Recent Trends To Increase The Service Life Of The Engine With The Help Of Improvement Of Wear Resistance Of Piston Ring - A Review Study

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ABSTRACT:

Now a day's various surface treatment methods are used on cylinder piston group (CPG) components to increase service life of internal combustion engines, reduce exhaust gases and improve efficiency. The wear resistance of thermal sprayed molybdenum, molybdenum blend, chromium, chromium blend, WC blend and other material coatings applicable to synchronizer rings or piston rings was investigated in this study. Among thermal spraying methods, plasma spraying is most widely applied in the automotive industries, because it has a high spray rate and deposition, the process consumes fuel gases which are inexpensive and easily obtainable. The wear test results revealed that the wear rate of all the coatings increased with increasing wear load. This review paper describes the various materials for piston ring coating as well as various methods recently using to increase the wear resistance and also increase life of the piston rings.

KEYWORDS: *Service life of engine, Significance of piston rings, Plasma spraying, CVD coating, HVOF coating, PVD coating, Thermal spraying, Tribology*

I. INTRODUCTION:

The requirement placed on the internal combustion engine is continuously change throughout the history of its development. To increase the service life of the engine we have to think about to increase the life of the all parts of the engine. In engine 30% energy of total energy is lost due to the friction between piston ring and cylinder liner. For this purpose material use for these components is more important. Some research done on different material for checking their wear resistant which is better for piston ring material. Today, the most commonly used piston rings are coated with electroplated chromium layers. In recent years, much development work has be performed to replace chromium plating by chromium nitride alternatives. In the present investigation, physical vapour deposition (PVD) sputtering technology is used to influence the wear behaviour by thin films within a wide range of mechanical properties.

Among thermal spraying methods, plasma spraying is most widely applied in the automotive industries because (a) it has a high spray rate and deposition, (b) the process consumes fuel gases which are inexpensive and easily obtainable, (c) the process requires minimum preheating and cooling during spraying, (d) the technical reliability of plasma systems is well established in industrial applications, and (e) spraying conditions can be easily controlled upon various applications. In particular, molybdenum coatings fabricated by atmospheric plasma spraying have enhanced resistance to wear and heat and thus this coating technology was commercialized for application to the automotive industry.

II. SERVICE LIFE OF ENGINE:

Constant advances in combustion engines put increasing thermal and mechanical stress on components while its dimensions simultaneously decrease. The resulting exacting demands have to be met with innovative technologies. The development led from simple cast iron rings via steel rings on to coatings which reduce wear and friction. Nowadays PVD rings are used successfully for numerous applications. They are being used in commercial vehicles which have a required mileage of more than 1 million miles and modern highly stressed automobile diesel engines. PVD (Physical Vapour Deposition) technology is increasingly being used in conventional petrol engines. Its high wear resistance maintains the ring shape over a longer period of time. For instance this allows a reduction of the ring tension of PVD coated oil control rings which in turn results in considerable friction benefits.

III. SIGNIFICANCE OF PISTON RINGS:

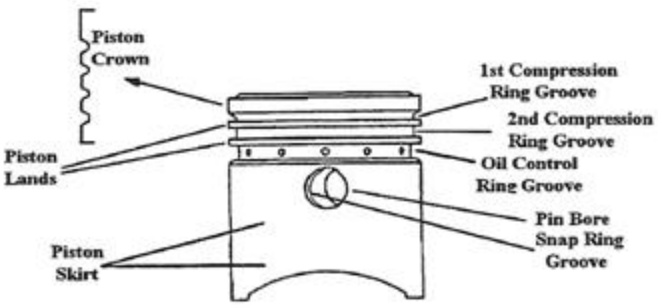

Fig. Terminology of piston & piston ring

Piston rings for current internal combustion engines have to meet all the requirements of a dynamic seal for linear motion that operates under demanding thermal and chemical conditions. In short, the following requirements for piston rings can be identified:

- Low friction, for supporting a high power efficiency rate.
- Low wear of the ring, for ensuring a long operational lifetime.
- Low wear of the cylinder liner, for retaining the desired surface texture of the liner.
- Emission suppression, by limiting the flow of engine oil to the combustion chamber.
- Good sealing capability and low blow-by for supporting the power efficiency rate.
- Good resistance against mechano-thermal fatigue, chemical attacks and hot erosion.
- Reliable operation and cost effectiveness for a significantly long time.

➢ **Types of piston ring & its functions:**

(1) Compression ring:

- Seals in combustion pressure
- Minimise blow-by
- Transfer heat

(2) Oil Control ring:

- Prevents excess oil from being left on cylinder wall

IV. PLASMA SPRAYING:

In plasma spraying process, the material to be deposited (feedstock) is typically as a powder, sometimes as a liquid, wire is introduced into the plasma jet, emanating from a plasma torch. In the jet, where the temperature is on the order of 10,000 K, the material is melted and propelled towards a substrate. There, the molten droplets flatten, rapidly solidify and form a deposit. Commonly, the deposits remain adherent to the substrate as coatings; free-standing parts can also be produced by removing the substrate. There are a large number of technological parameters that influence the interaction of the particles with the plasma jet and the substrate and therefore the deposit properties. These parameters include feedstock type, plasma gas composition and flow rate, energy input, torch offset distance, substrate cooling, etc.

