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Experimental and Investigation on Piston by Using Yttrium Oxide

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ABSTRACT: Diesel engines are widely used in transport sector and other areas. Improvement of performance and reduction of smoke density (Emissions) is the important aspect in the combustion ignition engine. The performance of the engine can be increased by the following factors: (a) Reducing the heat energy going out as waste through exhaust gas, (b) Increasing compression ratio (c) Using proper injection timing, (d) Using catalyst coating on the piston top in the combustion chamber. In this project coating on the piston top is selected. This method improves the performance of engines, also reduces the smoke density (Emissions). Many researchers are studying the performance analysis aspects and are coming with useful results. Hence in this experiment an attempt has been made to study the performance of Diesel engine by using the metal catalyst coatings on piston top of Internal Combustion Engine. To overcome the problems of low efficiency and high smoke density of diesel engine, it was decided to coat the catalyst on the top surface of the piston and to speed up the combustion process, supplying more quantity of oxygen at the time combustion. This process of coating the piston will give the better result.

I. INTRODUCTION

Protective coatings are used in oil and gas storage, transmission and distribution network to prevent steel structures against corrosion. Steel structures like trains, ships, automobiles, airplanes, underground buried gas pipelines, fuel storage tanks etc require the use of protective coatings. The importance of a coating can be judged from the fact that it can hardly be ignored in any corrosion protective scheme. Protective coatings are unique specialty products which represent the most widely used method of corrosion control. They are used to give long term protection under different corrosive conditions. The function of a protective coating or lining is to separate two highly reactive materials; to prevent corrosive environment species from contacting the reactive underlying steel structure. This is to say that a coating or a lining acts as a barrier to prevent either chemical compounds or corrosion currents from contacting the substrate. Corrosion protection of over-ground and under-ground steel structures with the help of organic coatings are one of the most proven methods. Other methods include Cathodic Protection (CP), environmental modification, material selection and design. If the resistivity of electrolyte is increased and the electron flux is retarded, the rate of corrosion is decreased. By applying coatings of high resistivity, such as epoxies, vinyls, chlorinated rubbers, etc. the flow of electric current to the metal surface is impeded. Also the higher the thickness of a coating, the higher would be its electrical resistance.



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II. PURPOSES OF A COATING

- Protection of steel structures from the environment by acting as a barrier between the substrate and the aggressive environment, such as the marine and industrial environments.
- Control of solvent losses.
- Control of marine fouling; certain constituents in coating control growth of mildew and marine fouling in seawater.
- Reduction in friction (coating reduces friction between two contacting surfaces).
- Pleasant appearance; certain types of coatings provide a pleasant appearance and produce attractive surroundings.
- Change in light intensity; by selection of appropriate coatings the light intensity in rooms and buildings can be varied as desired.

COATING AS A MEANS OF CORROSION CONTROL

This concept is entirely reasonable and logical. Furthermore, a coating would be completely effective as a means of stopping corrosion if the coating material:-Is an effective electrical insulator, Can be applied with no breaks whatsoever and will remain so during the backfilling process, and Constitutes an initially perfect film that will remain so with time. Although coatings by themselves may not be the one perfect answer to corrosion control, they are extremely effective when properly used. Most operators plan coatings and Cathodic Protection (CP) for all their steel structures like oil and gas transmission pipelines as a matter of course. A properly selected and applied coating will provide all the protection necessary on most of the pipeline surface to which it is applied. On a typical well-coated pipeline this may be better than 99% and, along with the CP, may give total protection.



APPLICABILITY

Application of the coating to the pipe must be possible by a method that will not adversely affect the properties of the pipe and with a minimum of defects. Ability to resist development of holidays with time. After the coating is buried, two areas that may destroy or degrade coatings are soil stress and soil contaminants. Soil stress, brought about in certain soils that are alternately wet and dry, creates forces that may split or cause thin areas. To minimize this problem, one must evaluate the coating's abrasion resistance, tensile strength, adhesion, and The coating's resistance to chemicals, hydrocarbons, and acidic or alkaline conditions should be known for evaluating their performance in contaminated soils.

