RE:MATERIAL - Reclaiming High Value Components using Additive Manufacturing Processes

The Weir Group PLC and The University of Strathclyde

A Scottish Institute for Remanufacture Case Study

A Challenging Market

The current market conditions for Oil & Gas are financially challenging and as such operators are looking for methods of prolonging product life using cost effective repair methods. For pump applications where the operating environment is corrosive and abrasive, the use of duplex and super-duplex steels is common. However, instances where duplex/super-duplex stainless steel components, such as pump shafts, have to be replaced due to relatively minor damage with a new, expensive and long lead time part are also common.

Wear damage on pump shafts

A Challenging Environment

Drilling for oil and gas is challenging and difficult for components of operating equipment as they frequently experience damaging conditions. Components used in these high wear and/or corrosive conditions are often manufactured from a super-duplex alloy. The properties of super-duplex can withstand the corrosive environment (in particular, crevice and pitting damage) and maintain mechanical integrity sufficient for high pressure pumping applications such as seawater injection and crude oil. The combination of corrosion resistance and strength of the material greatly increases the life expectancy of components in comparison to using low alloy, stainless steels or corrosion resistant alloys.

However, as the world is drilling deeper for reserves, super-duplex components in the oil and gas industry are required for more arduous operating environments and can experience damage due to fretting, erosion and other types of wear.

Additive manufacturing setup at Laser Additive Solutions Ltd

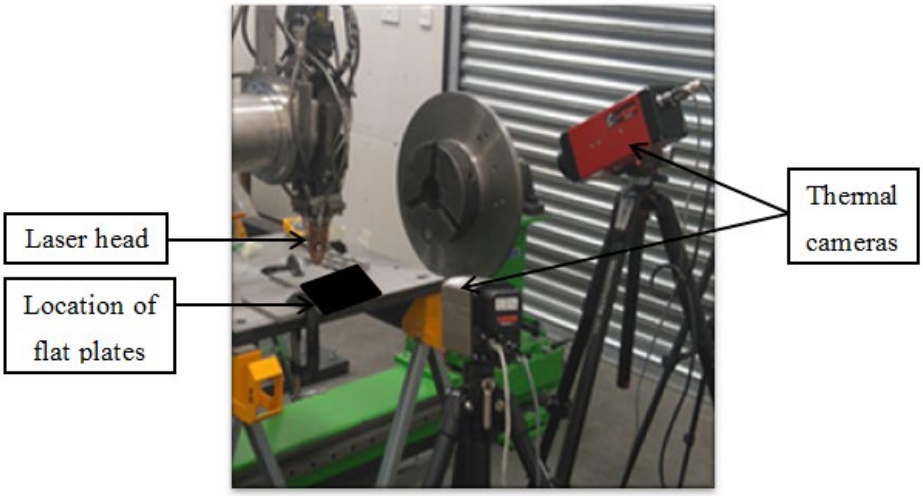
Shaft components made from super-duplex steel have been very difficult to repair using conventional welding methods due to shaft straightness issues i.e. weld repair by conventional methods would result in distortion to critical dimensions. Also, maintaining corrosion properties for the weldment, fusion zone and heat affected zones due to the precipitation of intermetallic phases occurring in the base material at very low temperatures is a challenge.

The purpose of this research was to assess the use of additive manufacturing techniques for the repair and salvaging of pump components, in particular pump shafts.

An Alternative Approach

Following an extensive review of the problem area, a Laser Metal Deposition (LMD) method was used to repair super-duplex base material. Working in partnership with The Weir Group and Laser Additive Solutions Ltd, the team successfully developed welding parameters to maintain mechanical and corrosion resistant properties in accordance with ASME IX welding code and ASTM G48 corrosion industry standard tests.

To further increase the confidence, the team carried out a semi-quantitative chemical composition of the additive layers, heat affected zone and substrate using energy dispersive x-ray spectroscopy and all met the supplier's composition.

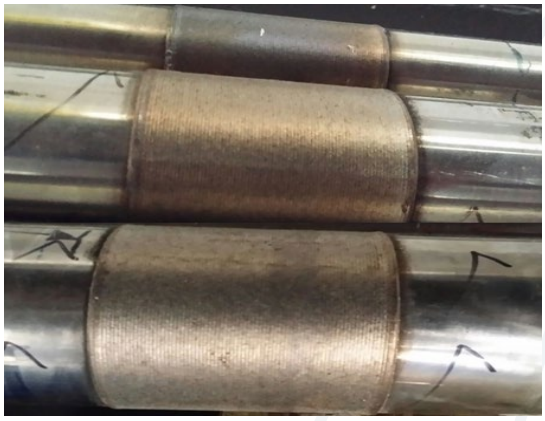


Land thermal cameras used to record the temperatures during the development of the LMD overlay process parameters on flat plates

LMD overlay stage on the round bar - representative of a pump shaft

Benefits Gained From the Project

Accessing matched funding from the Scottish Institute for Remanufacture enabled The Weir Group to investigate the feasibility of using additive manufacturing techniques to repair critical components, which ordinarily are costly to replace both in material cost and time. Results from the project show a potential pump shaft repair lead time reduction from 6 to 10 weeks (new component) to 1-2 weeks, with a repair costing only 20% of what a new shaft would be, as well as a service life extension of at least 20%.



LMD overlay on a critical feature that is damaged in service on a pump shaft

Polished samples taken from the LMD overlay and used in the ASTM G48 corrosion test

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