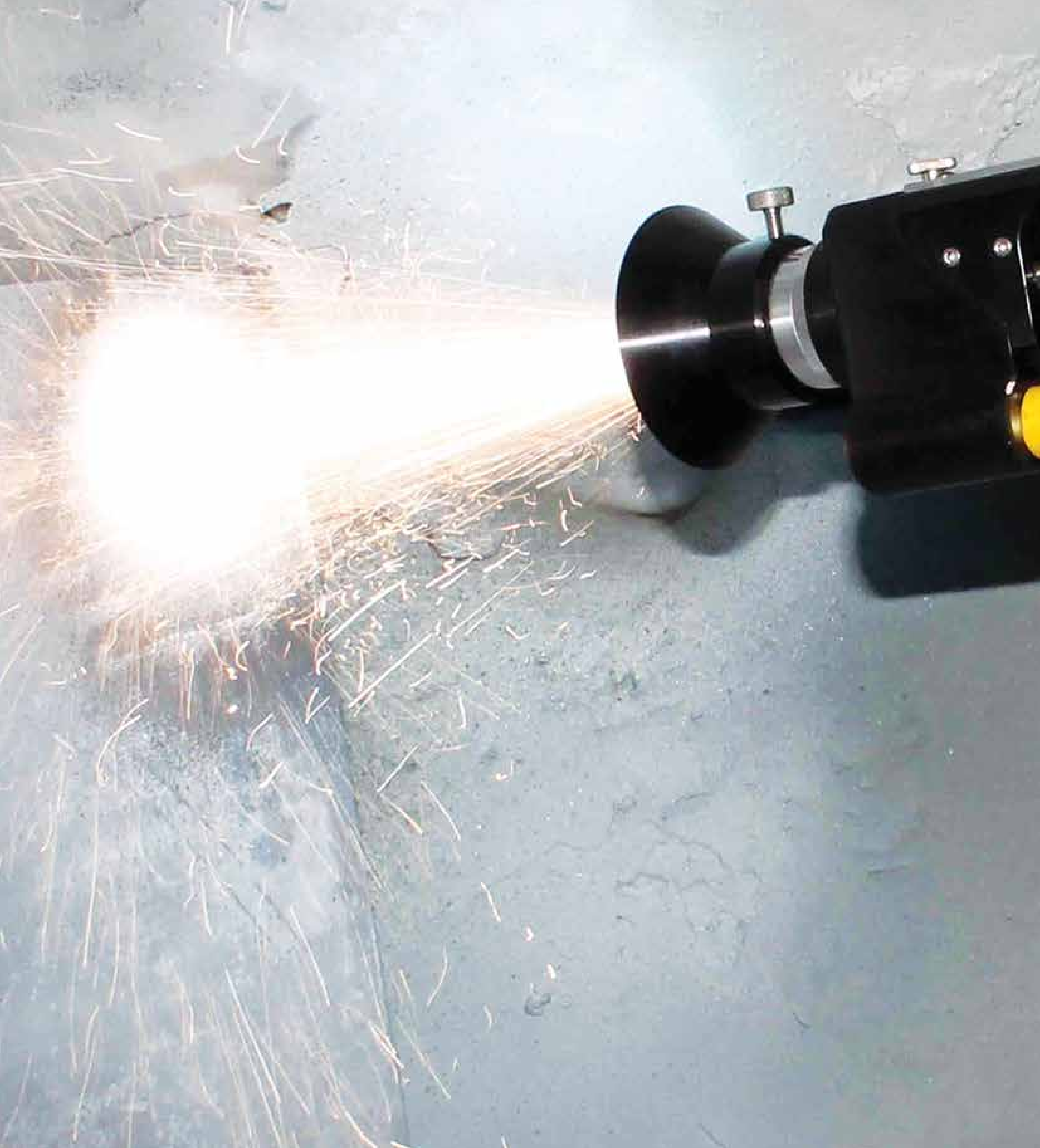
Technical Article

An Introduction to Thermal Spraying



Thermal spraying, also commonly known as metal spraying, is a surface engineering/coating process whereby a wide variety of metals, ceramics and polymers can be sprayed onto the surface of another material. The range of materials that can be sprayed is almost limitless - if the material can be heated to its melting point without boiling away, then it can be thermally sprayed.

Thermal spraying is widely used to provide corrosion protection to ferrous metals or to change the surface properties of items, such as improving the wear resistance or thermal conductivity. The range of thermal spray applications is vast. All methods of thermal spraying involve the projection of small molten or softened particles onto a prepared surface where they adhere and form a continuous coating. As the heat energy in the molten particles is small relative to the size of the workpiece, the process imparts very little heat to the substrate. As the temperature increase of the coated part is minimal, heat distortion is not normally experienced, which is a major advantage over hot-dipped galvanising or welding.

