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Hard Chromium Plating

Hard chromium plating is produced by Electro-deposition in a solution of chromic acid. It is also known as industrial, functional or engineering chromium plating and is very different from decorative chromium plating.

Hard chromium plating has a wide range of applications where wear and a low coefficient of friction are considerations.

Applications

In our Laboratory we see hard chromium used for rebuilding worn or mis-manufactured parts, original manufacture and wear resistance of tooling and gages. It's also used for protection of molds running corrosive or abrasive plastics and to provide mold release characteristics.

Typical chromed parts would be; automotive valve stems, piston rings, shock rods, Mac Pherson struts, the bores of diesel and aircraft engine cylinders and hydraulic shafts.

Hard chromium plating is commonly used to restore original dimensions to worn surfaces of large crankshafts for diesel, gas engines and compressors. Hard chrome also finds use in the repair of impaired printing and paper making roll bearing journals.

Hard chromium deposits are intended primarily to increase service life of functional parts by increasing their resistance to wear, abrasion, heat and corrosion. Plus hard chrome is used to restore dimensions of undersized parts.

Thicknesses

Hard chromium is deposited in thicknesses ranging from one to twenty thousandths and in certain applications to much greater thicknesses. Decorative coatings of chrome rarely exceed .05 mil.

With certain exceptions, hard chromium is applied directly to the base material. Decorative chrome is applied over undercoats of nickel, copper and nickel and can be then polished or used as plated.

Hard chromium plating is used for restoring mis-machined or worn surfaces. However, since 1970, in some cases, electro-deposition of hard chrome has

been replaced by thermal spraying and plasma coating since it can be applied more quickly and with better control over the coatings thickness. In these applications, coating thicknesses range between five and fifty thousandths and the excellent wear qualities and low coefficient of friction of chromium are highly advantageous.

However, care must be taken not to plate in fillet areas as a precaution against fatigue failures.

Considerations

The decision to employ hard chromium plating would be dictated by the following needs and requirements:

1. **The inherent hardness and wear resistance of electro-deposited chromium.**
2. **Thickness of chromium required**
3. **Shape, size, construction and material the part is made from.**
4. **Masking requirements for areas not to be plated.**
5. **Dimensional requirements and if additional mechanical finishing will be needed.**

Hardness of chromium electro-deposits is a function of plating conditions. Generally, chrome plated in the bright condition is optimally hard. Bright chromium deposits from conventional baths have a Vickers hardness of 900 to 1000; those from mixed catalyst baths have hardnesses of 1000 to 1100 or higher.

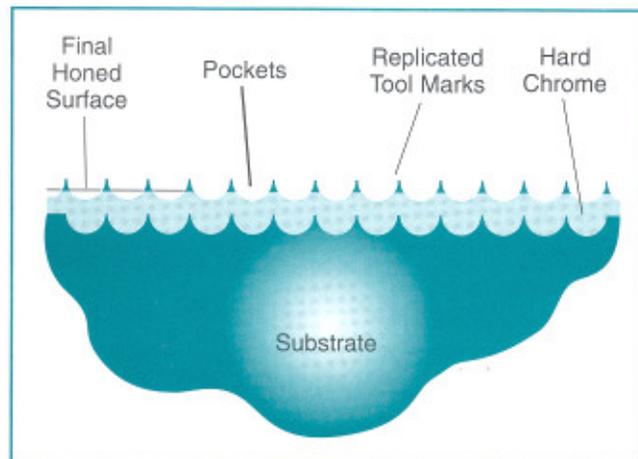


FIGURE 1: Honing of rough machined, plated surface to provide oil pockets



Microstructure

During deposition, the hard chrome develops pinpoint porosity or it can spontaneously develop microcracks. The areas between microcracks is called plateaus. Smaller plateaus are favored by more catalyst and less chromic acid in the plating bath and also by lowering the plating temperatures. Hard chrome plating can be nearly free of microcracks which will provide improved corrosion resistance and fatigue. However, the wear rate will suffer because it is a "softer" plating and without microcracks, it will not retain lubricating oil. This softer, continuous chrome has better shock resistance and is therefore often chosen for metal working tools.

The porosity and cracks markedly reduce the corrosion resistance and fatigue strength. However, they beneficially trap oil. Indeed, in many applications if there isn't enough porosity or microcracking, then wear rates may be unacceptably high, traceable to insufficient trapped lubricant. Often, the lowest wear rates are obtained when a combination of methods is used. For example, plated-in pinpoint microporosity, plus a heavily grit blasted or rough machined surface to create pockets with a final honing to even up the surface and leave a pattern of grooving. See Fig. 2.

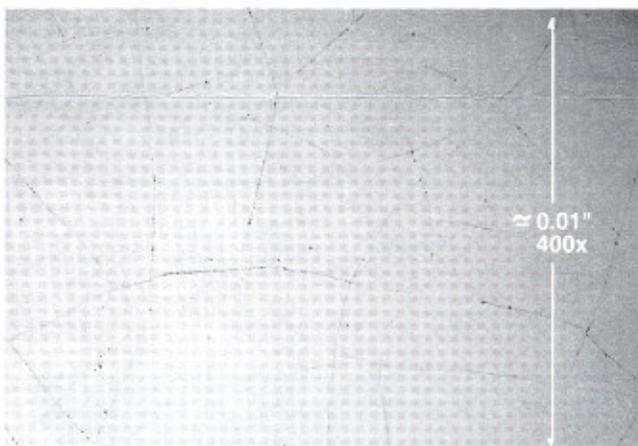


FIGURE 2: Microcracks and pores in Hard Chrome 400%.

