International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 11 | Nov 2023 www.irjet.net p-ISSN: 2395-0072

SMART MANUFACTURING METHOD FOR PISTON ROD CHROME PLATING

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Abstract - *Hard chrome plating is a proven method of improving the durability, wear, hardness and anti-corrosion characteristics of metal and alloy substrates. It is a process that is used to plate many automotive parts like suspension shock absorber piston rods, gear shafts, decorative plastic wheel center caps etc.Our current study focuses on advance technology in chrome plating i.e. HVOF process (HIGH VELOCITY OXY FUEL), Electroplating hard chromium is commonly used method for the piston rod platting due to the performance characteristics like increases the hardness and durability of the surface of piston rod, prevent corrosion, crack, hardness, wear resistance and surface finish. Considering recent focus on environmentally friendly processes & Tata group's vision for a greener, cleaner, more sustainable and equitable future for the planet via Sustainability ,Circular Economy this process of HVOF is vital important.*

Unfortunately hard chrome process contains hexavalent chromium which is highly toxic waste & is also banned under multiple environmental policies in many countries. Considering toxic impact of chrome plating seeking alternative mfg solution for hard chrome plating method is inevitable. As an alternative to hard chrome plating, HVOF process is studied in this paper. In this new HVOF process is compared with hard chrome process using different testings like hardness test & salt spray test. Test result shows HVOF is better than hard chrome for all performance parameters of suspension piston rod & also HVOF mfg process is enviormental friendly.

Key Words: Hard Chrome plating, High velocity oxy fuel, Suspension damper, piston rod plating, Damper Durability improvements, Piston rod scratches

1. INTRODUCTION

The automotive industry commonly uses hard chrome plating on suspension shock absorber piston rod due to its good characteristics against wear, corrosion performance. Hard Chrome has been used since 1940 in manufacturing industry. Chromium layer has high corrosion resistance, low friction coefficient and high hardness and wear resistance.

Our study part is shock absorber-piston rod on which hard chrome plating is most commonly used by all suppliers.

Basically, a shock absorber or damper is a hydraulic device designed to absorb and damp shock impulses coming from road inputs for comfortable ride & handling in a car. It does this by converting the kinetic energy of the shock into another form of energy (mostly heat) which is then dissipated. Most shock absorbers are in the form of dashpot (a damper which resists motion via viscous friction). [1]

Piston rod of a shock absorber operates strokes in and out of bottom tube via rod guide, & is in continues contact with hydraulic fluid and surrounding atmosphere. Piston rod surface are using the coating techniques such as a chrome plating for better wear, corrosion performance & smooth operation.

Since the process of hard chrome used in manufacturing piston rod is not environmental friendly alternative advance manufacture methods needs to be studied, which will have better performance & environmental friendly mfg. Process.

In this paper, we tried to explore on such smart manufacturing process for plating of piston rod, named HVOF process. (High Velocity Oxy Fuel process).

2. CHROME PLATING BASICS & GLOBAL ENVIRONMENTAL SCENARIAO

There are two main type of chrome plating:

Decorative chrome plating:-

In This process,firrstly a layer of nickel and then a layer of chromium is deposited. Once the nickel layer has been deposited, a chromium layer is added on top of object. The chromium layer helps increase the corrosion resistance of the material and also improve the resistance to scratching, wear and nickel layer gives the shine polish. Decorative chrome plating usually has a total thickness under 25 µm. This plating commonly applied in plastic material like wheel center caps etc. [2]

Hard chrome plating: -

This type is typically used in manufacturing industry. Hard chrome plating improves the corrosion resistance, wear resistance of object. Hard chrome plating is commonly applied to various types of steel and is almost always thicker than decorative chrome plating.

Hard chrome plating has excellent characteristics and inexpensive.Thickness of the hard chrome coating is 10~500µm.

