

Design and Analysis of Partially Ceramic Coated Connecting Rod

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ABSTRACT: Connecting rod is a heart of the engine which is mainly used to transmit the motion from piston to crank shaft. Connecting rods are manufactured using carbon steel, aluminum alloys in practical applications. Our aim of this thesis is design and analysis of partially ceramic coated connecting rod. In this work H- section connecting rod is modeled using Creo 2 in order to get more stiffness and strength and reduce the mass of the connecting rod for improving engine operating parameters. After that analysis carried out by two ways first, connecting rod is made of existing material Al 7068 (uncoated) second, connecting rod is made of new material MgO –ZrO₂ (coated) both materials has been investigated like structural and thermal analysis performed by using ANSYS 14.5. Finally, the result of existing material and new material has been compared in order to improve the connecting rod life and reduce the weight.

KEYWORDS: Connecting rod; Design; MgO– ZrO₂; Thermal; ANSYS 14.5.

I. INTRODUCTION

Mohamed Abdusalam Hussin et all (1) have Performed Finite element analysis of connecting rod is done by considering the materials, viz... Aluminium alloy. A.Prem kumar (2) he delt with connecting rod is replaced by aluminium based composite material reinforced with Boron carbide. And it also define the modelling and analysis of connecting rod. M.X. Calbureanu et al (3) has performed compare the behavior of the combustion engine piston made of aluminum alloys. Mr. J.D.Ramani et all (4) have done for load and stress analysis of the connecting rod and optimization for weight reduction. M.Naveen Ram et all (5) have performed evaluate and compare the fatigue performance for automotive crankshafts, namely forged steel and composite material. Based on the above investigation, we have performed ceramic coatings applied to the connecting rod are aimed to reduce heat in order to increase the life of the engine. In this paper has to determine the Thermal, structural analysis of ceramic coated connecting rod (Magnesium oxide (MgO) and zirconium oxide (ZrO₂)) over Al 7068 is done and behavior is analyzed. This shows the more thermal stability, and improves the performance of the engine life.

Material property	Existing material -connecting rod	New material - connecting rod
Poisson ratio	0.33	0.30
Density	2850 kg / m ³	5.74 g/cc
Thermal conductivity	190 W/ m K	3 W / m K
Specific Heat Capacity	1050 J / kg K	0.40 J / g ^o c
Young's modulus	73.1 GPa	210 GPa
Ultimate Tensile Strength	683 MPa	500 MPa
Yield strength	655 MPa	130 MPa
Coefficient of thermal expansion	23.4 x 10 ⁻⁶ / K	8 x 10 ⁻⁶ / ^o c

Table 1. Material Properties used for analysis.

All the properties are taken from previous benchmark for carrying out the experimental analysis (PSZ Zone case) as shown in table 1.

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II. MODELING

Connecting rod is modeled using creo 2.0 more efficient 3D modeling software package. This is shown in fig 1. After that model saved by using standard IGES, STEP Format.

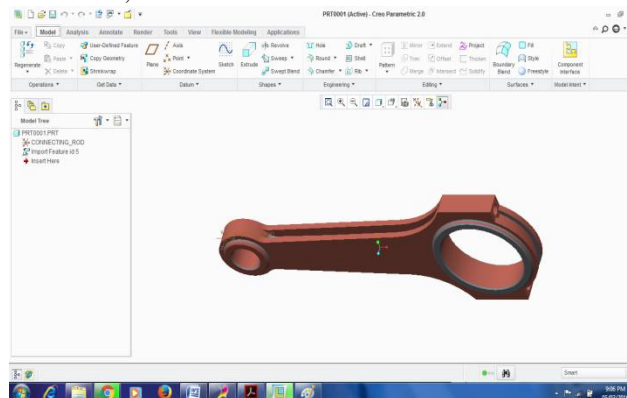


Fig 1. Connecting rod (H –Section)

The connecting rod is considered like both ends hinged for buckling about x-axis and both ends fixed for buckling about y-axis. This is subjected to alternating direct compressive and tensile forces. So, H section is get better stiffness compared to I - section

III. ANALYSIS

A. Finite element meshing and analysis

In this analysis ANSYS 14.5 work bench is used. Connecting rod model is imported in ANSYS 14.5 workbench through standard format IGES. Using SOLID 70 brick element (6) it is meshed as shown in fig.2. The boundary conditions for all DOF constrained at crank shaft end and compressive load applied at the piston end i.e. small end are applied to solve the problem using the Ansys 14.5 solver.

