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metco

Solutions Flash

Thermal spray, PVD and IONIT OX processes are excellent alternatives to hard chromium plating

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Today's situation

Hard chromium plating as a surface solution for wear and corrosion protection is a long and multifaceted success story.

However, concerns regarding operator health, operator safety and the environment based on the production of hexavalent chromium, or Cr(VI), during processing have caused many industries to search for alternative surface solutions.

For this reason, and above all, because of the environment concerns, the beginning of the 1990's saw alternative surface solutions being suggested and further developed. The main driving forces for these developments occurred in both Europe and U.S.A., especially in the latter. Today, there are massive restrictions on the use of processes that result in Cr(VI) emissions, for example as found with hard chromium plating.

As a result of globalization, the maximum emission values for Cr(VI) in water and the atmosphere will be further reduced. This will result in increasing process costs to cover the cost of meeting the tighter environmental regulations.

In spite of this, predominantly technological and economic factors determine the use of alternative technologies to hard chromium plating.

Alternatives

Thermal spray and thermochemical surface treatments are excellent, proven alternatives to hard chromium plating. In addition to the environmental reasons behind the use of these processes, they also offer other compelling advantages:

Improved long-term performance

- Thicker coatings that result in improved wear behavior with good corrosion resistance with reduced cost for repair and maintenance.
- Optimal residual stress level with significantly improved fatigue behavior.
- No hydrogen embrittlement on high-strength steel substrates.
- Lower tendency for pitting corrosion in humid or corrosive surroundings.
- Higher ductility that results in lower microcracking tendency.

Reduced Costs

The overall consideration of cost is complex. In each case, the specific requirements of each industry have to be taken into account with differentiation between the manufacturer and the user. Generally, the manufacturing costs are the critical issue for the OEM; whereas, the total lifetime process costs are important for the user.

Manufacturing Costs

- Lower manufacturing costs based on shorter machining times, reduced number of processing steps, no multiple layer coatings.
- Waste disposal costs are lower for thermal spray eliminated using IONIT OX surface treatment.
- Lower costs and risks in the area of legal conformity.

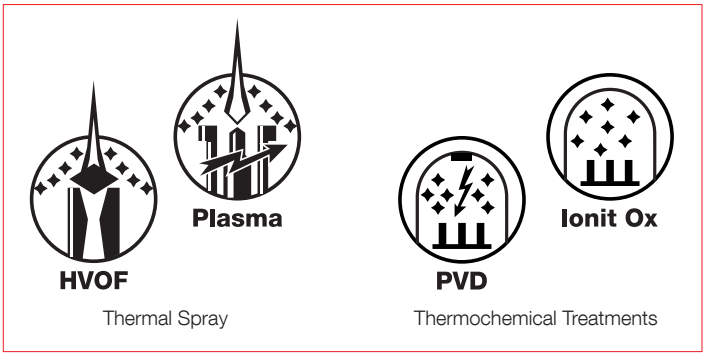
Life cycle costs

- Short turn-around time; in particular, this is important for airlines and for complex machinery and components (down-time and spare parts logistics).
- Reduced life-cycle total costs based on improved long-term performance.

The Oerlikon Metco Solution: A Choice of Distinct Technologies

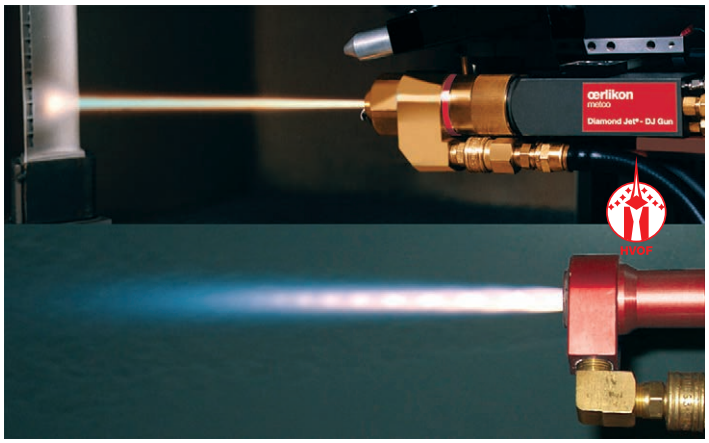
To offer our customers the optimal coating or surface treatment, Oerlikon Metco has developed a variety of different surface coatings and treatment technologies based on defined operating conditions using thermal spray, PVD and thermochemical treatments.

