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FEA Analysis of Four Strokes Spark Ignition Split Cycle Engine

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Abstract: Engine is a very important component in automobiles and it is act as a prime mover. Engine is a device which will converts heat energy into mechanical energy. Engine transmits power to road wheels against to sprung and unsprug weights which results the engine components are stressed. The engine components like cylinder, piston and piston rings are exposed to heat so that the thermal stresses are induced. The connecting rod and crankshaft are exposed to static and dynamic loads which results these components are stressed. Based on the above said points the stress and strain analysis is very important for engine components. The main aim of this work is to design and simulate the thermal and structural stress analysis of a split cycle four stroke spark ignition engine. The engine was designed by using solid works software and the three-dimensional thermal and structural analysis was done in the ANSYS software. The dynamic analysis of crank shaft was done by ANSYS.This work investigated the amount of heat flow in the engine components (compression and expansion cylinders and pistons) and failure analysis of engine components (Connecting rod and Crank shaft) of a split cycle four stroke spark ignition engine.
Key-Words: - SOLIDWORKS, FEA, Split Cycle engine.

I. INTRODUCTION

Internal combustion engine is a device which will converts heat energy in to mechanical energy. Split cycle engine is advanced engine as compared to conventionalICengine. In conventional engine (Four stroke S.I. engine) all process like suction, compression, expansion and exhaust occurs in single cylinder but in split cycle engine two process (Suction and Compression) occurs in compression cylinder and remaining two process (Expansion and Exhaust) occurs in expansion cylinder.

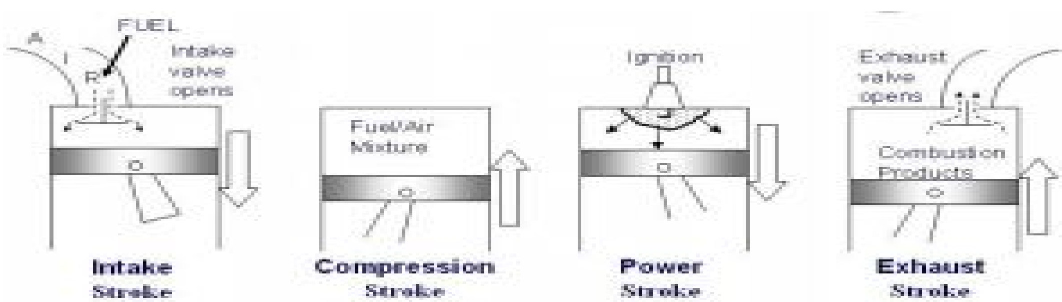


Fig.1. Working of conventional four stroke S.I. Engine

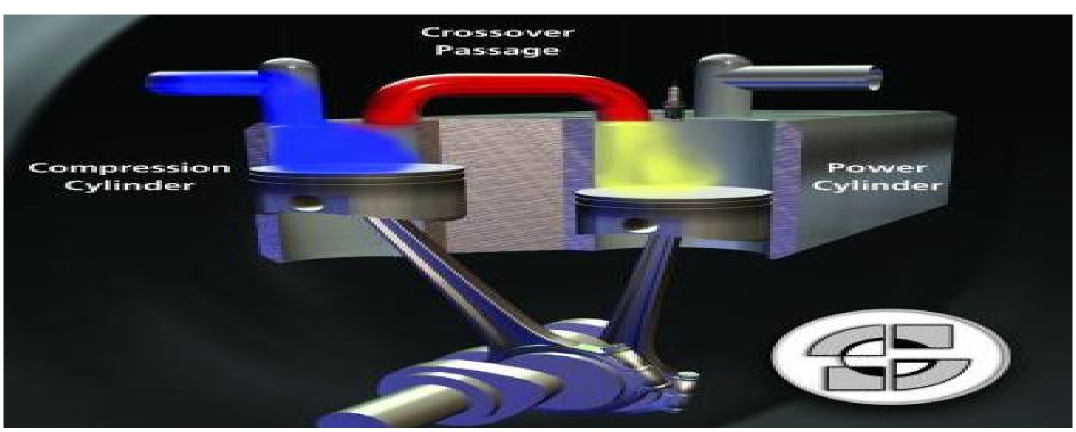


Fig.2. Working of split cycle four stroke S.I engine

II. LITERATURE REVIEW

SudeerGowdPatil et.al. (2012)The CFD analysis is carried out for both the conventional spark ignited engine and the Scuderi split cycle engine. The peak pressure, thermal efficiency and power output obtained in the Scuderi engine is 11 bar at 300 rpm, 5% and 20% more than the conventional engines [1].Prince Bora et.al.(2015)The split engines are more efficient than the conventional IC engines. The area under the P-V curves is also greater than that of the conventional IC engines [2].Guangyu Dong et.al.(2015)Studied that expansion ratio is increased to 26 since a 2.8% total efficiency improvement still can achieved from over expansion He was concluded that through the system optimization, a total thermal efficiency can be increased on split cycle engine[3].AnshulJangalwa et.al.(2013)Concluded that the Scuderi split cycle engines are more efficient than conventional engine and therefore they are future alternatives of the conventional engines. It reduces the emission of engine[4].Ulrik Larsen et.al (2014)In the Split-cycle, the working fluid concentration can be changed during the evaporation process in order to improve the match between the heat source and working fluid temperatures simplified cost analysis suggests higher purchase costs as result of increased process complexity [5].

III. METHODOLOGY

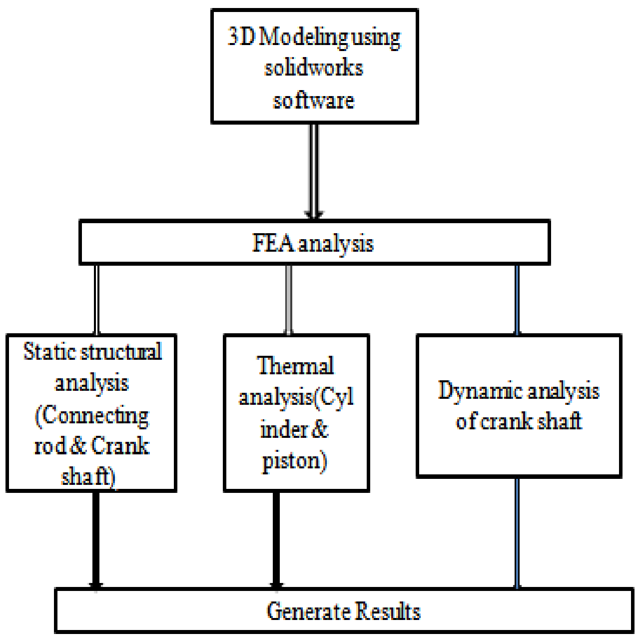


Fig.3. Drafting and analysis chart of four stroke split cycle S.I. engine

A. 3D models of split cycle engine components

The geometric models of split cycle engine coponents was designed in the solidworks

