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Fluid Surface Interaction (FSI) of Piston Head and Master Rod

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ABSTRACT

In this paper, Fluid Structure Interaction (FSI) of piston head and master rod will be examined. Various Parameters like temperature, total deformation, equivalent elastic strain and equivalent stress is to be examined. Model of master rod and piston head is created in CATIA V5 and its steady state thermal analysis is done.

General Terms

CATIA V5, CFD, ANSYS, STEADY STATE THERMAL ANALYSIS.

Keywords

Equivalent stress, FSI, Temperature, Convection, Total deformation, Total heat flux,temperature, static structural.

1. INTRODUCTION

FSI i.e. Fluid Structure Interaction occurs when fluid flow causes deformation of the structure. This in turn changes the boundary condition of the fluid flow. FSI applications involve coupling of fluid dynamics and structural mechanics. Basically, Fluid flow exerts hydrodynamic forces on a structure and deforms the structure. Fluid Flow can also modify thermal stresses within the structure. Modes of FSI include rigid body FSI, 1-way FSI and 2-way FSI. In rigid body FSI structure, only motion of solid structure in the fluid are considered. In 1-way FSI, we calculate, pass flow and thermal fields from CFD to structural analysis FEA CODE.

The analysis is performed on the CATIA model using Steady State Thermal analysis system. We have done 1-way FSI in workbench.

2. EXPERIMENTAL PROCEDURE

The model for the analysis was designed in CATIA V5.The model consists of piston head with bearings, Mater rod with bearings, piston ring and piston plug as shown in fig.1.

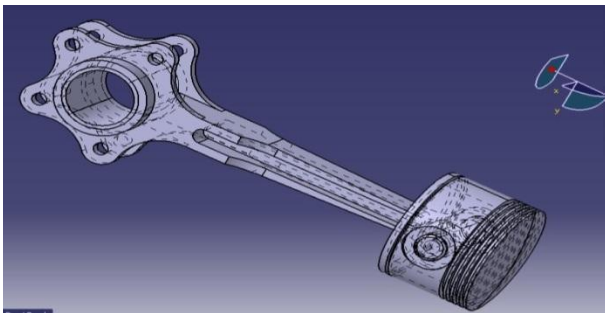

Fig 1. CATIA model of Piston and Master rod.

Then the model was imported into steady state thermal analysis system. Material used is Aluminum. Then meshing of the model was performed as shown in fig 2.

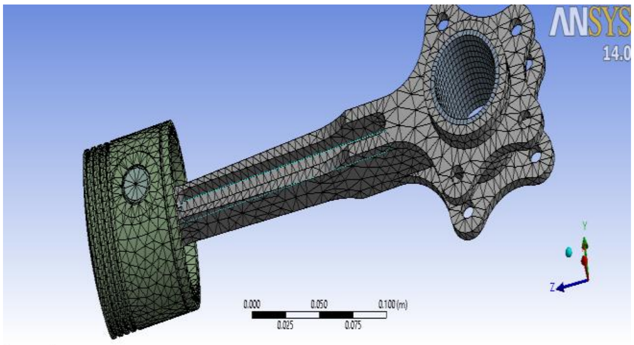

Fig 2. Meshing of CATIA model in ANSYS

Temperature of the piston head was set to 400 °C. For Convection, the whole body part was selected and film coefficient was taken as Stagnant Air. Then temperature (fig 3.) and total heat flux (fig 4.) over whole piston assembly was noted and examined.

Then coupling of State Thermal Analysis was done with Static Structural Analysis as shown in fig 5. A Pressure of 10 Pa is applied on the piston head (fig 6.) on which the temperature of 400°C was applied to find the results during compression stroke. Fixed support is provided to piston plugs in static structural analysis. Then total Deformation (fig 7). and Equivalent stress (fig 8). Was noted and examined.

3. RESULTS AND DISCUSSIONS

Fig 3 shows the temperature distributions over the piston-rod arrangement when a temperature of 400 °C is applied to piston head. It was observed the maximum temperature is at the piston head itself when temperature is being applied denoted by max. in the fig.3 and temperature gradually decreases as we move from piston head to master rod.

