Thermal spray coatings and hydraulic applications

A better alternative to chrome plating

Hard chrome plating was seen as a critical refurbishment process, particularly for hydraulic components. However, since the mid 1990s, this technology has started to be phased out in the USA, Canada and Europe due to the negative effects the chrome plating process has on the environment – disposing of the plating products – and on humans – the carcinogenic nature of hexavalent chromium and its process derivatives.

With the newly imposed restrictions on chrome plating, the thermal spray process has become more and more attractive as a wear resistant coating on components that were previously chromed. Because it is a more versatile process, the number of different coatings that can successfully be applied to hydraulic components, for example, has increased and the thermal spray process has now become standard in this industry.

Another example where thermal spray coatings have replaced hard chrome plating is for the landing gear of aeroplanes. High velocity oxy-fuel (HVOF) tungsten carbide, cobalt chrome sprayed coatings are extensively used for this application (Figure 1).

Chrome plated components suffer from a decrease in fatigue performance, which manifests as 'mud cracking' on the surface (Figure 2). The coating also has an inherent susceptibility to scoring, wearing and seal leakages.

The advantages of thermal spray coatings, on the other hand, include:

- Increased wear resistance and service life.
- Improved corrosion resistance due to the absence of the network of micro-cracks associated with hard chrome plated coatings.
- Spray coatings bond to a wider range of substrates with better bonding characteristics.
- Increased hardness.
- Thicker coating capabilities.

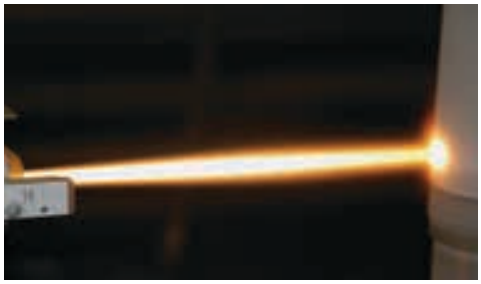

Figure 1: An HVOF thermal spray coating being applied to a hydraulic component.

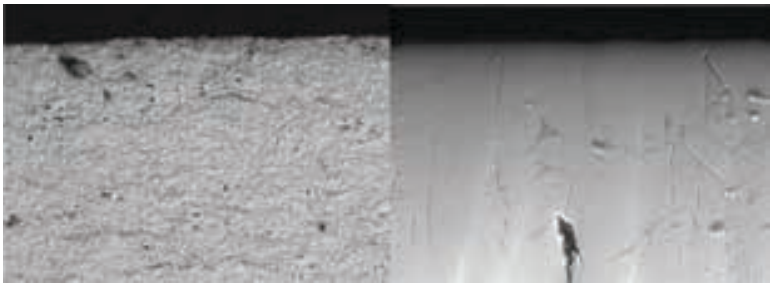

Figure 2: Comparative surface micrographs of a thermal spray coating (left) and a 'mud-cracked' hard chrome plated surface (right).

- Spray coatings do not affect the substrate.
- Surface fatigue problems are eliminated.
- Hydrogen embrittlement of the substrate is not a problem
- The process results in less re-work and fewer repairs.

Thermal Spray Technologies has tested thermal spray coatings, specifically developed to replace hard chrome, for wear resistance in accordance to ASTM G65. Their findings show that thermal spray replacement coatings significantly outperform plated hard chrome coatings.

Other data collected from applications in the field and from laboratories also shows that thermal spray coatings last three to five times longer than plated hard chrome coatings. Studies conducted internationally show that 70% of all base material and 80% of the energy costs can be recovered when a component is refurbished instead of replaced. While chrome plating has been the standard process used by repair shops, thermal spray processes can offer better quality and significantly extend service life.

Industry examples

The bearing and seal landings of gas turbine shafts (Figure 3) used to be repaired through hard chrome plating. These areas are now refurbished using the HVOF process, which results in a superior wear resistant coating.

The coating applied onto the axle of Boeing 747 undercarriage is a tungsten carbide-based HVOF coating that replaces the traditionally applied plated chrome coating. Boeing is currently at the leading edge of replacing chrome plating with thermal spray technology.

Other typical modern thermal spray applications include: print and blanket cylinders; centrifuge bowl ends; tension bars; feed screws for plastics injection moulding; gate valves; and ball valves.

The refurbishment of hydraulic equipment

In South Africa Thermaspray has, for several years, been refurbishing hydraulic equipment that was previously chrome plated. Thermaspray has also refurbished copper-plated hydraulic cylinders using a copper-based thermal spray coating.

Recently refurbished was an eight metre long hydraulic rod. This process had never been done in Africa before. For this process, erosion, abrasion, marine corrosion and seal friendly protection was required. The process entailed pre-grinding the outer diameter to remove previous damage as well as the chrome plated coating (Figure 4). An HVOF chrome carbide, nickel chrome coating (Figure 5) was then applied to the entire length of the rod. Final grinding and super finishing was then performed to the customers' requirements.

Most of the spray coatings applied for hydraulic type applications are finished in Thermaspray's in-house

Figure 3: The bearing and seal landings of gas turbine shafts are now refurbished using the HVOF process.

machining and grinding shop to a tolerance of 10 µm. Rods are sprayed in a large top-loading spray booth, which can handle rods up to 5 500 mm long weighing up to 6 000 kg.

The grinding of rods is done in a grinding workshop, where several large cylindrical grinding machines – with up to 3 800 mm between centres and 700 mm swing capability – fitted with diamond wheel grinding systems. For specific surface finishes, two dedicated finishing lathes are used for the polishing and/or super finishing of shafts.

Thermaspray has also developed several advanced coating systems for hydraulic rods that operate in severe environments. An additional advantage of HYDRAMAX coatings is that they can be used to refurbish damaged cylinders. This is due to the fact that much thicker coatings can be deposited with the thermal spray process. Hydraulic cylinders with local pitting or impact damage, or cylinders that were straightened and are therefore undersized, can be refurbished without having to replace the complete rod. Thermal spray coatings can also be used to provide other hydraulic system components, such as the barrel, with corrosion protection.

The corrosion and impact resistance of the thermal spray coatings compared to hard chrome plating have also been tested by the SABS. The salt spray corrosion test, which simulates an aggressive marine environment, was performed as per SABS/ISO 7253:1996. The chrome-plated sample showed corrosion damage after approximately 20 hours exposure and was severely corroded after approximately 60 hours. The HYDRAMAX-coated sample showed no corrosion damage after 1 000 hours of exposure.

The impact test was performed as per ASTM G14-88, and showed that the HYDRAMAX coatings have impact resistance, comparable, or better than hard chrome plated coating.

Currently, Thermaspray uses thermal spray processes to refurbishes hydraulic equipment for a number of large hydraulic companies in South Africa. Not only are the surfaces of these components better protected, but also the service life is significantly extended. ❑

Figure 4: Pre-grinding the outer diameter of a cylinder rod to remove previous damage as well as the chrome plated coating.

Figure 5: An HVOF chrome carbide, nickel chrome coating being applied to the length of the rod.