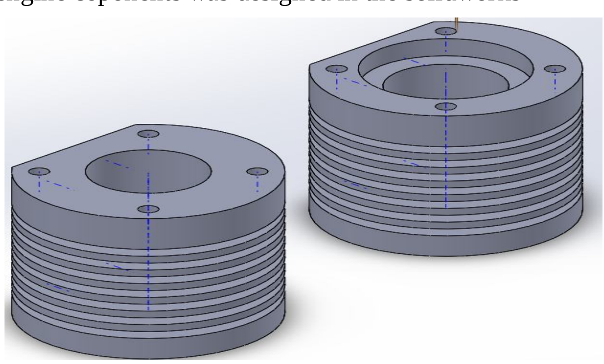


Fig.4. Proposed models of compression and expansion cylinders

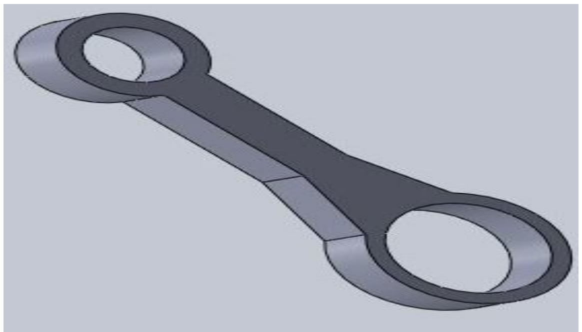


Fig.5. Proposed model of connecting rod

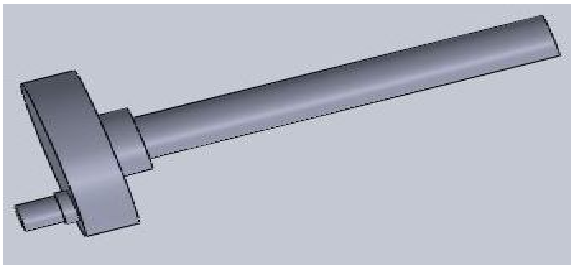


Fig.6. Proposed model of crank shaft

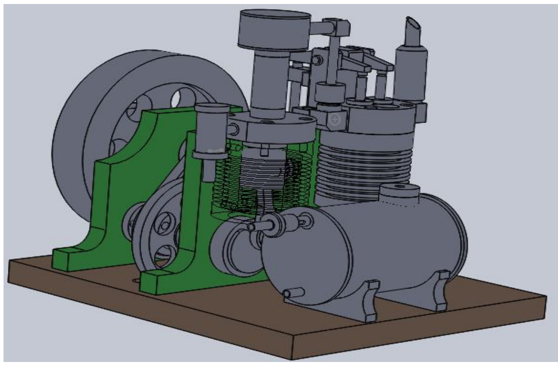


Fig.7. Assembly of four stroke spark ignition split cycle engin

B. *Fem Analysis*

The strength, safety, emission control and heat transfer are very important issues in engines. To meet these requirements, need to perform static structural and thermal analysis on split cycle engine. Static structural and thermal analysis was done by using ANSYS software and engine components are designed in solidworks.

C. *Material Selection*

Structural Steel

1	Yield Strength	250 MPa
2	Ultimate Strength	460MPa
3	Density	7.85e-006 kg mm^-3
4	Coefficient of Thermal Expansion	1.2e-005 C^-1
5	Specific Heat	4.34e+005 mJ kg^-1 C^-1
6	Thermal Conductivity	6.05e-002 W mm^-1 C^-1
7	Resistivity	1.7e-004 ohm mm
8	Strength Coefficient	920MPa
9	Strength Exponent	-0.106

D. Meshing

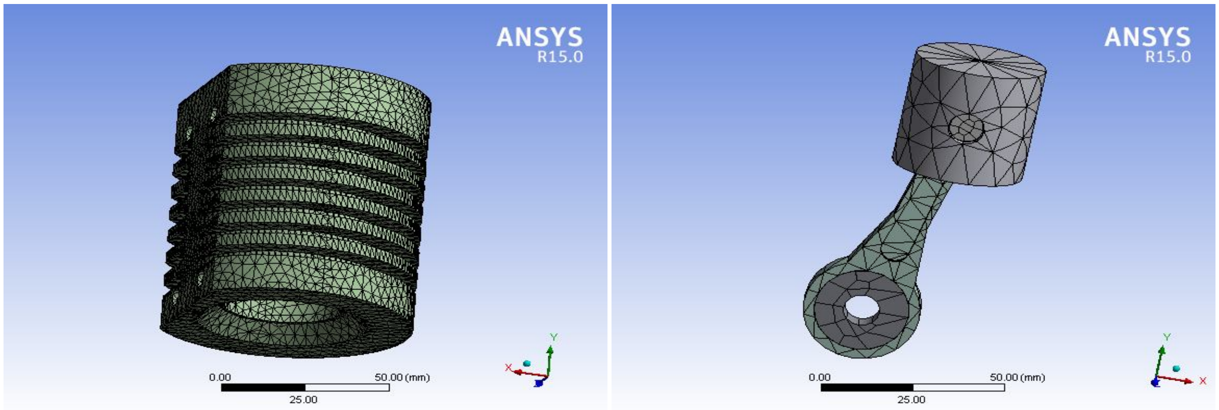
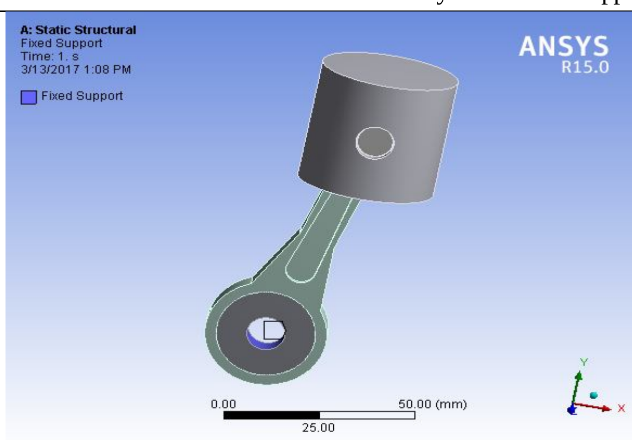
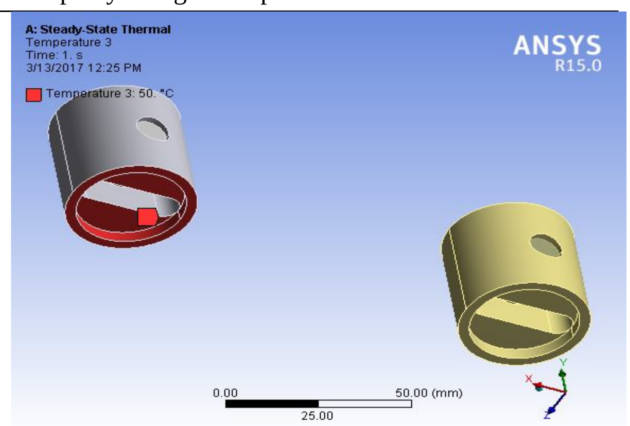