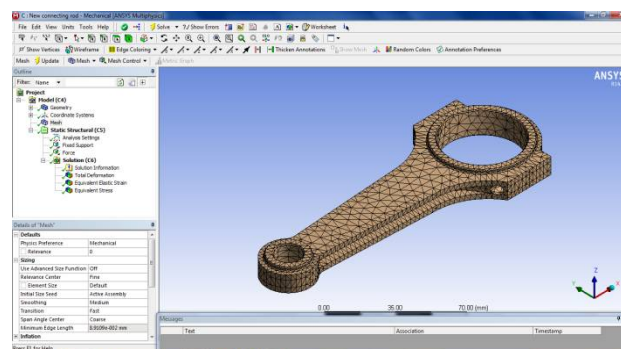


Fig 2. Mesh view – Solid 70 brick element

B. Static Structural Analysis

For the finite element analysis compressive force (7) is applied at the small end of the connecting rod. The analysis is carried out using ANSYS software. The maximum vonmises Stress, strain and displacement are noted from the ANSYS. This is shown in fig 4, 5 and comparison for different materials as shown in table 2

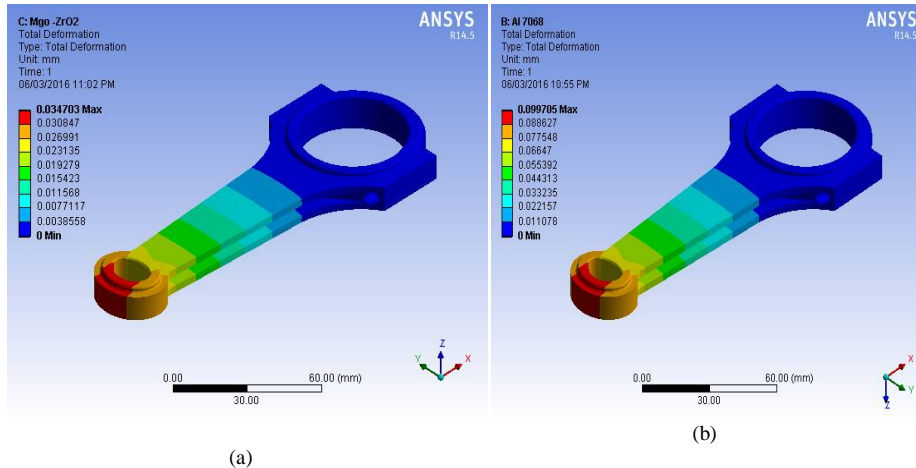


Fig 4. Static Structural analysis (a) Deformation for Coated connecting rod (b) Deformation for uncoated connecting rod

Behaviour analysis of static structural was carried out in fig 4 (a), (b) shows that deformation of coated and uncoated materials results. & fig 5 (a), (b) shows that results of Elastic strain and von –Mises stress for coated material connection rod. This was tabulated in 2