GOOD ADHESION TO PIPE SURFACE

A pipeline coating requires sufficient adhesion to prevent water ingress or migration between the coating and the pipeline, along with cohesion to resist handling and soil stress. Soil stress is the main cause of pipe coating failure. Soil stress effects can be seen on flexible PE coatings as characteristic wrinkling

Experience

Research and trial and error have gone into the development of every coating, with close cooperation between applicator, coating manufacturer, equipment manufacturer, and customer. The transition from laboratory to production line is usually a costly experience, which should not be ignored.

Reputation

This is an asset earned by consistent performance. Not only good quality work but also solving problems and correcting mistakes help to develop a reputation.

Reliability

Many variables affect the application of coatings. A reliable work force, wellmaintained equipment, and consistent quality performance are prerequisites for an applicator. Conformance to coating manufacturer's specifications The manufacturer's established minimum specifications for application of materials should be met.

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III. LITERATURE REVIEW

Abdullah Cahit Karaoglanli, Kazuhiro Ogawa, Ahmet Türk and Ismail Ozdemir, —Thermal Shock and Cycling Behavior of Thermal Barrier Coatings (TBCs) Used in Gas Turbines— has presented Gas turbine engines work as a power generating facility and are used in aviation industry to provide thrust by converting combustion products into kinetic energy. Basic concerns regarding the improvements in modern gas turbine engines are higher efficiency and performance. Increase in power and efficiency of gas turbine engines can be achieved through increase in turbine inlet temperatures. The materials used should have perfect mechanical strength and corrosion resistance and thus be able to work under aggressive environments and high temperatures. The temperatures that turbine blades are exposed to can be close to the melting point of the super alloys. Internal cooling by cooling channels and insulation by thermal barrier coatings (TBCs) is used in order to lower the temperature of turbine blades and prevent the failure of super alloy substrates. L. Wang, X.H. Zhong, Y.X. Zhao, S.Y. Tao, W. Zhang, Y. Wang, X.G. Sun, —Design and optimization of coating structure for the thermal barrier coatings fabricated by atmospheric plasma spraying via finite element method— has presented fabricating the thermal barrier coatings (TBCs) with excellent performance is to find an optimized coating structure with high thermal insulation effect and low residual stress. This paper discusses the design and optimization of a suitable coating structure for the TBCs prepared by atmospheric plasma spraying (APS) using the finite element method. The design and optimization processes comply with the rules step by step, as the structure develops from a simple to a complex one. The research results indicate that the suitable thicknesses of the bond-coating and top-coating are 60–120 μm and 300–420 μm , respectively, for the single ceramic layer YSZ/NiCoCrAlY APS-TBCD. Freiburg, D. Biermann, A. Peukera, P. Kersting, H. -J. Maier, K. Möhwald, P. Knödler, M. Otten, —Development and Analysis of Microstructures for the Transplantation of Thermally Sprayed Coatings— has presented thermally sprayed coatings and tribological surfaces are a point of interest in many industrial sectors. They are used for better wear resistance of lightweight materials or for oil retention on surfaces. Lightweight materials are often used in the automotive industry as a weight-saving solution in the production of engine blocks. It is necessary to coat the cylinder liners to ensure wear resistance. In most cases, the coating is sprayed directly onto the surface. Previous research has shown that it is possible to transfer these coatings inversely onto other surfaces. This was achieved with plasma sprayed coatings which were transplanted onto pressure-casted surfaces. Mr. Atul A. Sagade, Prof. N.N. Shinde, Prof. Dr. P.S. Patil, —Effect of receiver temperature on performance evaluation of silver coated selective surface compound parabolic reflector with top glass cover— has presented the experimental results of the prototype compound parabolic trough made of G.I and silver coated selective surface. The performance of collector has been evaluated with three kinds of receiver coated with two kinds of receiver coatings black copper and black zinc and top cover. This line focusing parabolic trough yields instantaneous efficiency of 60 % with top cover. A simple relationship between the parameters has been worked out with the regression analysis. [Latitude: 16.42° N, Longitude: 74.13° W] Andrew Roberts, Richard Brooks, Philip Shipway, —Internal combustion engine cold-start efficiency: A review of the problem, causes and potential solutions— has presents vehicle emissions continues to become more stringent in an effort to minimise the impact of internal combustion engines on the environment. One area of significant concern in this respect is that of the cold-start; the thermal efficiency of the internal combustion engine is significantly lower at cold start than when the vehicle reaches steady state temperatures owing to sub-optimal lubricant and component temperatures. The drive for thermal efficiency (of both the internal combustion engine and of the vehicle as a whole) has led to a variety of solutions being trialed to assess their merits and effects on other vehicle systems during this warm-up phase (and implemented where appropriate). The approaches have a common theme of attempting to reduce energy losses so that systems and components reach their intended operating temperature range as soon as possible after engine start. In the case of the engine, this is primarily focused on the lubricant system. Lubricant viscosity is highly sensitive to temperature and the increased viscosity at low temperatures results in higher frictional and pumping losses than would-be observed at the target operating temperature.

