Abstract

The effect of ceramic coating 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 constant speed and different load conditions without coating. Then, the inlet and exhaust valves faces were coated with about 500µm ceramic materials. Ceramic layers were made of 350-400 µm of 8%Yttria- Stabilized Zirconia (8%YSZ), and 50-100 µm of 4NiCr5Al as a bond coat. The coating technique used is the flame spray method. The ceramic-coated research engine was tested at the same operation conditions as the conventional (without coating) engine. The measurements showed a reduction in fuel consumption of about 7.6% and exhaust emissions were about (13% for HC and 14.5% for CO and 14% for CO2) .However, the exhaust gas temperature was increased by 34.5 °C (on average) after coating. Then, piston was coated also with the same ceramic materials (8%YSZ) and 4NiCr5Al as the bond coat and with the same thickness of about 500 µm. The engine was tested at standard conditions to see the effect of coated surfaces of valves and piston on the performance and emissions of the engine. The ceramic-coated engine was compared to the conventional uncoated engine.

The results of valves and piston test together indicate a reduction in fuel consumption by about 17.2% and exhaust emissions about (29.7% for HC and 30.7% for CO and 34.7% for CO2). Exhaust gas temperature under this condition was increased by about 72 °C (on average). Wear test measurements also showed that (8%YSZ) gives better wear resistance in comparison with the bare piston alloy under wear test. The total weight loss reduction at a load of 0.5 kg was 9.2 *10 % for YSZ, while it was 0.017% for bare piston alloy and 0.013% for YSZ at load 1.02 kg, while it was 0.04 % for bare piston alloy. At a load of 1.5 kg, the total weight loss reduction was 0.023% for YSZ, but it was 0.077% for the bare piston alloy under the same load.

The X- ray analysis of resultant coatings showed the presence of a number of crystalline phases formed during heat treatments like monoclinic and tetragonal. To assess the adhesion strength and the hardness of the coating, the adhesion strength between the substrate, and the coating layers was measured and found equals to (25) MPa and the hardness value is (650) MPa.