MODELING & THERMAL ANALYSIS OF RADIAL ENGINE

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ABSTRACT: *A reciprocating engine is a primary source of power generation in various mechanical applications from power generation to automobiles. To increase the speed of the engine and for more power transmission radial engines are used. Radial engine is a type of reciprocating internal combustion engine in which five pistons are associated to the crank shaft along with connecting rod. Radial engines are commonly used in aero craft, ships etc.,*

The main object of this project is to design the radial engine in defined parameters and can simulate the stress, shear, tensile loads, thermal analysis by using ANSYS Software. This process is done for each and every main component. These Analysis process is done in every manufacturing industries before assembling (Individual component Analysis). To showing the comparison between two materials for piston, master rod, inlet valve and radial connecting rod when the loads are different

1.INTRODUCTION:

The Radial Engine is a reciprocating type internal combustion engine configuration in which the cylinders point outward from a central crank shaft like the spokes on a wheel. This type of engine was commonly used in most of the aircrafts before they started using turbine engines.

In a Radial Engine, the pistons are connected to the crankshaft with a master-and-articulating-rod assembly. One of the pistons has a master rod with a direct attachment to the crankshaft. The remaining pistons pin their connecting rods` attachments to rings around the edge of the master rod.

1.1 RADIAL ENGINE WORKS:

Four-stroke radials have an odd number of cylinders per row, so that a consistent every-other-piston firing order can be maintained, providing smooth operation. For example, on a 5-cylinder engine the firing order is 1,3,5,2,4 and back to cylinder 1. Moreover, this always leaves a one-piston gap between the piston on its combustion stroke and the piston on compression. The active stroke directly helps compressing the next cylinder to fire, so making the motion more uniform. If an even number of cylinders was used, the equally timed firing cycle would not be feasible.

1.2 APPLICATIONS:

Radial engines have several advantages for airplanes:

- They can produce a lot of power. A typical radial engine in a B-17 has nine cylinders, displaces 1,800 cubic inches (29.5 liters) and produces 1,200 horsepower.
- Radial engines have a relatively low maximum rpm (rotations per minute) rate, so they can often drive propellers without any sort of reduction gearing.
- Because all of the pistons are in the same plane, they all get even cooling and normally can be air-cooled. That saves the weight of water-cooling.

2. DESIGN MEDIA

2.1 CAD

Computer aided design (cad) is defined as any activity that involves the effective use of the computer to create, modify, analyze, or document an engineering design. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as cad system. The term CAD/CAM system is also used if it supports manufacturing as well as design applications. The design software used to design the shaft and assembly of the Rotary Airlock Valve is pro/engineering.

2.2 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 schematic tool. 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.

2.3 CAPABILITIES AND BENEFITS:

1. Complete 3D modeling capabilities enable you to exceed quality arid time to arid time to market goals.

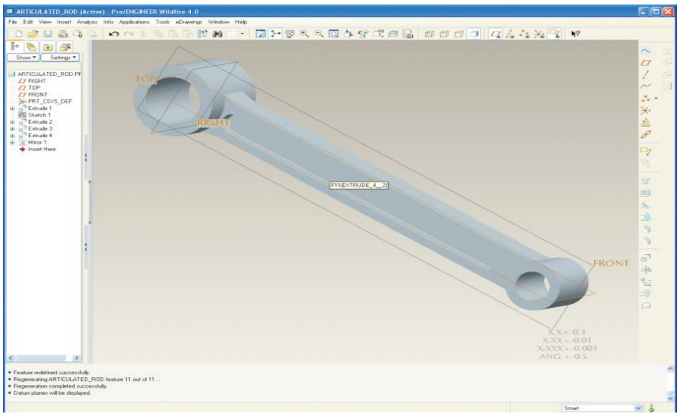
2. Maximum production efficiency through automated generation of associative C tooling design, assembly instructions, and machine code.

