

PROTECTIVE COATINGS FOR SUPERPLASTIC FORMING DIES: OPPORTUNITIES FOR THERMAL SPRAY TECHNOLOGY

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Abstract

Purpose: Superplastic forming (SPF) is an advanced sheet manufacturing process restricted to low volume and high value products. SPF ceramic dies have a lower production cost than conventional metal tools, and have short lead-times, but their brittle nature is a limiting factor for SPF applications.

Findings: A method for the investigation of ceramic dies' surface degradation mechanisms during SPF process at laboratory scale is proposed.

Research and practical implications: Suitable surface treatments have a remarkable effect on wear resistance; hence, the working surface of the die can be improved by the application of appropriate coatings, increasing the lifetime of the SPF ceramic dies. Thermal spray is a promising deposition method, since numerous coating solutions are achievable without expensive vacuum technology.

Originality: At the state of the art there is a lack of knowledge on protective coatings for SPF ceramic dies, which want to be filled with the outcomes of the proposed research project.

Keywords: Superplastic forming, Ti6Al4V, Ceramic die, Protective coating, Thermal spray

Research Questions

► *In order to implement ceramic dies into the SPF manufacturing process, is it possible to improve the ceramic die lifetime through a suitable protective coating?*

► *Is thermal spray technology capable of depositing a protective coating which meets the SPF process requirements?*

The AFRC

The Advanced Forming Research Centre (AFRC) is the largest group in the UK concerned with metal forming research. The world-leading research hub, located near Glasgow International airport looks to pioneer advanced forming and forging techniques to support design and manufacturing for the UK's aerospace, energy, marine and automobile industries.

The current AFRC members range from major multi-nationals such as Boeing, Barnes and Rolls-Royce, through to specialist suppliers such as National Instruments, Schuler and ACB. This wide range of supporting industries enables the AFRC to engage effectively with multi-scale problems, developing forming and forging technologies to support the design and manufacture of new products.

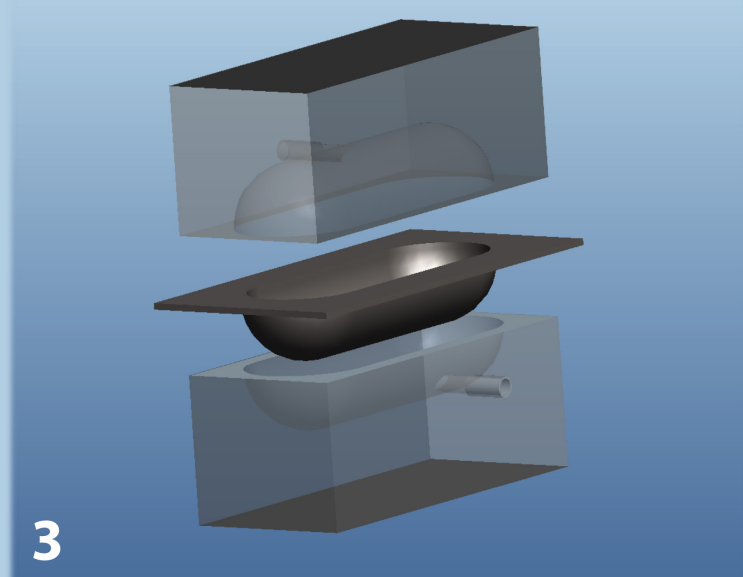
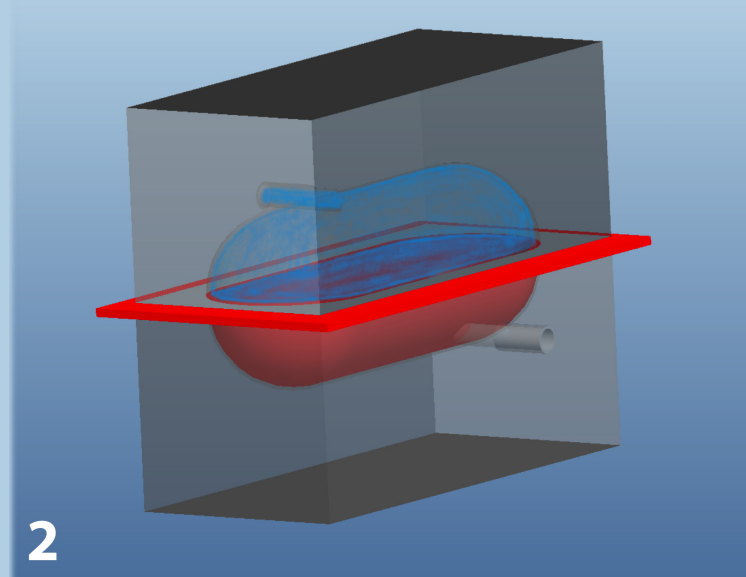
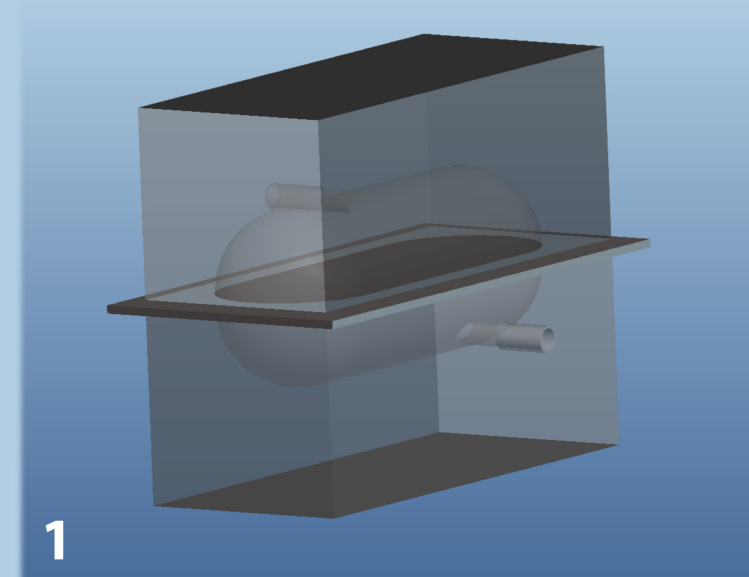


