bumped Pier 1 Imports Inc. (NYSE: PIR), a retailer of home furnishings, down one spot and off the bottom of the S&P Midcap 400 Index In 2008, PTC once again achieved revenues of over $1 billion something it had not been able to accomplish since 1999.

CREO Elements/Pro, a product formerly known as Pro/ENGINEER is a parametric, integrated 3D CAD/CAM/CAE solution created by Parametric Technology Corporation (PTC). It was the first to market with associative solid software. The application runs on Microsoft Windows platform, and provides solid modeling, assembly modeling and drafting, finite element analysis, and NC and tooling functionality for mechanical engineers. The Pro/ENGINEER name was changed to CREO Elements/Pro on October 28, 2010, coinciding with PTC's announcement of CREO, a new design software application suite.

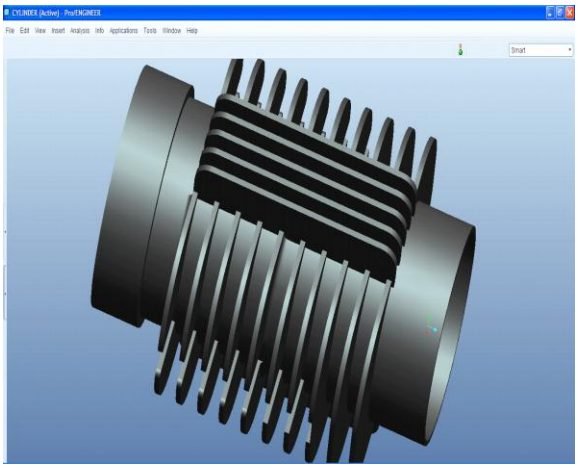
CREO Elements/Pro (formerly Pro/ENGINEER), PTC's parametric, integrated 3D CAD/CAM/CAE solution, is used by discrete manufacturers for mechanical engineering, design and manufacturing.