3. Ability to simulate and analysis virtual prototype to improve production performance and optimized product design.

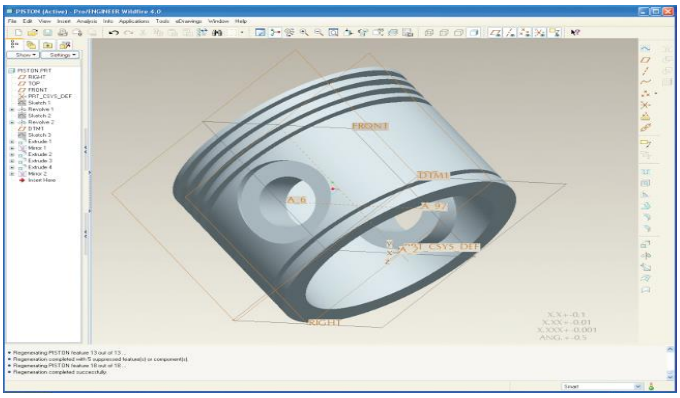
4. Ability to share digital product data seamlessly among all appropriate team members

3. MODELING OF RADIAL ENGINE

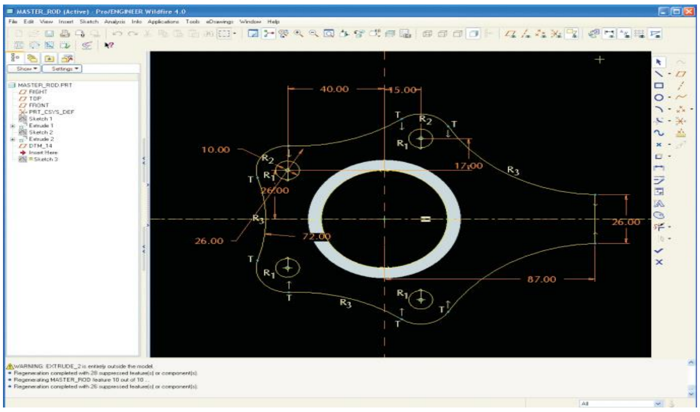
3.1 SOLID MODELING OF ARTICULATED ROD:

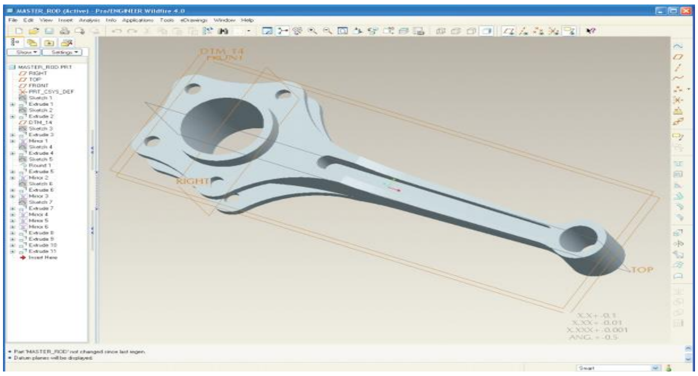


3.2 SOLID MODELING OF PISTON:

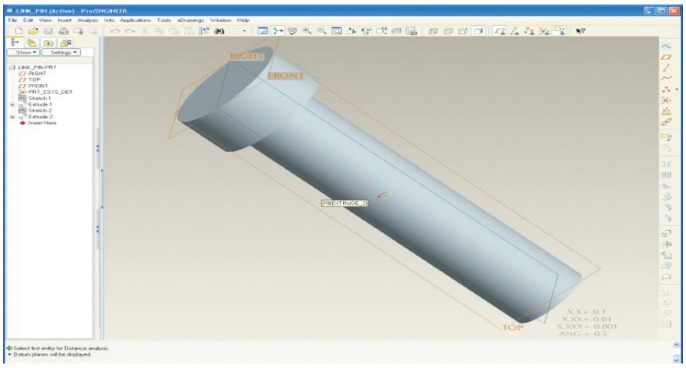


3.3.SOLID MODELING OF MASTER ROD:

