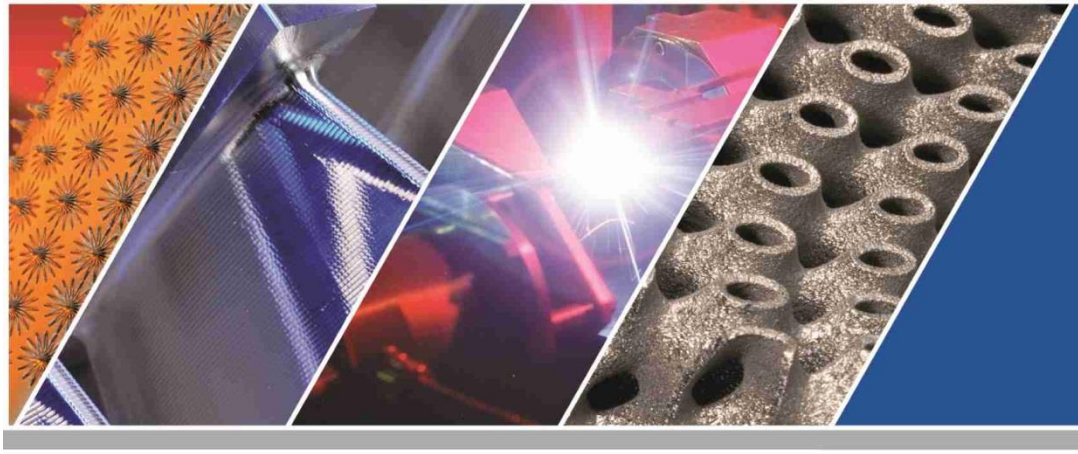
# Evaluation of New Thermal Spray Coating Technologies for Improved Industrial Performance and Cost Benefits



**JOINT INDUSTRY PROJECT OUTLINE**

**PROP305095**

## Summary


Thermal spraying is a family of well-established industrial coating processes including flame, twin wire arc spraying, high velocity oxy-fuel (HVOF), and plasma spraying. In recent years, there have been a number of new developments which potentially offer significant benefits to industry in terms of materials performance, cost and weight savings over established thermal spray coatings. These include new process developments such as the high pressure (HP) kerosene fuelled and ultra high pressure (UHP) ethanol fuelled spray guns and high velocity air fuelled spray (HVAF) systems, aimed primarily at reducing the operating costs of high velocity spraying. In addition to these, a number of internal diameter (ID) spray systems are now available. The impact of REACH legislation is also driving the development of new lower cost materials, including alternatives to ceramic metal (cermet) coatings such as WC-CoCr and $Cr_3C_2$-NiCr. These include SiC and TiC based carbides combined with lower cost binders such as iron based alloys and ceramics. There is also interest in using the cold spray process to apply cermet coatings.

This project will conduct a pre-competitive technology review and performance evaluation of a number of these processes and materials to enable TWI's Industrial Members to assess whether the technologies are of benefit to their business prior to undertaking more in-depth, application specific coating development for industrialisation. The work will focus on:

- New thermal spray coating processes
- Internal diameter thermal spray coating processes
- New lower cost and REACH compliant wear resistant coatings

OEMs, Tier 1 and 2 suppliers and manufacturers will all benefit from joining the project to validate a number of new thermal spray coatings processes and materials for a wide range of industrial applications including hard chrome plating replacement.



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## Project Concept

The HVAF and HP & UHP HVOF processes claim to offer significant benefits in terms of process operating costs In terms of process, both claim to offer comparable particle speeds to cold spraying, which may result in denser coating with minimal oxide/porosity compared to conventional HVOF processes. As such, the processes potentially offer considerable savings in terms of CapEx and OpEx. They also offer improved versatility, compared to cold spraying, by being able to spray higher melting point materials.

