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Ceramic coating effect on IC engine performance

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Present work is intended to investigate the temperature distribution for a ceramic coated internal combustion (IC) engine piston. For comparison purpose analysis was also made on uncoated piston and results were compared with the temperature distribution obtained from the application of different type of coating on the piston. The effect of coating thickness on temperature distribution is also analysed. It is found that increase in coating surface temperature with coating thickness is in a decreasing rate.

These thermal barrier coating (TBC) materials have found a wide application in internal combustion (IC) engine metallic parts as these engine parts operate at a very high temperature. These coatings serve to insulate metallic components from large and prolonged heat loads by utilizing thermally insulating materials which can sustain an appreciable temperature difference between the load bearing alloys and the coating surface. TBC based on ceramics have low thermal heat transfer coefficient and hence makes possible to utilize the maximum amount of energy inside the engine by increasing the maximum temperature limit [1].

In the present work, the piston temperature distribution for uncoated and coated piston is calculated in order to control the thermal stresses and deformations within acceptable levels. TBC consist of three layers; the metal substrate, metallic bond coat and ceramic topcoat. The metal substrate is taken as aluminium alloy while the metallic bond coat, a sandwich between metal substrate and ceramic coating, is chosen an alloy with the composition of nickel, chromium, and aluminium. The top coat is the ceramic topcoat, Al_2O_3–40% TiO_2 and Al_2O_3–40% ZrO_2 having very low thermal conductivity.

Finite element analysis were performed to evaluate temperature gradients of the uncoated aluminium alloy piston and ceramic materials. The temperature distributions of an uncoated aluminium alloy piston and coated piston are shown in Figure 1 and Figure 2.. The maximum surface temperature on the piston crown of the aluminium alloy piston was found as 325.26°C while with ceramic coating Al_2O_3–40% TiO_2 is 454.36°C and for Al_2O_3–40% ZrO_2 it is 383.96°C. It is evident that application of ceramic material enhances the performance to the diesel engine as it allows to utilize the maximum amount available energy inside the engine. The maximum surface temperature of the ceramic coated piston is improved approximately 39% for Al_2O_3–40% TiO_2, 18% for Al_2O_3–40% ZrO_2 than the uncoated piston by means of ceramic coating.

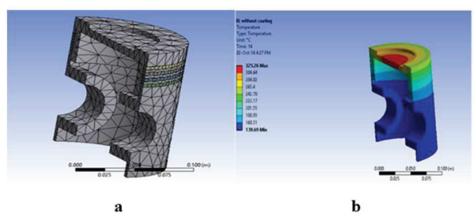

Figure 1: (a) Piston model and (b) temperature distribution for uncoated piston

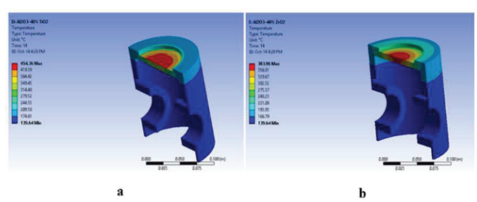

Figure 2: Temperature distribution for coated piston (a) Al_2O_3-40% TiO_2 (b) Al_2O_3-40% ZrO_2

Reference

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