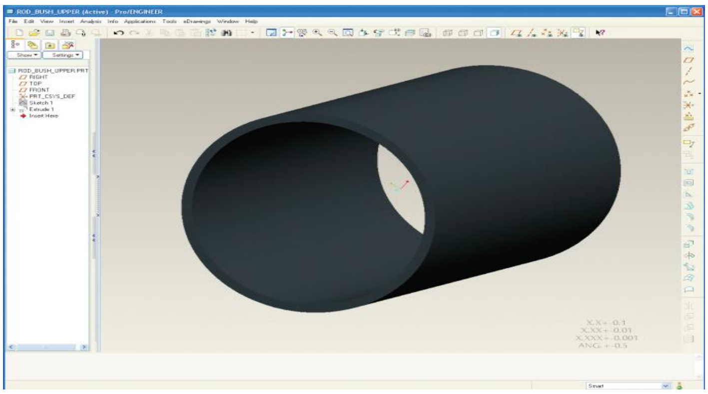




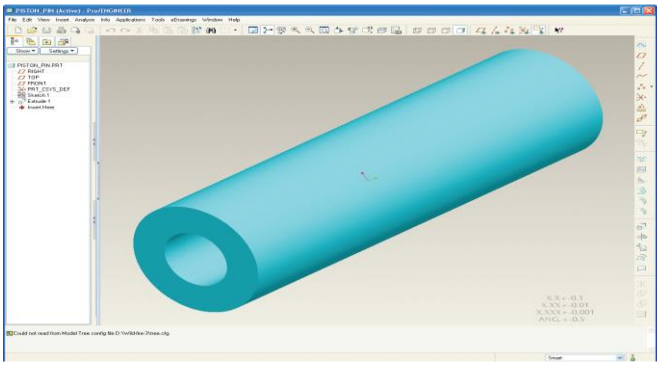
3.4. SOLID MODELING OF PISTON LINK:



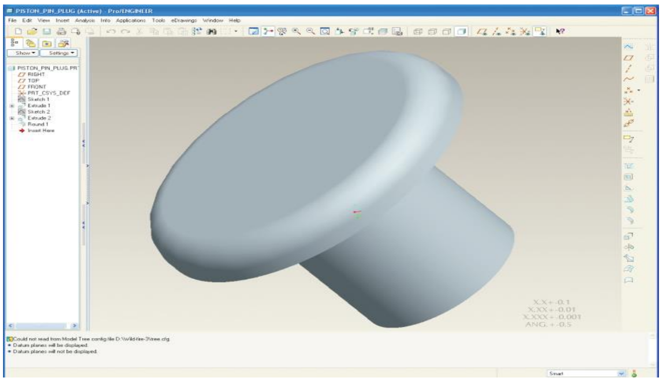
3.5 SOLID MODELING OF ROD BUSH UPPER:



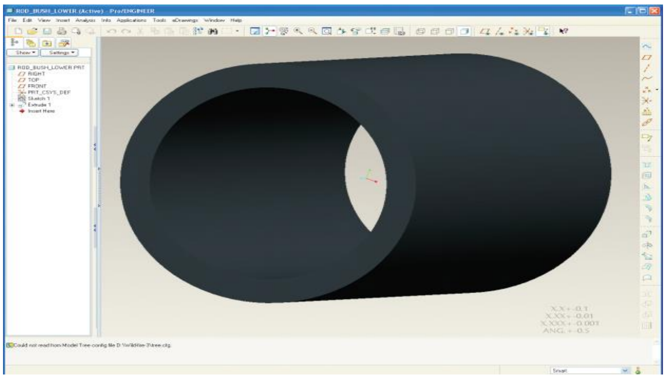
3.6 SOLID MODELLING OF ROD PISTON PIN:



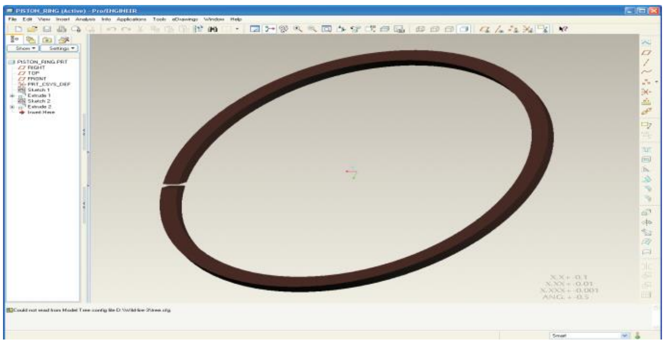
3.7 SOLID MODELING PISTON PIN PLUG:



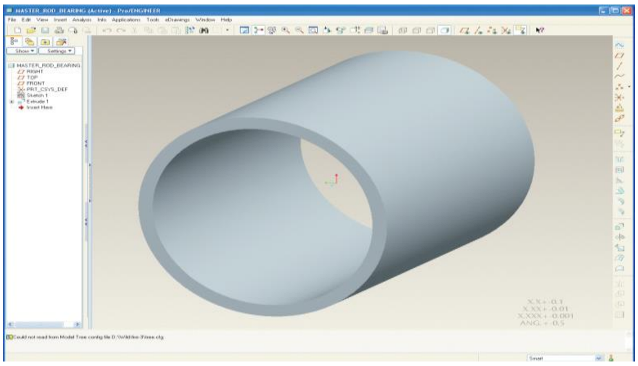
3.8 SOLID MODELING OF ROD BUSH LOWER:



