Available online at www.ijapie.org

International Journal of Advanced Production and Industrial Engineering

IJAPIE-SI-IDCM 611 (2018) 54–56

Special Issue on

INNOVATIVE DESIGN & COMPUTATIONAL MODELLING

Coefficient of friction and microhardness analysis of CrC coating

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Abstract : Efficiency and performance are two critical characteristics of the internal combustion engine. The power generating component is required to be efficient so as to increase the overall performance of the vehicle and to make maximum use of the energy. The present study mainly focused upon development of CrC coating on cast iron substrate. The study shows that CrC coating enhanced tribological properties. Microhardness of developed coating as well as coefficient of friction is analyzed in this research

Keywords: Coefficient of friction, microhardness, CrC coating, PVD technique.

I. INTRODUCTION

An efficient power generating component (engine) of a vehicle (automobile) improves the overall performance of the automobile. Also, it plays an important role in utilizing the maximum use of the internal energy generated by the combustion of working fluid. And because of these reasons a lot of research is going on in this sector to increase and maintain the performance of the engine [1].

Many researchers have investigated the mechanisms of damage to piston, which mainly involved wear, temperature, and fatigue [2–5]. Since internal combustion engine with high efficiency has a tendency to operate at higher temperatures, the heat resisting properties of piston rings have become a major issue. And hence, the demand for better piston rings for internal combustion (IC) engine increases particularly in diesel engine pistons rings for higher heat resistance.

The tribological behavior of piston rings has been recognized as an important influence on the performance of internal combustion engines regarding power loss, fuel consumption, oil consumption, and harmful exhaust emissions. Therefore, the piston ring is one of the largest sources of friction in the internal combustion engine over the standard range of engine speeds and loads encountered in service [4, 5]. In practice, the damage in piston rings is attributed first to wear (as there are parts in contact and relative motion), then to lubrication and fatigue. Also, piston assembly accounts for approximately 35–45% of all the internal combustion engine frictional losses [6,7]. In spite of continuous evolution and research on piston rings, its failure is still a common phenomenon. It is the only component of the engine that encounters failure from different origins such as thermo-mechanical stresses, wear, fatigue, extreme temperatures, oxidations, etc.

The failures also occur due to the engine working conditions like advanced ignition timing, lean carburetor jetting, foreign material trapped inside, inappropriate piston-to-cylinder clearance, low octane fuel, loss of lubrication, high compression ratio and soon. [8,9]. Different types of coatings are used on piston rings to improve their characteristics. The coating can increase the hardness along with excellent surface finishing, thus reducing the friction and wear rate.

Various conventional techniques are being used for a long time [10]. Thermal spray coatings such as wire spray, high oxy fuel velocity spray, plasma spray Coatings are used act as an effective barrier to tribological failure [11]. As thermal spray processes advantage is that the large variety of single material or composite materials use to coat the substrate without significantly heating it [12–14].

The present study study mainly focused upon development of CrC coating on cast iron substrate and find out the effect of developed coating on the tribological properties such as wear behavior.

II. EXPERIMENTAL PROCEDURE

In this investigation, a four-stroke, single barrel and direct infusion diesel motor has been used. Table 1 shows deposition condition of CrC coating using PVD (physical vapor deposition) on cast iron substrate materials. PVD coating technique is used to develop coating and enhanced tribological properties. The multilayer coatings were prepared to utilize a PVD. Initiallya Cr target was controlled by a DC control power for the deposition of the Cr–C coating. Both the Ar and N_2were supplied continuously to prevent coating from contamination.

Additive layer of Si was deposited on the substrate material for improving adhesive strength of substrate material. Test examples were cleaned in a ultrasonic cleaner with surfactant for 15 min took after by de-ionized water for 10 min and after that dried at 100 °C for 15 min before the covering statement. Prior to deposition, the coating chamber was pumped down to 2.6×10^{-3} Pa. The CrC coating was successfully developed on CI substrate having variable film thickness ranging from 100-200 microns

Table 1 Deposition conditions of CrC Coating

Coating temperature (C)	250
Deposition time per run (min)	50
Cathode current (A)	135
Bias voltage (V)	110
Coating pressure (Pa)	4 *10

III. RESULTS

The wear measured on the cylinder liner surface is small (wear depth of sample 2 is<100nm), both in comparison to real wear and comparison to the total surface amplitude. The results reveals that coefficient of friction is minimum at coated sample 4 having film thickness 200 microns and maximum at coated sample 1 having film thickness of 100 microns as shown in figure 1.

Figure 2 reveals the result of micro hardness of CrC coating on cast iron substrate. Microhardness of CrC coating minimum at coated sample 1 having film thickness 100 microns and maximum at coated sample 4 having film thickness of 200 microns.

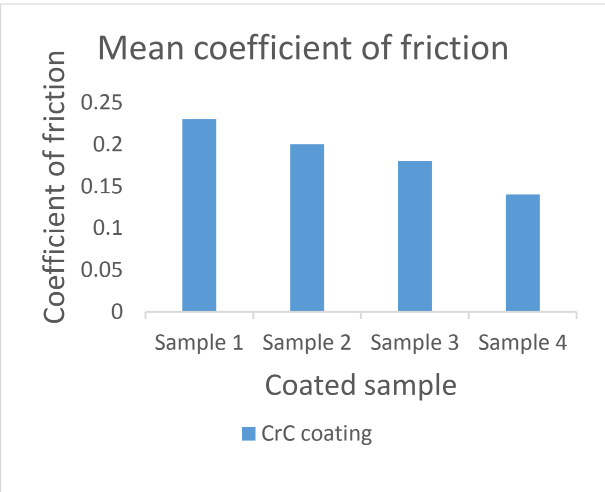

Fig. Shows variation of coefficient of friction of CrC coating

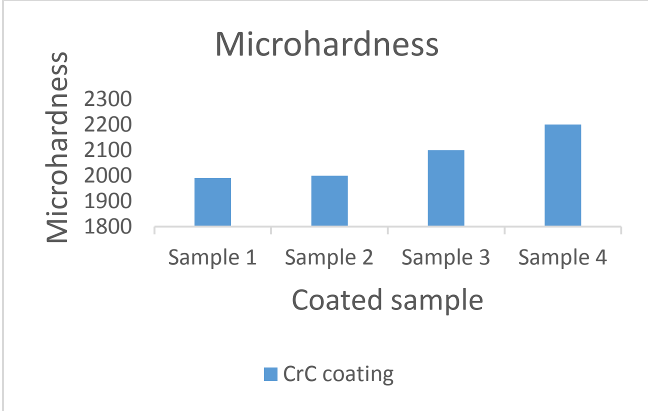

Fig. 2 Shows variation of microhardness of CrC coating

IV. CONCLUSION

The CrC coating on CI substrate was successfully developed using PVD coating. The experimental results of coating sample 4 having film thickness of 200 microns shows excellent tribological behavior and high hardness value.

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