

WELDING & JOINING MATTERS MEDIA PACK 2024

**WELDING
& JOINING
MATTERS**

A Journal of The Welding Institute

The Welding Institute
Issue 1
Spring 2022



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WELDING & JOINING MATTERS

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'Welding and Joining Matters is the UK journal for all of those working in the fields of welding and joining as well as the related fields of surface coatings, inspection and non-destructive testing which is now two years old. It is published quarterly by The Welding Institute and has an international readership through the individual and industrial company memberships of the Institute. The circulation is to more than 5000 specialists. The articles are written to be educational and informative and consequently each issue has great appeal for retention and recirculation. Hence it provides an attractive and readable publication for advertisers. We look forward to receiving your enquiries for advertising space in our great new journal.'

Claire Kimpton, Chair, Professional Board, The Welding Institute

Key Facts

Welding & Joining Matters

- Circulation of over 5000 subscribers.
- 75% of subscribers UK-based and 25% around the world notably in Malaysia, India, the Middle East and Australia.
- Readers include those at senior levels in companies responsible for sourcing, specifying and purchasing equipment, systems, services and finished fabricated products.
- Each issue is themed with articles and features on that theme. Themes for the 2024 issues are shown on the back page.
- In addition to the themed articles the editorial includes regular features on Industry News, Product Innovation, 'Job Knowledge', 'Ask the Expert', 'Inspection and Non-destructive testing' and 'Equipment and systems'. There will also be Branch News, International News and updates on codes and standards.



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Industry Feature

THE CHALLENGES OF GENERATING CLEAN ENERGY - CHANGING OUR MANUFACTURING PHILOSOPHY

BY PROF. DR STEVE JONES, PhD, CEng, FWeldI
Chief Technology Officer for the Nuclear Advanced Manufacturing Research Centre Professor of Joining Technologies, University of Sheffield.

Albert Einstein once said, "nuclear power is one hell of a way to boil water", and who are we to argue with the great man. But whether you are a proponent or opponent of nuclear power the positive impact it's had in driving towards a low-carbon clean energy economy cannot be denied. In 2020 the UK obtained 21.5% of its primary energy from low carbon sources, with nuclear contributing to 31% [1]. According to 'investment monitor' [2], by 2035 the UK grid will lose 7.833TWh (7.8333GW) of power whilst at the same time expecting energy demand to increase to between 40% and 60% of current usage.

The UK's existing fleet of reactors can be defined as Gen II technology status (figure 1), and up until June 2021 this consisted of 14 advanced gas cooled reactors (AGRs) and 1 pressurised water reactor (PWR). From July 2022 this fleet will be reduced to 9, (8 AGRs and 1 PWR) [4]. AGRs utilise graphite as a moderator and CO₂ gas pressurised at 40 bar as a coolant. Its operating temperature is around 650 °C offering a thermal efficiency of 41%. Light water PWRs (LW-PWRs) on the other hand use regular water H₂O as both the coolant and moderator, which differentiates them from the heavy water (D₂O) reactors. Typically they operate between 290 °C and 320 °C and at 140 to 150 bar delivering 34% efficiency.

An alternative financial model known as the regulated asset base (RAB) model [6] aims to widen the investor pool for nuclear power. This model allows developers of infrastructure to earn immediate revenues by adding charges to consumers' utility bills during the construction, which does not inspire confidence in this energy sector if history is anything to go by. Therefore, strong incentives exist for organisations to formulate innovative ways to reduce manufacturing costs and construction times to generate revenue from energy generation sooner, whilst concurrently meeting or exceeding regulatory requirements.

For the next 30 years a portfolio of light-water GW plants (Gen III+), SMRs (Gen III+) and advanced modular reactors (AMRs Gen III+) is expected, whilst simultaneously seeking major engineering solutions to our waste management strategy through generating a geological disposal facility (GDF) figure 2. In addition to these fission challenges, the UK will pursue its first prototypical fusion energy plant for commercial viability - the Spherical Tokamak Energy Production (STEP) reactor by 2040.