In this way, the customer has the advantage that he can select the optimum solution from a broad portfolio of coating solutions considering both the technology and the manufacturing costs (Cost of Ownership).



High Velocity Oxy-Fuel Spray — HVOF

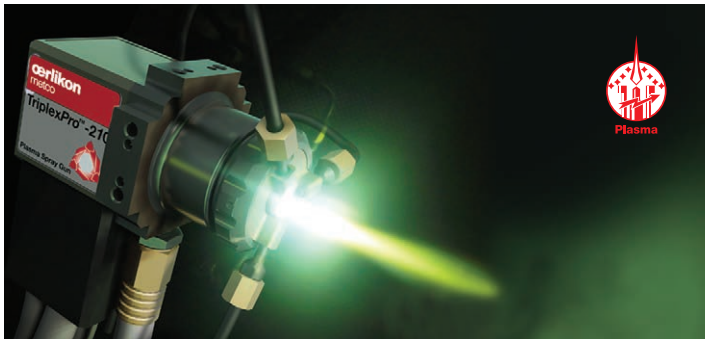
At present, HVOF sprayed cermet coatings represent the most successful alternative to hard chromium plating. Numerous applications have become established in a variety of industries such as aircraft landing gear, hydraulic actuators and calender rolls in the paper industry. These coatings are deposited with spray systems using gaseous fuels such, as hydrogen, propane or natural gas, or kerosene as a liquid fuel. Predominantly, cermets (WCCo, WCCoCr and CrC / NiCr) are selected primarily for wear protection. In applications requiring corrosion protection at moderate levels of wear, such as printing rolls, coatings based on stainless steel and nickel-chromium are used.



Top: DiamondJet™ 2700 (methane fuel); bottom: WokaJet (kerosene fuel)

Plasma Spraying with TriplexPro™-210

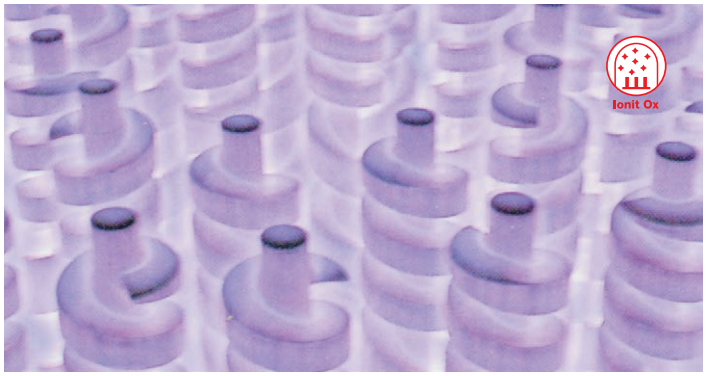
Oerlikon Metco has developed new coating systems for highly stressed, cost critical applications that use the patented, universal three-cathode plasma gun — TriplexPro-210. In contrast to conventional plasma spray guns, the TriplexPro-210 increases the material deposition efficiency by up to 50 % and, in some cases, increases the powder feed rate by 300 %. These factors make the TriplexPro-210 a very attractive solution that ensures a level of production efficiency and reduction of spray material costs never reached before.



