Abstract

The effect of ceramic coating and fuel additives on the performance and emissions of a diesel engine was investigated. The research engine was a four-stroke, direct injection, single cylinder, diesel engine. This engine was tested at a constant speed and at different load conditions by using ethanol and biodiesel blended diesel fuel at certain mixing ratios of E5, E10, B5, B10 and using B100 as a basic fuel for the machine as a substitute for diesel fuel. Experimental results showed that the reductions in brake specific fuel consumption are 18.6%, 26.42%, increasing in brake thermal efficiency are 28.65%, 42.79%, reductions in exhaust gas temperature are 8%, 10.03%, reductions in CO emission are 27.14%, 47.14%, and reductions in HC emission are 43.46%, 52.47% for E5, E10, respectively. Also, the reductions in brake specific fuel consumption are 5.12%, 7.81%, 14.7%, increasing in brake thermal efficiency are 13.76%, 19.18%, 31.28%, reductions in exhaust gas temperature are 6.4%, 17.09%, 18.54%, reductions in CO emission are 7.14%, 14.28%, 22.85%, and reductions in HC emission are 15.9%, 33.21%, 42.75% for B5, B10, B100, respectively.

Then, the inlet and exhaust valves, the head of piston and cylinder head of the engine were coated by ceramic materials. Ceramic layers were made of (210-240) μm of alumina (Al_2O_3) and (30-60) μm of $4NiCr_5Al$ as a bond coat for inlet and exhaust valves, (350-400) μm of yttria stabilized zirconia (YSZ) and (50-100) μm of $4NiCr_5Al$ as a bond coat for head of piston and (280-320) μm of silicon carbide (SiC) and (40-80) μm of $4NiCr_5Al$ as a bond coat for cylinder head. The coating technique adapted in this work is the flame spray method. The coated engine with valves, piston and cylinder head ceramic were tested for the same operation conditions of the engine (without coating) and operated on diesel fuel and biodiesel blends. The results showed that the reduction of brake specific fuel consumption is 19.29%, 15.91%, 14.65% and 7.06%, the increase in brake thermal efficiency is

23.68%, 19.77%, 16.51% and 6.32%, the increase in exhaust gas temperature is 9.01%, 7.22%, 15.7% and 11.42%, the reduction of CO emission is 18.57%, 20%, 20.5% and 27.77%, the reduction of HC emission is 28.97%, 43.9%, 38.88% and 36.41% for diesel, and B5, B10 and B100, respectively.

Wear test measurements showed that the ceramic materials give better wear resistance in comparison with the base metals under wear test. The total weight loss reduction at a load of 0.5 kg was 1.77*10^{-3}% for alumina (Al_2O_3), while it was 3.656*10^{-3}% for valve alloy and 2.12*10^{-3}% for alumina (Al_2O_3) at a load 1.009 kg, while it was 3.554*10^{-3}% for the valve alloy. At a load of 1.52 kg, the total weight loss reduction was 1.329*10^{-3} for alumina (Al_2O_3), but it was 4.281*10^{-3} % for the valve alloy under the same load. The total weight loss reduction at a load of 0.5 kg was 3.027*10^{-3}% for yttria stabilized zirconia (YSZ), while it was 0.01% for piston alloy and 3.01*10^{-3}% for yttria stabilized zirconia (YSZ) at a load 1.009 kg, while it was 3.631*10^{-3}% for piston alloy. At a load of 1.52 kg, the total weight loss reduction was 6.055*10^{-3}% for yttria stabilized zirconia (YSZ), but it was 0.02% for the piston alloy under the same load. The total weight loss reduction at a load of 0.5 kg was 1.633*10^{-3}% for silicon carbide (SiC), while it was 5.019% for cylinder head alloy and 1.398*10^{-3}% for silicon carbide (SiC) at a load 1.009 kg, while it was 3.679*10^{-3}% for cylinder head alloy. At a load of 1.52 kg, the total weight loss reduction was 4.614*10^{-3}% for silicon carbide (SiC), but it was 0.01 % for the cylinder head alloy under the same load.

The X- ray analysis of the resultant coatings showed the presence of a number of crystalline phases like hexagonal aluminum oxide, tetragonal zirconium yttrium oxide, cubic zirconium oxide, tetragonal zirconium oxide and hexagonal silicon carbide before rig tests and hexagonal aluminum oxide, tetragonal zirconium

yttrium oxide, monoclinic zirconium oxide, tetragonal zirconium oxide and hexagonal silicon carbide after rig tests.

To assess the adhesion strength and the hardness of the coating, the adhesion strength value between the substrate and the coating layers was measured and found equal to (26.8) MPa for yttria stabilized zirconia, (31.6) MPa for alumina coating and (39.64) MPa for silicon carbide coating. The adhesion strength depends on the type of bonding layer and, spraying distance. The hardness value of yttria stabilized zirconia coating was found equal to (710) MPa, (788) MPa for alumina coating and (855) MPa for silicon carbide coating.