Delivering confidence and capability in building such reactor technologies requires a blend of manufacturing innovation along with a capable and secure supply chain. Furthermore, a move away from myopic practices towards a more stoic approach in recognising advancements made within adjacent high-value safety critical sections is critical for the UK to accelerate progression in the nuclear sector. Couple this with a balance of manufacturing entry and a drive towards standardisation and harmonisation, whilst continuously challenging the status quo, is a very healthy mindset to improve our engineering and construction fitness.

Figure 1: Generations of reactor development - existing UK fleet include Gen II AGRs developed from Gen I Magnox, and Gen II PWRs. Next generation of PWRs (GW and LW) developed SMR will be Gen III+ [3].

Figure 2: GDF disposal tunnel under way at Onkalo [7].

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Industry Feature

Market studies highlight that manufacturing costs contribute to approximately 10% of the overall cost of a large GW power plant - circa £2Bn. Whilst these studies may corroborate such investment, this proportion of cost assumes a 'right first time' (RFT) output and negates the consideration of the more realistic costs that often occur from financial penalties linked to costly overruns from poor practices, stochastic processing events and human error, which can easily double this figure. Those 20th Century manufacturing principles and methods that have a strong influence on these factors, whilst established and compliant with codes and standards (CAS) need to be challenged to remove or minimise these defects.

The UK's SMR (Gen III+) reactor design is likely to use the ASME BPVC section III 'rules for construction of nuclear facility components' and national standards where appropriate, which builds on extensive materials and processing knowledge of LW-PWRs. It is anticipated that modularisation practices where 90% of the power plant will be built in a factory environment, will be exploited. This will accelerate transition to the grid through improved working environments and improved digital connectivity. Such practice results in minimising workforce fatigue, exploitation of automated and mechanised techniques to reduce process variability, whilst simultaneously improving compliance with existing codes and standards to meet safety-case requirements.

The UK is also working on novel ways to manufacture critical primary island components for the US's DOE-sponsored SMR programme involving EPRI, NuScale Power Inc, the Nuclear AMRC, and several partners. The project goal is to remove 40% of the cost and demonstrate the feasibility of manufacturing a Reactor Pressure Vessel (RPV) in <12 months (figure 3). The key technology developments associated with this programme include the use of powder metals (PM), powder metals and hot isostatic pressing (PM-HIP), electron beam welding (EBW) and diode laser overlaying (DLO) applied to several material supply combinations, i.e., forging to forging, forge to PM-HIP and PM-HIP to PM-HIP. It is important to note, that these technologies are seen as complementary to those advancements being made by casting and forging suppliers and not as direct replacements, as their investment costs must be considered in parallel with the component's design, process variability, inspection capability, functionality and lead-time. This compendium of complementary methods provides additional benefits in the reduction of supply-chain bottlenecks and equivalent mass of CO₂ emissions saved per kWh when generated by the grid from current UK power stations. This is a new parameter used by the Advanced Manufacturing Research Centre (Nuclear, AMRC) in assessing its decarbonisation benefits from advanced manufacturing practices.

The Nuclear AMRC's R&D activities specifically focus on four key manufacturing strands offering concerted benefits expected of adopting an integrated manufacturing philosophy. Those technology strands are:

1. Solid-state forming and bonding (PM-HIP and HIP bonding)
2. Power beam processing - welding, overlaying and additive manufacturing
3. Modularisation and standardisation
4. Codes, standards, and specifications

1. Solid-state forming and bonding (SSFB) research, combining powder metallurgy and hot isostatic pressing (PM-HIP) technology provides prospects for increased design freedom and modular configurations. Concurrently, from a performance perspective, those benefits provide improved material utilisation, improved through-thickness (Z-grade) properties and dissimilar metal bonding (DMB) capability, along with augmented inspection characteristics benefiting from improved homogeneity.

2. The use of single pass autogenous electron beam welding (EBW) applied to wrought nuclear grade and PM-HIP steel sections >100mm thickness provide significant benefits over conventional arc welding methods. These include reduced processing times resulting from single pass welding, elimination of groove joint profiles, removal of external pre-heating and post-weld hydrogen bake-out schedules.

Figure 3: NuScale SMR vessel for developing PM-HIP, EBW, and DLO technologies.