Unfortunately hard chrome process contains hexavalent chromium which is highly toxic waste and it will have critical environmental impact.many countries have restricted Cr6 due to enviourmental impacts. Below table shows country wise permissible limits [3]

Table-1: Global permissible limits for Cr6

Country	Permissible exposure limit (Cr6+) / m^3 of air as 8 hour time weighted average.
USA, Denmark	5 µg
Japan, Germany, France	50µg
United Kingdom and South Africa. Sweden	20µg

Main factor limiting chrome plating process is negative effect on environment, chromium coating process expose enviourment to hexavalent chromium and other hazardous by-products.Hexavalent chromium can be absorbed through skin and can cause of cancer of liver/ organs and brain damage. Potential damage to environment that processing water can cause, chrome-plating facilities must treat their wastewater before releasing it. [4]

For damper piston rod, additional disadvantage of hard chrome plated piston rod is friction between a piston rod and its oil seal, resulting wear of oil seal.Oil seal wear/ damage leads to the damper cylinder oil leak

The search of alternative coating/plating mfg. process is also considered to reduce oil seal wear, improved corrosion resistance and lower overall cost. In industry various alternative method to hard chrome available e.g. HVOF (High velocity oxygen fuel), plasma spraying, electro less nickel alloy plating etc are available. One of most smart mfg. method with no adverse impact on environment is : HVOF (High velocity oxygen fuel) same we will study in this paper in comparison with hard chrome plating.

3. HARD CHROME PLATING Vs HVOF

Suspension damper piston rod is studied for hard chrome plating process vs HVOF process.

Criteria of the piston rod coating is toughness, Corrosion resistance, wear resistance accordingly, hard chrome plating is most commonly used for piston rod plating.

Typical performance indicators of chrome plating mentioned below are for piston rod-

Table-2: Typical values for suspension damper piston rod plating-

Characteristics	Typical values of piston rod plating
Hardness	@ 900 HV
Corrosion resistance (SST)	Min. 240 Hrs Red rust, 96 Hrs white rust

3.1 Hard Chrome Plating Process-

Hard chrome plating is an electroplating process that involves applying a layer of chromium to a surface by submerging it in a chromic acid solution. Hard chrome plating increases the durability, hardness, wear resistance and corrosion resistance of metal components.

The electrolyte used in the chromium is an aqueous solution of chromic anhydride (CrO_3) with the addition of sulphuric acid (H_2SO_4). Anodes are insoluble and are made of pure lead or lead-antimony alloy. , in this electrolytic process chrome deposited from a chromic acid solution.Hard chrome plating is commonly applied to various types of steel and is almost always thicker than decorative chrome plating.

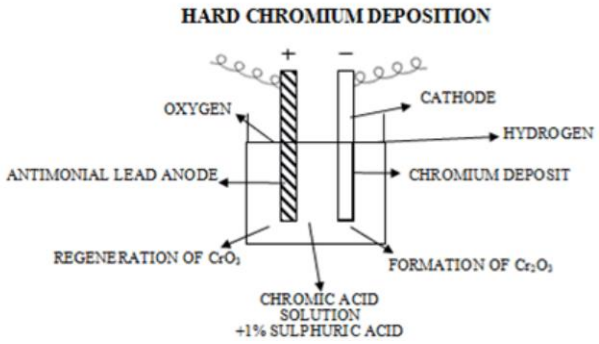

Fig-1: Hard Chromium deposition mechanism

Chrome plating is used for wear and corrosion resistance in addition to its tribological (low friction) characteristics. However, there are environmental concerns associated with disposal of the plating solution. This has led to many users of chrome plating seeking alternative coating methods. One option is to replace hard chrome with high velocity oxy-fuel (HVOF) sprayed coatings of cermet materials such as WC/Co (Tungsten Carbide/Cobalt). The HVOF sprayed coatings can offer superior wear and corrosion protection. [8], [9]

3.2 HVOF (High Velocity Oxygen Fuel)

HVOF spraying was developed in the 1980s and is a subset of thermal spraying. HVOF spraying works by mixing fluid fuel and oxygen, which is fed into a combustion chamber and ignited. The resultant gas has an extremely high temperature and pressure, which is ejected through a nozzle at

supersonic speeds. To the high velocity gas stream, powder is injected, which partially melts. The stream of hot gas and powder is directed towards the surface to be coated. The resulting dense coating has low porosity and high bond strength, providing many benefits such as corrosion resistance. [5]