3D MODEL IS DEVELOPED USING PRO-E:-

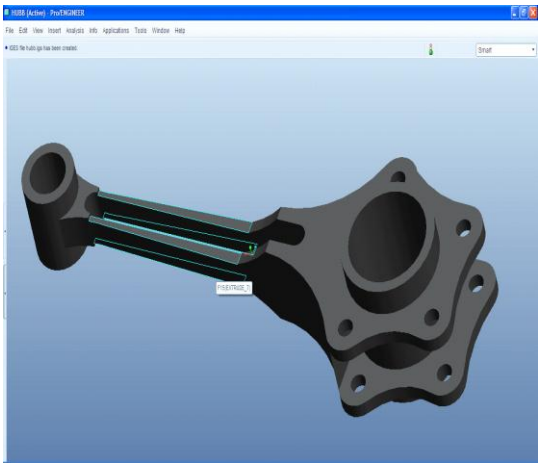
MAJOR COMPONENTS:-



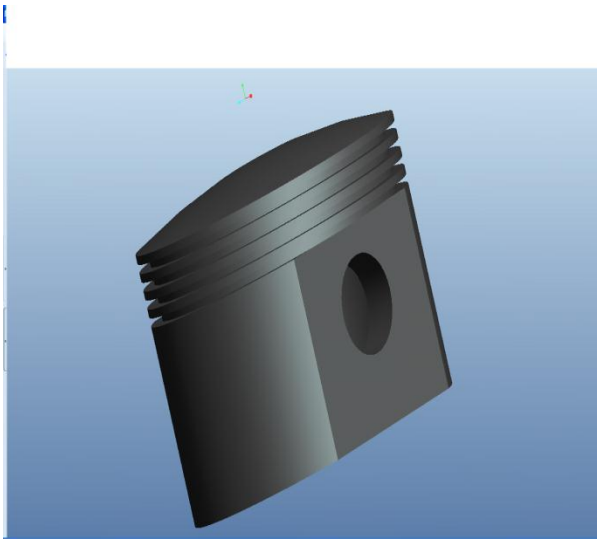
Main Internal Sytem



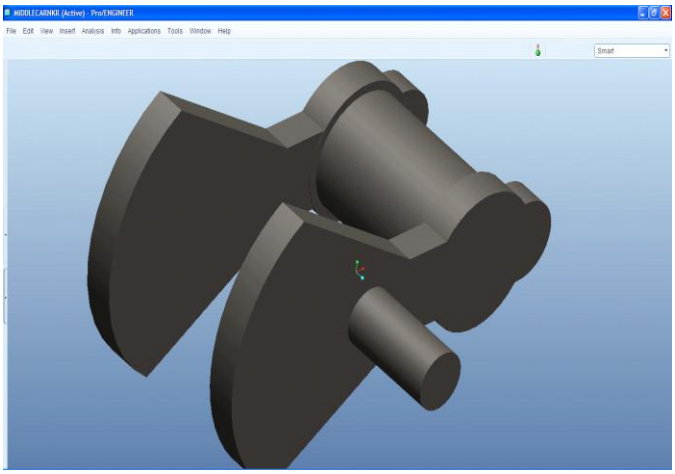
Cylinders With Cooling Fins



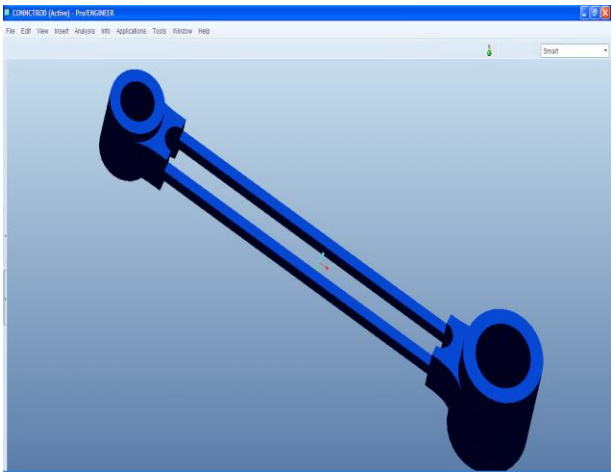
HUB (Master Rod)



