Jülich Thermal Spray Center (JTSC) - a new research and innovation infrastructure of Forschungszentrum Jülich

Introduction

On December 13th, 2019, the Jülich Thermal Spray Center (JTSC) was officially launched (https://www.fz-juelich.de/iek/iek-1/EN/Research/JuelichThermalSprayCenter/JTSC_node.html). This event took place after the thermal spray conference 9RIPT (*Les Rencontres Internationales de la Projection Thermique*) which was the first time held in Jülich. This successful conference attracted more than 130 participants and focused on the different aspects of thermal spray. It is meanwhile the largest European conference on this topic. More than 80 participants took the opportunity and joined after the conference the official inauguration of the Jülich Thermal Spray Center (JTSC).

Figure 1 Photo of the inauguration of the Jülich Thermal Spray Center (courtesy H. Moitroux).

Thermal spray technologies

Thermal spray combines a number of coating technologies in which powderous feedstocks are deposited, depending on the process with different velocities and temperatures (see Figure 2), on a substrate. These coatings are typically thicker than 10 µm and can reach several millimeters. The technology is a fast growing one with an annual growth rate of about 8% driven by the world-wide increasing demands in electricity production, air transport, automotive manufacturing, and other advanced technologies [*The 2016 Thermal Spray Roadmap, Journal of Thermal Spray Technology, 2016].* Especially high-end coating processes and materials solutions are of extreme interest for industrial applications. Although thermal spray is world-wide of increasing importance, the visibility of this technology is still limited and should be further enhanced by the JTSC.

Jülich Thermal Spray Center offers a unique infrastructure composed of thermal spray processes (for a total investment value well exceeding 5 million €) combined with unique expertise built up over several decades. The current installation of new spray equipment at IEK-1 (Institute of Energy and Climate

Research: Materials Synthesis and Processing) completes this suite of facilities which is unique both from a national and international perspectives. The installed facilities cover the complete range of advanced process parameters as shown in Figure 2.

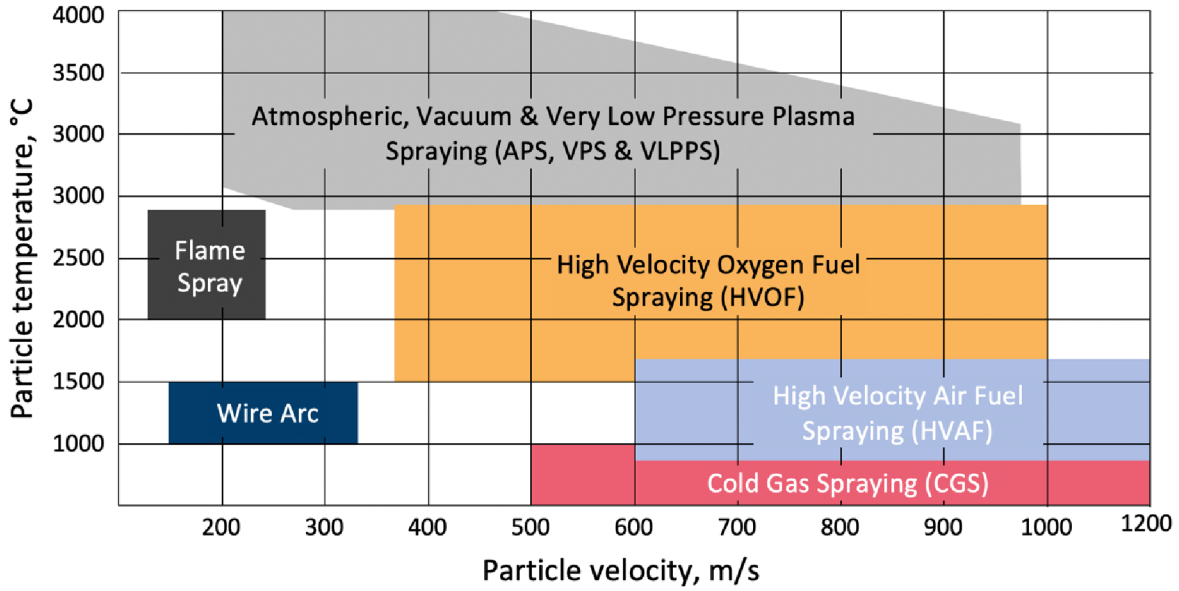

Figure 2 Typical particle temperatures and velocities of different thermal spray processes.

Many energy conversion systems such as aero engines, flexible gas turbines, combustion engines, or concentrated solar power units have an extended demand for advanced high temperature coatings. Especially new solutions for both thermal and environmental barrier coatings are strongly needed and are of high industrial relevance. IEK-1 has a long lasting expertise in this area and is for such thermal spray coatings one of the world-wide leading institution. Several new projects with industrial partners are being launched, incorporating innovative concepts e.g. coating of additive manufactured parts or new surface treatments by laser ablation (both patented).
In addition, the development of refurbishment technologies by thermal spray is an emerging attractive field with several projects running. Knowledge and capacities in this field are also being geared towards additive manufacturing, which is within the thermal spray community a fast growing activity due to the advantages of thermal spray processes. Especially, the newly installed cold gas system will have a major impact within this topic.
An additional field of growth focus is the application of spray methods for applying functional coatings, as solid state battery cathodes by aerosol deposition, membranes on metallic supports by VLPPS or high temperature wear and corrosion resistant coatings for Concentrated Solar Power (CSP) applications.
In addition to the described fields, the JTSC is also open for other applications of the different thermal spray techniques.