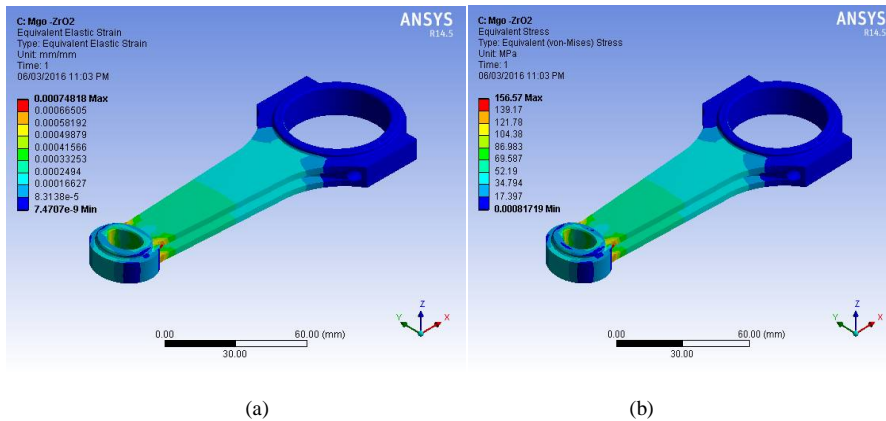


Fig 5. Static Structural analysis (a) Von – mises strain for coated connecting rod (b) Von – mises stress for coated connecting rod

Sl.No	Material	Load		
		Deformation(mm)	Max. Stress(MPa)	Strain (mm / mm)
1	Existing Material (Al 7068)	0.099	154.28	0.002142
2	Modified material (MgO – ZrO ₂)	0.0347	156.57	0.000748

Table 2 Result for Structural Analysis

Based on the above table it observed that existing material deformation and stress values are 0.99 mm and 154.28 MPa which is compared with modified material i.e. coated material deformation and stress values are 0.0347 mm and 156.57 MPa. It shows that higher strength for modified materials.

C. Thermal Analysis

The working medium above the piston contains a mixture of compressed air, un-burnt fuel and burnt gases at the moment when the combustion begins. Temperature and convectional heat transfer occurs at the top of the piston. So, there are temperature and convection heat transfer boundary conditions applied to the model. Here temperature

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200⁰ C applied at the small end, big end of the connecting rod and analysis carried out by using ANSYS 14.5. They are shown in the fig. 6 to fig. 8 below and comparison of different materials as shown in table 3.

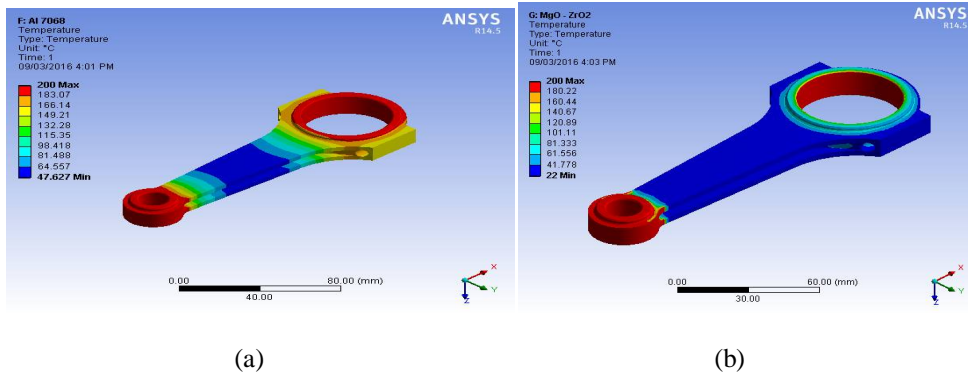


Fig 6. (a) Temperature distribution of uncoated (b) Temperature distribution coated connecting rod

The above fig 6 shows that thermal analysis was carried out it observed that temperature distribution for uncoated connecting rod is higher temperature is occur nearly 183.07⁰C in H section area. For coated connecting rod temperature distribution is lower temperature occur nearly 41.73⁰C it shows in blue color in H section