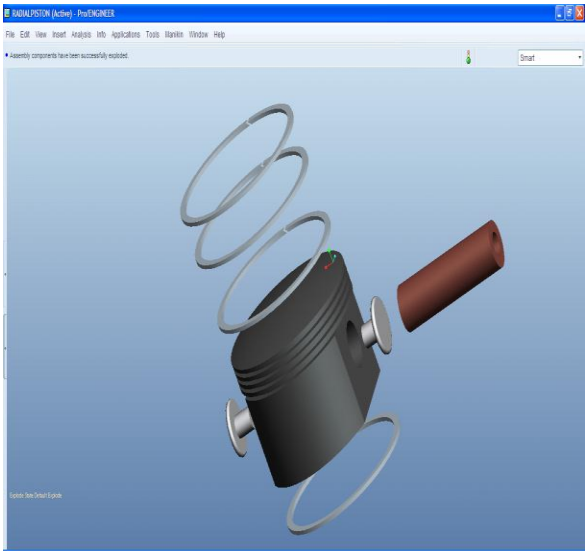
HEAD



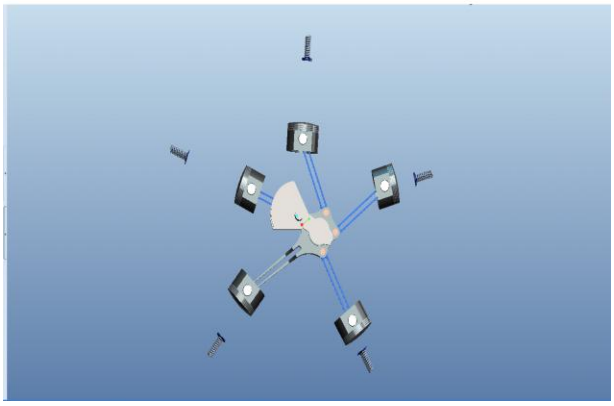
Middle Crank Shaft



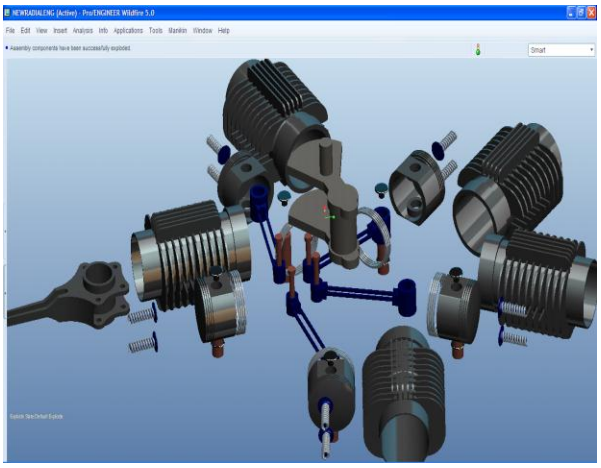
Radial Connecting Rod



Radial Piston Assembly



Internal System With Inlet, Outlet Valves



Total Sub-Assemblies Which Are Developed

ANALYSIS

ANSYS is an Engineering Simulation Software (computer aided Engineering). Its tools cover Thermal, Static, Dynamic, and Fatigue finite element analysis along with other tools all designed to help with the development of the product.

The company was founded in 1970 by Dr. John A. Swanson as Swanson Analysis Systems, Inc. SASI. Its primary purpose was to develop and market finite element analysis software for structural physics that could simulate static (stationary), dynamic (moving) and heat transfer (thermal) problems. SASI developed its business in parallel with the growth in computer technology and engineering needs. The company grew by 10 percent to 20 percent each year, and in 1994 it was sold. The new owners took SASI's leading software, called ANSYS®, as their flagship product and designated ANSYS, Inc. as the new company name.

BENEFITS OF ANSYS:

The ANSYS advantage and benefits of using a modular simulation system in the design process are well documented. According to studies performed by the Aberdeen Group, best-in-class companies perform more simulations earlier. As a leader in virtual prototyping, ANSYS is unmatched in terms of functionality and power necessary to optimize components and systems.

The ANSYS advantage is well-documented. ANSYS is a virtual prototyping and modular simulation system that is easy to use and extends to meet customer needs, making it a low-riskinvestment that canexpand as value is demonstrated within a company. It is scalable to all levels of the organization, degrees of analysis complexity, and stages of product development.

- **Advanced Post-Processing:**

ANSYS provides a comprehensive set of post-processing tools to display results on the models as contours or vector plots, provide summaries of the results (like min/max values and locations). Powerful and intuitive slicing techniques allow to get more detailed results over given parts of your geometries. All the results can also be exported as text data or to a spreadsheet for further calculations. Animations are provided for static cases as well as for nonlinear or transient histories. Any result or boundary condition can be used to create customized charts.

- **Exploring design:**

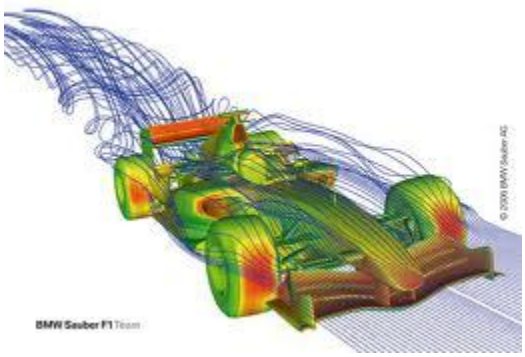
A single simulation just provides avalidation of a design. ANSYS brings you to the next level with design explorer a tool designed for fast and efficient design analysis. You will not need more than a few mouse clicks to get a dipper understanding of your design, whether you want to examine multiple scenarios or create full response surfaces of your model and get sensitivities to design

parameters, optimize your model or perform a Six Sigma analysis.

- **Communicating results:**

ANSYS lets you explore your design in multiple ways. All the results you get must then be efficiently documented: ANSYS will provide you instantaneous report generation to gather all technical data and pictures of the model in a convenient format (html, MS Word, MS PowerPoint…).**Capturing the knowledge:**

ANSYS provides a unique set of tool that will allow you to capture knowledge, standardize on simulation processes and provide tools to perform the most complex simulations in a simple way. You will be able to create simulation wizards to guide the users through the steps required to perform a given simulation, automate simulation tasks… so you get the best and most comprehensive information on your design, faster.



