

## Corrosion Protection Through The Use Of Thermal Spray Coatings

Historically coatings have been developed and used to provide protection against corrosion and wear in order to protect the base material from chemical and physical interaction with its immediate environment. In theory, degradation mechanisms such as corrosion and wear are individually considered, however, in practice this is never the case and one will always encounter some combination of degradation.

The general perception in industry of thermal spray coatings is that primarily zinc, aluminium, zinc-aluminium alloys and aluminium-metal composites are applied for corrosion protection of components' surfaces. Although a wide range of applications have been successfully thermally sprayed with the abovementioned alloys for adequate atmospheric corrosion resistance, the corrosion resistance capabilities of thermally sprayed coatings extends far beyond atmospheric corrosion protection only.

Advances in coating materials, together with the possible industrial applications where thermally sprayed coatings can or do already play a role, have led to the expansion of the range of corrosion-resistant coatings available. These days thermal spray coatings can provide a range of protection from everyday atmospheric corrosion through to the protection of surfaces exposed to high temperature corrosion. Many thermal spray coatings also provide wear- resistance with - corrosion-resistance.

### Coatings and Corrosion

The corrosive attack on a material can be classified either as general uniform corrosion (constitutes approximately 30% of recorded failures) or as localized corrosion (constitutes approximately 70% of recorded failures). Several applications where thermal spray coatings have been applied for corrosion protection are listed below:

Large steel structures such as bridges, pipelines, oil tanks, etc., exposed to atmospheric corrosion, as well as ships, offshore platforms and seaports exposed to moist atmospheres and seawater, require adequate protection against their immediate environment. Thermal spray coatings are applied to these structures as sacrificial coatings, i.e. the coating will corrode preferentially to the protected base material at any surface discontinuity where the base material

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is exposed. The metals used for this type of application include zinc, aluminium and zinc-aluminium where zinc out-performs aluminium in alkaline environments and aluminium out-performs zinc in acidic conditions.

Thermally sprayed coatings of austenitic stainless steel, aluminium bronze, nickel-base alloys and super-alloys, are often used when corrosion is associated with wear. These coatings provide no galvanic protection and will thus not protect the substrate if discontinuities in the coating are present, which will expose the base material. In cases such as these, a protective layer between the coating and the base material is added for increased corrosion protection. Corrosion barriers created by coatings such as 316L stainless steel and Hasteloy C-276 have proven very successful in the corrosion protection of petroleum industry applications. Cermets such as tungsten carbide-cobalt and tungsten carbide-cobalt-chrome are thermally sprayed to components that experience severe wear and corrosion degradation in the oil and gas industry.

Coating materials that are used in the paper and pulp industry generally include iron- and nickel base alloys, nickel-chromium self-fluxing alloys, carbides and oxide ceramics, depending on the application. The components used in this industry can have large dimensions and are subjected to high wear and corrosion challenges.

High temperature degradation of metals and alloys is a serious problem in many industries. The depletion of high-grade fuels and the use of residual fuel (containing impurities such as sulphur, sodium and vanadium) or oil in energy generation systems contribute to the aggressive corrosive degradation of the components. The impurities found in the residual oil form low melting point compounds (ash) on the surface of the materials and induce accelerated oxidation. This accelerated oxidation (hot corrosion) occurs when these molten compounds dissolve the protective oxide layers that naturally form on the material during boiler/gas turbine operation.

Through the use of suitable thermally sprayed coatings, the exposed surfaces of materials can be protected against high temperature corrosion. Thermal spray coatings such as chrome carbide-nickel chrome, Inconel 625 and nickel-chrome are extensively applied for the protection of the surfaces of components that operate at high temperatures.

Coatings are extensively applied in the metal processing, chemical, aerospace, power generation and turbine (land-based and gas) industries, to name but a few, to protect the surfaces of materials against corrosive and wear environments.

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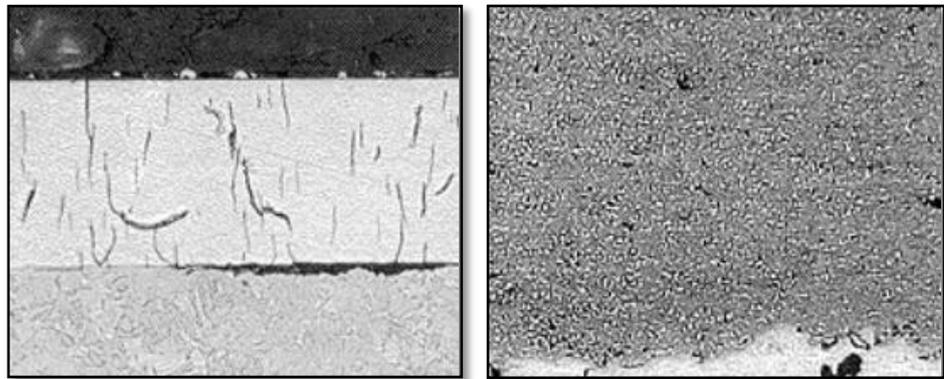


## High Velocity Oxy Fuel coatings as Hard Chrome replacement

Although chrome plating has been a trusted industry solution for wear and corrosion resistance, strict environmental pressures and legislation (leading to high process costs) imposed on the chrome industry for the disposal of the process by-products have steadily escalated over recent years. High Velocity Oxy Fuel (HVOF) coatings are extensively used in industry to replace hard chrome coatings due to the additional corrosion protection provided by the HVOF coating, as well as the fact that the HVOF process is an environmentally friendly process (waste disposal in the form of metallic dust is relatively easy).

Hard chrome coatings are inherently full of micro-cracks (Figure 1) and when these micro-cracks extend through the coating to the base material, a path for corrosive medium to reach the substrate is created and this can lead to coating adhesion failures and base material corrosion. The HVOF thermally sprayed coatings are much denser without any micro-cracks.

Field data has shown that tungsten carbide, chrome carbide and chrome oxide coatings can last up to 3 to 5 times longer than hard chrome plated coatings.



**Figure 1: Difference in hard chrome coating (left) versus an HVOF thermal spray coating (right).**

Extensive testing of HVOF-applied tungsten carbide coatings as replacement for hard chrome plating for landing gear of aircraft was performed in the 1990's. The fact that the HVOF thermally sprayed coatings had no environmental risk, fewer processing steps and a shorter production cycle has shown that the coating performance of the thermally sprayed HVOF tungsten carbide coatings is superior to hard chrome with less fatigue debit on the substrate material.

The corrosion resistance of three coated samples was evaluated by atmospherically exposing the coated samples and salt fog testing in accordance with ASTM B117.

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## 18 MONTH TEST FOR CORROSION RESISTANCE



HVOF APPLIED  
TUNGSTEN CARBIDE



TRIBALOY 400



HARD CHROME

**Samples of 4340 Steel Plates Coated With 1) HVOF WC/CO, 2) Tribaloy 400, and 3) Hard Chrome after 18 months of atmospheric exposure plus once weekly spraying with salt water**

*Figure 2: Superior corrosion resistance of an HVOF thermally sprayed coating compared to two other types of coatings ([www.thermalsprayusa.com](http://www.thermalsprayusa.com)).*

The superior corrosion resistance of the HVOF thermally sprayed coating is shown in Figure 2.

### Conclusion

Thermally sprayed coatings are extensively used in a vast number of industries for corrosion and wear protection of surfaces. Thermal spray coatings can be applied to surfaces for protection in environments ranging from mild atmospheric to aggressive high temperature environments.

### References:

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