To create the molten particles, a heat source, a spray material and an atomisation/projection method are required. Upon contact with the target surface, the particles flatten, freeze and mechanically bond, firstly onto the roughened substrate, and then to each other, as the coating thickness is increased.

Thermal spraying is a technology which protects and greatly extends the life of a wide variety of structures, equipment, and vessels, in the most hostile environments and in situations where protective surface coatings are vital for longevity. The variety of metallised coatings is vast but can be broken down into two main categories, anti-corrosion coatings and engineering coatings. The largest volume business for metal spraying is for anti-corrosion purposes, but the range of engineering coating uses is also large and they are used to provide wear resistance, as thermal barriers, for electrical and thermal conductivity, chrome replacement, and insulation, across many industries.

The type of industries using the metal spraying process is endless and includes offshore, oil and gas, marine, tube and pipe and general fabrication, petrochemical, construction, water supply, sewerage, ship building, aerospace and airside support. These industries use metal spraying for the protection of structures, vessels, pipelines, water / fuel / storage tanks, bridges and gantries, to name just a few. Both corrosion and wear are major problems for these industries.

This article will concentrate on the use of thermal spraying for corrosion control, and brief descriptions of the various systems will be given together with a case study of a typical use.

Thermal spraying

Thermal spraying can be carried out by four processes, Flame spray, Arc spray, Plasma and High Velocity Oxy-Fuel (HVOF), and by manual or automated spraying systems, although normally only Flame spray and Arc spray are used for corrosion protection coatings. The exception to this can be the application of corrosion resistant alloys by HVOF in very harsh environments.

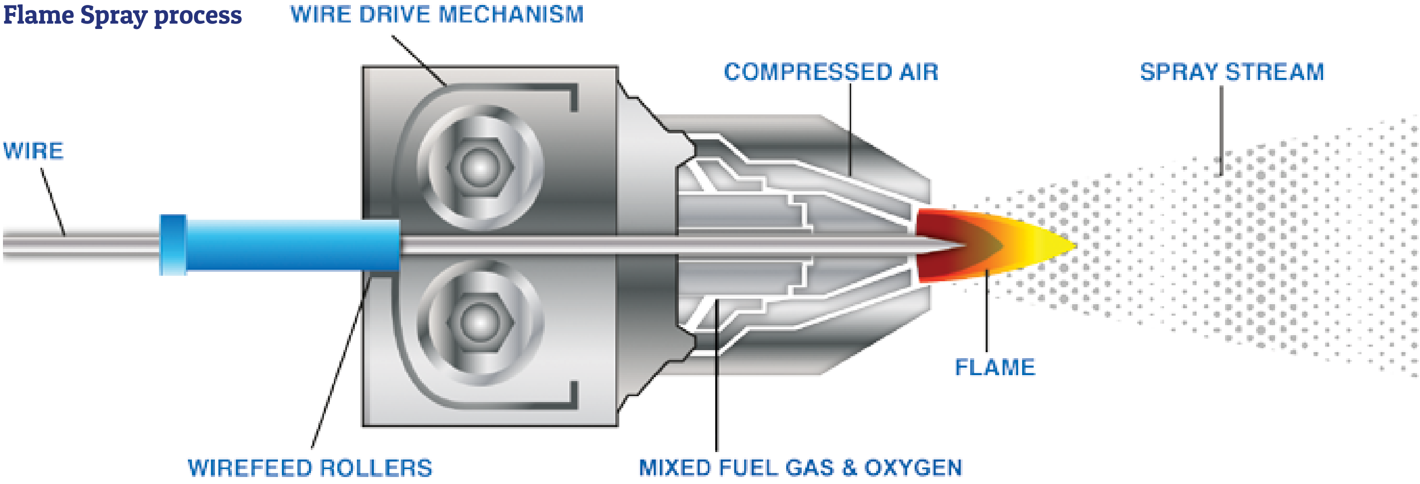
Flame Spray process

In this process, the heat source is commonly propane or acetylene fuel and oxygen gas. The material to be sprayed can be in the form of metallic wire or powder or ceramic rods, and the transfer medium is compressed air. In the process, the gas fuel and oxygen are mixed and ignited to produce a flame. The material, either a wire, powder or rod, is fed into the flame. For wire flame spray, the material is melted and the compressed air, passing through a spray nozzle atomises the molten metal and propels it onto the work piece. The larger the wire diameter, the higher the spray rate. For powder flame spray, the powder particles (metal or ceramic) are softened in the flame and the speed of the flame gases through the nozzle sprays the softened powder onto the work piece.