V. HIGH VELOCITY OXYGEN FUEL SPRAYING (HVOF):

In spray processes called high velocity oxy-fuel spraying mixture of gaseous or liquid fuel and oxygen is fed into a combustion chamber, where they are ignited and combusted continuously. The fuels can be gases (hydrogen, methane, propane, propylene, acetylene, natural gas, etc.) or liquids (kerosene, etc.). The jet velocity at the exit of the barrel exceeds the speed of sound. A powder feed stock is injected into the gas stream, which accelerates the powder up to 800 m/s. The stream of hot gas and powder is directed towards the surface to be coated. The powder partially melts in the stream, and deposits upon the substrate. The resulting coating has low porosity and high bond strength.

The types of coatings that are most widely viewed as being capable of replacing hard chrome plating are the thermal spray technologies, especially high-velocity oxy-fuel (HVOF) thermal spraying. With this process, the coating material, in powder form, is fed into the combustion chamber of a gun where, a fuel, such hydrogen, ethylene or kerosene, is burned with oxygen, and the heated and softened powders are expelled as a spray with the supersonic gases. Powders deposited using HVOF includes pure metals, metal alloys, cermets and certain ceramics and polymers. The reason why HVOF is the preferred thermal spray process for chrome replacement is because it produces low porosity (<1%), highly adherent (bond strength > 50MPa) coatings which generally have an oxide content less than 1% even for reactive metals. As a flexible dry-coating technology it avoids high volume waste streams associated with electroplating and provides a choice of coating materials for each application.

The high-velocity oxy-fuel (HVOF) thermal spraying process has shown to be one of the best methods for depositing conventional Cr3C_2–NiCr feedstock powders, because the hypersonic velocity of the flame shortens the time of interaction between the powder and the flame. These effects in conjunction with the relatively low temperature (as compared to plasma based techniques) result in less decomposition of the carbide particles during spraying. In addition, the high kinetic energy acquired by the powder particles ensures a good cohesion in the coatings and allows producing carbide based coatings with a minimum porosity and de carburisation. However, the effects of feedstock powder characteristics, type of HVOF spray system and spray parameters have been shown to affect the coating microstructure and consequently its wear resistance.

VI. PHYSICAL VAPOR DEPOSITION (PVD COATING):

Physical vapor deposition (PVD) is a variety of vacuum deposition methods used to deposit thin films by the condensation of a vaporized form of the desired film material onto various workpiece surfaces.

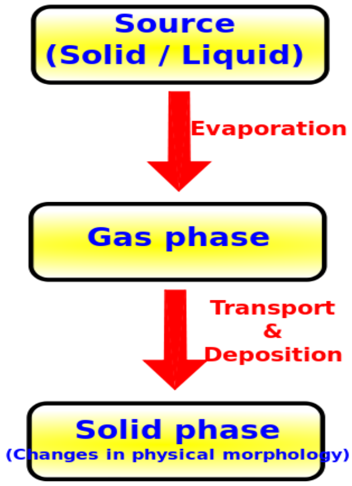

Fig: Process of Physical vapour deposition

In the present investigation, physical vapour deposition (PVD) sputtering technology is used to influence the wear behaviour by thin films within a wide range of mechanical properties. This depends on vacuum deposition in CrxN, which is very promising in relation to other coatings . Studies on different coating materials have taken place and emphasize the demand for suitable surfaces.

The wear of piston rings is investigated with respect to PVD hard coatings as a surface finish with an adjustable profile of mechanical properties. Therefore, PVD CrxN coatings have been deposited, characterized and used in model wear tests for simulating the complex tribological system piston-ring–cylinder. This tribological system can be seen as an example for mechanical components working under intensive wear conditions over a long period of time. As the investigation shows, PVD hard coatings can reduce wear rates very effectively.

VII. CHEMICAL VAPOUR DEPOSITION (CVD COATING):

Chemical vapour deposition (CVD) is a chemical process used to produce high-purity, high-performance solid materials.