These alone have contributed to >80% improvement for the RPV's circumferential weld, consequently removing 325kg of weldable consumable. Furthermore, as the joint maintains above 99% of its chemical homogeneity (some minor losses occur through elemental vaporisation), the weld can be normalised to create a near homogeneous microstructure - figures (4a and 4b).

The comparative energy used for a single submerged arc weld joint [8] with component dimensions 0.1m x 2m x 1m and an EB weld joint [9] resulted in an energy reduction of 1.1GJ, (306kWh), and 71.3kg of carbon dioxide equivalent (CO₂e) and we consider that a greater reduction is achievable.

Whilst standard EB chamber systems provide ideal processing environments they are generally size limited and expensive. Modularisation in construction and assembly offer game-changing capabilities, but this philosophy can be applied to tooling and processing systems too. Modular 'local-to-product vacuum' systems compress cost and lead-time further, but such developments have been difficult to translate to FOCAL reactors due to the perceived performance risk from limited data available in the nuclear sector. This is now being researched by several suppliers of EB equipment where the author believes further benefits will be realised.

Figure 4a: As-EB welded overlay parent metal (PM) showing heterogeneous HAZ and IZ. Material 120mm thick SA 508 Grade 3 class 1.

Figure 4b: Normalised EBW weld heat treatment showing homogeneous HAZ and IZ. Material 120mm thick SA 508 Grade 3 class 1.

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We have a range of advertising opportunities in Welding & Joining Matters. However because this is a technical journal, space is limited and is booked on a first come first served basis.

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We have a number of display advertising slots available throughout the magazine which can be booked at the following rates:

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Quarter page (w)90mm x (h)130mm

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Welding in the marine, shipbuilding and offshore energy industries.

APRIL 2024 ISSUE

Joining technology for non-metals, polymers and composites.

JULY 2024 ISSUE

Brazing and soldering, solid-phase welding and power beam processes.

OCTOBER 2024 ISSUE

Advances in training and skills. Welding in Scotland.

JANUARY 2025 ISSUE

Advances in quality control and non-destructive testing of welds and joints. Welding in the North-East of England.

Processes

SURFACE ENGINEERING PART 1 – AN INTRODUCTION TO THERMAL SPRAY TECHNOLOGIES

By Dr Melissa Riley, CEng, FIMMM, Consultant for Surface Engineering TWI Ltd.

Thermal flame spraying Copyright TWI Ltd



Processes

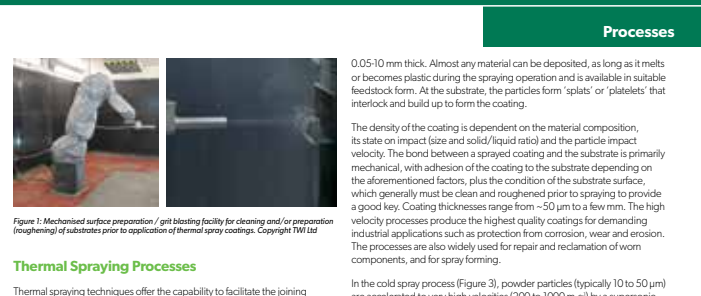


Figure 1: Mechanised surface preparation / grit blasting facility for cleaning and/or preparation (roughening) of substrates prior to application of thermal spray coatings. Copyright TWI Ltd

Introduction

Surface engineering and coating technologies are critical to the performance of many engineering components, providing performance and lifetimes that are unachievable by the substrate alone. The drive towards net zero is pushing the boundaries of materials performance with the cost of using high performance materials and/or repairing failed components becoming an increasing burden for industry and taxpayers.

As such, surface engineering and coating solutions are increasingly attractive to enable components to withstand increasingly demanding applications and harsh environments. However, changes to current and future environmental legislation (such as REACH) are also leading to some traditional surface engineering processes to be phased out, requiring qualification of innovative solutions.

In parallel, the drive for electrification is also fuelling the need for critical and strategic materials, limiting availability and driving prices of common engineering alloys (such as nickel and cobalt). Surface engineering and coatings offers a means of making more efficient use of these resources, using high performance coatings on lower cost substrates.

