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Worth knowing about Hard Chrome

What is hard chrome?

Hard chrome is a coating of metallic chromium, which is deposited electrolytic on cast iron, iron, steel and other metallic materials.

The coating consists of metallic chromium in thicknesses of typically 30 - 700 µm. The outer surface reacts with oxygen forming chrome oxides making the surface passive towards corrosion in aggressive environments. It is possible to vary the crack density and the crystal structure of the hard chrome coatings in order to increase corrosion resistance.

Hard chrome is used to reduce friction, add wear resistance or increase corrosion resistance. Different types of hard chromium coatings do exist.

Where to apply hard chrome?

Hard chrome is used as wear- and corrosion resistant coating; for instance on cylinders, axles & bearings, piston rods, tools, various machine parts and piping elements used in offshore, machine construction, food processing or in processing industry in general.

Hard chrome is also used as coating on printing cylinders because the high surface tension of chromium reduces friction and causes a bad wetting with oil.

Hard chrome can be plated in large coating thicknesses designed to sustain even very high Hetzian stress preventing fatigue fractures within the basic material.

How to treat customer items?

Hard chrome plating is an art because the process is born with bad material distribution and high gas production. Proper design of rags and anodes are the key to hard chrome coatings in high quality.

Our work is based on customer drawings and specifications. Consulting the client we specify all the requirements for surface functionality and quality prior to ordering. Quite often we include free test plating before the final agreement is concluded.

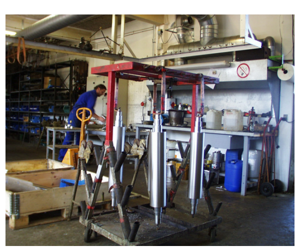
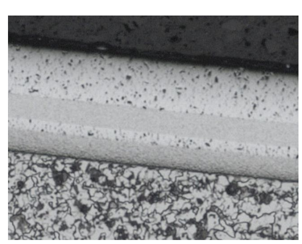
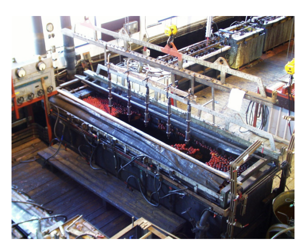
Be aware …

The hard chromium process is known by its low current efficiency and its poor material distribution ability. Roughness and brilliance hinges to the quality and surface finish of the parts to be plated.

Nearly 80% of the process energy is used to split water into oxygen and hydrogen. It is essential that the gas production is "controlled" and that the gases are removed in an appropriate way from work piece cavities and surface. Plating of internal surfaces is a special discipline that requires considerable experience.

The electric current flows the shortest way during plating! This implies that design of the anode is essential ensuring the best possible material distribution. Angles and sharp edges should be avoided as chrome here is deposited in excess, in contrast to hollows and shielded areas, where lack of chrome will be the case. The chrome layer thickness often varies +/- 20% or more. Grinding to tolerance might be required but can normally be avoided designing the anode correctly.

Hard chrome coatings creeps during production due to changes in crystal structure leading to coatings with either micro cracks or internal tensile stresses. Cracks typically have a length of about 2 µm, but can unfortunately grow into each other forming cracks down to the base metal. Shotpeening and heat treatment can to some extent eliminate tension and hydrogen.

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Structural properties

Hard chrome is plated from a hard chromium plating solution containing approx. 300 g/l chromic acid, 3 g/l sulphuric acid and special catalysts.

Controlling the hydrogen evolution and the cathode film thickness implies controlling the microstructure of the coating ranging from tight coatings with inner tension to tension-free coatings with up to 2000 micro-cracks per cm. The chrome is deposited in a hexagonal crystal lattice, reorganizing itself into a tighter body-centered cubic structure, setting free the build-in H_2.

The pillar structure of conventional coatings implies hardness, but also crispness. The classic hard chrome coating is micro-cracked and tension-free but not tight. Chemistry controls the release of inner tensions and transforms these into micro-cracks measured as number of cracks per cm.

The pillar structure of the coating can be eliminated, allowing hard chrome to be plated as tight amorphous chromium layers possessing lower hardness and reduced crispness. It might be wise to have both the pillar structure and the amorphous structure in the same coating. A cross section cut through such coating reveals a number of well defined horizontal layers, plated as designed.

