Hydraulics & pneumatics
Serving fluid power and motion control engineers worldwide
REPRINTED FROM MARCH 12, 2015

A chrome alternative for corrosive environments

BY M. WOODS, T. DAMIRGI AND E. ROLINSKI | Advanced Heat Treat Corp.

Environmental limitations on the usage of hex-chrome coatings[1] have yielded many alternative coatings and surface treatments for hydraulic and pneumatic cylinder piston rods. Piston rod surfaces need to have low coefficient of friction and resist wear from abrasion, erosion and sliding. But they also must be resistant to corrosion[2].

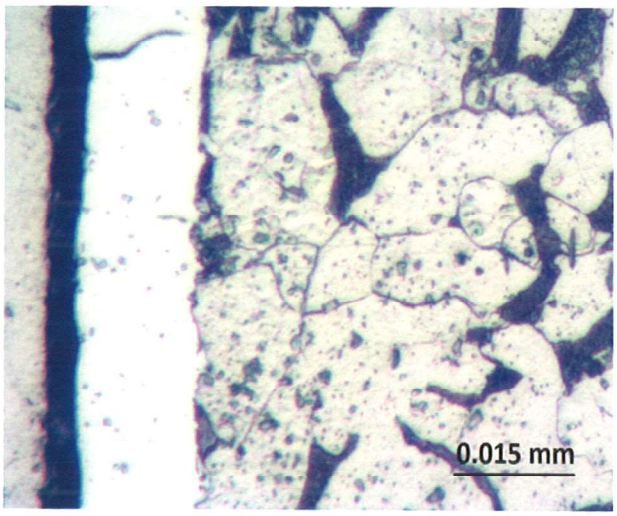

Figure 1A. Photo micrograph of Cr--plated 1020 steel, etched with 2% Nital.

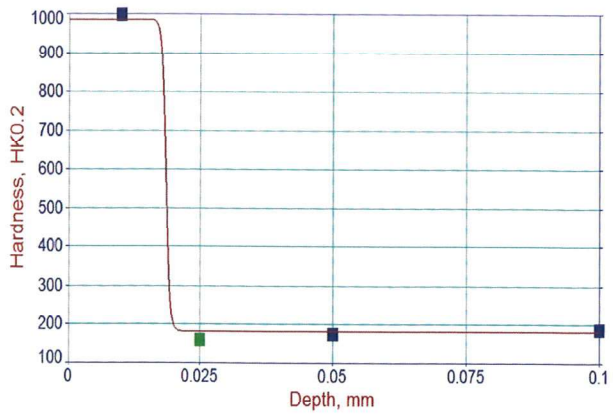

Figure 1B. Hardness profile on cross section of the sample shown in figure 1A.

Destruction of the galvanically-plated chromium coatings, still used frequently, occurs through spalling. This disqualifies many engineering components from their applications. To the contrary, nitrided components typically develop corrosion spots, and although those can be cleaned off without affecting performance of the parts for a long time, they may still lead to premature failure. Enhancing corrosion resistance of the nitrided/nitrocarburized layers by post oxidizing is a significant step in further enhancing performance of the parts. We recently developed UltraOx® to meet and exceed those requirements. The treatment combines controllable ferritic nitrocarburizing (FNC) carried out either by gas or plasma method with post-oxidizing and proprietary impregnation step, all carried out in the same shop[3]. The new technology is an alternative to other much more complex methods such as Melonite QPQ, Tenifer Q, Nitrotec and other processes[2-4]. UltraOx® has been developed using a new approach to the common problem by emphasizing microstructure-corrosion correlation[5]. Many actual and potential applications of the process are in the field of hydraulics and pneumatics.

Characteristics of the layers

Chromium plating can produce a monolithic layer on top of the steel component as shown in Figure 1A. The layer has significant hardness in the range of 800-900 HK (65-70 HRC equivalent) and it is plated over a comparatively soft steel base, Figure 1B. As it can be noticed, gradient of the hardness is very sharp at the surface and this may not be a very preferred stress profile in many applications. To the contrary, compound layer present in the nitrocarburized layer (Figures 2A and 2B) is supported by the diffusion zone, which exhibits a smooth transition of the hardness. Compound zone is not a coating like the chromium layer. To the contrary, it is formed by diffusion of nitrogen and carbon in the steel. Therefore, there is no problem with its adhesion to steel. It has been proven that the chromium-plated layer has micro-cracks, and because of that, flaking might occur if the direction of sliding is not perpendicular to the crack[6-8].