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IV. METHODOLOGY

Yttrium oxide

Yttrium oxide is a conversion oxide coating formed on the metal surface as a result of a chemical reaction of the metal atoms with an oxidizing agent (air, aqueous solution, molten salts).

Conversion coating is a film of a chemical compound formed in the reaction of the substrate substance with another substance. This reaction distinguishes conversion coating from a conventional coating applied on the substrate surface without changing its chemical state.

Examples of conversion coating are Anodizing and Phosphating (oxide film on the surface of anodically connected metal in an acidic electrolyte solution) and Phosphating (coating consisting of an insoluble)

Yttrium oxide coating is used mostly for Carbon steels, Alloy steels, Tool and die steels and Cast irons. Stainless steels and Copper alloys may also be yttrium oxide coated. Yttrium oxide coating of steel is composed of magnetite - ferrous-ferric oxide Fe_3O_4 ($\text{FeO} \cdot \text{Fe}_2\text{O}_3$), which is formed as a result of oxidation of iron by Oxygen of air or from oxidizing ions (in aqueous solutions or molten salt).

1. Hot alkaline yttrium oxide process
2. Cold yttrium oxide process
3. Molten salts yttrium oxide process
4. Benefits of yttrium oxide coating

Hot alkaline process is the most popular method of yttrium oxide coating.

The temperature of hot alkaline solution should be in the range 275-295°F (135-146°C). The boiling temperature is determined by the salts content. At the temperatures above 295°F (146°C) the obtained oxide coating turns red and rusty. The temperatures below 275°F (135°C) indicate low concentration of salts resulting in too slow oxidizing process. Boiling temperature is adjusted by either addition of salts (temperature increase) or dilution of the solution (temperature decrease).

Typical compositions of hot alkaline solutions: Sodium hydroxide (NaOH) 80-90 oz/gal (600-700 g/l) + sodium nitrite (NaNO_2) 27-33 oz/gal (200-250 g/l) Sodium hydroxide (NaOH) 80-90 oz/gal (600-700 g/l) + sodium nitrate (NaNO_3) 53-33 oz/gal (400-250 g/l) Sodium hydroxide (NaOH) 67 oz/gal (500 g/l) + sodium nitrate (NaNO_3) 67 oz/gal (500 g/l) Sodium hydroxide (NaOH) 87-100 oz/gal (650-750 g/l) + sodium nitrate (NaNO_3) 13 oz/gal (100 g/l) + sodium nitrite (NaNO_2) 13 oz/gal (100 g/l) Potassium hydroxide (KOH) 133-160 oz/gal (1000-1200 g/l) + potassium nitrate (KNO_3) 20-33 oz/gal (150-250 g/l) Stages of hot alkaline process Cleaning. The part is mechanically cleaned and degreased in an alkaline solution. Water rinsing. Pickling (acid cleaning). Oxide films and rust stains are dissolved in acid. Water rinsing.