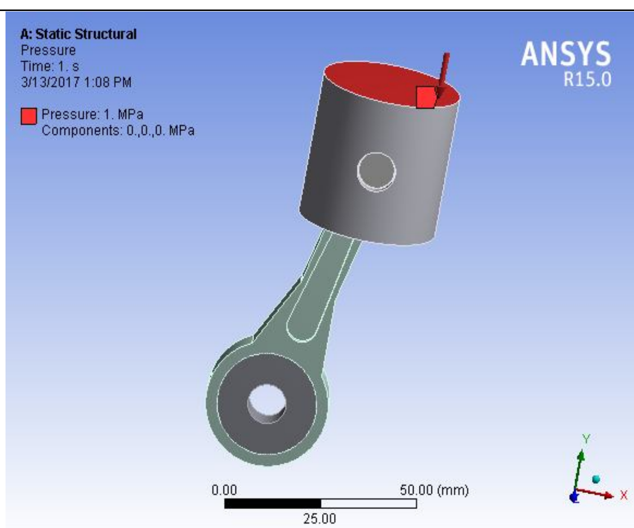
Fig.8. The proposed meshing model of split cycle engine components
(Cylinder and Piston and connecting rod assembly)

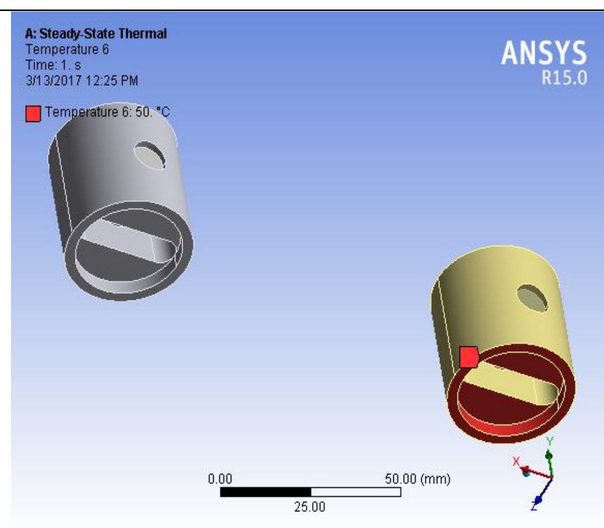
E. Boundary conditions

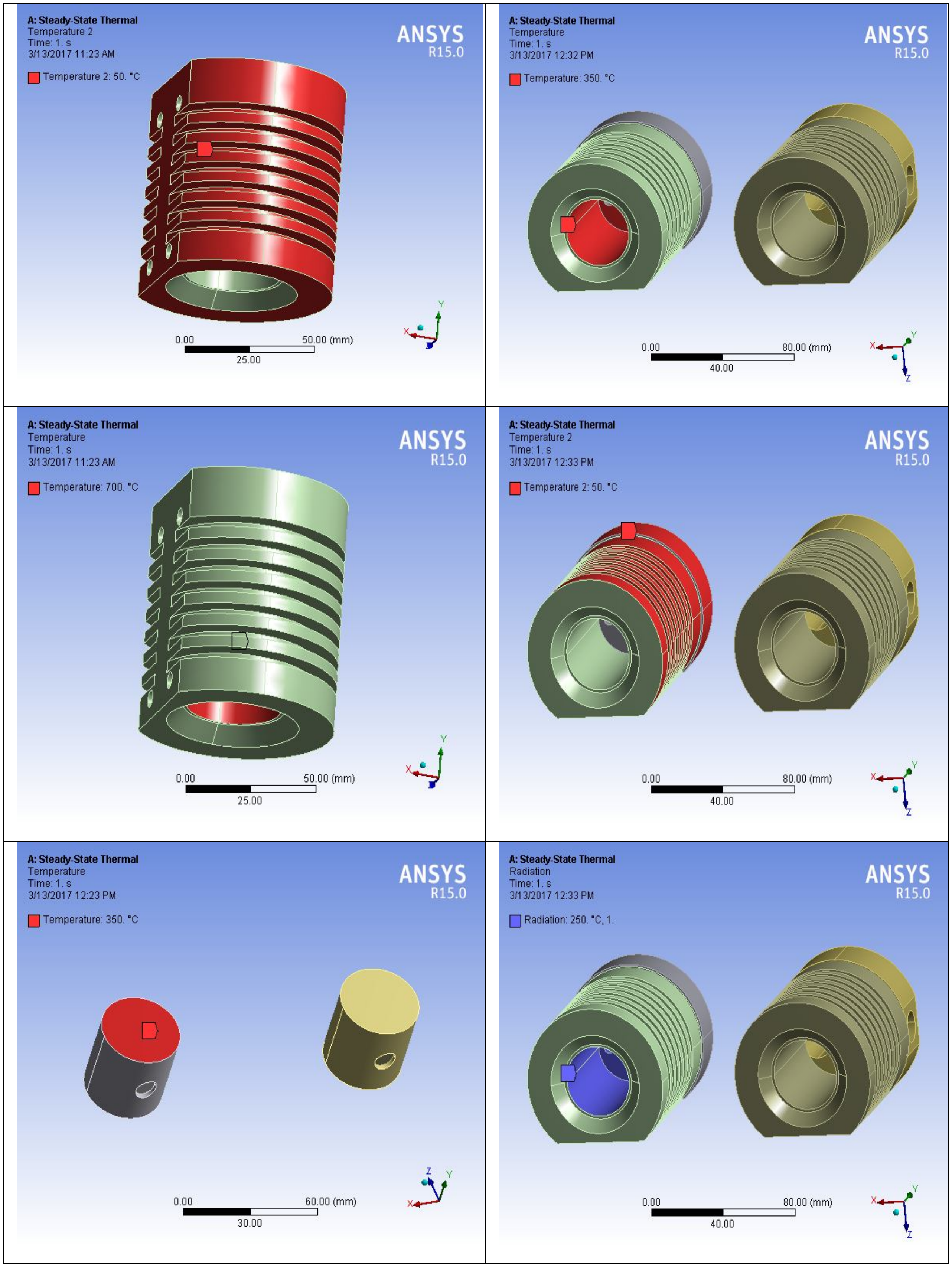
Table.1. Boundary conditions are applied on split cycle engine components