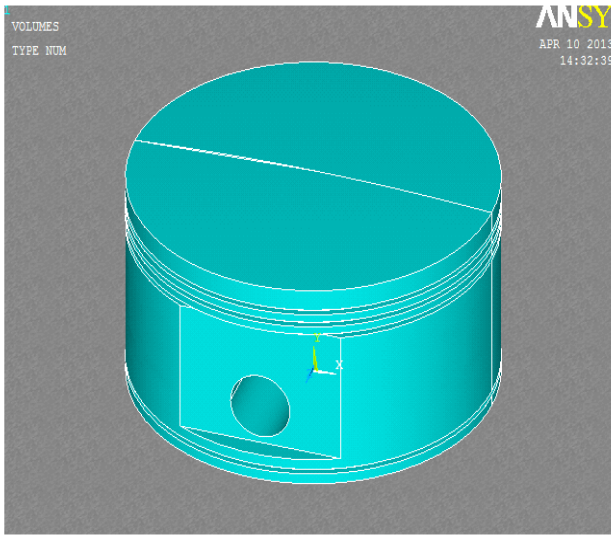
ANSYS

For all engineers and students coming to finite element analysis or to ANSYS software for the first time, this powerful hands-on guide develops a detailed and confident understanding of using ANSYS's powerful engineering analysis tools. The best way to learn complex systems is by means of hands-on experience. With an innovative and clear tutorial based approach, this powerful book provides readers with a comprehensive introduction to all of the fundamental areas of engineering analysis they are likely to require either as part of their studies or in getting up to speed fast with the use of ANSYS software in working life. Opening with an introduction to the principles of the finite element method, the book then presents an overview of ANSYS technologies before moving on to cover key applications areas in detail. Key topics covered: Introduction to the finite element method Getting started with ANSYS software stress analysis dynamics of machines fluid dynamics problems thermo mechanics contact and surface mechanics exercises, tutorials, worked examples With its detailed step-by-step explanations, extensive worked examples and sample problems, this book will develop the reader's understanding of FEA and their ability to use ANSYS's software tools to solve their own particular analysis problems, not just the ones set in the book.

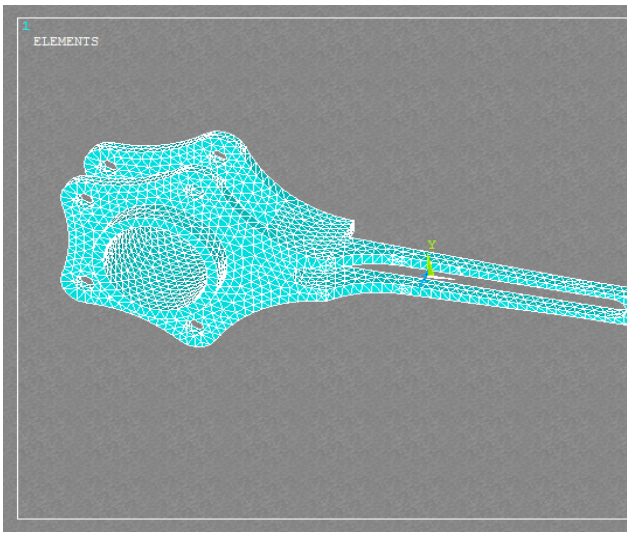
At ANSYS, we bring clarity and insight to customers' most complex design challenges through fast, accurate and reliable simulation. Our technology enables organizations to predict with confidence that their products will thrive in the real world. They trust our software to help ensure product integrity and drive business success through innovation.

INDIVIDUAL COMPONENT ANALYSIS:-

IMPORTING THE COMPONEENT FROM **CAD (**PRO-E) TOOL TO **CAE** TOOL (ANSYS):



IMPOTED COMPONEENT (ELEMENT)



MESH VIEW (STRUCTURAL MESH)

ANSYS PROCESS:-

1. PREFERENCES ---- THERMAL(Transient)
2. PRE PROCESSOR
   a. Element type -- SOLID Tet 10NODE 185
   b. Material model – Al alloy 4032 T6, Gray cast iron

   Thermal conductivity =3.82*10^7, 75 w/m-k
   Density = 0.27, 7150kg/m^3
   c. Real constants – NONE
   d. Meshing -- TETRA FREE
3. SOLUTION --- Solve - current L.S (Solves the problem)
4. GENRAL POST PROCESSOR --- Plot results – contour plot -- nodal solution.. (BENDING MOMENT AND STRESS VON-MISSES STRESS)