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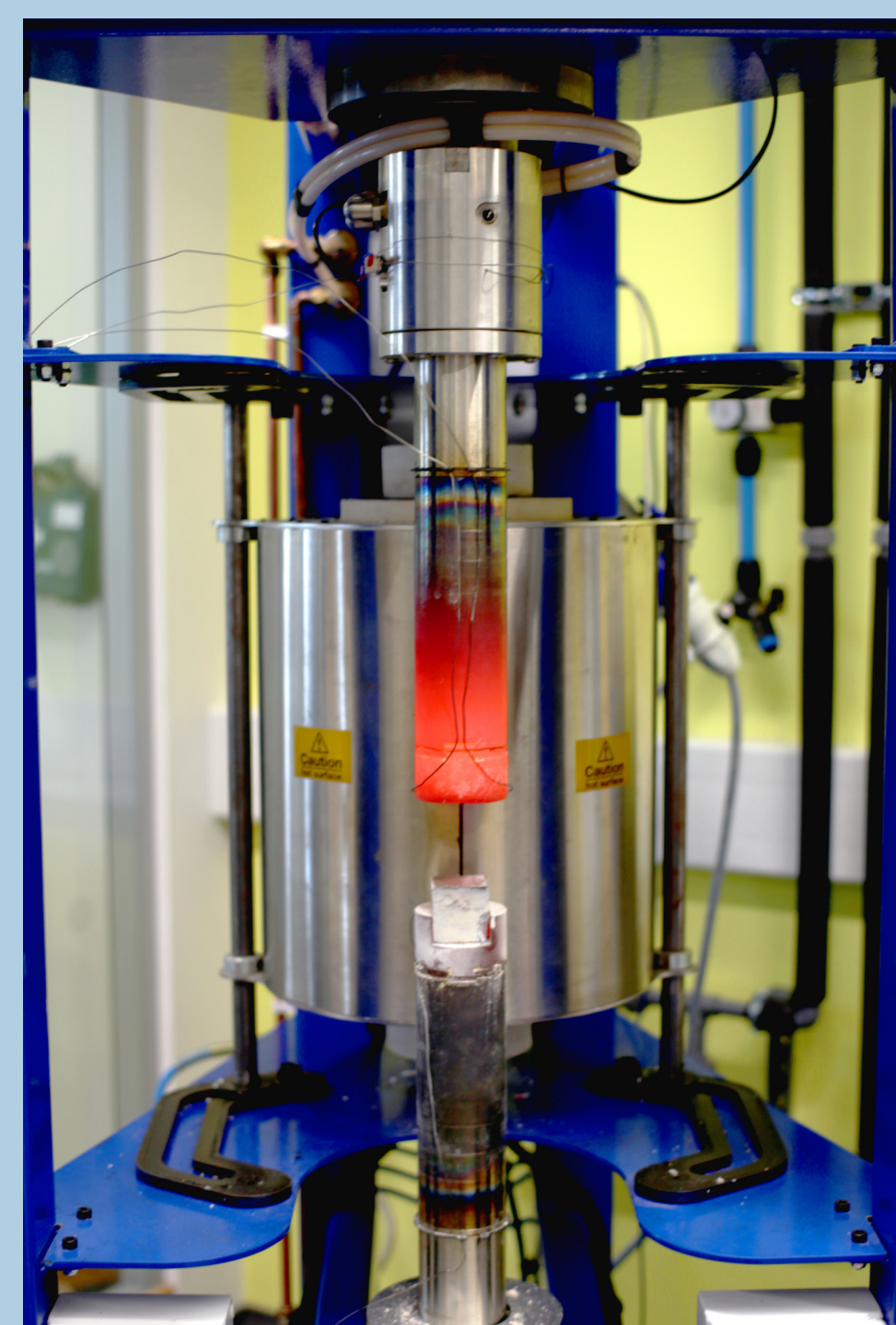