Black oxidizing in the boiling alkaline bath. The part is immersed into the bath for 5-40 minutes. Water rinsing by pressurized water stream. Drying. After-finish treatment. The oxide surface is sealed by oil, wax or lacquer. After-finish treatment not only imparts required cosmetic appearance (matte, glossy, lustrous) but also improves corrosion resistance and anti-friction properties of the part. to top

4.1.2 Cold yttrium oxide is a process of non-conversion black finish coating deposited from phosphoric acid solutions containing selenium and copper compounds. Cold yttrium oxide coating is not really oxide. It is softer than conventional yttrium oxide coating. The color of cold yttrium oxide coating is not consistent and may be rubbed off from the surface. Cold yttrium oxide coating is used as a simpler and less hazardous substitute of hot yttrium oxide process. to top

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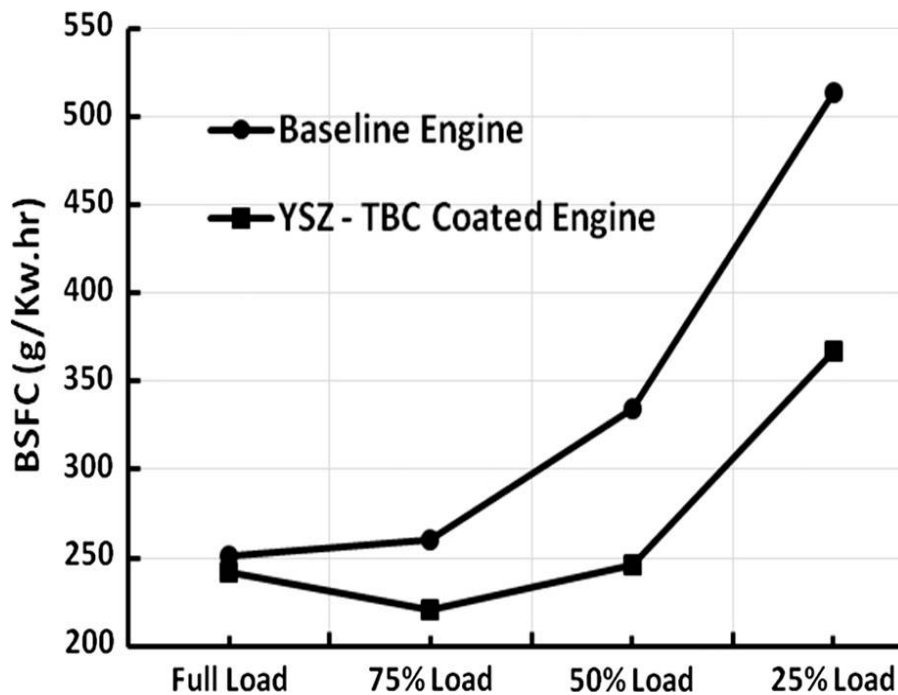


Fig 4.1

4.1.3 Molten salts process involves molten oxidizing salts, Oxygen of which reacts with iron atoms forming a film of yttrium oxide.

A mixture of sodium nitrate (NaNO_3) and potassium nitrate (KNO_3) in equal quantities is used for the molten baths preparation. Melting point of such eutectic composition is about 485°F (250°C)

Typical operating temperatures of the molten salt baths are 550-650°F (288-343°C). Stainless steels may be treated at the melt temperature 900°F (482°C).