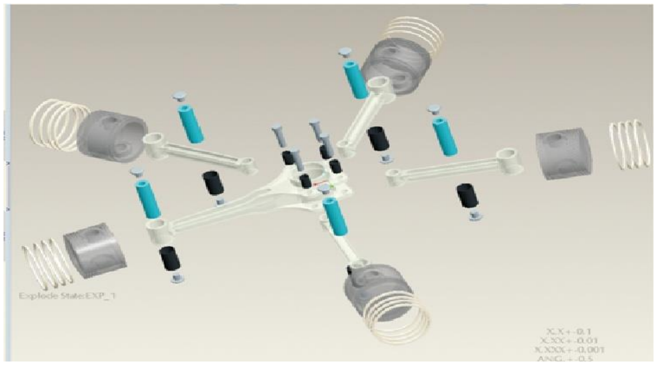
3.9 SOLID MODELING OF PISTON RING:



3.10 SOLID MODELING OF MASTER ROD BEARING:



4. ASSEMBLING OF THE COMPONENTS



4.1.Bottom-Up Design (Modeling):

The components (parts) are created first and then added to the assembly file. This technique is particularly useful when parts already exist from previous designs and are being re-used.

4.2.Top-Down Design (Modeling):

The assembly file is created first and then the components are created in the assembly file. The parts are build relative to other components. Useful in new designs

4.3.Degrees of Freedom:

An object in space has six degrees of freedom.

- **Translation** – movement along X, Y, and Z axis (three degrees of freedom)
- **Rotation** – rotate about X, Y, and Z axis (three degrees of freedom)

5.ANSYS PROCESS:-

1. PREFERENCES ---- THERMAL(Transient)
2. PRE PROCESSOR
   a. Element type -- SOLID Tet 10NODE 185

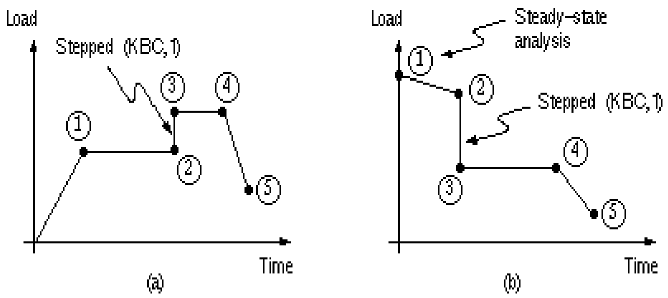
b. Material model – Al alloy 4032 T6, Gray cast iron
Thermal conductivity =3.82*10^7, 75 w/m-k
Density = 0.27, 7150kg/m^3
c. Real constants – NONE
d. Meshing -- TETRA FREE

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)

6.ANALYSIS

The ANSYS/Multi physics, ANSYS/Mechanical, ANSYS/Thermal, and ANSYS/FLOTRAN products support transient thermal analysis. Transient thermal analysis determines temperatures and other thermal quantities that vary over time. Engineers commonly use temperatures that a transient thermal analysis calculates as input to structural analyses for thermal stress evaluations. Many heat transfer applications-heat treatment problems, nozzles, engine blocks, piping systems, pressure vessels, etc.-involve transient thermal analyses.

Figure 6-1 Examples of load-versus-time curves



For each load step, you need to specify both load values and time values, along with other load step options such as stepped or ramped loads, automatic time stepping, etc.

6.1 Elements and Commands Used in Transient Thermal Analysis

Transient thermal analyses use the same elements as steady-state thermal analyses., "Steady-State Thermal Analysis," for brief descriptions of these elements.

6.2 Tasks in a Transient Thermal Analysis

The procedure for doing a transient thermal analysis has three main tasks:

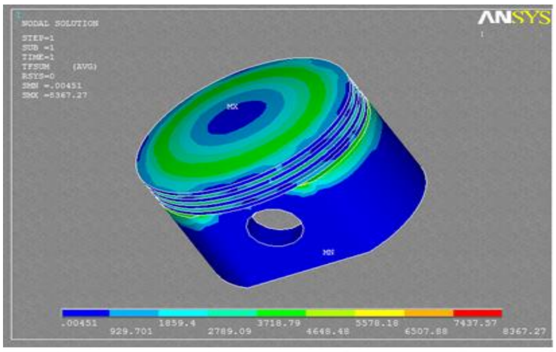
- Build the model.
- Apply loads and obtain the solution.
- Review the results.