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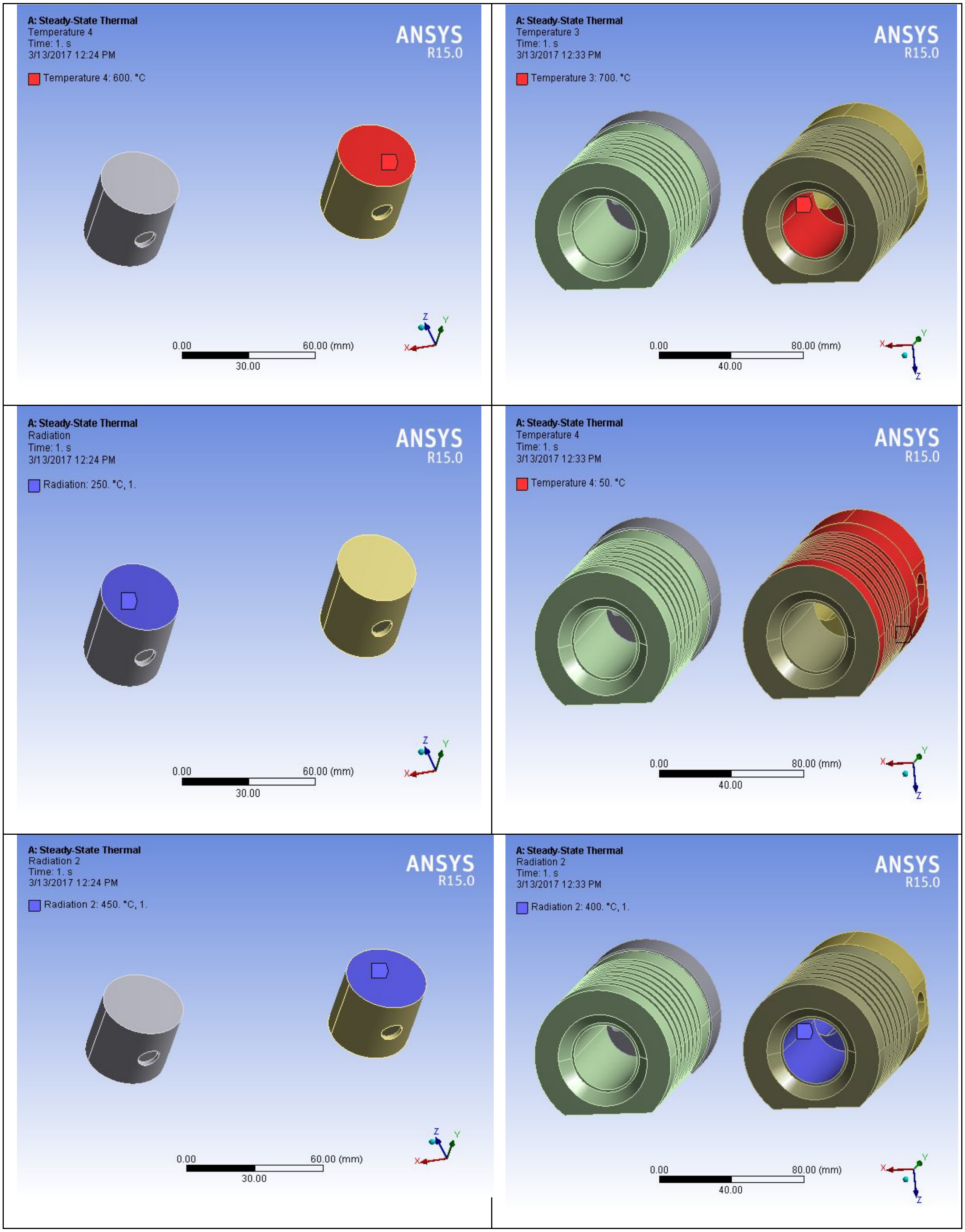

Fig.9. Boundary conditions are applied at split cycle engine components

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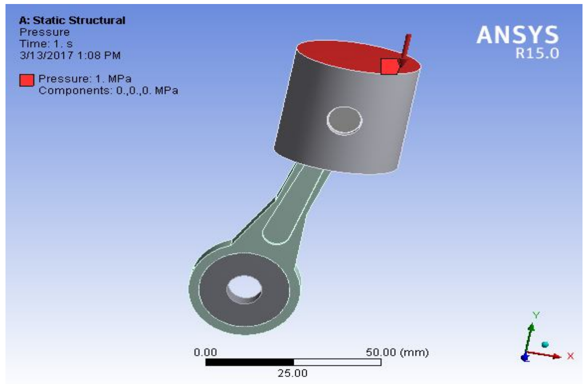

Fig.10. Load is acting on piston and connecting rod assembly

IV. RESULTS AND DISCUSSIONS

Fig 13 shows the maximum von miss stress of stainless steel connecting rod. The maximum von miss stress value was 103.42 MPa.Fig.17.& 21 shows the total heat flux of stainless steel compressions and expansion pistons and cylinders. The total heat flux values were 3.57 and 21.14 w/mm^2. Fig.24. shows the maximum von miss stress of stainless steel crankshaft under dynamic conditions. Thevalue of Von miss stress were 0.22MPa.

Table.2. Static structural analysis of split cycle engine connecting rod and piston assembly