Benefits of yttrium oxide coating

- Decorative black color. Required surface appearance (shiny, glossy or matte) may be obtained. The color is stable at increased temperatures.
- Minor dimensional changes. Thickness of yttrium oxide coating does not exceed 3×10^{-5} inch (0.75 μm), half of which is added to the part dimension and the second half penetrates into the part depth.
- Strong adhesion between the coating and the substrate. Yttrium oxide coating does not peel from the surface.
- Good lubrication characteristics. Yttrium oxide improves anti-galling properties. In addition to this after-finish oil/wax decreases coefficient of friction of the yttrium oxide coated parts.
- Low light reflection. Reduced light glare of moving parts, surgical instruments and hand tools coated with yttrium oxide causes less eye fatigue.
- No hydrogen embrittlement. Since Hydrogen is not evolved in the chemical process of yttrium oxide coating, no hydrogen diffusion into the metal occurs.
- Slight improvement of corrosion protection. Yttrium oxide coating provides some corrosion protection for internally used parts (not in corrosive environments).

Yttrium oxide

Yttrium oxide or blackening is a conversion coating for ferrous materials, stainless steel, copper and copper based alloys, zinc, powdered metals, and silver solder. It is used to add mild corrosion resistance, for appearance and to minimise light reflection. To achieve maximum corrosion resistance the yttrium oxide must be impregnated with oil or wax. One of its advantages over other coatings is its minimal buildup.

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Fig 4.2

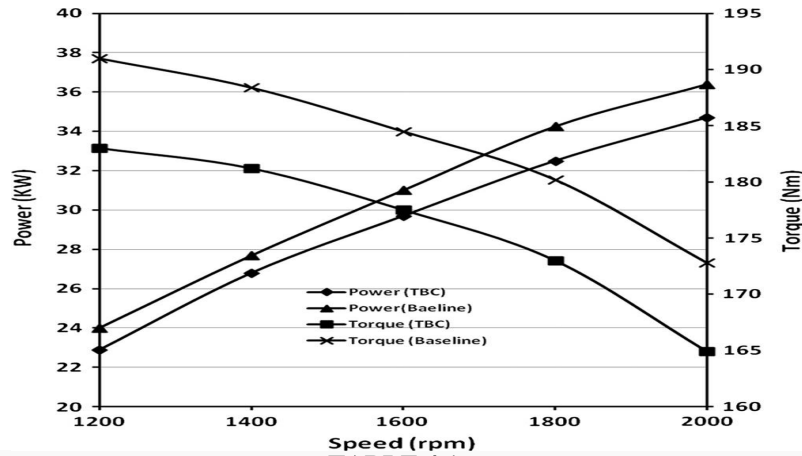


TABLE 4.1

WORK PIECE MATERIAL	SURFACE TREATMENT	COATING THICKNESS(μm)	WEAR mm ³ /Nm
PISTON	-	-	2.30
PISTON	YTTRIUM	60	2.15
PISTON	YTTRIUM	80	1.90

4.2 VARIOUS METHODS OF COATING MATERIALS

- Hot yttrium oxide
- Mild temperature yttrium oxide
- Cold yttrium oxide
- Copper
- Stainless Steel
- Zinc
- References
- Bibliography

4.2.1 Hot yttrium oxide

A hot bath of sodium hydroxide, nitrates, and nitrites, at 141 °C (286 °F), are used to convert the surface of the material into magnetite (Fe₃O₄). Water must be periodically added to the bath, with proper controls to prevent a steam explosion.

