Joining of Metallic Additively Manufactured Products and Materials

JOINT INDUSTRY PROJECT OUTLINE

PROP301761

Summary

Additive manufacturing (AM) is developing quickly as an alternative to more traditional manufacturing methods, particularly for the manufacture of complex shapes which cannot be realised by conventional manufacturing methods and for parts where the design is optimised (for example material reduction, weight reduction, load-carrying capacity, dynamic or damping characteristics).

Some parts produced by AM processes may be limited in size and need to be incorporated into larger structures or assemblies produced by either AM or more conventional means, requiring high integrity joints to be made.

The aim of this joint industry project is to examine methods for joining AM produced parts and to examine the influence of the AM materials and processing on the integrity and performance of the joints.

When considering the potential number of applications, materials and joining methods that could be utilised to exploit the advantages of AM, the number and diversity of tests that may be required can appear daunting. However, when considered with a grounded and focussed industrial approach, there are commonalities within the range of accepted practice and detailed knowledge that can be used to reduce these activities to a manageable level. It is the intention of this project to concentrate on "filling in the gaps" to allow structures which include joints in AM materials to be designed, manufactured and applied into service with confidence.

TWI Ltd, Granta Park, Great Abington, Cambridge CB21 6AL, United Kingdom. Tel: +44 (0)1223 899000

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Project Concept

AM processes have been developed which use a variety of heat sources including power beams (laser or electron beam, EB), electric arc and thermal spray processes and consumable feedstocks in the form of either powder or wire. AM processes have been shown to produce parts which, when compared to conventionally produced materials, may have identical chemistry but have different microstructures and physical properties.

TWI has performed some preliminary work on the joining of AM materials using an established welding process, focussing particularly on materials where it has been shown that unusual microstructures are produced. Whilst this work has shown that joints can be made successfully and with acceptable quality, it does not address a number of questions relating to the in-service performance of joints in AM parts.

This project seeks to address some of the unknowns in this field by performing joining trials on representative samples of AM material which are relevant to the requirements of the Sponsor Group in terms of material and joint type, grade and joining process; and then performing specific tests required to establish the joint performance and effects of the joining process on the surrounding AM material. These tests will then extend into testing, relevant to the expected service environment, as required.

Current industrial best practice and state-of-the-art knowledge will be investigated and maintained and compared to specific results obtained within the project. As far as possible, where direct comparison and correlation can be made, testing best practice will be extended into the field of AM to allow accepted methods to be used and the results accepted during qualification of joints including AM for service.

Arc and Wire AM parts can exhibit unusual microstructures, the effect of these on joining processes needs further investigation

Objectives

The objectives of this project are to:

- Design and manufacture standardised representative AM samples, for use in subsequent joining trials, in materials relevant to the requirements of the sponsor group;
- Make joints in AM material using the methods selected by the sponsor group, identify suitable processing methods and parameters;
- Assess the performance of non-destructive testing methods on joints containing AM materials.
- Perform testing to assess the properties of the joints and the efficacy of using standardised tests on AM material;

Benefits

The sponsors of this project will gain:

- Performance data to support the selection of joining processes and methods for structures containing AM material relevant to their potential applications;
- Detailed knowledge of the properties of joints containing AM material relevant to their potential applications and service environments;
- Quantitative data supporting the applicability and acceptability of standard mechanical and non-destructive test methods to joints containing AM material;
- Sufficient information and knowledge to be able to plan, design, test, gain certification and/or approval and use in production structures containing AM and joints containing AM material

Approach

Initially, a series of simple geometrical shapes will be designed to allow various standard test pieces to be extracted from them. These will be standardised in terms of manufacturing method and test pieces will be produced by methods chosen by the Sponsor Group which may include:

- Selective Laser Melting, Electron Beam Melting, Laser Direct Metal Deposition and Metal Spraying (powder processes);
- WireEB, ArcAM and Arc/Laser Hybrid (wire processes);

The microstructures of the samples will be characterised and compared to the nearest equivalent "conventional" material (casting, forging, rolled plate).

Following this preliminary assessment, trials will be conducted using a range of joining processes as selected by the Sponsor Group. The type of joining process selected will be driven by the end use applications, but it is expected that these will be chosen from power beam (laser and electron beam), arc based processes, diffusion bonding, brazing and solid state joining processes. During these trials, any behavioural differences between "conventional" and AM materials will be noted and a description and best practice document for each process written. During the joining trials, industry standard non-destructive testing methods will be used and the quality of results reported.

Finally, tests will be made to assess and compare the performance of AM material to a similar "conventional" material. Where a direct correlation can be found, this will be confirmed by limited selected tests, and where AM is shown to have an effect on achievable joint quality and properties, more detailed tests will be undertaken to establish the performance boundaries.

Lloyd's Register will be participating in this project providing experience in certifying products to many global standards, codes and regulations which will ensure that the appropriate and necessary steps are taken to work towards compliance to the standards of an independent, third-party certification body. LR will also share its knowledge and expertise in a wide variety of disciplines from design and metallurgy through to final inspection in an impartial manner, providing a grounded and real-world focus on safety, quality and compliance factors.

LR has also been researching and developing audit and assurance products and services for additive manufacturing across a number of industries over the past 18 months, including our global launch of goal-based certification guidance notes and our collaboration with TWI, Rolls Royce Nuclear and ENGIE Lab-Laborelec in a previous joint industry project.

Additionally, LR has representation on a number of working groups and conduits to formal Standards organisations, including ISO TC/261 (Standardization in the field of AM) and ASME Y14.46 (Product Definition for AM) and the EU PED Conformity Assessments Body Forum (CABF). Furthermore, LR is funding PhD research in specific areas of Additive Manufacturing and also supports the work of the UK National Strategy Group for AM.

Both LR and TWI are working towards the aim of enhancing the knowledge and adoption of AM within key industries. We have connections to the various parts of the additive manufacturing community, supporting and contributing our expertise and knowledge to help clients better understand and utilise this technology.

Deliverables

The main deliverables from this project will be:

- A series of standard AM part designs which allow extraction of common test pieces and the manufacturing methods for those parts;
- Identification of the relevant code, standard or specification requirements that need to be addressed.
- A series of best practice descriptions and processing parameters for joining methods selected by the sponsor group;
- An assessment of the performance of industry standard non-destructive testing processes on joints
- A comparability assessment for standard tests and a series of results on the range of AM materials and tests selected by the sponsor group.

These deliverables could be made more specific to accommodate that suit the needs of different types of sponsor, eg a Purchase Spec template for joining of AM parts for those who specify but do not manufacture in-house, or a WPS (or set of WPSs) for different materials or joint types for those carrying out manufacture.

Price and Duration

To be advised

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/

JIP Co-ordinator: Kirsty Jones

Email: jip@twi.co.uk

Project Leader: Adrian Addison

Email: adrian.addison@twi.co.uk