TriplexPro-210 in operation

IONIT OX

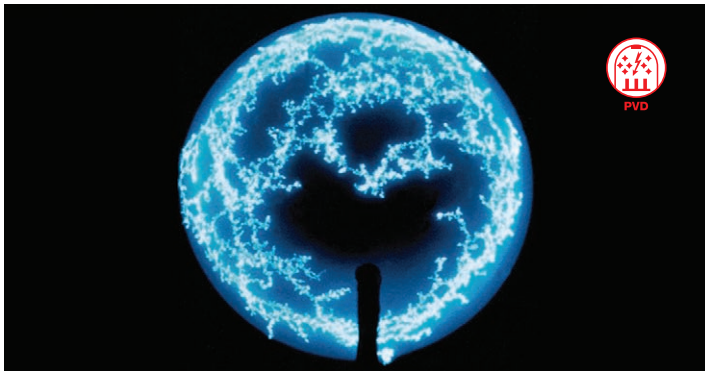
The patented IONIT OX process combines thermochemical processing — gas nitrocarburizing, plasma activation (plasma nitrocarburizing), and oxidation. Gas nitrocarburizing uses ammonia and carbon dioxide process gases with a precisely controlled chemical decomposition for the formation of nitrogen and carbon. This forms a nitride compound layer and a diffusion layer with a defined structure and phase composition. The activation of the nitrided surface occurs in the plasma nitrocarburizing process, during which the nitrided surface of the component is bombarded with nitrogen, hydrogen and carbon ions. The final oxidation step produces a closed oxidation layer approximately 2 µm thick, which is characterized by superior corrosion and wear protection as well as good friction properties.



Parts being treated with the IONIT OX process

PVD (Physical Vapor Deposition)

The PVD coatings developed by Oerlikon Metco are deposited using the PVD Arc process. High levels of ionization with this process, up to 100 %, guarantee a much higher hardness and density with superior bonding for wear resistant coatings versus the PVD Sputter process. Compared to other classical hard coatings, CrN coatings are characterized by excellent bonding and low friction values, offering many advantages, especially in forming and stamping operations. The chemically saturated, dense structure of CrN results in excellent sliding behavior of bulk materials on tool surfaces, such as that needed in the processing of plastics. Coatings based on a modified form of CrN exhibit a quasi-amorphous, doped surface layer of ceramic that provides a well-defined, anti-adherence property when processing strongly sticking bulk materials in the plastics industry.



PVD Target in the PVD Arc process

Customer Benefits (example: hydraulic actuators)

Based on the levels of loading, hydraulic rods are coated as an alternative to hard chromium plating using::

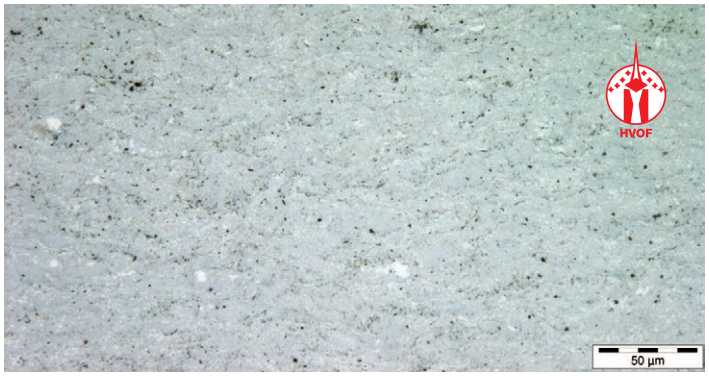
- Thermal Spray
  - HVOF-applied carbides (WCCo, WCCoCr or CrC/NiCr)
  - HVOF applied metallic alloy (NiCr)
  - HVOF applied metallic alloy + plasma sprayed ceramic top coat)

or

- Thermochemically treated
  - IONIT OX

Better long-term performance

HVOF sprayed cermet coatings exhibit advantages in their fatigue, wear and corrosion behavior compared to hard chromium plate, as indicated by the coating structure of the HVOF coating. Cross-sections of the sprayed coatings do not exhibit cracks or large pores that could have a negative effect on fatigue or corrosion behavior. The high hardness results from carbides embedded in the matrix.