Corrosion resistance

Chromic acid always oxidizes the outmost surface layer regardless the structure of the chrome coating. Chrome oxide is formed protecting the coating against corrosion attack even in acidic environments.

The chrome oxide layer is thin (3 -5 nm) and vulnerable to certain types of wear, although the film is restored in oxidizing environments. Reducing environment may cause several kinds of corrosion. Crevice corrosion and tribocorrosion are the most important types.

Crevice corrosion occurs if the oxygen of the crevice is consumed without supply of new oxygen. The acidity of the slit decreases, which leads to the formation of a local galvanic cell. The crevice surface acts as cell anode and dissolves (corrodes), while the surface just outside the crevice acts as the cell cathode.

Tribocorrosion occurs if the outmost oxide film continuously is worn away in acidic environments. The metallic chromium hydrolyzes under hydrogen formation and corrosion attack accelerates.

Cathodic protection immunizes chrome coatings in all environments preventing corrosion.

Wear resistance

Hard chrome is resistant to abrasive wear (moving particles plans away the surface coating) as long as the surface pressure of the abrasive particles are low. Limited space and hard particles can peel off chromium from the surface accelerating destruction of hard chrome coatings.

Hard particles hitting the coating with high speed in a path perpendicular to the surface can lead to erosive wear and destroy the chrome oxide film initiating corrosion attack provided that the flowing media is acidic and reducing.

Hard chrome resists in the best way adhesive wear (the "mountain tops" of the coating breaks off due to sliding contact with other surfaces) due to the coating hardness. However the poor wetting ability increases the risk of chrome oxide film break-down and thus the risk of corrosion.

Hard chrome resists fatigue wear in an excellent way provider the chrome layer is thick enough. Fatigue wear can be found in multilayer structures due to differences in hardness and elasticity modules. Cyclic pressure loads leads to surface cracks eventually followed by flaking.

Wetting

The high surface tension of hard chrome implies bad wetting particular with oil products. The wetting ability can be exploited actively. For instance is hard chrome suitable as coating on press rolls and similar pressing tools

Roughness

The chrome oxide layer provides low friction between hard chrome and other metals. However friction is also influenced by the roughness of the raw work-piece because hard chrome do not possess any levelling ability at all.

Temperature resistance

Hard chrome is temperature resistant up to 450 °C and shows good heat conductivity. The hardness drops dramatically at temperatures above 450 °C changing the coating properties and applications.

Electrical and magnetic properties

Hard chrome is not ferromagnetic and has an electrical resistivity of 125 $\mu\Omega \cdot$ cm

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Technical specification:	**Chrome** Classic	**Chrome** MultiResist	**Chrome** MultiLayer
Appearance, surface finish	blank	blank → gloss	satin → blank
Special properties	moderate micro-cracked	maximal micro-cracked	tight multilayer
Lattice structure & chemistry	body-centred cubic	body-centred cubic	amorphous + b.c. cubic
Operating temperature, °C	< 450	< 450	< 450
Typical applications	wear components	aggressive environments	off shore & similar
Typical basic materials	castings, irons, steels	castings, irons, steels	castings, irons, steels
Typical layer thickness, µm	30 – 700	100 – 300	100 – 200
Thickness variations, % [1) 2)]	10 – 100	20 – 60	20 – 40
Hardness, HV	950 – 1050	1000 - 1050	1050
Salt spray test, hours	Salt spray test in accordance with ISO 9227		
* no rust = Ra 10	48	240	506
* few rust spots = Ra 9	72	506	> 500
* rust attack = Ra 8	> 100	> 500	>> 500
No. of micro-cracks, typical:			
* inner surfaces, no./cm	350 – 400	400	450
* outer surfaces, no./cm	300 – 800	400 – 2000	0 – 2000
Roughness, microns	0,3	0,1 – 0,2	0,2 – 0,4

Pre-treatment:	always performed unless agreement tell us not to do so
* degreasing	alkaline or organic
* stripping of old coating	performed if specified in contract
Post-treatment	performed if specified in contract
* inner surfaces	honing might be required to keep tolerances
* outer surfaces	grinding might be required to keep tolerances
Heat treatment	performed if specified in contract
Final inspection	always performed unless agreement tell us not to do so

[1] Thickness variations depend on geometries of anodes, rags and work-pieces
[2] Post-treatment can be avoided designing special anodes and rags optimized to reflect the work-piece geometries