(1) Hot wall thermal CVD:

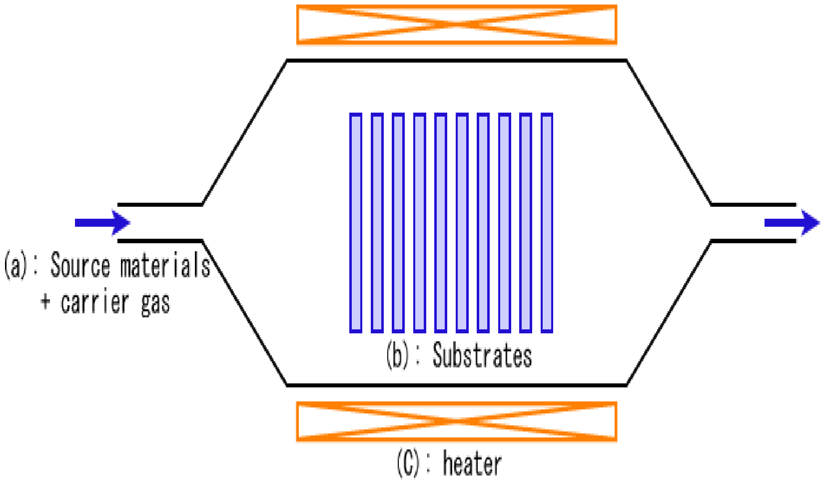

Fig: Hot wall thermal CVD

(2) Plasma assisted CVD:

Plasma-Enhanced CVD (PECVD) – CVD process that utilizes plasma to enhance chemical reaction rates of the precursors. The lower temperatures also allow for the deposition of organic coatings, such as plasma polymers, that have been used for nanoparticle surface functionalization.

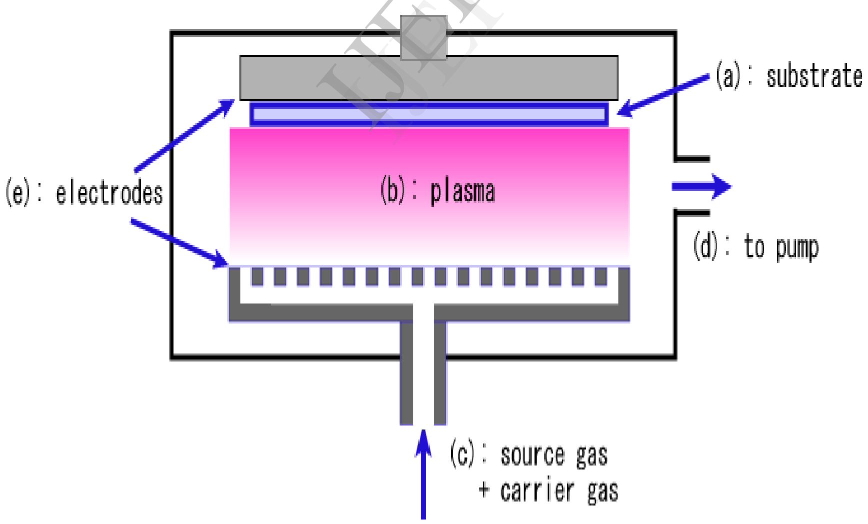

Fig: Plasma assisted CVD

VIII. CERAMIC-METAL COMPOSITE COATING WITH PLASMA SPRAYING TECHNIQUE:

To obtain the durable and wear protective coatings, peculiar material preparation process was used. Two processes, "composite powder process" and "mixed powder process", are compared and "composite powder process" was adopted.

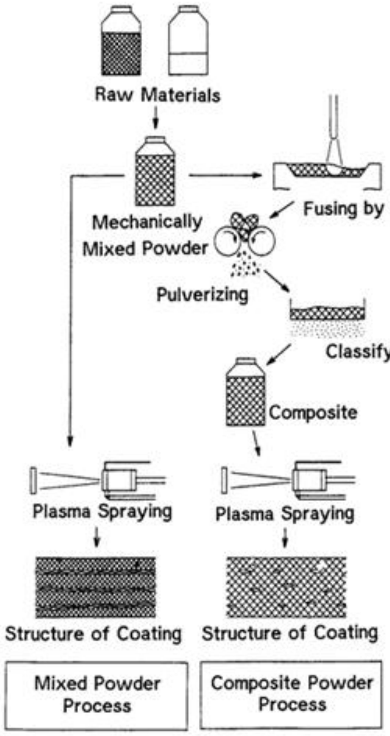

Fig: Ceramic-metal composite coating with plasma spraying technique

Above fig. shows two kinds of production processes of two material composite coating which were named as "composite powder process" and as "mixed powder process". In the "composite powder process", were two material once melted with an arc furnace then pulverized and classified to obtain suitable grain size for plasma spraying.

IX. CONCLUSION:

The Plasma-sprayed molybdenum/chromium carbide and plasma-sprayed chromium oxide piston ring face coatings proved to have superior wear resistance over the plasma-sprayed molybdenum / molybdenum carbide and the electroplated chromium. The piston ring coated with ceramic metal composite by low pressure plasma spraying, proved excellent results on the wear resistant characteristics. For future successful applications of CrC–NiCr HVOF coatings as alternative to hard chromium, many factors like wear resistance, friction coefficient, costs and environmental issues have to be considered collectively. The PVD coatings substrate characterization — high hardness, moderate compressive residual stresses and sufficient adhesion on metallic substrates — provide good behaviour of coatings in this tribological application.

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