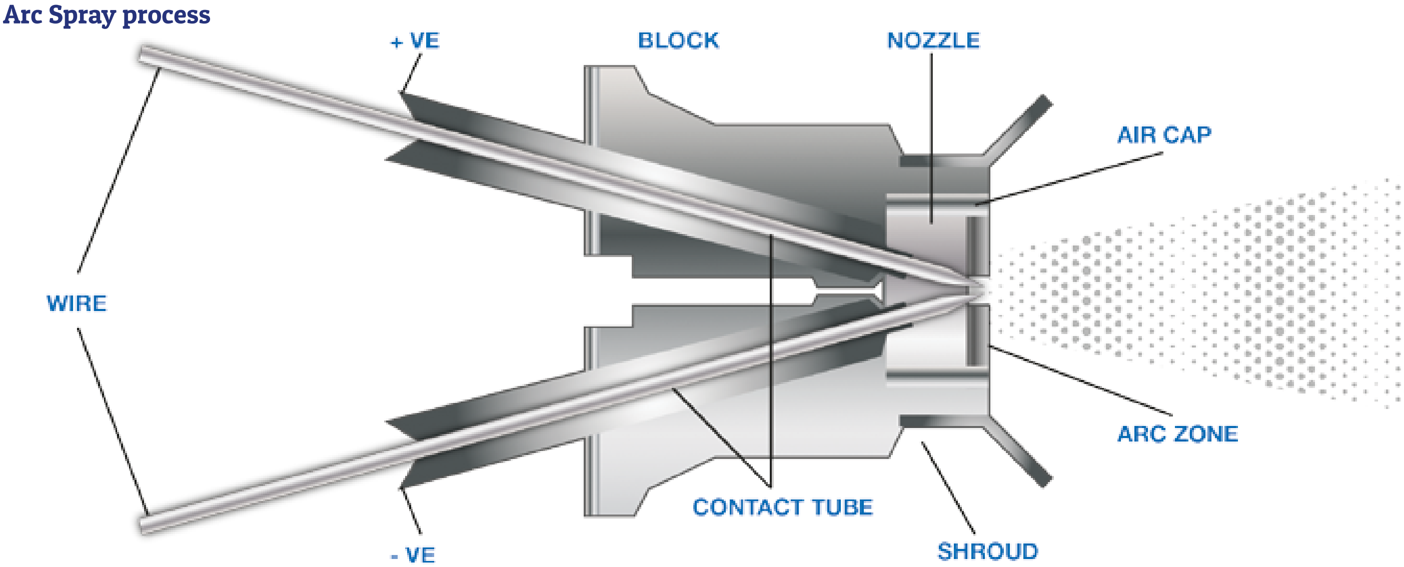
Arc Spray process

The heat source is electric and the material to be sprayed is in the form of wire and transfer is by compressed air. In the process two wires (hence a common term for the process is Twin Wire Arc Spray), are fed into the pistol and electrically

Flame Spray process



Arc Spray process



charged, one positive and one negative. The wires are forced together and form an electric arc, melting the wire. Compressed air, passing through a nozzle, atomises the molten metal and sprays it onto the work piece. There are three methods of wire feeding, push, pull and push/pull. The higher the current rating of the system, e.g. 350A, 700A etc., the higher the spray rate.

Plasma Spray process

The heat source is a plasma arc and material to be sprayed is a powder (ceramic, metal or plastic) and transfer is via plasma jet. Plasma is the term used to describe gas which has been raised to such a high temperature that it ionises and becomes electrically conductive. In the case of Plasma spraying, the plasma is created by an electric arc burning within the nozzle of a plasma gun and the arc gas is formed into a plasma jet as it emerges from the nozzle. Powder particles are injected into this jet where they soften and then strike the surface at high velocity to produce a strongly adherent coating. The work piece remains cool because the plasma is localised at the gun.

HVOF Spray process

In this process, the heat source is liquid or gas fuel and oxygen flame, and the material to be sprayed is a metal powder which is transferred to the workpiece by the flame The process fuel, commonly liquid kerosene, is mixed with oxygen and ignited. The combustion gases pass through a converging/diverging nozzle and accelerate to around 1,500m/sec. The powder is injected into the accelerated flame where it softens and gathers speed. The high impact speed of the particles produces a highly adherent, dense coating structure.

