ABSTRACT

Automotive systems play an important role in everyday life throughout the world. As determined by literature, 33% of the fuel energy procurable for heavy-duty vehicles is engaged in overcoming friction caused by engine, transmission, brakes, tires, and auxiliary equipment's. Further, approximately only 20% of the losses happen due to problems in engine, the rest of losses happen in account of decreasing the frictional losses that has an immediate impact on the efficiency of the engine. Most of mechanical losses of friction within the engine about 65-70% arise by engine piston rings, cylinder liner assemblage, and bearings. The conventional components of an automotive could be substituted by composite materials containing more than two reinforcements are combined into the material matrix to minimize the losses due to friction and enhance its strength. Now a days, materials of nano-hybrid composite are used to improve the performance than a single-reinforcement composite material. In nano-hybrid composite of automobile components, the lightweight not only save consumption of fuel but also reduce the emissions produced by an engine.

In this current research, it is aimed light weight Nano-hybrid composite Piston Rings (NPRs) are used as substitute to Conventional cast iron Piston Rings (CPRs) to better the engine performance and decrease the losses of friction and emission. An Analytical Hierarchy Process (AHP) is the methodical procedure for material selection was utilized to choose the matrix material and reinforcements. A metal matrix Al6061 with micro-SiC, nano-ZrO_2 ceramics, and nano-Graphite (Gr) solid lubricant reinforcements were used to fabricate new composites. The composed bottom pouring stir casting method was utilized to produce samples of nano-hybrid composite.

Characteristic studies were performed to find out the hardness, tensile strength, density, thermal conductivity, corrosion, tribological test, and microphotography study by means of Scanning Electron Microscope (SEM). Taguchi method was adopted for the Design of Experiments (DoE) to find out tribological properties viz frictional co-efficient and rate of wear. A pin-on-disc tribometer was utilized for conducting tribological experiments, and the confirmation test was carried out. As for engine piston rings, the weight loss by wear and coefficient of friction are considered as important parameters. The nano-hybrid composite materials that consisted weight of 6.75% of combined reinforcement was considered for the study as it was appropriate. Then, microphotography assessment for all hardness and wear testing samples revealed that matrix material in partial uniform mode, even without agglomeration, a nano-sized reinforcement material has been added. An amalgamated reinforcement of 6.75% by weight with a sample matrix of Al6061 was recognized to produce novel Nano-hybrid composite Piston Rings (NPRs) identical to the dimensions of Conventional cast iron Piston Rings (CPRs).

Age-hardening has been done for 10-12 hours by using heater and age hardening equipment’s and machining for NPRs were done by utilizing computer numerical control machine. Then, finished through electro less nickel plating, and finally new NPRs were acquired. To reduce the manufacturing uncertainties, six compression piston rings and four oil piston rings were produced by using similar process. As the differences in weights were established to be negligible with 0.4% to 0.6% of maximum deviation. By using the current CPRs and the newly fabricated NPRs at various loads the combustion, emission characteristics, and performance of diesel engine was tested. For these studies, a single cylinder, four-stroke, water-cooled Kirloskar VCR SI-CI engine was utilized as a test engine. It has 87.5mm of cylinder

bore, 110mm of stroke length, and run at a steady speed of 1500 rpm. At all loads, brake thermal efficiency was established to be comparatively superior in NPRs-operated engine than that of the current CPRs-operated engine. The reason could be due to the fact that nano- and micro-reinforcements play an important role owing to their unusual ratio of high-surface-to-volume for the stage reinforcing with matrix material Al6061. Inside the combustion area, high temperature was maintained because the likelihood of complete fuel burning is elevated, which resulted in relatively high brake thermal efficiency, heat release rate, in-cylinder pressure, and exhaust gas temperature.

Test results of emission revealed that the use of NPRs decreases Carbon monoxide (CO), Hydrocarbons (HC) in comparison to the use of CPRs. The values of Oxides of Nitrogen (NOx) showed a marginal rise, as high temperature is being managed in the combustion chamber in NPRs as compared to the use of CPRs.

The engine fixed with the latest NPRs was dismantled to carry out rundown analysis, after operating for 70 hours for a period of 90 days, at different load conditions. To assess wear characteristics, crack, and other damage, the interior parts were inspected and examined in addition to gathering of dirt, carbon, and sludge. Cracks were not found in both sides of the NPRs. It was noticed in the engine oil that no foreign particles were found. This proves that the NPRs yield better performance and can be utilized as a replacement for the existing CPRs.

Therefore, this present research work proved that the newly fabricated NPRs have good potential to substitute the currently used CPRs in providing less fuel consumption. The significant factor is that it can be utilized without any alteration, for the engine structure.