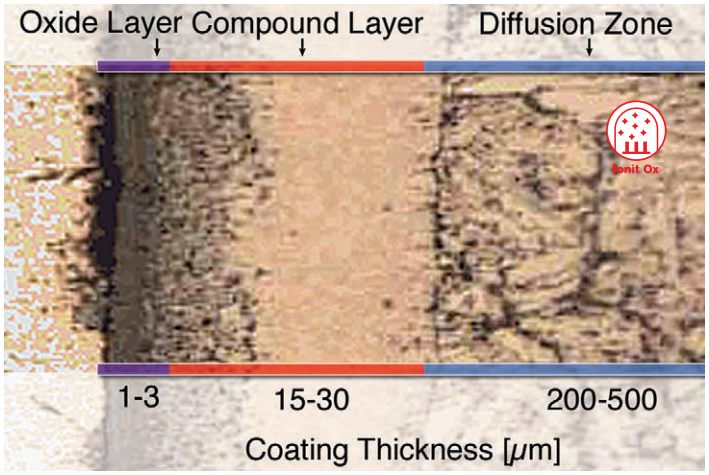


HVOF Sprayed WOKA 3652 (WCCoCr)

Hard chromium coatings can only be produced crack-free and corrosion resistant under special production conditions. A hard chromium coating produced under normal conditions exhibits regularly distributed cracks within its structure. The structure can be improved through multiple layer deposition; however, this results in increased processing expense and time.

Hard Chromium: etched, V2A etching medium

The surface of the components treated with IONIT OX exhibits three regions: the diffusion layer providing excellent mechanical support as a result of the hardness gradient from the soft base material to the hard nitride compound layer, the compound layer with a hardness up to 1100 HV and the oxide layer with its unique morphology, very good corrosion properties and low friction values. This type of structure guarantees high levels of wear protection together with excellent corrosion resistance.



Structure of an IONIT OX coating

Lower Life Cycle Costs

The higher long term performance clearly results in a reduction in maintenance and inventory costs, thus further reducing the cost-of-ownership. Furthermore, faster turn-around time using the HVOF process reduces the downtime of parts and components. A specialty of the HVOF process is the capability to repair bearing seats locally without damage to paint or labels.

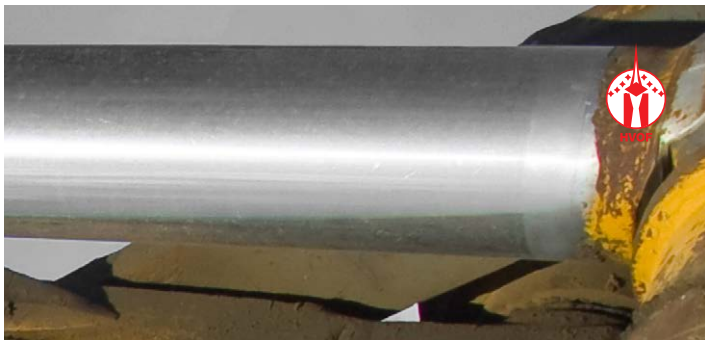
Environmental Protection

Environmental protection is one of the most important challenges of the 21st century. Products, manufacturing sites and manufacturing processes must meet present legislation. Of particular importance is the EU Directive 2000/52/EG, which requires that all components must be free of carcinogenic Cr(VI). In this respect, the IONIT OX Process combines the advantages of cost reduction with the fact that Cr(VI) can neither occur during processing nor be found in the product. IONIT OX treated parts can be recycled later without any environmental problems.

Hydraulic actuators application examples

Earth moving machinery

This hydraulic rod was coated with WOKA 7202 material applied using an Oerlikon Metco DiamondJet 2700 HVOF gun. After 3200 hours of operation, it shows almost no indications of wear. In addition, using suitable seals, hydraulic system leakage and seal wear is clearly lower than hard chromium plating. In comparison with hydraulic rods coated with HVOF, hard chromium plated rods have much shorter lifetimes. Hydraulic rods coated with HVOF also withstand higher levels of abrasion resistance.