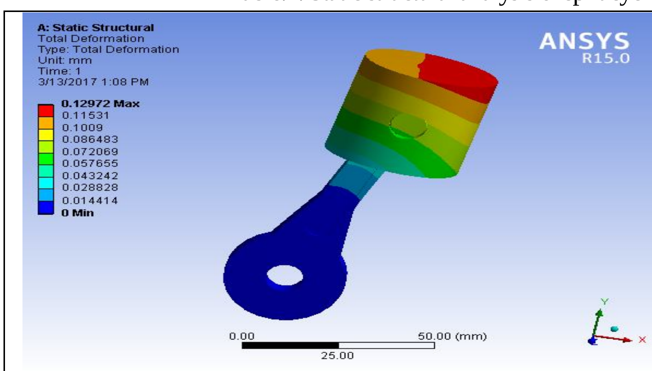

Fig.11. Total deformation

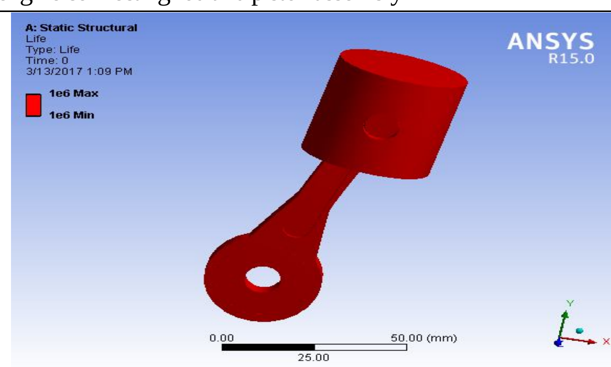

Fig.17. life

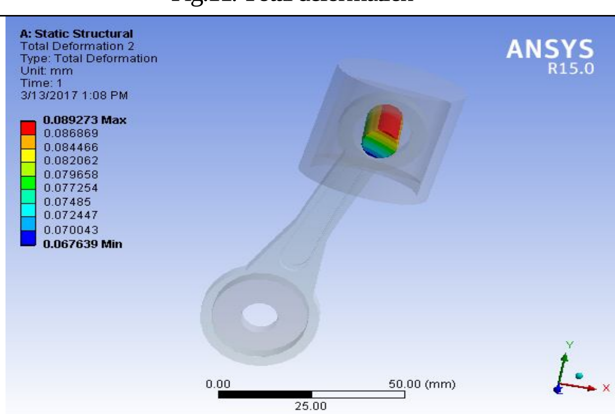

Fig.12. Total deformation on gudgeon pin

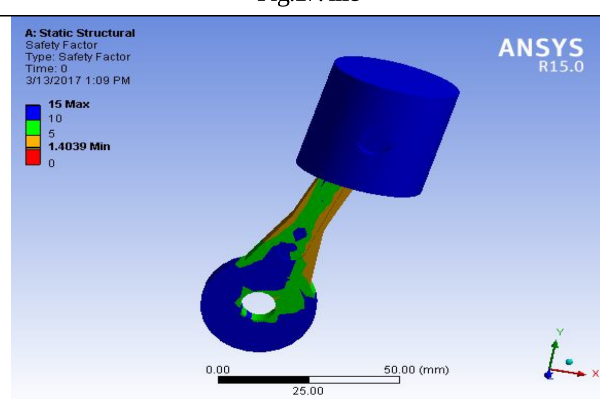

Fig. 18. Safety factor

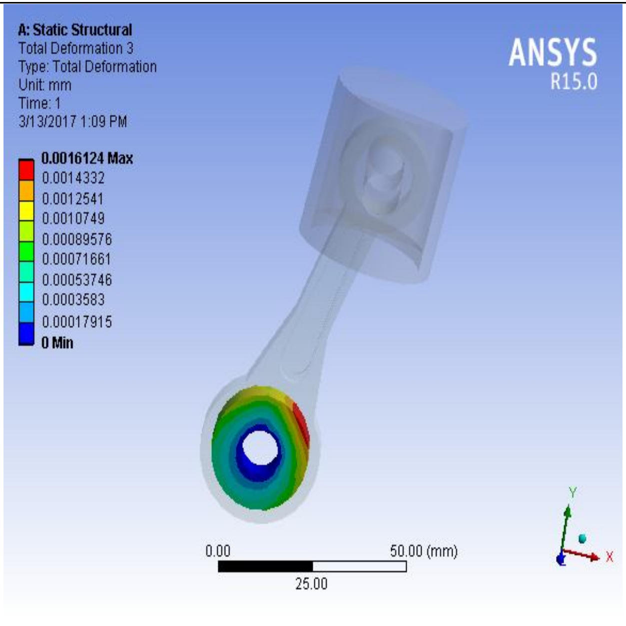

Fig.13. Total deformation on connecting rod big end

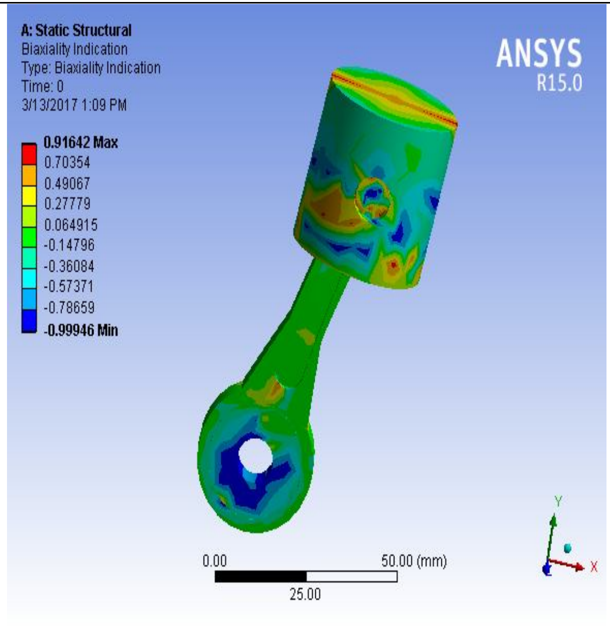

Fig.19. Biaxiality indication

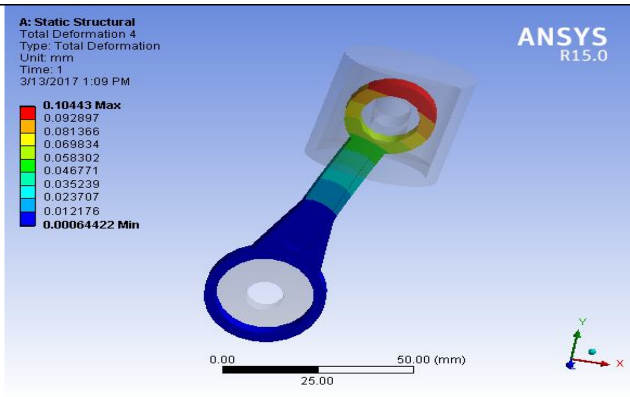

Fig.14. Total deformation on connecting rod

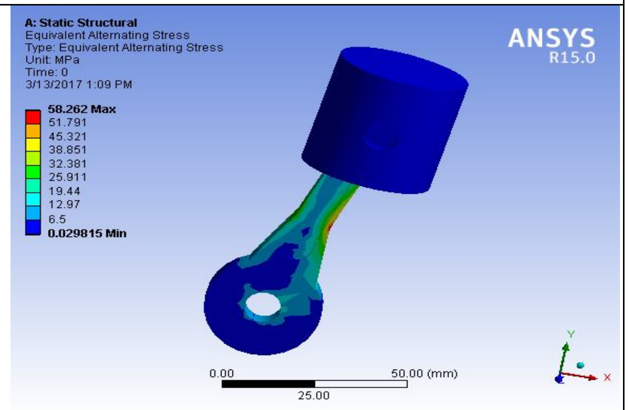

Fig.20. Equivalent alternating stress

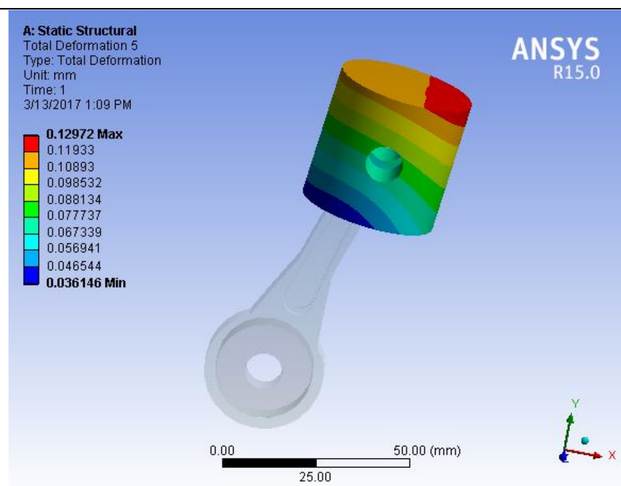

Fig.17. Total deformation on piston

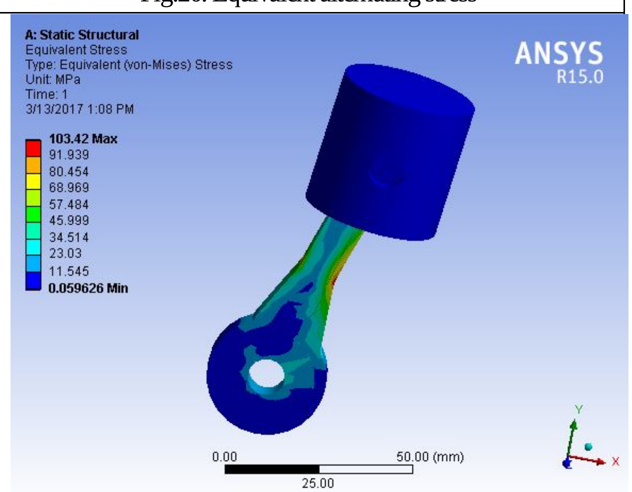

Fig.13. VonMises stress

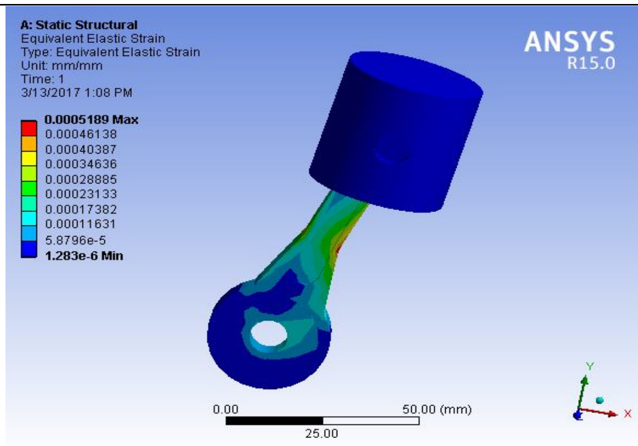