The use of thinner/denser 'flash carbides' also opens up cost/performance improvements over coatings produced using conventional HVOF spraying systems. For example HVAF 'flash carbides' i.e. 15-30±1-3 µm WC-CoCr HVAF coatings are claimed to offer comparable performance to electrolytic hard chrome plating. Cost savings are made due to the use of less material and process gases, and the elimination of grit blasting and dimensional grinding post spraying.

In addition to process developments, a number of companies (eg Thermico, Praxair Surface Technologies, Oerlikon Metco, Spraywerk and Kermetico) have recently launched new ID spray guns which offer the ability to coat components down to 60mm diameter. Although plasma ID spraying has existed for a number of years, these higher quality HVOF ID coatings potentially offer an alternative to hard chrome plating for internal bore applications in a wide range of industrial applications.


As well as process developments, industry is also seeking lower cost spray consumables for producing wear resistant coatings for use in harsh environments. Traditional wear resistant coatings, such as tungsten carbide and chromium carbide, are expensive, and also are increasingly subject to REACH legislation relating to the use of alloys containing Co, Cr, Ni and other metals. Therefore there is a drive to reduce the use of these materials. A number of newer commercially available consumables which feature alternative carbides, such as SiC and TiC, in lower cost metallic and ceramic binders and offer potential cost savings, particularly when coupled with lower cost processes. For example, SERAM Coatings AS (https://www.seramcoatings.com/) has developed a new ThermaSiC material, which claims to offer significant improvements in performance, process economics and environmental considerations. TWI has shown that it is possible to deposit the new ThermaSiC material by HVOF opening up a number of potential coating applications particularly relating to wear resistance at elevated temperatures.

This project will carry out an independent, state of the art review of coating processes and consumables for improved wear performance in industrial applications and assess the relative cost benefits of these materials/processes when compared with conventional benchmark HVOF coatings. The proposed project will generate independent, preliminary coating performance data using new thermal spraying technologies and materials, enabling Sponsors to evaluate the coatings for a wide range of applications across all industry sectors, compared to current benchmark materials such as HVOF WC-CoCr, $Cr_3C_2$-NiCr and alumina coatings.

## Objectives

- To review the state of the art with regard to new thermal spraying processes such as UHP HVOF and HVAF processes and carry out independent assessment of the performance and quality of coatings compared to current benchmark coatings.
- To review the state of the art with regard to internal diameter thermal spraying equipment and evaluate the performance and quality of coatings produced using ID spraying systems compared to conventional coatings.
- To review new, low cost alternatives to traditional wear resistant thermal spray coating consumables and carry out independent performance evaluation of a range of new materials.

# Evaluation of New Thermal Spray Coating Technologies for Improved Performance and Cost Benefits

## Benefits

- Independent pre-competitive coating performance data concerning new thermal spraying processes (HVAF and UHP HVOF), ID spraying processes, and lower cost alternative wear resistant coating materials for application across a wide range of industry sectors.
- Performance evaluation data on new abrasion resistant coating materials for high temperature or other harsh environment applications.
- Cost effective alternatives to current benchmark hard wear resistant coating materials on the market.
- Increased technology and manufacturing readiness for new thermal spraying processes and materials to enable industry to utilise processes and materials in product development and production environments across a wide range of industry sectors.
- Lower density coating materials, compared to existing solutions such as WC (tungsten carbide) which may offer a competitive advantage and potential weight savings for components in aerospace, defence, space and automotive applications.

## Approach

The project will include state of the art technical review of new thermal spray coating processes and consumables for improved performance and cost benefits. The proposed project will generate independent, preliminary coating performance data using new thermal spraying technologies and materials enabling Sponsors to evaluate the coatings for a wide range of applications across all industry sectors.

The project will be split into five tasks:

- WP1 - Technical Review
- WP2 - New Thermal Spray Process Evaluation
- WP3 - Internal Diameter Thermal Spray Process Evaluation
- WP4 - New Wear Resistant Coating Performance
- WP5 - Industrialisation and Economic Benefits of New Thermal Spray Processes and Materials

Following completion of the technical review a number of process and materials will be down selected for performance evaluation in WP2-4. WP5 will focus on the industrialisation of the various processes and materials including evaluation of the relative costs compared to current benchmark materials.