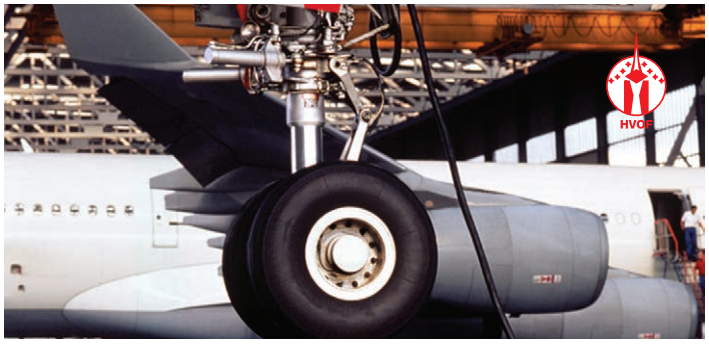


Hydraulic rod: HVOF sprayed, Cr_3C_2/NiCr, 3200 hours of service.

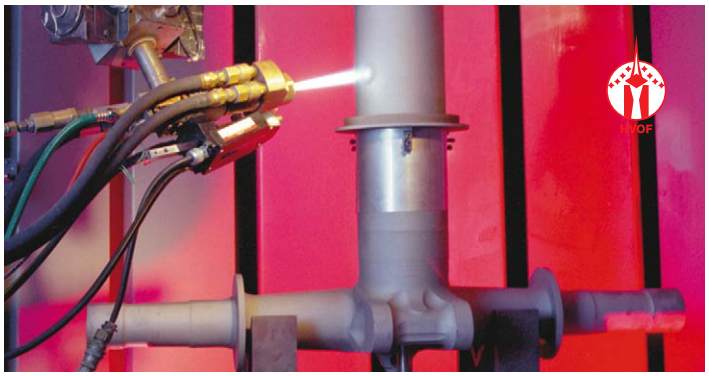
Hydraulic rod: Hard chromium plated, 682 hours of service.

Aircraft Landing Gear

In the past the hydraulic actuators of aircraft landing gear were almost exclusively hard chromium plated. A major change has already occurred with new aircraft from Boeing and Airbus that are nearly all equipped with HVOF coated landing gear. Beside the main shaft, all surfaces previously coated with hard chromium plate can now be coated with HVOF. As an added bonus, the HVOF process can also be used to repair bearing seats locally without destroying the paint or any of the labels.



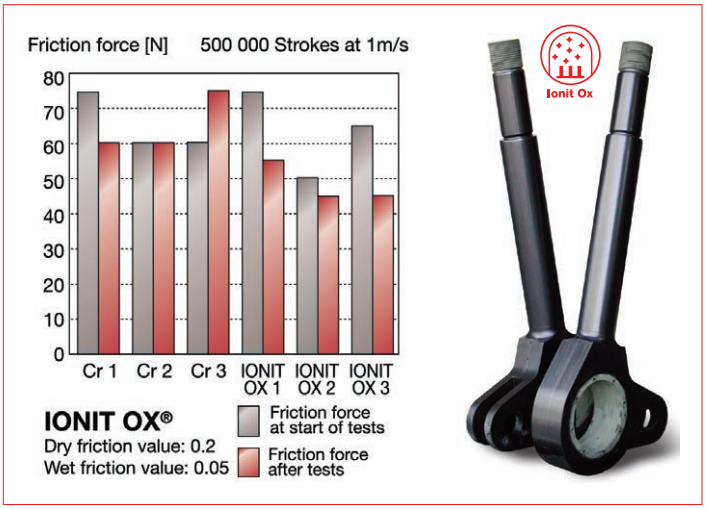
Hydraulic actuators of aircraft landing gear



Landing gear during the HVOF coating process

Hydraulic actuators for a mobile crane

The direct comparison of IONIT OX coatings, a solution without the Cr(VI) of hard chromium plate shows improved wear behavior and much better frictional characteristics. The repair of worn or damaged parts are also possible.