As noted above, flame spray or arc spray are the processes commonly used to apply corrosion protection coatings, but what are the differences between the two? As with many engineering situations, a clear and precise answer to this is not easy. In some cases, the coating properties achieved by one or the other process does provide a simple answer, for example, arc sprayed aluminium has a bond strength approximately 2.5 times higher than flame sprayed aluminium. Other factors include deposit efficiency, ease of operation, environment, set-up time, maintenance time and costs, coating cost, safety.

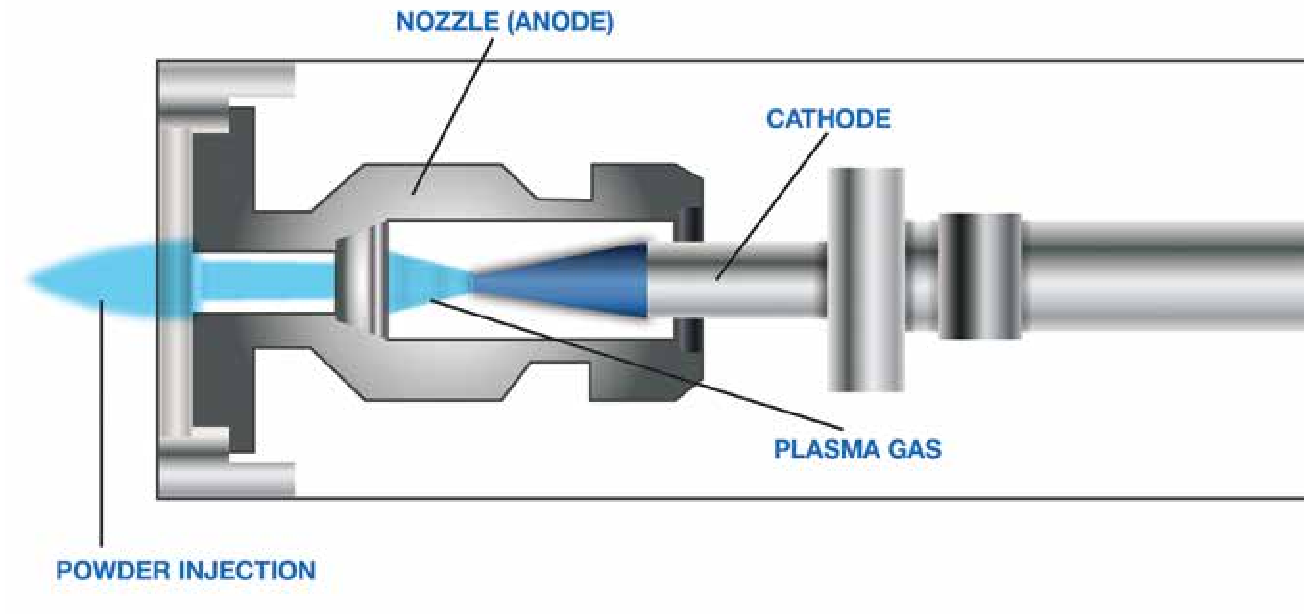
Plasma and HVOF coatings are more commonly used to apply engineering coatings. In simple terms, the coatings produced by plasma and HVOF are of a higher quality, bond strength and density than flame or arc coatings but are costlier and slower to apply. Hence, the reason flame and arc spray coatings are more widely used for corrosion protection of larger structures. There are a number of applications, for example high temperature combined with high abrasion in boilers, where HVOF coatings are suitable and used.