Superplastic Forming



Steps of SPF process:

- 1) loading of a sheet part into the dies and clamping;
- 2) heating of the part at process temperature, then application of gas pressure to deform the sheet;
- 3) cooling down and unloading of the formed workpiece.

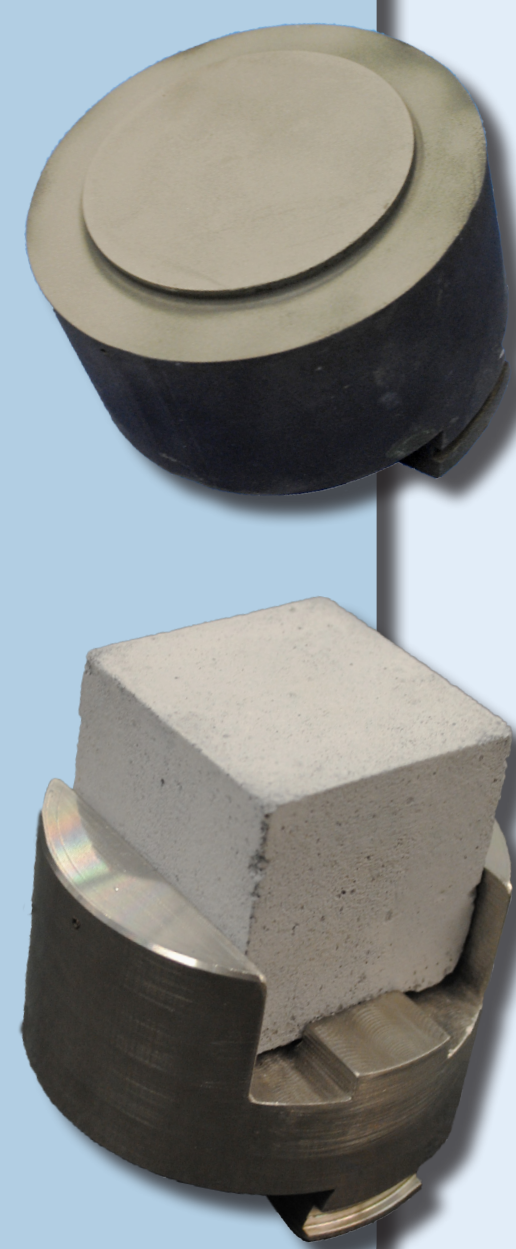


Test Rig

A purpose built test rig for simulating the die - titanium alloy (Ti6Al4V) part interface during SPF process conditions is available at the AFRC, with which it is possible to:

- Simulate die - part loading pressure and shearing
- Temperature test up to 1000°C
- Automated working to simulate a full production cycle