The optimum performance may have higher wear rates at the beginning when there is the least bearing area but the most trapped oil. Lowest wear rates when there is the best compromise between contact area and trapped oil area. As wear proceeds, the

wear rates may climb as contact area continues to increase and trapped oil decreases.

In specifying hard chrome finishes, be guided by experience. If contact pressures are low then more porosity and roughness is better. If contact pressures are high, then less is better. If scoring occurs, then experiment with an increase in hardness. If shock loading occurs, then drop the hardness and plateau space.

Hard Chrome plating has proved itself to be a useful process to provide a long life, durable bearing surface. Merely specifying a "hard chrome finish" may not provide the results you are seeking.

Hardness

Hardness testing of thinly plated parts can be a problem. Typical Rockwell regular and superficial tests cannot be employed since they read an average between the plated surface and the substrate hardness. Transverse metallography and microhardness is both destructive and expensive. The use of a witness sample of the parent material that is plated at the same time can be helpful in determining hardness.

Also, since the hardness testing results will vary. Depending on the deposition rate, it will make a difference whether testing is near an inside corner, on a flat, or at an outside corner.

Although not a quantifiable test method, it often works out that a more satisfactory method is to establish acceptable and unacceptable limits for the surface appearance. Hardness correlates pretty well with appearance, so some agreed upon reference surfaces can be made up and set aside for to establish standards.

Metals Handbook, Volume 5, 9th edition, pg. 84, offers an informative table. The scratch hardness scale that they use is somewhat arbitrary.

Appearance	Scratch Hardness
Matte	640
Milky	830
Slightly Milky	990
Bright	1000
Slightly Frosty	1005
Frosty (smooth)	1020
Frosty (rough)	1060
Burnt	1165

You can write in your Purchase Order a hardness requirement based strictly on appearance.



If you really insist on having a hardness requirement then you will have to specify all of the testing details: exact location, thickness range where the test was taken, microhardness scale such as Vickers or Knoop, load on indenter, method of sample preparation and retest privileges.

Fatigue Strength

A serious problem with hard chromium is loss of fatigue strength. For example, a steel hardened to HRC40 or more, may have its fatigue strength reduced by half! The reasons originate in the intrinsic cracking of hard chrome and hydrogen embrittlement of the steel by the aggressive chemicals used in plating, cleaning and stripping.

There has been some success in obtaining a compressive layer through shot peening with shot that has no sharp edges at all. Essentially, work hardening the surface. Excellent quality control of the shot is required. Some have had success with ultrasonic stress relief when hard chrome is plated on a very hard substrate.

Uniformity

Hard chromium is laid down by an electroplating process. Compared with other electroplating processes, the hard chrome plating baths have a slow or poor plating ability and this ability is very dependent on plating bath chemistry. Plating can be good over a period of time but if the bath composition shifts, it will markedly change the plating rate and the quality of plating.

Although the throwing power of the process is slow, the little bit of hard chrome that migrates into a precision bored hole or an internal thread can be very difficult to remove. Such holes should be closed off with a Teflon plug. All plugs should be removed before draining and rinsing.

On single parts or short runs, you are dependent on the plating shop's past experience in getting a uniform plating job. On long production runs, the plating shop can usually figure out with time, just what anode configuration will result in acceptable uniformity. There are three dimensional computer programs that will simulate the electric field between the anode and the parts when immersed in the plating solution. However, they do not simulate the convection and the circulation of the plating solution between the anode and the part to be plated, so the results of the computer models are imperfect. They

will, however, markedly reduce the plating shop's amount of experimentation.

A good simulation program is essential when evaluating a potential supplier of hard chrome plating. Also, you should look for good record keeping of anode configuration vs. results for all the parts the shop is running.

Residual Stress

All residual stress in your part must be under control before plating. You must do a stress relief or the plating results will be variable. The density of porosity and microcracking and flaking in service will all be effected.

Residual stress is very difficult to quality control and your plating shop will probably insist on a clause in the P.O. that lets them out of any performance requirements if you provided parts having residual stress.

Stripping

It seems inevitable that parts have to be stripped and replated. The stripping method will depend on the substrate. Hydrochloric acid with inhibitors works for some substrates while deplating in an alkaline solution performs for others.

In either case, high strength alloys can suffer hydrogen embrittlement and pitting can be a problem. Early into a hard chrome plating contract it may be advisable to have the plating shop plate and strip some parts to determine what is the best process for deplating, prior to any production crisis.

Summary

Hard Chrome plating has proved itself to be a useful process to provide a long life, durable bearing surface. However, in using this process, one must be very careful to insure the substrate is properly prepared as to stress relief, surface finish and cleanliness. It is also important to closely work with the electroplater to achieve optimum results for your application. Merely specifying a "hard chrome finish" may not provide the results you are seeking.

We appreciate receiving feedback—it let's us know we're alive! The last issue's article on Electroless Nickel Plating was very well received. If there is a specific subject you would like to have covered, just FAX back your comments on the back page of Nuts & Bolts.

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