### WP1 – Technical Review

The technical review will be conducted to identify the range of new thermal spraying equipment available from technical, commercial and academic literature including:

#### New thermal spray process developments

- High velocity air fuel (HVAF) spraying
- Cool/warm HVOF (modification of conventional HVOF spraying equipment)
- Kerosene fuelled, high pressure (HP) HVOF system
- Ethanol fuelled, ultra high pressure (UHP) HVOF system

### Internal diameter spraying systems

- HVOF ID spraying
- HVAF ID spraying

### New thermal spray materials developments

- ThermaSiC
- Nanocrystalline / amorphous coatings
- Lower cost alternatives to WC-CoCr and $Cr_3C_2$-NiCr (eg TiC, SiC with Fe based binders)
- HVAF 'flash carbide'
- Alternatives to other coatings which will be subject to REACH legislation etc

## WP2 – WP4 Process and Materials Performance Evaluation

Following completion of the technical review a number of process and materials will be down selected for performance evaluation in WP2-4 based on the Sponsors interests. WP5 will focus on the industrialisation of the various processes and materials including evaluation of the relative costs compared to current benchmark materials:

- WP2 – New process developments
- WP3 – Internal diameter spraying systems
- WP4 – New thermal spray materials developments

TWI will aim to source test coupons from equipment suppliers and thermal spraying coating providers for independent performance analysis. Where appropriate, TWI will prepare coatings in-house.

Coatings produced using the coating processes and materials outlined above will be compared with current wear resistant benchmark coatings such as WC-CoCr, $Cr_3C_2$-NiCr and alumina and are expected to include the following tests, subject to budget availability and the Sponsors technical requirements:

- Metallography, SEM and EDX analysis of the deposited coatings in the as-sprayed conditions.
- Vickers $HV_{0.3}$ Microhardness (BS EN ISO 6507-1:2005)
- Surface Roughness (ISO 4288-1998)
- Adhesion / cohesion (ASTM C633)
- Erosion (GE E50TF121)
- Pin-on-Plate (PoP) Sliding Wear (ASTM G133)
- Micro abrasion (BS EN ISO 26424)
- Corrosion performance (salt spray and electrochemical testing)
- Cavitation resistance (ASTM G32)

### WP5 - Industrialisation and Economic Benefits of New Thermal Spray Processes and Materials

Following completion of the technical work packages (WP2-4), additional steps will be identified for industrialisation of new processes and materials to benefit industry. It is expected this task will include:

- Capex requirements for thermal spraying processes and equipment.
- Deposition characteristics for the new thermal spraying processes / materials.
- Cost comparison between new thermal spraying processes / materials against current industry benchmark coatings.
- Recommendations on potential applications for new thermal spraying processes / materials based on their relative performance / cost benefits compared to existing processes.
- Recommendations on industrial best practice and standards for application of new materials and processes.

## Deliverables

- Technology review report including an overview of new thermal spraying processes, internal diameter spraying systems and new thermal spray consumables.
- Coating performance data relating to each technical work package (new processes, ID spraying systems and new thermal spraying consumables).
- Recommendations on the technology/manufacturing readiness of new thermal spraying processes and materials and indication of the relative cost performance benefits compared to current technologies.
- Six monthly progress meetings and presentations summarising the work to date.
- Final report detailing the results of each technical work package, along with recommendations on the technology/manufacturing readiness of new thermal spraying processes and materials.

## Price and Duration

The above approach is based on a total budget of £300,000 (excluding VAT) over 2 years, which requires £15,000-25,000 per company per annum from 6-10 Sponsors. The scope of work and associated budget requirements will be defined following the project launch in September 2019.

It is anticipated that the project will commence with an agreed scope of work with a minimum of four Sponsors.

## Further Information

For further information on how a Joint Industry Project (JIP) runs please visit:

http://www.twi-global.com/services/research-and-consultancy/joint-industry-projects/

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