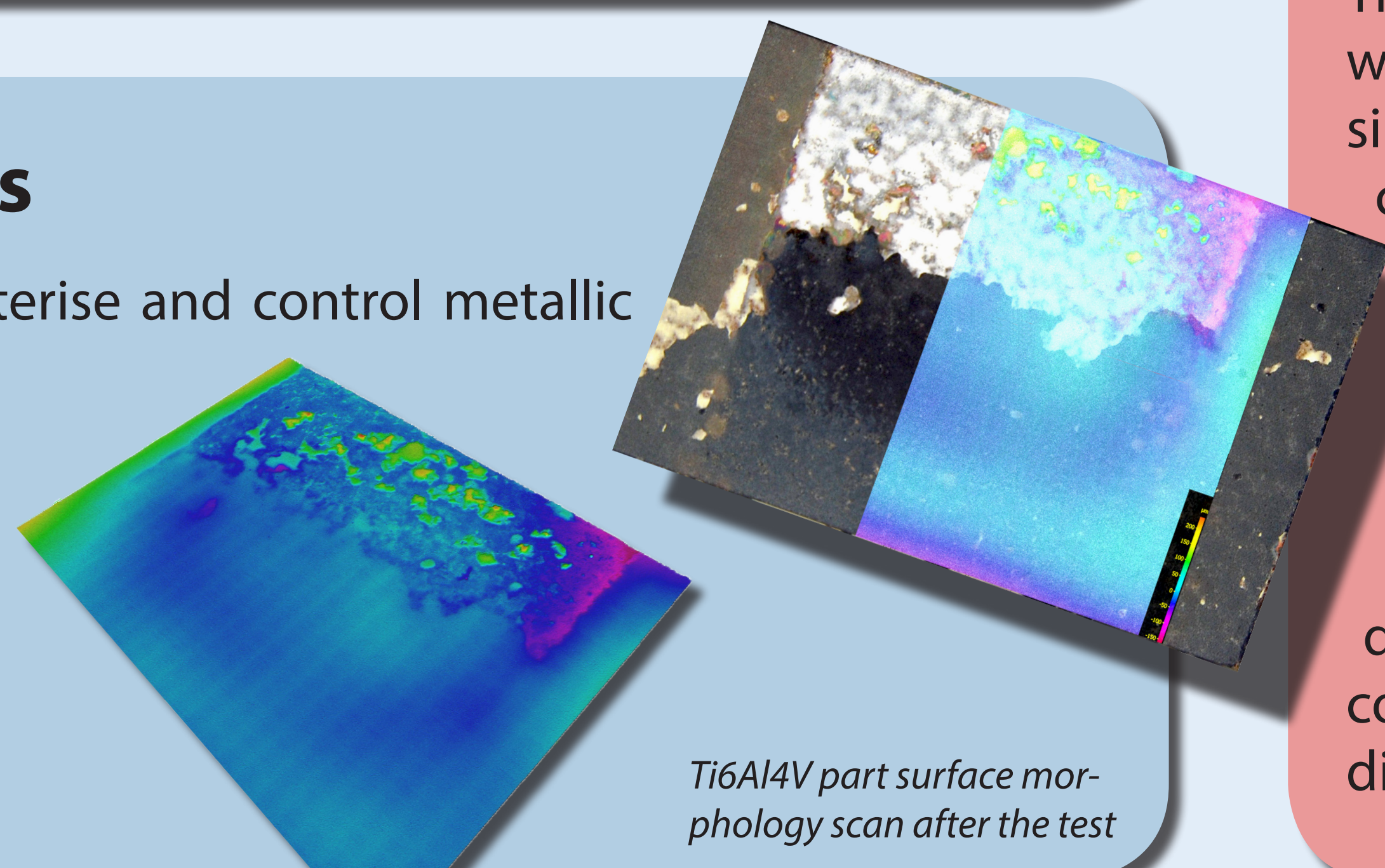
Left: Test Rig configuration able to simulate SPF conditions.
Right: Metallic and ceramic tools for the Test Rig



Characterisation Methods

A protocol has been created to characterise and control metallic and ceramic dies in the test rig considering the following techniques:

- Surface morphology
- Thermal imaging
- SEM analysis



Ti6Al4V part surface morphology scan after the test

Opportunities

The implementation of protective coatings on SPF tools could provide a substantial economic benefit to the SPF process, making it accessible to further manufacturing applications.

Thermal spray coatings are well known and used for similar applications. The capabilities to test those coatings in SPF conditions are available at the AFRC.

The research project is intended to study the best deposition method and develop a suitable protective coating for high temperature applications, increasing the die lifetime.



The 1,200 Tonn SPF press at the AFRC



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