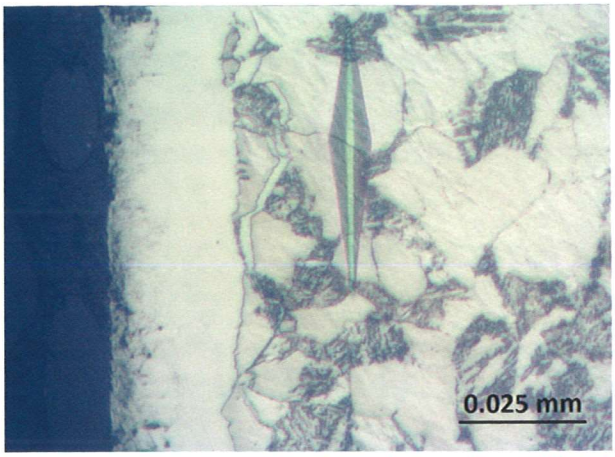

Figure 2A. Photomicrograph of 4130 steel after UltraOx® treatment, etched with 2% Nital. Note the dark oxide layer and the compound layout below it.

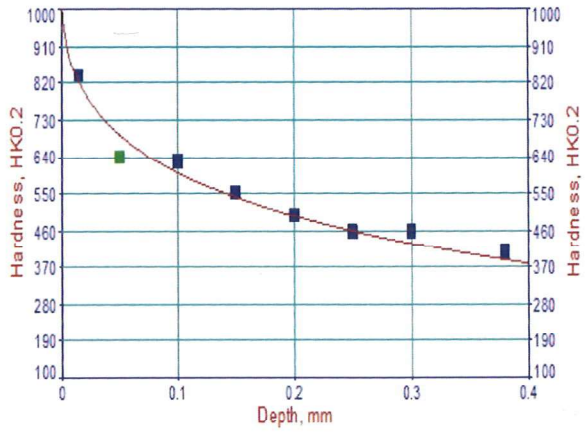

Figure 2B. Hardness profile on cross section of the sample shown in figure 2A.

The UltraOx® treatment assures very esthetic look of the parts, Figure 3. The black appearance of the surface is achieved with a special post-oxidizing step carried out after FNC in the same furnace. In lieu of the color, surface hardness of the component is significantly increased. This is extremely important since most of the failures start at the surface[2]. It can be noted a multi-zone character of the near-surface region. The outer zone is built of Fe_3O_4 (magnetite), and the zone directly underneath is the two-phase compound zone. Both of these zones are saturated with the proprietary sealant during the post-impregnation step. Coating used for impregnating acts as an electrical barrier, protecting the interface solid-solution from electronic transfer of the species, i.e. protects from electrochemical reaction which is also called electrochemical corrosion. The zone below is very compact since it has iron-reach nitride containing less nitrogen than the intermediate, porous zone.

Figure 3. Outer tube for industrial shock absorbers showing UltraOx®.

Application examples

UltraOx® is not only an environmentally friendly process but also allows for uniform all-over treatment of the steel component. Therefore, it is more versatile than hard chromium plating, so there is no shadowing effect from connecting electrodes. Parts of any geometry can be treated. Some of the parts treated by Advanced Heat Treat Corp. are also of significant size, such as piston rods for skid-steer loaders and other off-highway equipment. Other parts are quite small and detailed, such as the outer tube for an industrial shock absorber, Figure 3. Durability of the UltraOx® layer is at least twice of the chromium plated coating. Many actual and potential applications of the process are in the field of hydraulics and pneumatics. hp

M. Woods, T. Damirgi and E. Rolinski, Advanced Heat Treat Corp. are with Advanced Heat Treat Corp., Waterloo, Iowa. For more information, call (319) 232.5221 or visit www.ahtweb.com.

References

1. EPA, Draft Toxicological Review of Hex Chromium: In Support of Summary Information on the Integrated Risk Information System (IRIS). 75 Fed. Reg. 60454 (2010), www.phoneline.com, May 2011.
2. J. Spies, Chapter 6 in E. J. Mittemeijer and J. Somers, Thermochemical Surface Engineering of Steels, Ed Woodhead Publishing, 2014.
3. M. Woods, UltraOx® Treatment, Trade Name, 2012.
4. M. L. Doche, V. Meynie, H. Mazille, C. Deramix and P. Jacquot, Improvements of the corrosion resistance of low-pressure nitrided and post-oxidized steels by a polymer impregnation final treatment, Surface and Coatings Technology, 154, (2002), pp. 113-123.
5. J. A. Segui, Simulation-Led Strategy for Corrosion Prevention, Corrosion/Materials Science, Comsol News, 2014, pp. 36A-38A.
6. K. R. Newby, Industrial (Hard) Chromium Plating, Metals Hanbook Vol. 5, Surface Engineering, Ed. ASM Intl. 1994, pp. 177-191.
7. Zhenkun Yang, Alternatives to hard chromium plating on piston rods.
8. M. Keshavarz Hedayat, Comparison of conventional and active screen plasma nitriding of hard chromium electroplated steel. Elsevier, 2009