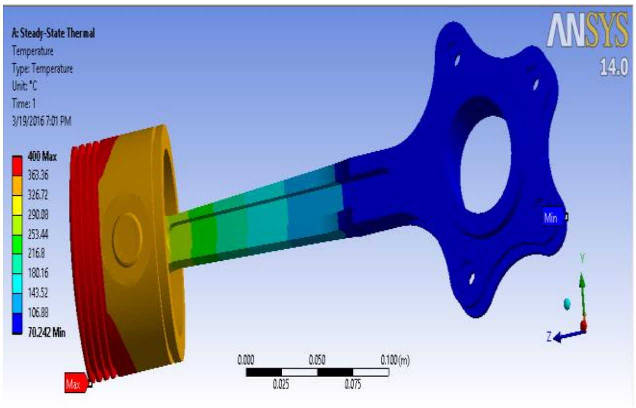

Fig 3. Temperature variations on piston-rod assembly

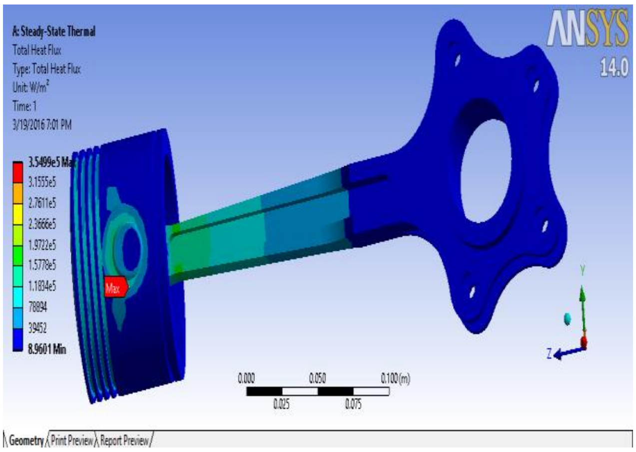

Fig 4. Total heat flux

Fig 4 shows the total heat flux over the piston-rod assembly. It was observed that maximum heat flux was found at the piston head where the temperature was applied.

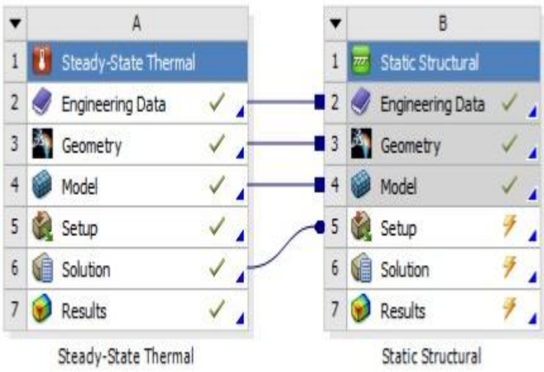

Fig 5. Coupling of steady state thermal with static structural.

In fig 5, coupling is done of steady state thermal system analysis with static structural analysis. All the results of steady state thermal analysis was automatically imported to static structural analysis and finally total deformation and equivalent stress was found using static structural analysis.

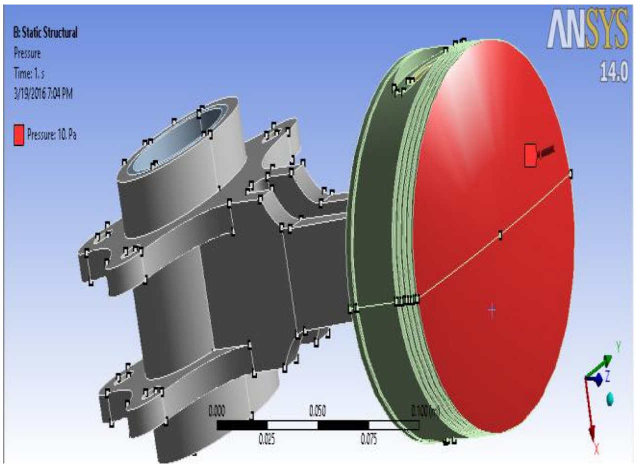

Fig 6. Application of pressure on Piston Head

Fig 6 shows the application of pressure on the piston head. Red colour denoted the piston head and pressure is applied normal to the surface of piston head as denoted by arrow.