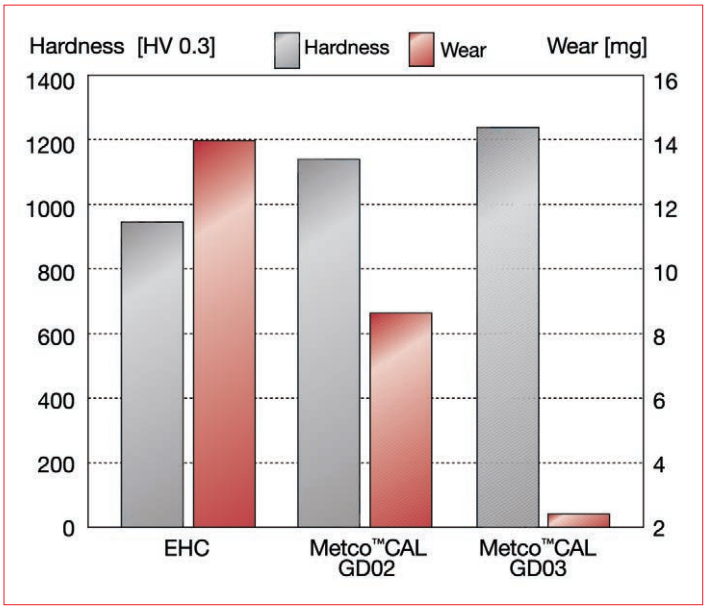
Comparison of hydraulic rods for a mobile crane with hard chromium plating vs. IONIT OX

Application example: calender and printing rolls

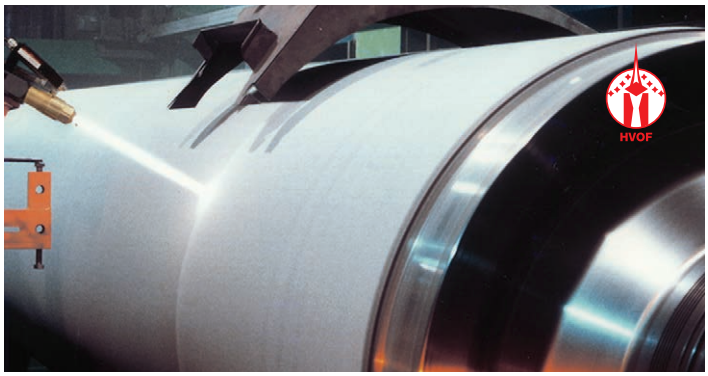
Calender rolls

HVOF-sprayed calender rolls offer paper manufacturing customers the advantage of longer lifetimes. Compared to hard chromium plating, HVOF coatings are more wear resistant, harder and usually exhibit superior corrosion protection.

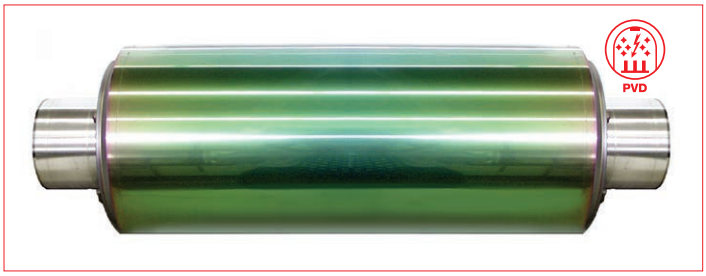
PVD-treated (CrN mod) calender rolls used for processing elastomers reduce sticking and layer formation on the rolls. The high surface hardness of over 2000 HV provides excellent abrasive wear resistance.



Comparison of hardness and wear resistance of hard chromium plate compared to thermal sprayed rolls (Metco™CAL).



HVOF coating being applied to calender rolls



Calender rolls for processing elastomers, coated with PVD CrN-mod

Other printing machinery rolls

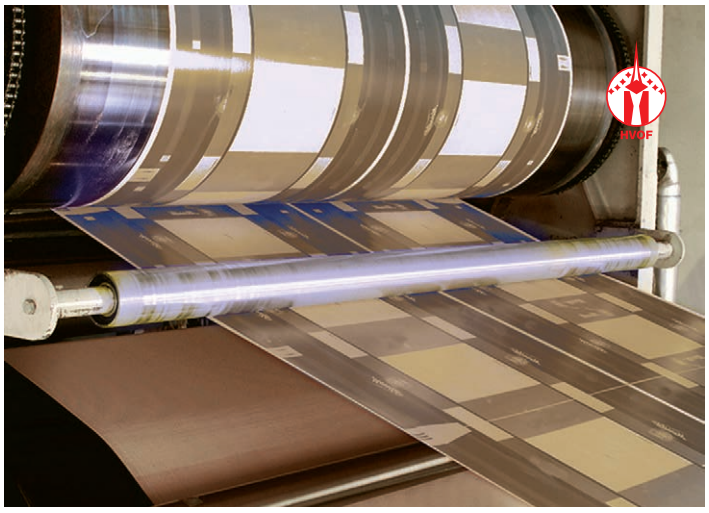
Large, thermal sprayed central impression rolls for flexographic printing machines are more economical than hard chromium plated rolls, and repairs can be carried out using brush electroplating. A further advantage of thermal spray is the short turn-around total processing time.

