Development of MoN coatings for pistons in a diesel engine

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Abstract

In this study, the surface of a piston of a diesel engine was coated with molybdenum nitride (MoN) by using arc PVD method, and its surface behavior was subsequently analyzed. Tests for micro hardness and surface roughness were carried out in order to examine the surface characteristics of the pistons. It was observed that the hardness of coated piston was 2010.8 HV while hardness of uncoated piston was 125 HV. The results showed less deformation and fewer scratches due to wear on the MoN-coated piston as compared to the uncoated one.

Keywords: MoN; PVD; Microhardness; Surface roughness.

Introduction

In an internal combustion engine, the tribological execution of the piston ring and barrel liner framework has for quite some time been perceived as vital in accomplishing the required motor productivity and solidness regarding power misfortune, fuel utilization, oil utilization, pass up, and even harmful fume discharge [1]. In existing motors, the warm requirement set on the basis of warm solidness of a specific material constrains the productivity of the motor. Manufacturing motor and ignition chamber segments using earthenware materials stretches the life of these segments and supplements the proficiency of the motor [2,3]. In an internal combustion engine, cylinders are the segments which are utilized as a part of the burning assembly of a motor. In the event that the tribological highlights of cylinders are enhanced, vitality devoured by contact will decline, and general outflow and execution esteems will move forward. Coating the cylinder surface by different earthenware materials enhances the highlights of this material which results in production of segments with less weight and volume. Average cylinder materials are light amalgams, cast press, nodular cast press, and alloyed steels. The cylinders for high-speed motors are basically made of aluminum silicon combinations [4]. Because of their auxiliary properties, inordinate surface harshness and deficient quality, cylinders are prone to excessive wear. Thus, protracting the life of cylinders will both stretch the existence of the motor and add to the economy of the motor. Utilizing the PVD technique, various clay materials can be used to make coatings of required thicknesses. One of such artistic material is MoN, which has been pulled into consideration because of its trademark high protection from wear and to consumption with a thin covering. It can be seen that the examinations led so far are promising and can be additionally created. The vast majority of these examinations are completed under lab test conditions rather than genuine motor conditions. Be that as it may, genuine motor conditions can't be replicated even in an exceptionally well planned research center; since the synthetic and mechanical complications that occur during combustion load are extremely mind boggling [5]. This is the reason why it was imperative for us to lead our investigations in genuine motors.

In this examination, cylinder surface of a diesel motor was covered with MoN using the curve PVD technique. The investigation was carried out in order to break down the tribological impacts for the surface coating of a cylinder in frictional components.

Experimental procedure

In this investigation, a four-stroke, single barrel and direct infusion diesel motor was used. Table 1 provides the characteristics of the motor, Table 2 provides the data regarding the curve PVD (physical vapor affidavit) [6] and creation parameters in regards to MoN coating. A lining of MoN was made on the cylinder of the motor utilized for this investigation. The surface of which is an earthenware material with a thickness of 2.0 ± 0.3 lm. The investigation was carried out for uncoated and MoN-coated cylinders.

Table 1 Test engine specifications.

Item	Specification
Type of engine	Lombardini 6LD 400
Stroke	4
Number of cylinders	1
Bore/stroke (mm)	86/68
Compression ratio	18:1
Maximum engine power (kW)	6.25 (3600 1 /min)
Fuel type	Diesel
Lubricating	Full pressure
Type of injection	Direct injection
Pressure of injection (kg/cm^2)	200
Type of coolant	Air coolant
Maximum engine speed (1/min)	3600
Engine volume (mm^3)	382 427 491

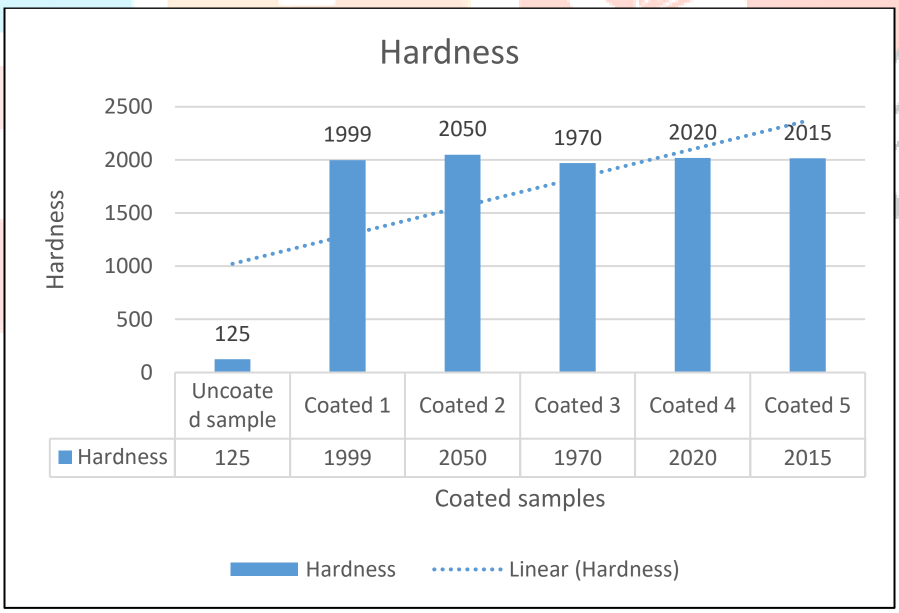
Table Deposition conditions of arc PVD and MoN coating.

Coating thickness (lm)	2.0 ± 0.3
Hardness (HV)	2000 ± 400
Coating temperature (C)	300
Deposition time per run (min)	60
Cathode current (A)	125
Bias voltage (V)	100
Coating pressure (Pa)	$4\ 10^1$

Results and Discussion

The surface properties of pistons are one of the most important aspects that affect the coefficient of friction, wear and lubrication of the sliding surfaces within the cylinder. There are two factors that affect the surface properties of the piston. First is the chemical composition and the second is the sensitivity during treatment. An inverse relation exists between surface roughness and wear resistance. Thus, the amount of wear that occurs in pistons can be reduced by reducing the surface roughness and increasing the matrix micro hardness. Increase in wear is observed more on rough surfaces as compared to the smoother ones. Thus, the application of thin coating is important for improving the frictional and wears characteristics. The surface topography, residual stress, microstructure and the thickness of coating depends on the type of the coating material.

Surface roughness values of the samples of coated and uncoated piston were compared. Roughness of coated piston was measured to be 3.74 lm and for the uncoated piston it was 4.16l mpriorto tests. Hardness values of the coated and the uncoated cylinder liners were measured to be 2010.8 and 125 HV (kg/mm^2), respectively as shown in figure 1. Low roughness level in the coated piston is due to reduced abrasive wear occurring on the piston surface. Increase in contact area on rough surfaces increase the frictional coefficient of piston surfaces. Surface roughness values of the materials have great effects on the wear and friction coefficients.



Conclusions

The conclusions derived from this study are as follows:

1. When the piston surface is coated by the arc PVD method, pistons can be used without any need to apply any additional process on the surface after the coating.
2. Surface hardness of the coated piston is higher than the uncoated one and this has positive effects on wear resistance.

3. The surface of the coated piston is harder than that of the uncoated one and this contributes to the piston's load capacity. As a result, these engines can be run on higher compression ratios.

References

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