As such, there is a critical need for improved, cost-effective surface engineering processes and materials for use in ever more demanding environments. Deposition of high-quality coatings and overlays that ensure reliability and longevity in service, at a price industry can afford, is essential if the UK is to meet net zero targets.

Overview of Coating Processes

An important factor in the development of surface engineering and coating solutions is to understand the industrial service requirements and economic factors influencing process selection for the intended application. There is no one solution fits all, and coating and overlay selection is very much dependent on the requirements of the end application. In some cases, the latest state-of-the-art processes may be the route forward, but in others, it may be application of well-established, relatively cheap processes that can provide solutions to many industrial challenges.

The range of surface engineering and coating techniques are vast, ranging from atomistic (eg physical and chemical vapour deposition processes), particulate deposition (such as thermal spraying), bulk application (such as wet spray/dip processes, printing, cladding and overlay technologies) and surface modification techniques (such as laser shock or shot peening, carburising or nitriding).

This article provides an overview of thermal spraying technologies that are increasingly being used to improve performance, extend the lifetimes of critical infrastructure and provide solutions to the many industrial challenges associated with meeting Net Zero targets.

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Thermal Spraying Processes

Thermal spraying techniques offer the capability to facilitate the joining of a very wide range of dissimilar materials, as coatings and spray formed materials. Initially, thermal spraying was mainly used for repair, rebuilding, retrofitting and surface protection against corrosion, erosion and wear, before being introduced into manufacturing processes for high added value components within the aerospace and nuclear sectors. The technology is widely used in aerospace, automotive, original equipment manufacture, corrosion prevention, printing and paper industries, glass manufacturing, and medical and dental applications. The range of the applications is vast, from biological and wear resistance applications, corrosion and/or oxidation protection, high temperature applications, electrical and optical components, electromagnetic shielding and electrical insulation, and biomedical coatings.

Process categories

Thermal spraying is divided into five main categories, including the relatively new cold spraying process (Figures 2 and 3):

- Flame spraying (powder and wire).
- Twin wire arc spraying (TWAS).
- Plasma spraying.
- High velocity oxy-fuel (HVOF) / high velocity air-fuelled (HVAf) spraying.
- Cold spraying.

A number of process variants exist commercially, including proprietary processes such as the detonation gun (D-Gun) process.

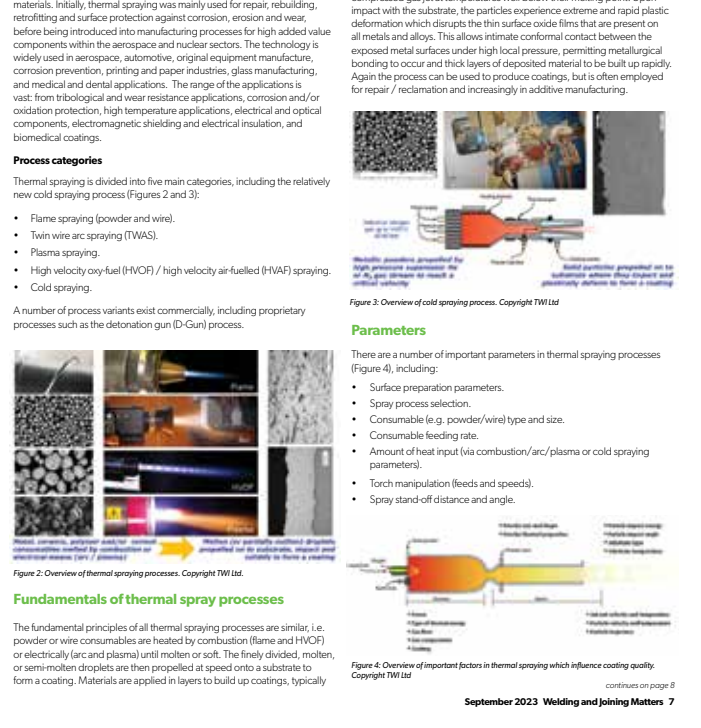


Figure 2: Overview of thermal spraying processes. Copyright TWI Ltd.