The rest of this chapter explains each task in the transient thermal analysis process. Because not every transient analysis includes exactly the same tasks, the text both provides general descriptions of the tasks and relates them to example analyses.

7. THERMAL ANALYSIS RESULTS FOR RADIAL ENGINE

7.1 PISTON:-

Material used:-al alloy 4032 T6
Thermal flux sum when 500 temp



MINIMUM VALUES

NODE	2772	2343	2783	74
VALUE	-5703.7	-2584.6	-5777.9	0.0045E-06

MAXIMUM VALUES

NODE	2771	231	2804	2781
VALUE	5708.8	2.0059	5747.2	8367.27

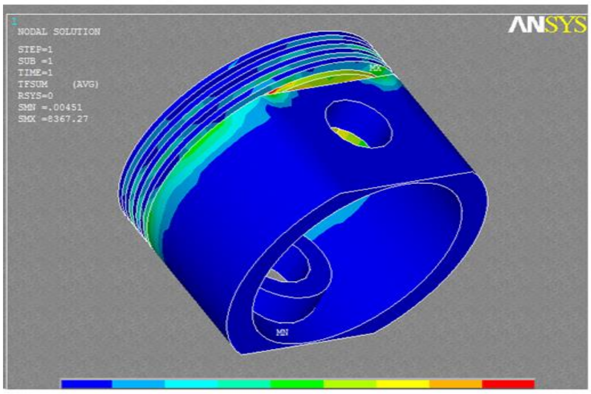
Material used:-gray cast iron
Thermal flux sum when 500 temp:-

MINIMUM VALUES

NODE	2774	1716	2785	716
VALUE	-5838.4	-6612.2	-5489.5	0.4509E-02

MAXIMUM VALUES

NODE	2773	2507	2806	1716
VALUE	5846.7	51.523	5532.5	6612.8



7.2 MASTER ROD
MATERIAL USED:-Aluminium

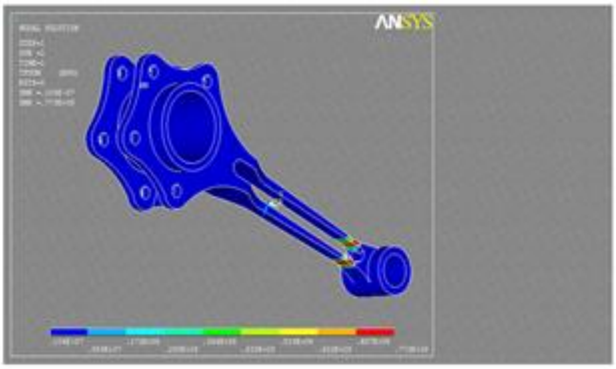
Thermal Flux When Heat 100 At Top And At Bottom 50 Temp