Corrosion protection

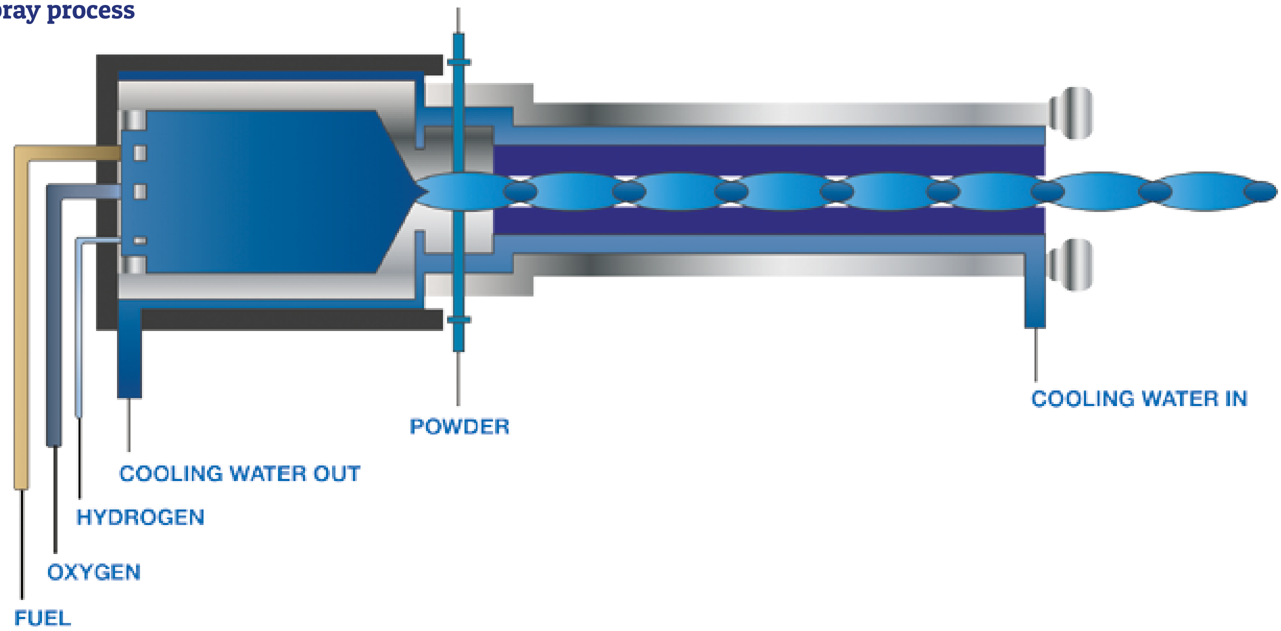
As a protective system for structural steelwork, coatings of thermal sprayed zinc, aluminium and their alloys are unsurpassed. After accelerated testing but more importantly, long term real life tests and examples, several independent standards cite greater than 20 years' service of the coating before first maintenance. This is in the harshest environments including coastal, industrial and seawater splash-zone for example.

Zinc, aluminium and zinc/aluminium alloys are commonly used for corrosion protection. The choice of material to be

Plasma Spray process



HVOF Spray process



used for a specific project depends on many factors such as environment (corrosive atmosphere, high temperature etc), local specifications, life expectancy, adhesion requirements, availability of material, and access. In general terms, zinc is used in relatively low corrosion applications, such as water tanks, some bridges and general steelwork. Aluminium is used in harsher corrosion applications, such as immersion, salt water contact, splash zones. In addition, aluminium is used in high temperature applications such as flare stacks. Zinc/aluminium alloy tends to be used in environments where corrosion resistance of zinc is border line.

The most common system used in the petrochemical industry, is Thermal Sprayed Aluminium (TSA). In this industry, Corrosion Under Insulation (CUI) in pipeline and storage systems is an on-going problem and consumes a significant percentage of the maintenance budget. A large portion of this money is spent on expensive items such as external piping inspection, insulation removal and re-installation, painting and pipe replacements. The application of TSA has been shown to be a successful CUI prevention strategy allowing the industry to move towards inspection-free and maintenance-free piping systems and significant maintenance cost reductions

Case study

A recent project saw the Metallisation Arcbeam spray concentrator used successfully at a Middle Eastern oil refinery by one of its customers. Anti Corrosion Protective Systems (APS), based in Dubai, have been using thermal spraying for over twenty years across a variety of projects. This latest project is significant in that APS has successfully used the Arcbeam spray concentrator where High Velocity Arc Spray (HVAS) has been previously specified. The Arcbeam produces very dense coatings with low levels of porosity, and was an ideal solution for the oil refinery project. Typical porosity levels lower than 2% are achievable with the unit, which is key to enhancing the performance of the applied coating in these harsh refinery applications.

The internal shells of two absorber columns, which were 5.2 metres in diameter, and two cooling columns, 5.4 metres in diameter, were treated on the inner shell and at the bubble cap and support ring areas. The surfaces were prepared by grinding to remove sharp edges and smooth out any heavily pitted areas. The coating areas were blasted to SA 3 cleanliness, with a minimum of 90µm profile, with garnet then followed by a final sweep blast with aluminium oxide.

The internal shells of the absorber and cooling columns were coated with two layers of Hastelloy® 73E at 225-250µm per coat using the ARC140 system. The surface coating was finished with one coat of one coat of a single component, air curing, polymeric sealer (Sprayseal F), which applied by brush until full penetration was achieved. The area coated was approximately 80m2 per column.

Editor's note: This article is based on information supplied by Stuart Milton, Metallisation Ltd, Dudley, UK