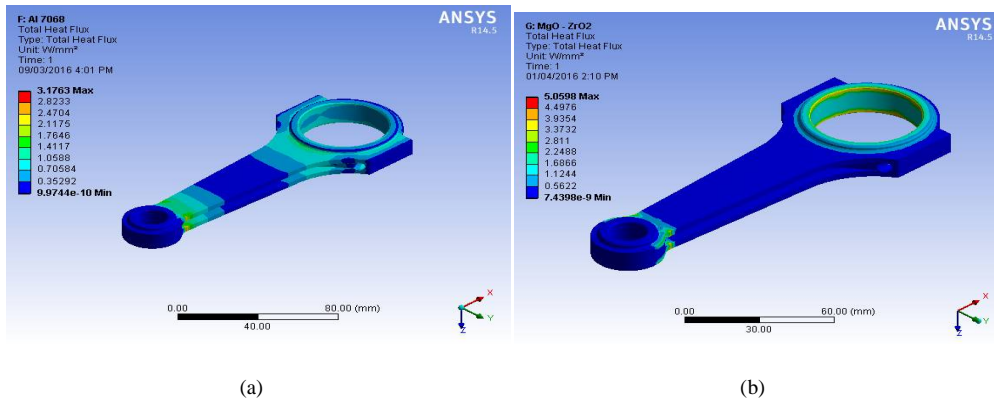


Fig 7. (a) Heat flux for uncoated connecting rod (b) Heat flux for coated connecting rod

The above fig shows that heat flux for coated connecting rod is 5.05 W/mm² compared with uncoated connecting rod is 3.17 W/mm² which observed that heat carrying capacity is higher in coated connecting rod its get improve life of the connecting rod

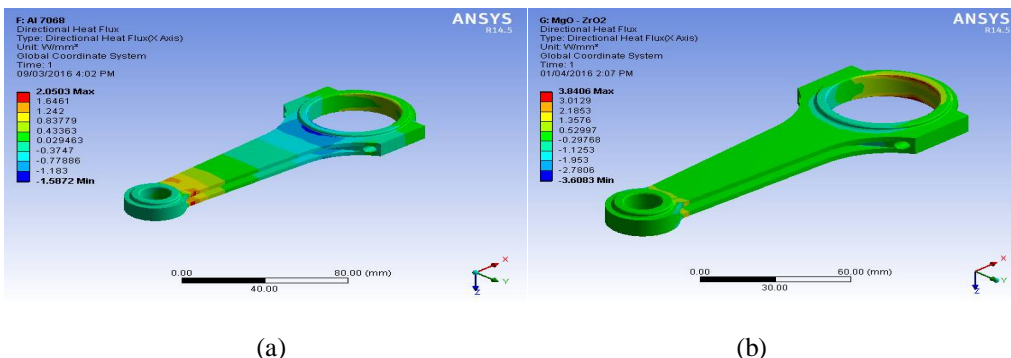


Fig 8. (a) Directional Heat flux for uncoated connecting rod (b) Directional Heat flux for coated connecting rod

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The above fig shows that Directional heat flux (X axis) for coated connecting rod is 3.84 W/mm² which observed that heat carrying capacity is higher in coated connecting rod its get improve life of the connecting rod

Material	Directional Heat Flux (W/mm ²)		Total Heat Flux (W/ mm ²)	
	Max	Min	Max	Min
Existing Material (Al 7068)	2.05	-1.58	3.17	9.97e-10
Modified material (MgO – ZrO ₂)	3.84	-3.60	5.05	7.43 e-9

Table 3 Result for Thermal Analysis

Thermal analysis result comparison was made in table 3 it observed that maximum total heat flux is 5.05 W/mm² for modified material (i.e. Partially coated connecting rod) in order to improve the life of the connecting rod. It helps to increase the engine life in the vehicle.

D. Mass Reduction

$$\begin{aligned} \text{Mass reduction} &= \text{Mass of the uncoated connecting rod} - \text{Mass of the coated connecting rod} \\ &= 0.1261 \text{ kg} - 2.5397\text{e-}02 \text{ kg} \\ &= 0.1007 \text{ kg} \end{aligned}$$

IV. RESULT AND CONCLUSION

Thus the obtained result shows the structural analysis and thermal analysis are compared and tabulated above. It was observed that coated material is best compared with the uncoated materials. It increases the stress, heat flux and reduces the mass reduction of connecting rod. In order to improve the performance of the engine life in Vehicle.

V. CONCLUSION

In this paper, the connecting rod is modeled using Creo 2.0 software and analyzed by ANSYS 14.5 Software. The behavior of structural analysis and thermal analysis are carried out for uncoated i.e. Existing material (Al 7068) over coating of ceramic material (MgO – ZrO₂) is done by connecting rod in order to improve the performance of the engine life. The analyses results indicate that the coated section of the connecting rod, which is close to the big end regions, cause an increase in the temperature.

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