Effective laser powder bed fusion through digital integration showcased in the aerospace industry

The Encompass project has developed an integrated design decision support system to improve the productivity of metal additive manufacturing

Additive manufacturing (AM), often referred to as 3D printing, has significant potential to enable novel products with improved performance, improved material efficiency, reduced environmental footprint and reduced production costs. One of the promising AM techniques, laser powder bed fusion (PBF-LB) is a process that has been available for over 20 years but has yet not reached its full potential. Starting in 2016, the ENCOMPASS project's aim was to digitally integrate the steps of the PBF-LB process chain – the design, build and post-build processes. Through their collective expertise the consortium's partners have been able to develop a software-based integrated design decision support (IDDS) system for PBF-LB which has been evaluated on four end user examples to test its effectiveness. A key element of the system is a designer-facing design interrogation tool considering both the AM build and subsequent post-build steps (post-processing and inspection) to enable better decisions to be made up front.

This unique IDDS system has been tested with Rolls-Royce and ITP Aero to prove its positive impact in reducing the amount of materials and energy used to produce nickel-base alloy parts for the aerospace sector. Beyond the aerospace use cases, the automotive and medical sectors are also early evaluators of the developments. The system leverages a unique newly developed extensible architecture that considers the whole PBF-LB process chain and integrates in an optimal way with the design workflow, empowering developers of AM processes to capture its data in a structured way, as well as add to the design rules of AM and thus accelerate the maturity of the overall process.

When rolled-out into a company using AM, the use of the IDDS system is expected to significantly reduce time from 'design to piece', increase the process chain productivity, and reduce cost of production.

An ambitious goal for a ground-breaking technology

The project's partners have tackled a difficult challenge head-on – to improve the efficiency and capability of the overall AM chain and, as a result, contribute to Europe's relevance in global leadership and innovation for the foreseeable future. Its slow adoption is many-fold: PBF-LB is slow and expensive, its overall efficiency is low, it has a limitation in the part size that can be manufactured, and usually requires several iterations of builds to get up to the expected level of quality, resulting in the need for a large amount of inspection and destructive testing.

The project's partners started by identifying the hurdles they had to overcome, detailed below, and which have ranged from issues concerning the existing decision support and geometric design tools, to the complex requirements for component simulation and post-processing.

In spite of the fact that there are a number of tools for conventional manufacturing process chains when designing a part for PBF-LB, to check the potential manufacturability of a specific geometry is hindered by the limited knowledge and tools available. Design tools also do not factor in the post-processing required in such processes, specifically access for support removal, access for inspection, and consideration of orientation and support for surface finishing. Lastly, while component simulation can be used to inform decision making at the design stage, design rules based on physical predictions of distortion during the build have not yet been developed.

The architecture developed includes an extended data format for data exchange, as well as a CAD-based user interface, with suggestions of product and process redesigns. This new data format has allowed the development of a knowledge repository based on functional workflows.

As a result, the system provides integration at the digital level by enabling synergies between the steps of the process chain. The partners have been able to provide a user support interface within a CAD environment; to provide digital tools for simulating and optimising melt strategies; to provide digital tools for simulating post-build material and quality processes; and to apply monitoring solutions for key variables of the post process; and finally to develop a framework for the optimisation of PBF-LB products and process design.

Project partners

The project partners include some of the leading organisations in the field of AM, including the Manufacturing Technology Centre, Renishaw, Rolls-Royce, Altair and the University of Liverpool (UK); Fraunhofer ILT and ESI Group (Germany); ITP Aero (Spain); DePuy Synthes (Ireland); the European Welding Federation (Belgium) and Centro Ricerche Fiat (Italy).

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