PISTON:-

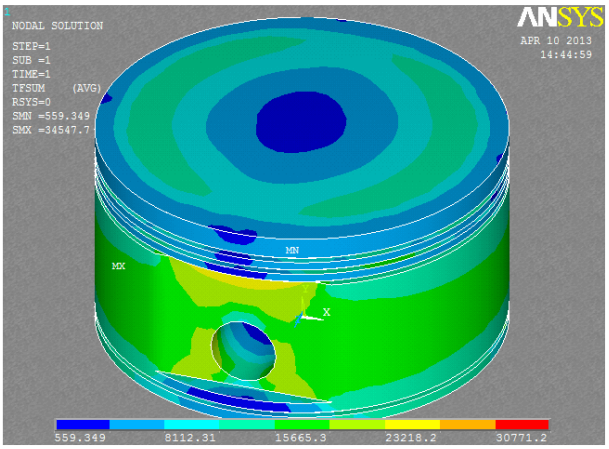
The following x,y,z values are in global coordinates

THERMAL FLUX VECTOR SUM WHEN LOAD (HEAT GENERATION) IS 2000K ON TOP SURFACE:-

Area which is chosen is where the blast is taken

Material used for piston:-aluminum alloys 2024

Nodetfxtfytfztfsum
6371 -3663.0 -10473. -5504.7 12386.
Minimum values
Node 5143 3421 6232 6129
Value -19841. -34022. -17319. 588.42
Maximum values
Node 5179 6344 6311 3421
Value 20080. 53.315 17107. 34056.



Material used:- forged aluminum

Nodetfxtfytfztfsum

6371 -4590.4 -13108. -6898.5 15508.

Minimum values

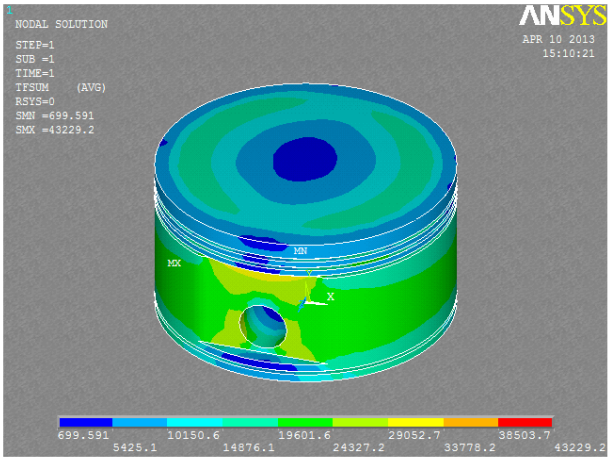
node 5184 3421 6232 6129

value -24963. -42586. -21688. 735.92

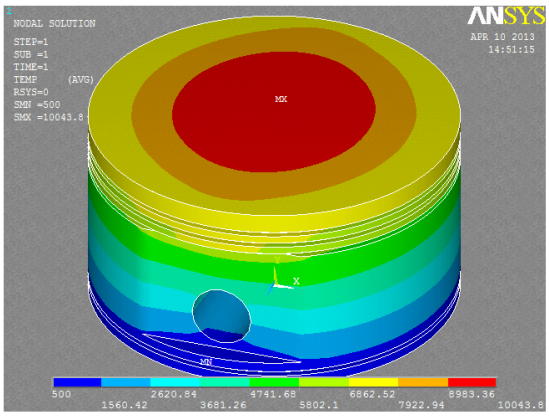
Maximum values

Node 5180 6344 6311 3421

Value 25142. 66.676 21399. 42630.



