JIP on AM: progress in oil and gas

Additive Manufacturing in the oil & gas/maritime industry has made significant progress with the conclusion of the JIP (joint industry project) focused on AM. On January 30th of 2020, two guidelines were published for the qualification of parts produced by Laser Powder Bed Fusion (LPBF) and Wire Arc Additive Manufacturing (WAAM) and an accompanying economic model.

By Lucien Joppen

Valeria Tirelli, fifth from the left (red jacket). The participants of JIPs celebrate the official release of guidelines, at DNV GL office in Høvik, Norway.

An important prerequisite for the success of this project was the participation of partners representing the complete value chain (Fig. 1). In Additive Manufacturing, the collaboration of multiple partners with expertise in specific processes and activities, is essential. The partners collaborated in two coherent and seamlessly aligned programs.
First of all, to develop a guideline for the qualification of additively manufactured parts managed by DNV-GL. The final guideline provides a framework to ensure that metal spare parts and components, produced via Wire Arc Additive Manufacturing (WAAM) and Laser-based Powder Bed Fusion (LPBF), are according to specifications. This means that the parts meet stated quality and are manufactured in a safe and repeatable manner.
Second, to create a toolbox for part selection, supply chain set-up and economic viability managed by Berenschot. In addition, real parts were produced as a case study to ensure the development of a high- quality guideline that is in tune with realistic (economically and timely feasible, ed.) manufacturing practices. This production process also enabled the consortium to assess all activities that need to be monitored and qualified to ensure a complete guideline.
At the end of JIP, many case studies have been developed and parts produced with AM to support the AM guidelines.

Avoiding long downtimes

An interesting case study is the Crank Disk (see image on the next page) produced via LPBF by Aidro for Kongsberg. The original part, produced with conventional manufacturing, takes from 8 to 10 weeks while the 3D-printed part requires less than one week to be printed in Inconel 718, using EOS M290 printer. This is a good example of how AM can accelerate the replacement of parts and avoid long downtimes due to relatively long leadtimes.
Other case studies were made with LPBF or WAAM and all the JIPs members contributed to the production and testing of these 3D-printed parts. A variety of parts have been manufactured via the above-mentioned 3D-print technologies.
Parts were produced using Laser Powder Bed Fusion: an Equinor-impeller in Inconel 625 (printed by SLM Solution), the same impeller in Ti-6Al-4V (printed by Additive Industries), a Kongsberg propeller blade in titanium (printed by SLM Solution) and a Kongsberg crank disk ring in Inconel 718 (printed by Aidro with EOS printer) shown above.
Parts were produced using Wire Arc Additive Manufacturing: a Vallourec circulating head using X90 low-alloy construction steel, a BP cross-over in Inconel wire, in two versions: limited scale and full scale, a Kongsberg crank pin, using S700 low-alloyed wire and a Technip FMC/Total-designed crossover, using F22 alloy steel.

Operators	Contractors	Fabricators	
bp	SLM SOLUTIONS	ArcelorMittal	ivaldi
equinor	TechnipFMC	voestalpine	aidro
Shell	IMI Critical Engineering	Additive Industries	vallourec
TOTAL	KONGSBERG	University of Strathclyde Glasgow	IMMENSA TECHNOLOGY LABS
	SIEMENS	SANDVIK	
		HIPtec	Quintus TECHNOLOGIES

Figure 1: An important prerequisite for the success of this project was the participation of partners representing the complete value chain. In Additive Manufacturing, the collaboration of multiple partners with expertise in specific processes and activities, is essential.

Business impact model

"Using real world parts is essential in a project like this", says Valeria Tirelli, CEO of Aidro, one if the JIP-members. "Both the guideline and the business impact model need to be tested under conditions that resemble real-life situations. By using real world parts, it is possible to assess the differences between traditional manufacturing processes and the Additive Manufacturing process. There are advantages of AM across the supply chain. The main pro's are faster manufacturing times, improved performance, lighter and more compact components."

According to the JIP-group (see picture on the first page of this article), the guideline offers a quality assurance methodology for the selected Additive Manufacturing processes and parts. Parts are divided into three categories depending on the consequence of failure: AM Class 1 (AMC 1) is intended for non-critical components, AM Class 2 (AMC 2) is intended for less-critical components and AM Class 3 (AMC 3) is intended for critical components.

The crack disk 3D printed by Aidro with EOS M290 and machined by Kongsberg.

Assurance steps

Depending on the AM-Class, different assurance steps are involved based on the AM-technology used, such as build process qualification testing, production testing and part qualification testing:

- All parts shall be manufactured using a qualified build process. A build process is qualified through a defined Build Process Qualification Testing (BPQT) procedure. The purpose of the BPQT is to prove and provide a baseline that, when using a certain set of essential parameters, a certain quality is achieved.
- Production testing is intended as a control to ensure that the manufacturing process produces parts according to the qualified build process not just once, but also on, for example, the second, tenth or twentieth build. The extent of production testing and type of tests carried out are different for the different AM technologies
- Depending on the criticality of the part to be manufactured, the part itself or a representative geometry may need to be tested. This is due to the unique possibility AM brings to produce the material and geometry simultaneously. The methodology and extent of part qualification testing depends on both AM Class and AM technology.