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Thermal Analysis of Air Gap Insulated Piston using Different Composite Materials for Crown

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ABSTRACT

piston essentially consists of a long cylindrical casting closed at the top end open at the bottom end, with wrist pin attached at the center, which transmits the thrust to the connecting rod and then to the crank shaft. The piston provides the means where by gas loads are transmitted to the connecting rod/crank shaft system i.e. it transforms heat energy into the mechanical energy. The piston acts as a cross head to react cylinder wall size loads in the connecting rod/crank system. The piston is a carrier for the gas and oil sealing elements (piston rings). The piston design should be such that the seizure does not occur. It should have the shortest possible length so as decrease the overall size of the engine. It should offer sufficient resistance to corrosion due to some products of combustion. It should lighter in weight so that the inertia forces created by its reciprocating motion are minimum. It must have longer life. The material used for the piston at one time was cast iron, which has good wearing qualities. As the technology developed, the aluminum alloy containing replaced cast iron as the piston material.

In most of the internal combustion (IC) engines about 25% of the energy is lost through the coolant about 30% is consumed through friction and other losses, several methods are adopted for achieving low heat rejection to the coolant using ceramic coating on the piston [1] and creating air gap in the piston [2]. Flat top pistons have been replaced by the dashed pistons, domed pistons and pistons with intricate contours to swirl the fuel mixture and promote better fuel atomization. The shape of the piston crown controls the movement of air and fuel as the piston comes up on the compression stroke. This, in turn, affects the burn rate and what happens inside the combustion chamber. Several metal matrix composites are developed various applications. The metal matrix

compound are found suitable to the applications in the aerospace and the automobile industries.

The materials used for the piston crown were Al alloy, silicon carbide (SiC) reinforced Al-alloy metal matrix composite and silicon nitride (Si_3N_4) reinforced Al-alloy metal matrix compo-site. The finite element analysis using ANSYS was employed to model and analyze the piston for the thermal analysis.

The temperature drop of 183.835^{0}C, 233.289^{0}C and 435.955^{0}C was available in the piston crowns made up of Al-alloy, SiC/Al-alloy and Si_3N_4/Al-alloy composites. The heat loss to the coolant was minimum in the piston with crown made up of Si_3N_4/Al-alloy composite. The saving in thermal energy could increase the engine thermal efficiency.

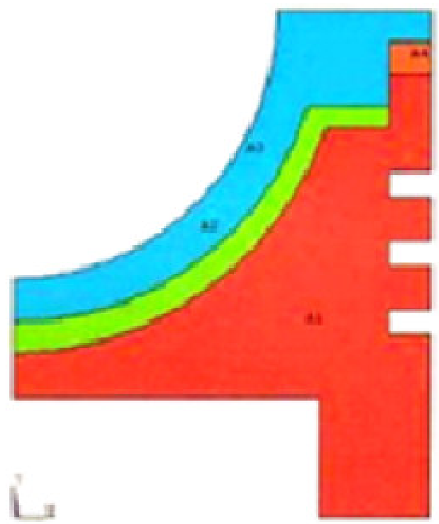

Figure 1: 2-D and 3-D geometric modeling of piston.

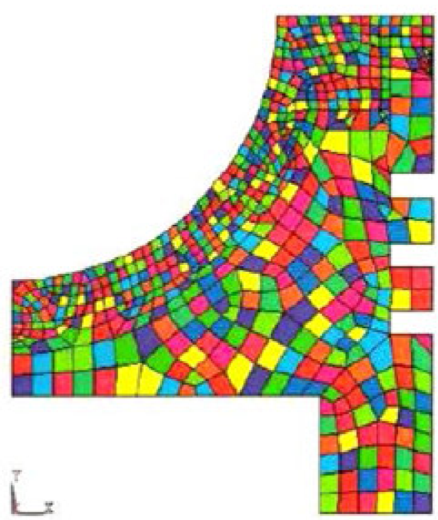

Figure 2: The meshed 2-D piston.

Figure 3: Temperature distribution in the air-gap piston with crown made up of the Al-alloy.

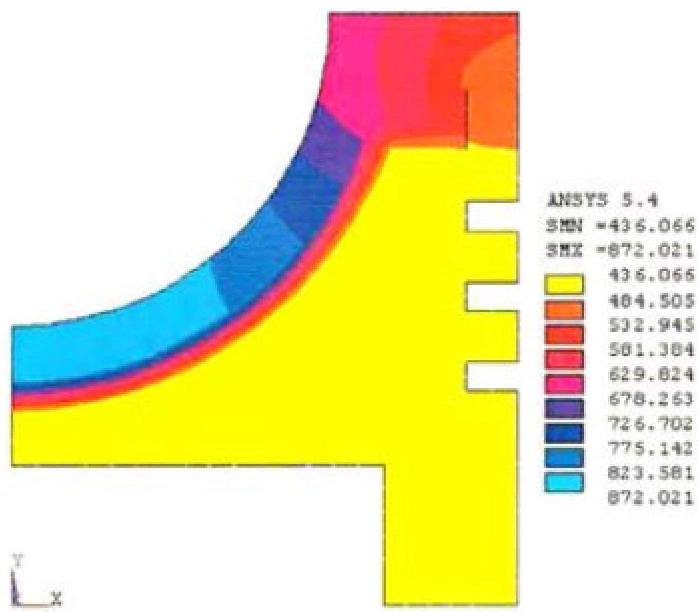

Figure 4: Temperature distribution in the air-gap piston with crown made up of the Si_3N_4/Al-alloy composite.

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