There is a worldwide trend to replace hard chromium plated printing rolls with thermal sprayed rolls. The objective is to reduce cost.

A variety of different thermal spray coating systems have been used for many different types of plate and rubber covered rolls:

- HVOF: NiCr or 316L coatings (austenitic stainless steel) applied with a DiamondJet 2600 or WokaStar spray gun
- Plasma: Use of the TriplexPro-210 spray gun as an economical alternative.

While the 316L coating predominantly provides corrosion protection, the NiCr coating (more expensive) in this application provides the wear resistance.



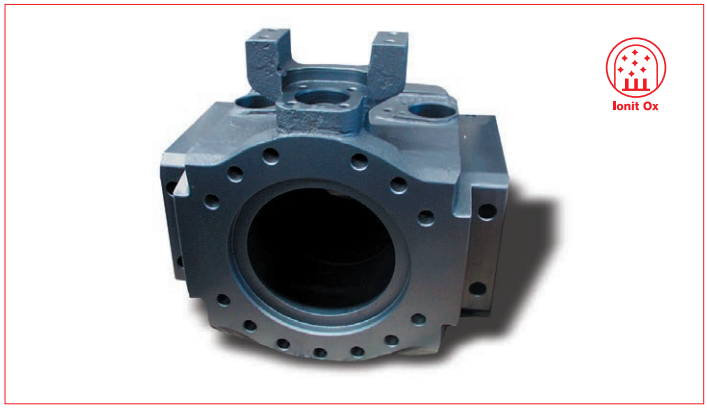
Flexographic printing.

Other application examples

Cylinder head for mobile cranes

Advantages of IONIT OX

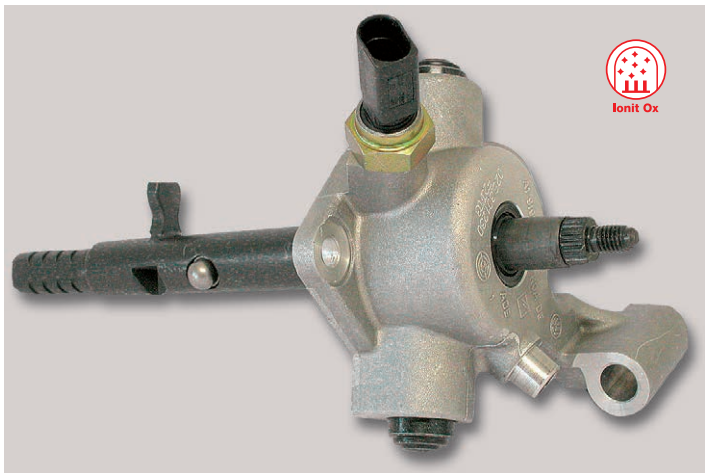
Based on the combination of wear protection, corrosion protection and improved sliding wear, IONIT OX is an ideal form of surface protection for hydraulic components where a thin layer is adequate. Considered economically, IONIT OX optimally fulfills the profile of requirements.



Cylinder head for a mobile crane treated with IONIT OX

Transmission shafts

The large reduction in the number of processing steps amounts to a cost reduction of at least 20 % with improved corrosion resistance, increased fatigue strength and lower wear rates.