External access to the facilities and cooperation with academia and industry
The center is oriented towards increasing the visibility and application of thermal spray technologies within the scientific community. While in the past cooperation within Helmholtz Association, Fraunhofer society, different universities and industry already took place, the center will now allow all interested institutions to launch proposals for initial/start-up research work and IEK-1 will reserve up to 25 % of the resources for this use. Short proposals (1 page, available from the website) can be submitted at any time. After discussion with IEK-1 experts on the feasibility of the envisaged approach, a decision will be

made within 3 months after submission. In case of a successful project the continuation of the research will be supported, especially additional funding schemes should be considered then.
In addition, a user group for regular exchange and evaluation of the projects will be established.

Facilities of the center

The different thermal spray technologies available in the JTSC will described briefly in the following.

Advanced vacuum plasma spraying unit (VPS)
This continuously up-graded unit can be operated in the conventional vacuum plasma spraying (VPS) mode e.g. for the deposition of dense, high purity metallic coatings, very low pressure plasma spraying (VLPPS) mode for the deposition of dense, crystalline ceramic coatings (i.e. gas tight (!) membranes or Environmental Barrier Coatings), and plasma spray physical vapor deposition (PS-PVD) mode for the evaporation of powder feedstock and deposition from the gas phase gaining unique high temperature capabilities with a non-line of sight capability. This mode is especially attractive for advanced thermal barrier coatings with columnar microstructure.
In addition to the VPS chamber, 3 different spray facilities for spraying under atmospheric conditions are available within the center which are all equipped with six axis robotic systems and tilt able turntables allowing the development of coating processes in an industry-like environment:

APS work horse with Triplex and HVOF technology
This spray facility allows the operation of standard atmospheric plasma spraying (APS) torches like F4, 9MB and internal coating gun F100. In addition, more advanced torches with high process stability as the Triplex 210 and the Sinplex gun can be used for the deposition of various typically ceramic feedstocks. Furthermore, a high velocity oxygen fuel (HVOF) system (Diamond jet) for the deposition of dense metallic and ceramic coatings is installed.

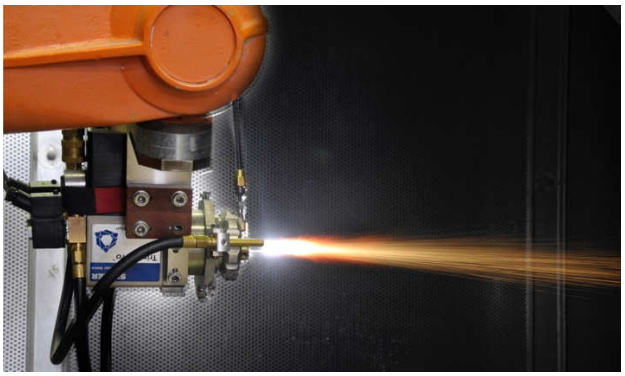

Figure 3 Triplex torch in operation

Axial injection APS and Kinetics cold spray
Here the powerful APS Axial III torch with an axial injection system can be operated. This torch is ideal for suspension plasma spraying (SPS) allowing unique columnar microstructures, a major research topic of the present TBC development. Also a cold spray system (Kinetiks) can be operated here for the deposition of dense metallic coatings.

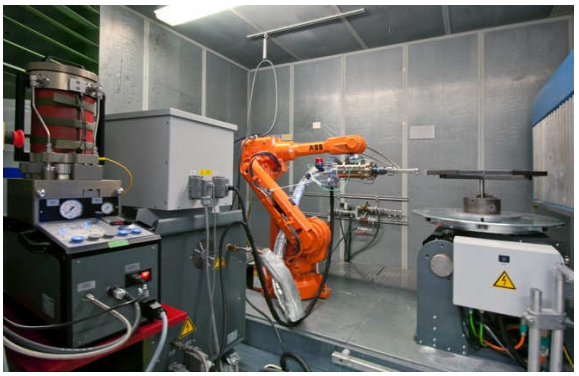

Figure 4 Spray booth with Kinetiks cold gas spray gun

Kinetic spray deposition

This newest spray system is designated for the use of highly kinetic spray technologies. A newest generation cold spray system as well as a high velocity air fuel (HVAF) system is available which allows highest particle velocities for the deposition of mainly metallic coatings as well as repair and additive manufacturing processes.

Trumph laser cladding unit

This unit allows the deposition of fine metallic structures (e.g. embedded sensors) and the surface structuring by ablation processes. In combination with thermal spray the last is a powerful and highly innovative tool to improve coating systems.

Aerosol deposition

In this chamber the aerosol deposition process for the deposition of highly dense ceramic layers at room temperature is installed.

Characterization

For the characterization of the spray processes various tools are available:

- Particle diagnostics (DPV2000, Accuraspray, PIV)
- Plasma diagnostics (Optical emission spectroscopy (OES), enthalpy probe)
- Characterization of stress state (In situ coating property (ICP) sensor, XRD)

A powerful characterization tool for the characterization of high temperature coatings as TBCs and EBCs are burner rigs which allow the test under realistic thermal gradient conditions. One rig allows gradient testing with simultaneous injection of Calcium Magnesium Aluminum Silicates (CMAS), an important research topic.

In addition, a wide range of powder, suspension and material characterization techniques are available at IEK-1 or Jülich campus.

In summary, the Jülich Thermal Spray Center offers a unique assembly of processing and characterization facilities operated by highly trained staff. The center is now easily accessible to external institutions.