Fundamentals of thermal spray processes

The fundamental principles of all thermal spraying processes are similar, i.e. powder or wire consumables are heated by combustion (flame and HVOF) or electrically (arc and plasma) until molten or soft. The finely divided, molten, or semi-molten droplets are then propelled at speed onto a substrate to form a coating. Materials are applied in layers to build up coatings, typically

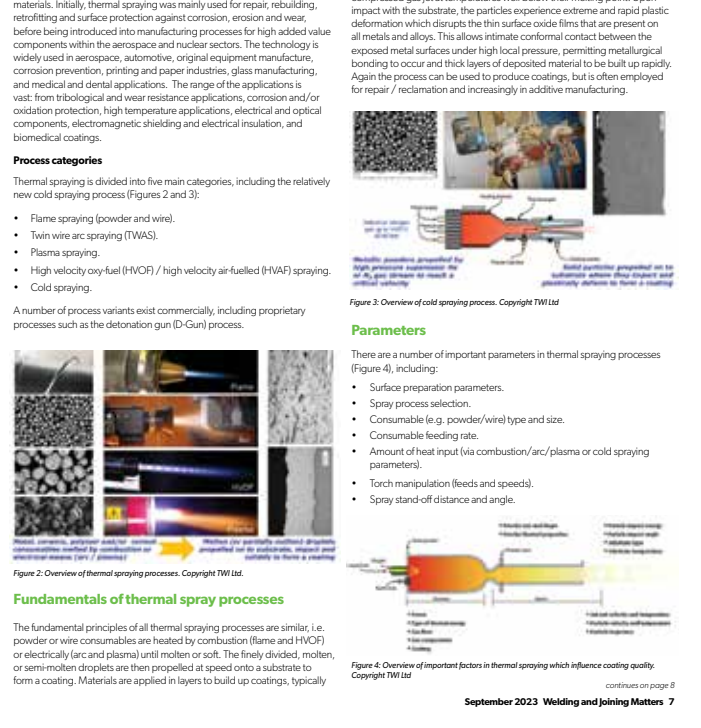


Figure 3: Overview of cold spraying process. Copyright TWI Ltd

Parameters

There are a number of important parameters in thermal spraying processes (Figure 4), including:

- Surface preparation parameters.
- Spray process selection.
- Consumable (e.g. powder/wire) type and size.
- Consumable feeding rate.
- Amount of heat input (via combustion/arc/plasma or cold spraying parameters).
- Torch manipulation (feeds and speeds).
- Spray stand-off distance and angle.

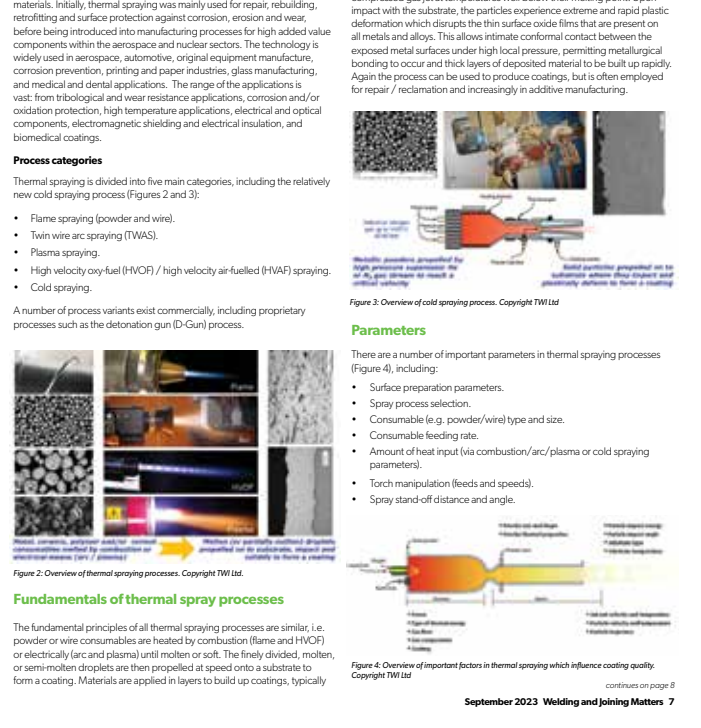


Figure 4: Overview of important factors in thermal spraying which influence coating quality. Copyright TWI Ltd

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