Fig.12. Equivalent elastic strain on connecting rod

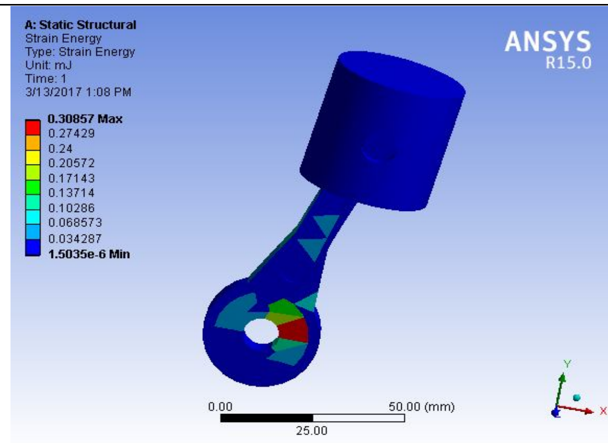

Fig.14. Strain energy

Table .3.Thermal analysis of compression and expansion pistons

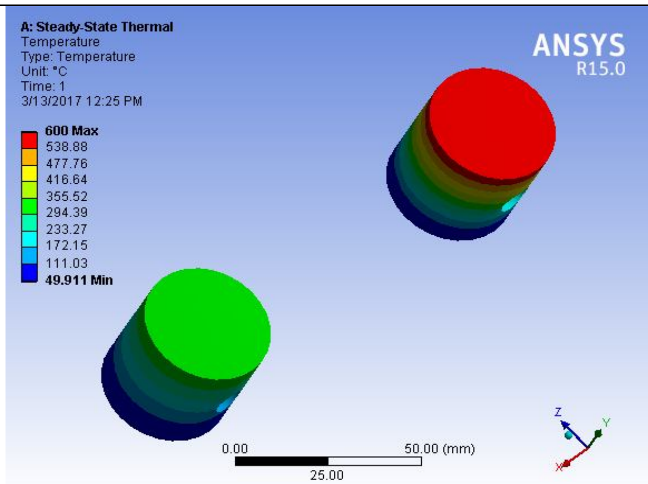

Fig.15. Temperature on split cycle engine pistons

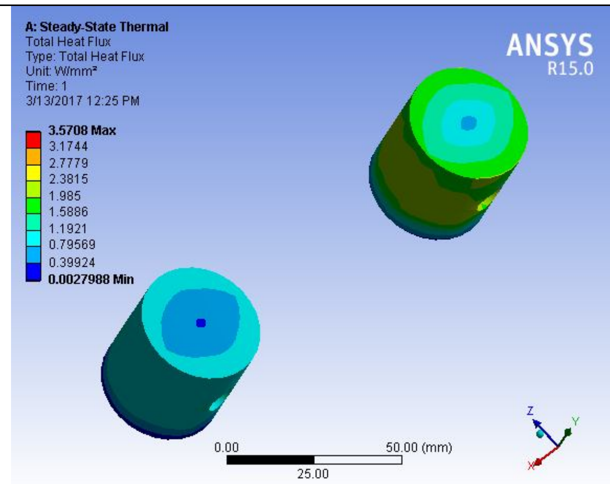

Fig.17.Total heat flux

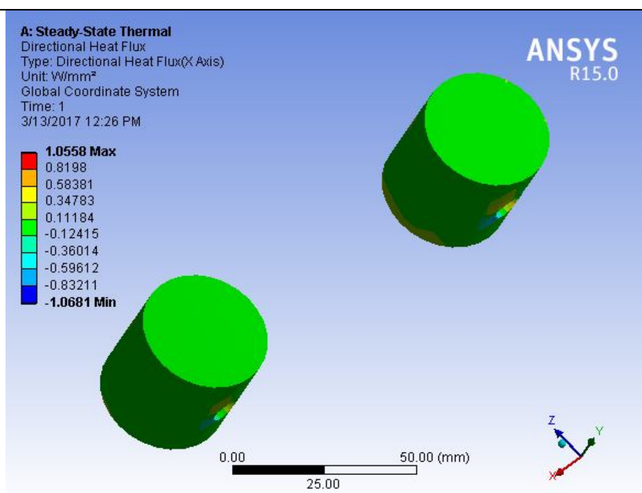

Fig.16. Directional heat flux

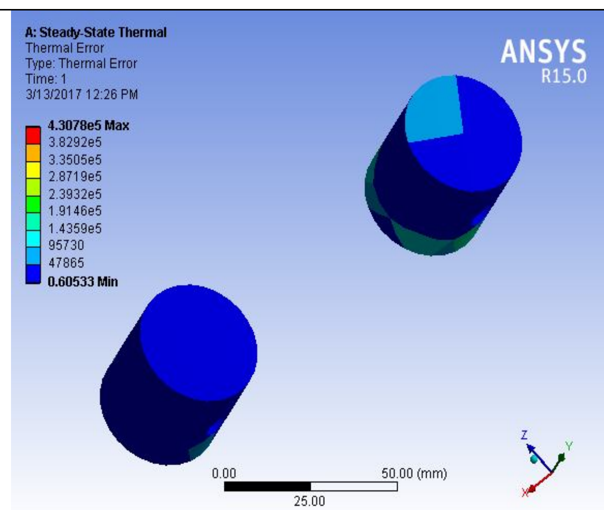

Fig.18. Thermal error

Table.4. Steady State Thermal analysis of compression and expansion cylinders

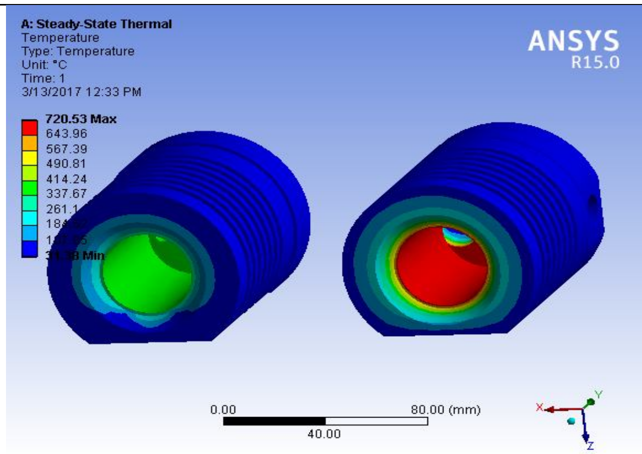

Fig.19. Temperature distribution of compression and expansion cylinders

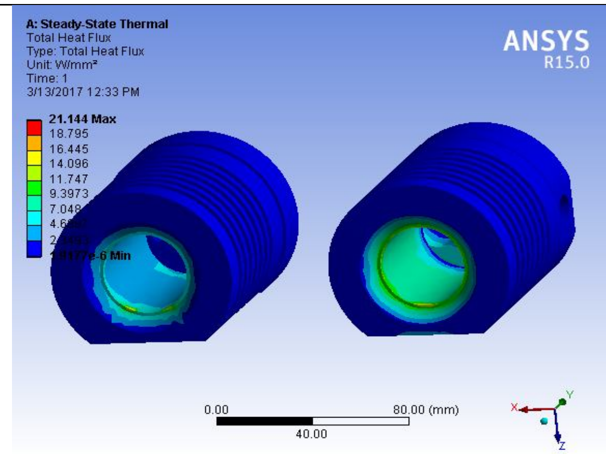

Fig.21.Total heat flux of compression and expansion cylinders

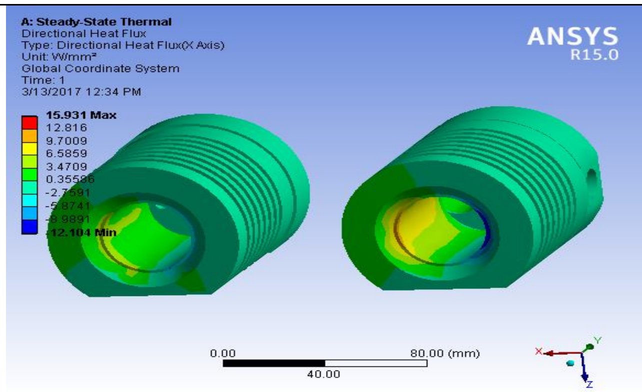