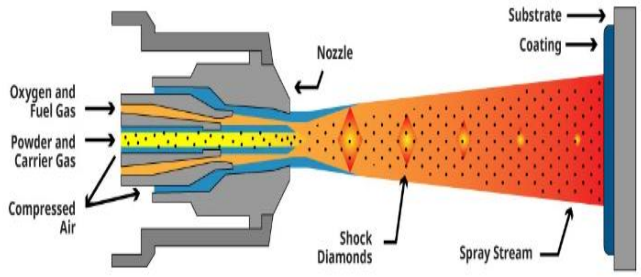

Fig-2: High velocity oxy-fuel process [5]

Cr3C2-NiCr coating deposited by HVOF process performance is compared with hard chrome plating. In hard chrome plating, it may contains the micro cracks which is weak point & may lead to surface corrosion, But the thermal spray high velocity oxy-fuel structure is way smoother than hard chrome & hence has less micro cracks, as shown in fig3.

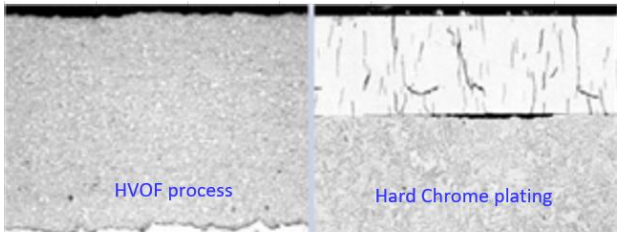

Fig-3: HVOF vs Hard chrome caoting

4. EVALUATION AND DETAIL ANALYSIS

Corrosion is the main element involved in determining the lifetime of a product for which HVOF process helps by creating a layer of thick chromium uniform and high hardness.

From the point of view of the metallographic analysis, we find that the sample correspond to conditions imposed, chromium deposit is constant, and the layer hardness is also better.

On the surface, the material hardened has high hardness, as we move towards core, hardness in this layer decreases, making part more tough.It is also observed that the thickness of chromium deposited is uniform and shows no irregularities, leading to the conclusion that throughout the process of chrome plating were fully thicker & uniform.

5. RESULTS

Hardness Test Result-

HVOF is better than hard chrome plating since it does not have micro cracks, which may cause corrosion on the substrate. There is a stark regularity in protection offered by HVOF as compared to hard chrome plating with tungsten carbide offering nearly a hundred fold superior plating over hard chrome plating.

Corrosion Resistance test result-

Test have shown that HVOF coating a higher hardness, better wear resistance, less frequent replacement, very quickly large area coated and no air emissions, no high volume rinse water.

The corrosion protection offered by HVOF versus hard chrome is clear in the salt spray test image. During a salt spray test, HVOF was compared to chrome plating during an 18 month atmospheric exposure test. The resulting surfaces show the superior resistance to corrosion provided by HVOF compared to hard chrome plating.

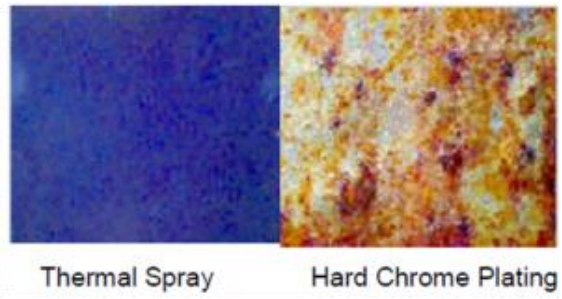

Fig-4: Thermal Spray versus hard chrome plating corrosion test

6. CONCLUSION-

In addition to enviormental friemndly process with no harmful Cr6+, Corrosion is another main element involved in determining the lifetime of a product for which high velocity oxygen fuel is giving better result than hard chrome plated.

Fortunately, there are numbers technical and environmental advantages of HVOF over hard chrome plating. High velocity oxygen fuel process is faster than the hard chrome process. HVOF conducted four step of process: degrease, grit blast, spray and finish grind. Compared hard chrome processes conducted nine steps. Degrease, alkaline wash, rinse, etch, rinse, plate, rinse, dry, finish grind. [7]

The smooth appearance shown in HVOF coating process than hard chrome coated. Typically coating thickness of thermal spraying is much thicker than electroplating & hence better wear resistance, corrosion resistance & environment friendly process.

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