MINIMUM VALUES

NODE	20	1544	369	2531
VALUE	-25.248	-12.780	-23.047	0.0000

MAXIMUM VALUES

NODE	10	1439	61	20
VALUE	23.871	12.724	23.995	25.334



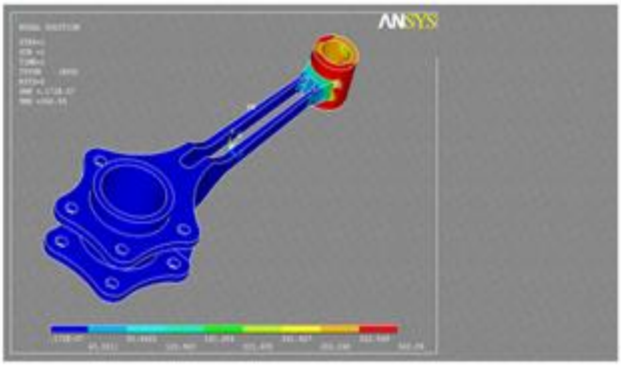
Material Used :-STEEL ALLOY

MINIMUM VALUES

NODE	179	444	338	3206
VALUE	-348.72	-196.71	-340.12	0.43095E-07

MAXIMUM VALUES

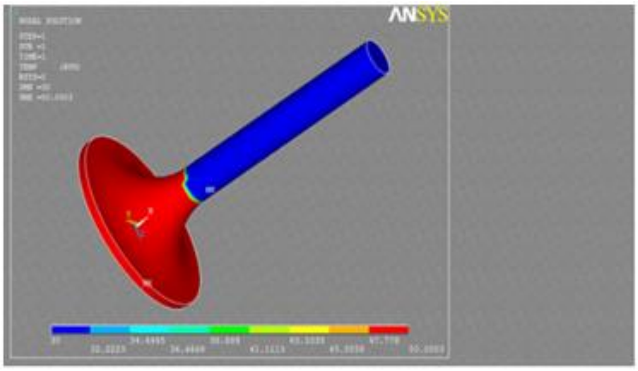
NODE	289	3305	204	204
VALUE	342.07	204.87	358.70	362.89



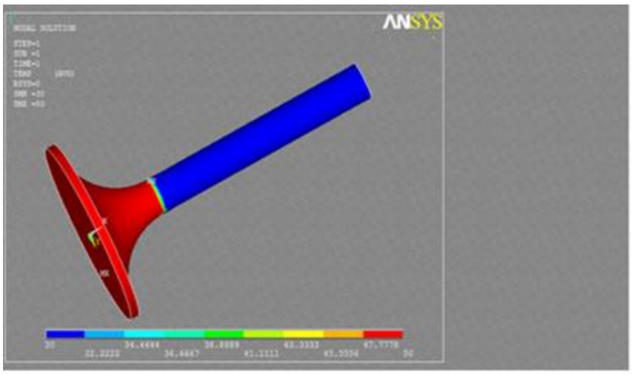
7.3 INLET VALVE

Material Used:- Stainless Steel

MAXIMUM ABSOLUTE VALUES
NODE 113
VALUE 50.000



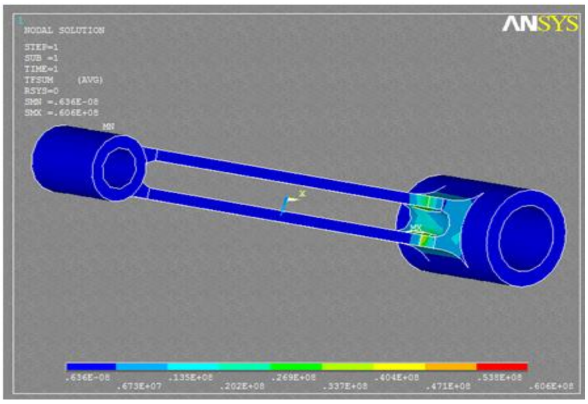
Material Used:- chrome steel



MAXIMUM ABSOLUTE VALUES
NODE 32
VALUE 47.778

7.4 RADIAL CONNECTING ROD:-

Material used:- Gray cast iron



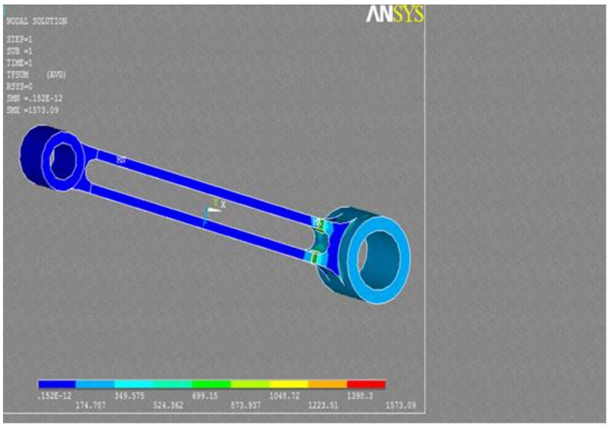
Material used:- al alloy

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



8.CONCLUSION

Using PRO_E tool Radial Engine Assembly (Five cylinders) is developed including few sub-assemblies. component applying same boundary conditions and same loads are appliedFor valves the max temperature is at node - 32; value- 47.778when the material is chrome steel. For valves the stainless steel receiving little temperature comparing with chrome steel.

The main objective of analysis is to showing the comparison between two materials for same 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.

9.REFERENCE:

1. Vivian, E. Charles (1920). A History of Aeronautics. Dayton History Books Online.

2. Day, Lance; Ian McNeil (1996). Biographical Dictionary of the History of Technology. Taylor & Francis. p. 239. ISBN 0-415-06042-7.

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