Transmission shaft treated with IONIT OX

Process Step	Conventional Processing	IONIT OX
1	Machining	Machining
2	Cleaning	Cleaning
3	Masking	IONIT OX Treatment
4	Case hardening	
5	Cleaning	
6	Straightening	
7	Grinding	
8	Hard chromium plating as required	
9	Hydrogen removal heat treatment	
10	Final grinding	

Mass produced small parts

The IONIT OX process represents an economical and environmental alternative with high reproducibility for high volume mass produced small parts compared to partial or complete chromium plating.

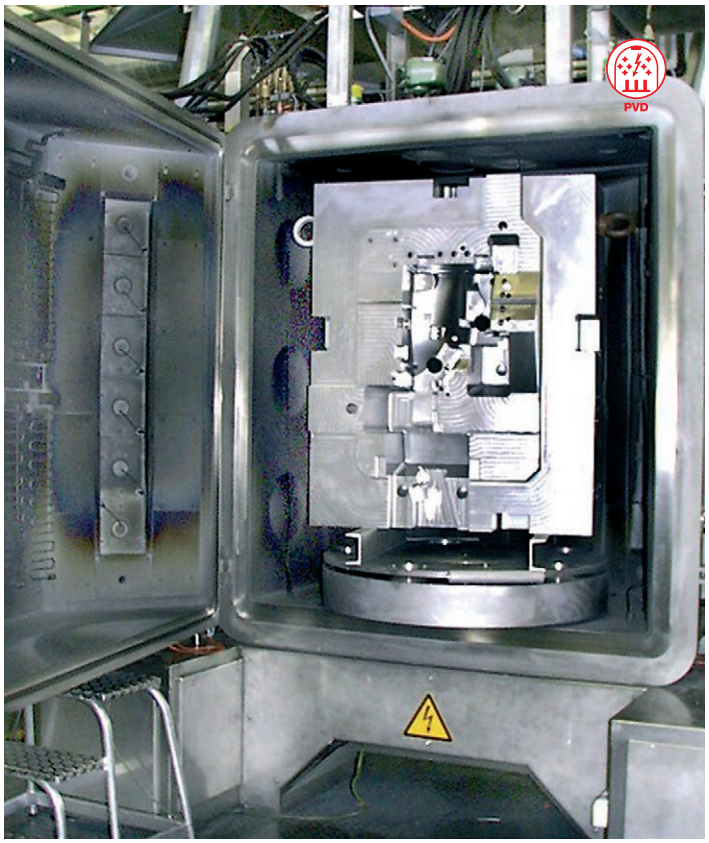
IONIT OX treatment for small parts and volume production

Tooling for injection molding
Coating tools for injection molding with a CrN coating results in clear customer benefits:

- Reduced tool wear processing highly abrasive, bulk plastics
- Easier opening of the mold
- No surface layer formation
- Excellent bond strength
- No microcracks
- No catalytic dissociation

The same benefits can be obtained with a PVD CrN coating on extruder screws.

PVD CrN mod coating on extruder screws

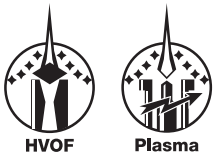


Injection molding tooling with CrN coating (PVD)

Conclusions and customer benefits

The broad range of surface treatments from a single supplier, together with in-depth practical experience and the knowledge of the advantages and disadvantages of each process, makes it possible to develop and provide a customized solution for each type of application.

Comparison of Thermal Spray to hard chromium plating



- Suitable for a wide range of substrate materials
- No limitation to the component size
- Better repair capability and simplified partial coating of new parts
- Reproducible coating properties for defined applications based on the process settings for the wide range of available spray materials
- Produce thicker coatings as a function of the coating material
- Faster processing of large and very large components
- Reduced number of process steps
- Less waste and lower costs for waste disposal
- On-site coatings using mobile spray units

Comparison of IONIT OX and PVD to hard chromium plating

- Dense crack-free coatings
- Excellent bond strength
- No spallation
- Little edge growth
- No hydrogen embrittlement
- Low surface roughness
- Low friction values
- Inert coating behavior
- No dangerous materials — environmentally friendly
- Very high coating hardness over 2000 HV (PVD)
- The IONIT OX process is independent of geometry, which expands considerably the range of components that can be treated.

Information is subject to change without prior notice.

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