NODAL TEMEPERATURE:-



MASTER ROD

Thermal flux when heat generated where the piston is attached 1000k:-

Material used :-aluminum alloys 7096

Minimum values

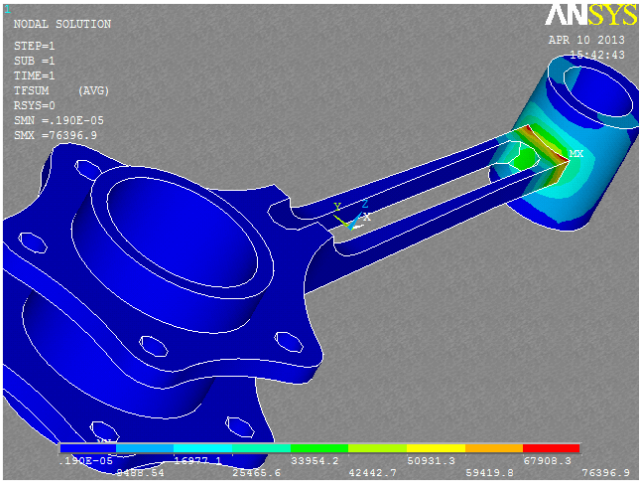
Node 2217 232 2519 1342

Value -66118. -17645. -34543. 0.19730e-05

Maximum values

Node 2444 258 2506 2217

Value 2134.7 17458. 28877. 66532.



Material used:- forged steel alloy

Minimum values

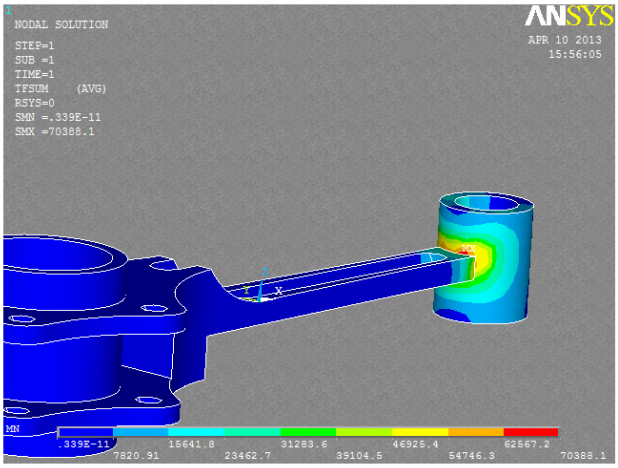
node 76 232 2527 1637

value -40230. -31837. -53376. 0.61078 e-11

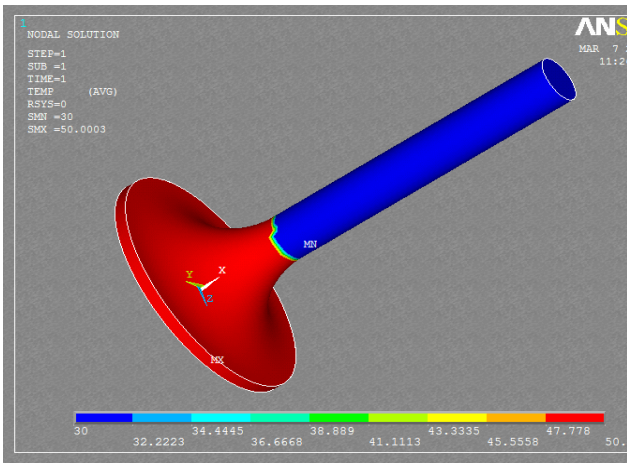
Maximum values

Node 334 258 231 2527

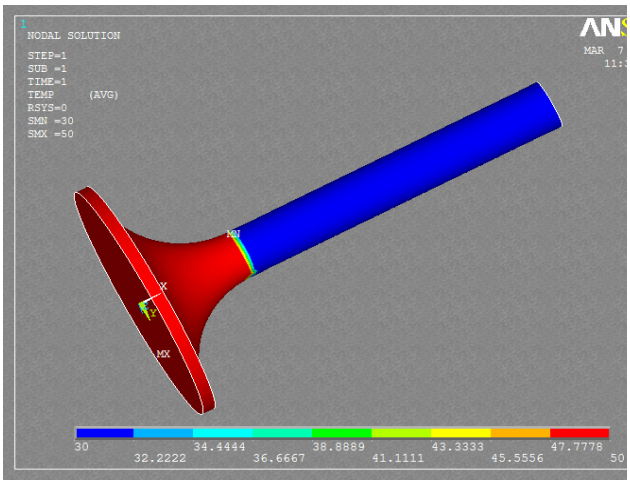
Value 206.85 31585. 34177. 58403.