Fig.20..Directional heat flux of compression and expansion cylinders

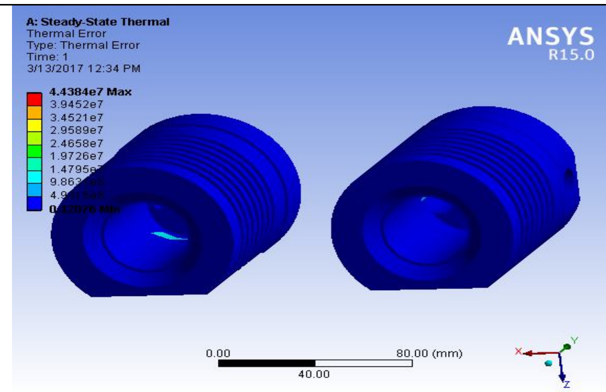

Fig.22. Thermal error of compression and expansion cylinders

Table.6. Dynamic analysis of crankshaft

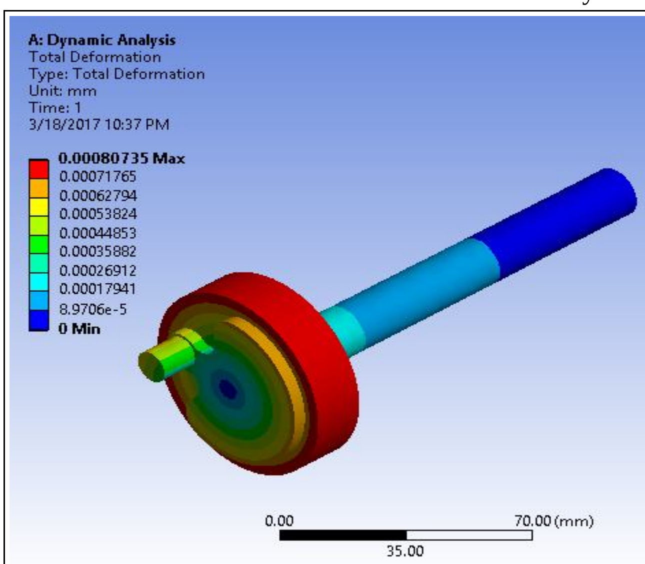

Fig.23.Deformation of crankshaft

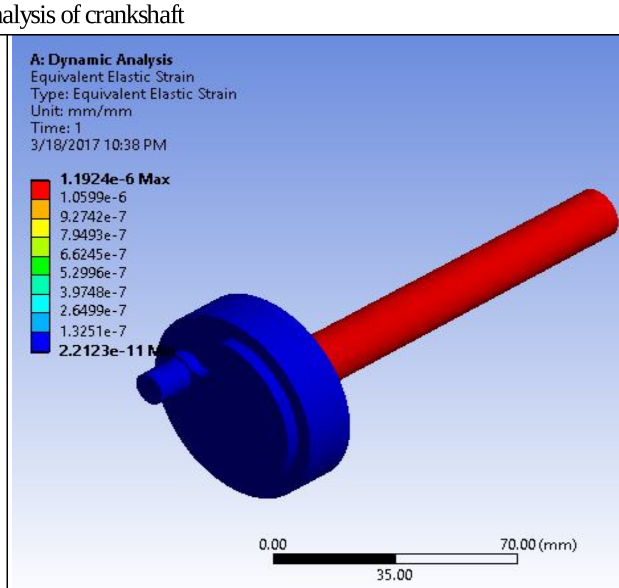

Fig.26.Equivalent elastic strain of crankshaft

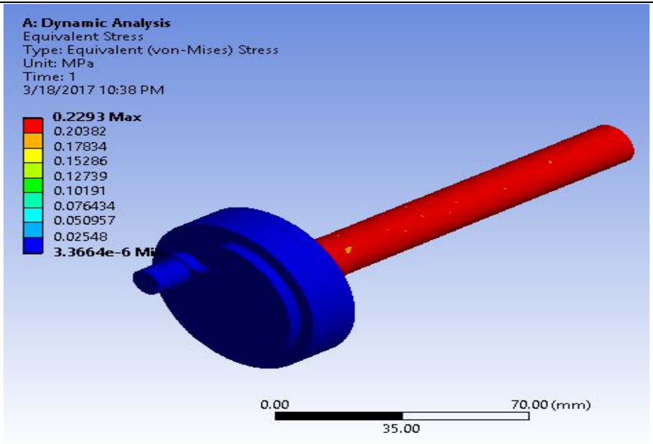

Fig.24. Equivalent stress of crankshaft

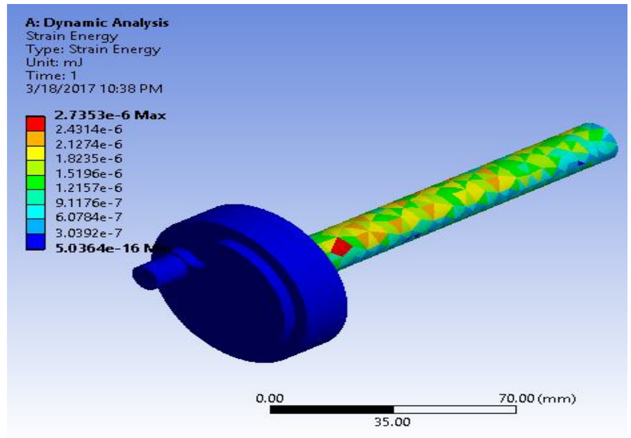

Fig.27.Strain energy of crank shaft

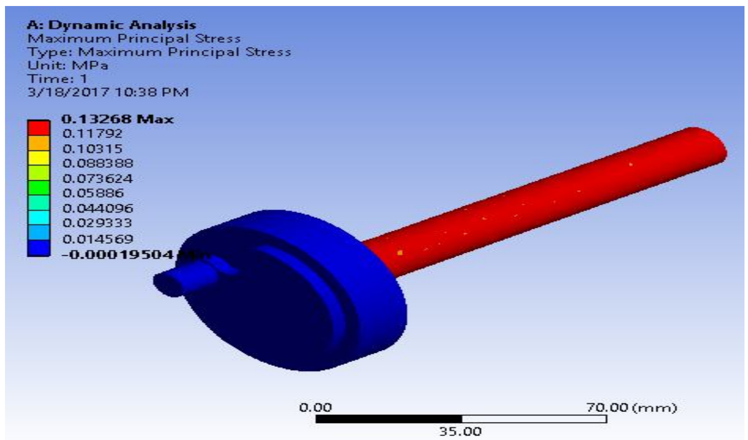

Fig.25..Maximum principal stress of crankshaft

V. CONCLUSION

Modeling and FEA analysis of split cycle S.I. engine components was done by using SOLIDWORKS and ANSYS 15 software. Static structural analysis was carried out on piston and connecting rod assembly