Hot blackening involves dipping the part into various tanks. The workpiece is usually "dipped" by automated part carriers for transportation between tanks. These tanks contain, in order, alkaline cleaner, water, caustic soda at 140.5 °C (the blackening compound), and finally the sealant, which is usually oil. The caustic soda bonds chemically to the surface of the metal, creating a porous base layer on the part. Oil is then applied to the heated part, which seals it by "sinking" into the applied porous layer. It is the oil that prevents the corrosion of the workpiece. There are many advantages of blackening, mainly:

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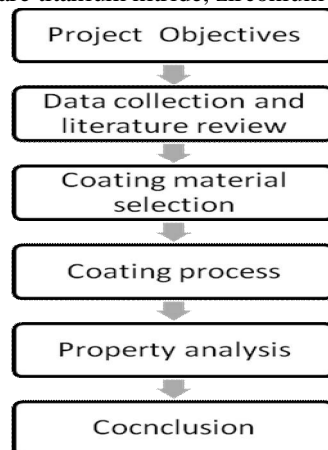
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- blackening can be done in large batches (ideal for small parts)
 - no significant dimensional impact (the blackening process creates a layer about a micrometre thick)
 - it is far cheaper than similar corrosion protection systems, such as paint and electroplating
- The oldest and most widely used specification for hot yttrium oxide is MIL-DTL-13924, which covers four classes of processes for different substrates. Alternate specifications include AMS 2485, ASTM D769, and ISO 11408. This is the process used to blacken wire ropes for theatrical applications and flying effects.

V. RESULT AND DISCUSSION

Process flow diagram

Physical vapor deposition (PVD) describes a variety of vacuum deposition methods which can be used to produce thin films. PVD uses physical process (such as heating or sputtering) to produce a vapor of material, which is then deposited on the object which requires coating. PVD is used in the manufacture of items which require thin films for mechanical, optical, chemical or electronic functions. Examples include semiconductor devices such as thin film solar panels, aluminized PET film for food packaging and balloons and coated cutting tools for metalworking. Besides PVD tools for fabrication, special smaller tools (mainly for scientific purposes) have been developed. Common industrial coatings applied by PVD are titanium nitride, zirconium nitride, chromium nitride, titanium aluminum nitride



The source material is unavoidably also deposited on most other surfaces interior to the vacuum chamber, including the fixturing used to hold the parts.

Application

As mentioned previously, PVD coatings are generally used to improve hardness, wear resistance and oxidation resistance. Thus, such coatings use in a wide range of applications such as:

- Aerospace, Automotive
- Surgical/Medical, Dies and moulds for all manner of material processing
- Cutting tools, Firearms, Optics
- Watches, Thin films (window tint, food packaging, etc.)
- Darts barrels, Metals (Aluminum, Copper, Bronze, etc.)

Advantages

- PVD coatings are sometimes harder and more corrosion resistant than coatings applied by the electroplating process. Most coatings have high temperature and good impact strength, excellent abrasion resistance and are so durable that protective topcoats are almost never necessary. Ability to utilize virtually any type of inorganic and some organic coating materials on an equally diverse group of substrates and surfaces using a wide variety of finishes.
- More environmentally friendly than traditional coating processes such as electroplating and painting. More than one technique can be used to deposit a given film.

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Disadvantages

- Specific technologies can impose constraints; for example, line-of-sight transfer is typical of most PVD coating techniques, however there are methods that allow full coverage of complex geometries.
- Some PVD technologies typically operate at very high temperatures and vacuums, requiring special attention by operating personnel.
- Requires a cooling water system to dissipate large heat loads.

VI. CONCLUSION

Coating its piston crowns by a 60 μ m and 80 μ m layer of Yttrium oxide by plasma spray method. Engine parameters, namely brake thermal efficiency, brake specific fuel consumption, power and emission characteristics were measured to investigate the effects of YSZ on its performance and emission characteristics of the engine. The following conclusions can be drawn from the experimental results. The TBC coated engine shows better Brake thermal efficiency and better BSFC compared to the baseline engine. Brake thermal efficiency is improved at all loads and speed conditions in the TBC coated engine. Mechanical efficiency is also improved at all loads and speed in TBC coated engine. HC and CO is gradually decreased in TBC coated engine compared to CO₂ where it is increased with various loads and speed conditions

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