PROTECTIVE COATINGS FOR SUPERPLASTIC FORMING CERAMIC DIES

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ABSTRACT

Superplastic forming (SPF) is an advanced sheet manufacturing process designed to form complex and large workpieces. It is generally used for aerospace applications, and due to its remarkable abilities, it is crucial to improve the tool manufacturing lead-time and lifetime to make the SPF applicable for further industrial applications. Recently, high temperature resistant steel dies are being replaced with emerging materials such as refractory ceramics. Ceramic dies have a lower production cost and have short lead-times, but their brittle nature is a limiting factor for SPF applications. Surface treatments can have a catalytic effect on the mechanical properties of the working surface of the die. Different materials can be used as coatings to further reduce die wear, so coatings need to be tailored to the final application. This study will be performed at the Advanced Forming Research Centre and it will consist on the development of a surface wearing monitor method for ceramic dies and, at a later stage, to develop and implement a cost-effective coating for the lifetime improvement of ceramic dies.

Keywords: superplastic forming, coating, surface wear, ceramic die

PROJECT OUTLINE

Investigate the surface degradation mechanisms of ceramic dies during SPF with applied protective coatings. Validate the effectiveness of the protective coatings in SPF manufacturing tools.

RESEARCH TARGETS:

- To control the micro-cracking on ceramic die surface and its interactions with workpiece by using suitable coatings
- To achieve advantageous knowledge to fit the use of protective coatings for different SPF applications
- To develop research capabilities on surface wear monitoring for ceramic dies

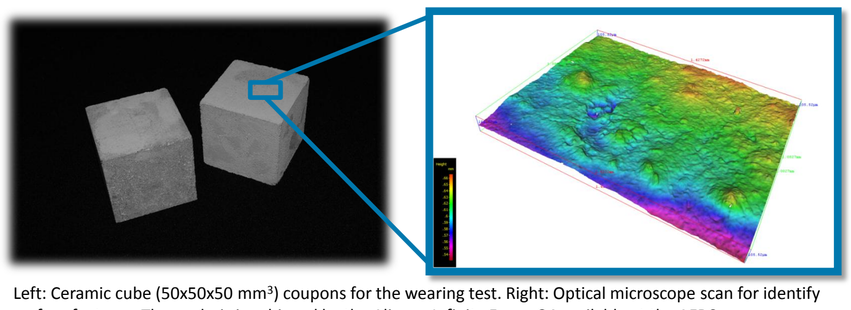
BUSINESS IMPACT:

- To enhance ceramic SPF die lifetime
- To validate the ceramic die as a valuable option for SPF manufacturing
- To increase productivity of ceramic dies

EXPERIMENT

1st phase

- Simulate die – part interface during SPF conditions
- Monitor the surface condition of ceramic die
- Provide protective coating improvements

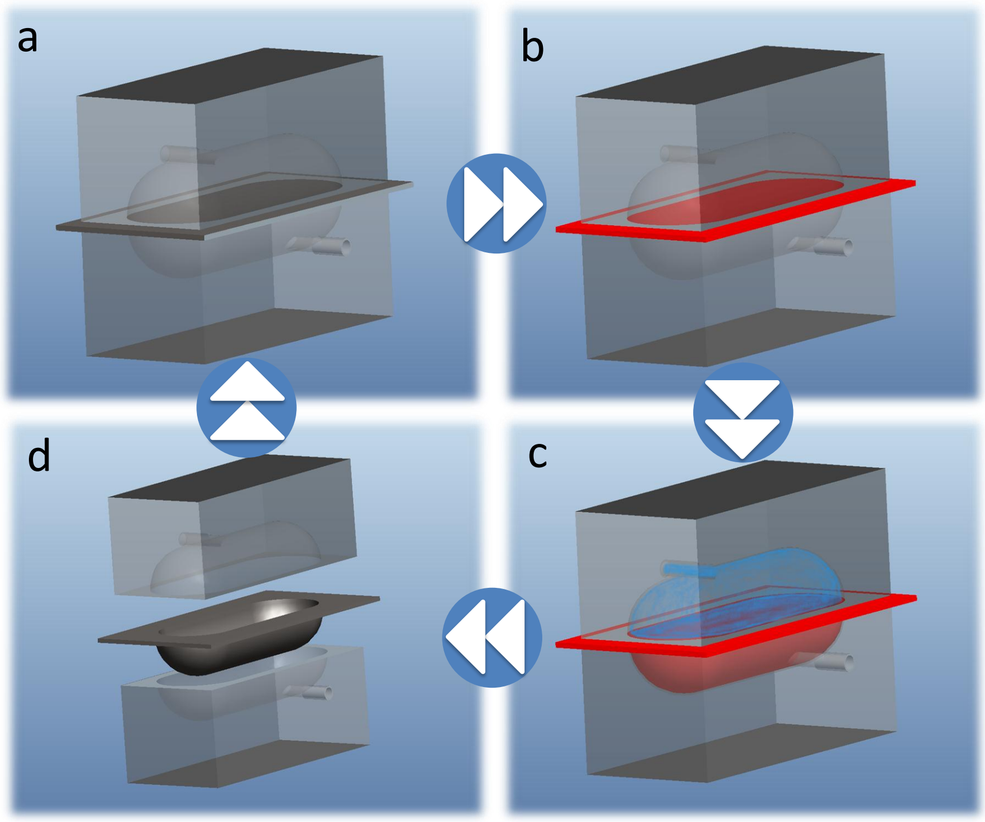


Left: Ceramic cube (50x50x50 mm³) coupons for the wearing test. Right: Optical microscope scan for identify surface features. The analysis is achieved by the Alicona Infinite Focus G4 available at the AFRC.

2nd phase

- Enhance AFRC coating deposition equipment
- Develop a coating system
- Build up a coating database for different applications

SUPERPLASTIC FORMING



Schematic view of SPF process: a) loading of a sheet part into the dies and clamping; b) heating of the part at convenient temperature (depending of the part material); c) application of gas pressure to deform the sheet; d) cooling down and unloading of the workpiece.

EQUIPMENT

A purpose built test rig for simulating the die part interface during SPF process conditions is available at the AFRC[1].

Simulate die – part loading pressure

Simulate die – part shearing

Temperature test up to 1000°C

Simulate a full production runs

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- World class manufacturing research in Forming and Forging
- Provide industrial partners with practical, affordable and exploitable solutions
- Create IP and spin out technology

[1] R. Zante and C. Knowles, "Advances in Monitoring Die Condition during Superplastic Forming," *Key Engineering Materials*, vol. 549, pp. 557–564, Jun. 2013.

Acknowledgements

The work described is supported by grants from the DMEM department of University of Strathclyde

EPSRC Engineering and Physical Sciences Research Council

AFRC Advanced Forming Research Centre