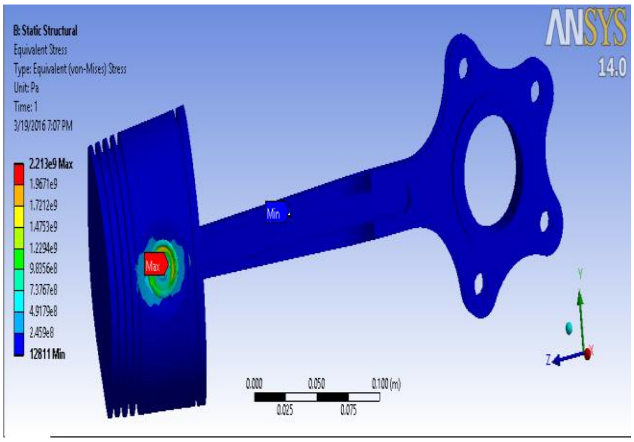

Fig 7. Equivalent stress on Piston-rod arrangement.

In fig 6, equivalent stress over was model was examined. It was observed that maximum stress was found to be on piston plugs as shown in the figure. It is clear from the figure that maximum stress occurs at a point where the fixed support is there.

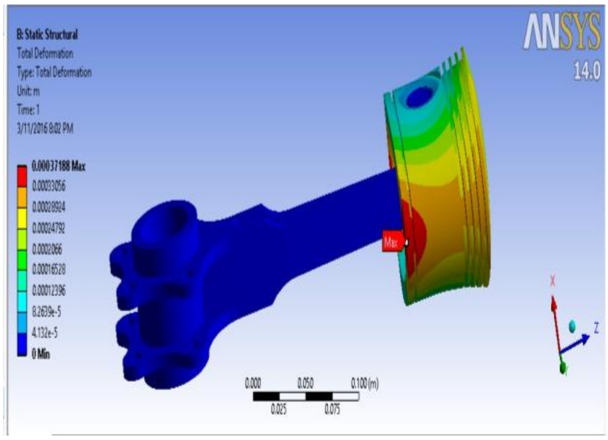

Fig 8. Total Deformation on Piston-rod arrangement.

Fig 8 shows the total deformation of the piston rod arrangement. As it is clear from the analysis done in fig 8, that maximum deformation is on the piston head itself, where the temperature was applied.

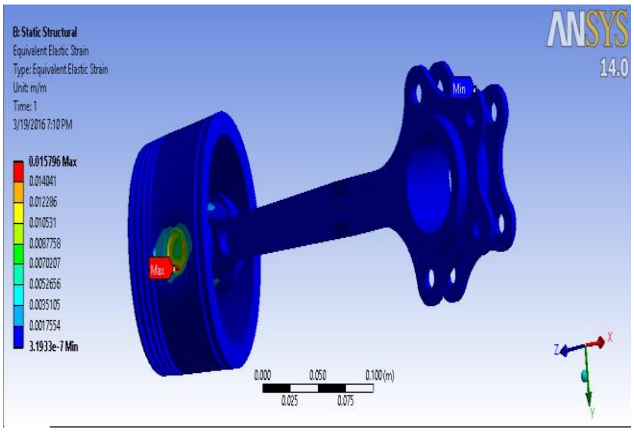

Fig 9. Equivalent Elastic Strain on Piston-Rod arrangement

Fig 9 shows equivalent elastic strain over the arrangement. Maximum strain occurs at a point where maximum stress is there because according to Hook's Law, Stress is directly proportional to strain within elastic limit. So maximum stress and maximum strain occurs at the point where fixed support was provided i.e. on the piston plugs.

4. CONCLUSIONS

In the above analysis, it was found that maximum stress and maximum strain was found to be at the fixed support i.e. at the piston plugs and maximum heat flux was at the point where the temperature is being applied i.e. on the piston head and maximum deformation was found to be at the piston head.

The stress produced is 221 Mpa which is below the material yield point (Aluminium). Hence the design is safe.

5. REFERENCES

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