INLET VALVE:-



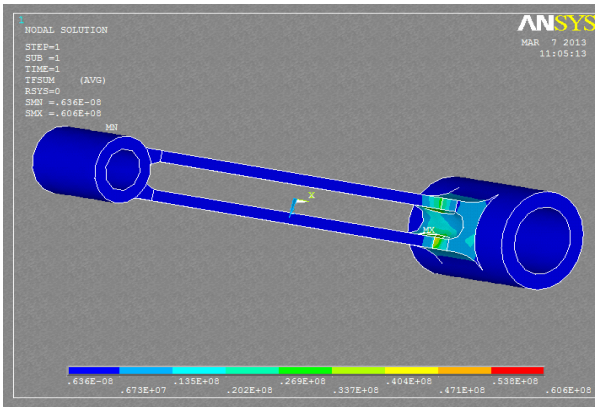
Material Used:- chrome steel



MAXIMUM ABSOLUTE VALUES
NODE 32
VALUE 47.778

RADIAL CONNECTING ROD:-

Material used:- Gray cast iron



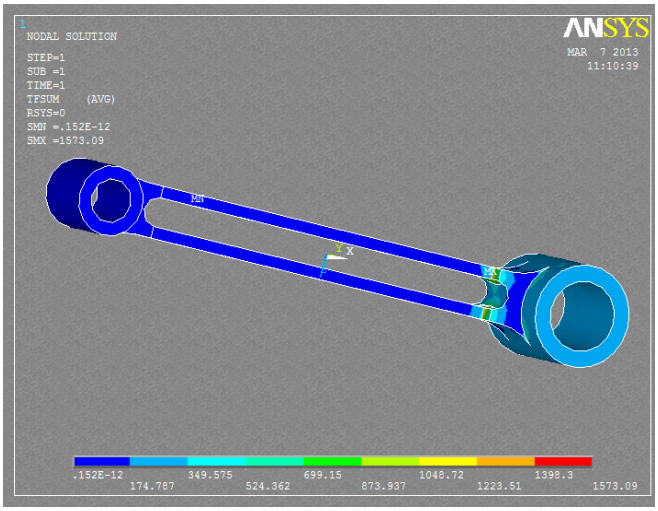
MINIMUM VALUES
NODE 205 303 240 408
VALUE -0.38527E+08-0.28993E+08-0.11025E+08 0.63612E-08

MAXIMUM VALUES
NODE 828 1015 198 1015
VALUE 0.10412E+07 0.35418E+08 0.87688E+07 0.41473E+08

Material used:-AL alloy

MINIMUM VALUES
NODE 205 1017 739 180
VALUE -928.61 -871.32 -338.72 0.16076E-12

MAXIMUM VALUES
NODE 635 1015 606 1015
VALUE 345.76 870.00 339.26 984.98



CONCLUSION

Using PRO_E tool Radial Engine Assembly (Five cylinders) is developed including few sub-assemblies. This assembly consists few sub-assemblies they are Cylinders with cooling fins, Middle crank, Master Rod, Connecting Rod, Piston Assembly, Valves. This project is deals with the Modeling and Thermal analysis of a RADIAL ENGINE ASSEMBLY (Five cylinders). The main objective of this project is to knowing of designing process using CAD tool (PRO_E)

and also preparing components and assembly. And also analysis is done using CAE tool (ANSY), using these software, Here we chosen two Different types of materials for same component. The materials are one is existing material and Another one is we chosen. The main objective of analysis is to showing the comparison between two materials for same component applying same boundary conditions and same loads are applied. This process is done for each and every main component. These Analysis process is done in every manufacturing industries before assembling (Individual component Analysis). For valves the max temperature is at node -32; value - 47.778 when the material is chrome steel. For valves the stainless steel receiving little temperature comparing with chrome steel. Finally the materials which are chosen (not existing) are gave better results comparing with existing material. For major components some results are shown they are Thermal Flux (Heat flows through Media) Thermal Gradient. The materials which are chosen having less deformations and less Conductivity.

kAnalysis: - Thermal Analysis (Transient).

REFERENCES

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2. Instructions For Assembly From http://www.machanicards.com
3. History of Radial engines From http://www.google.com
4. Firing order Definition From Answers.com http://www.answers.com/topic/firingorder