considered 1 MPa load. At 1 MPa load, the total deformation of each component, Von miss stress of connecting rod, strain energy and life values were noted. The study state thermal analysis was carried out on both compression and expansion pistons& cylinders at 700^{0}temperature. The total heat flux values of both piston and cylinder values were noted. In this analysis observed structural steel material is best for all components. All the result values were within the acceptable limits.

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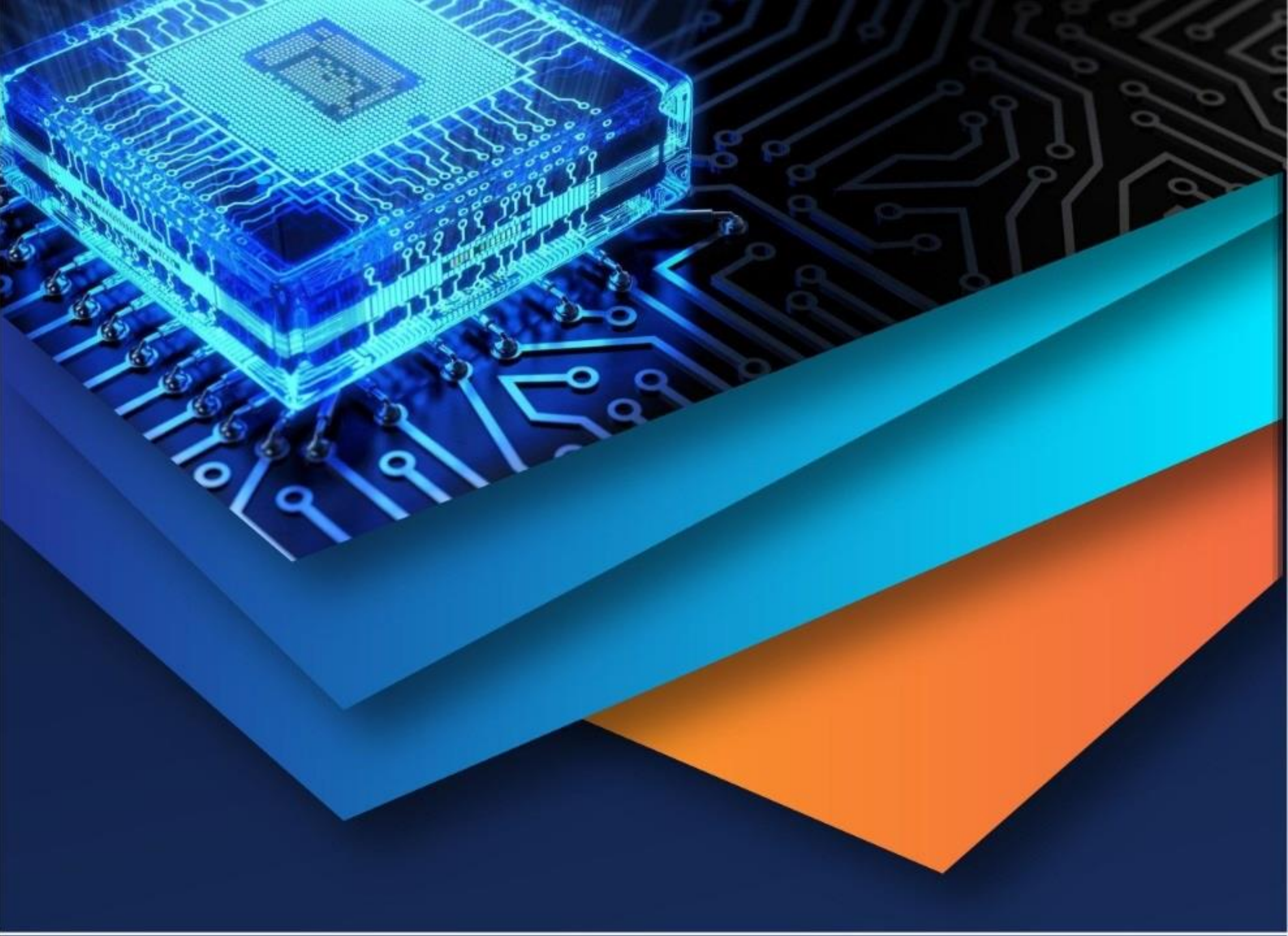
[5] System analysis and optimisation of a Kalina split-cycle for waste heat recovery on large marine diesel engines Ulrik Larsen*, Tuong-Van Nguyen, Thomas Knudsen, Fredrik Haglind



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