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Mechanical properties and fracture behaviour of LMD produced 2.4682 and wrought 2.4630 dissimilar welds

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Abstract

A bearing made of Stellite 31 (2.4682) has to be welded onto a housing of Nimonic 75 (2.4630) by autogenous laser beam welding. The bearing part is produced by laser metal deposition (LMD), the housing consists of wrought sheet metal. An investigation is undertaken in order to study the effect of the anisotropy of the LMD part on the weld quality. Tensile specimens were produced and tested under varying load directions and test temperatures, and application of different weld heat treatments. The fractured specimens were analysed by metallography and fractography. Tensile tests at room temperature show a dependency of the fracture location and the mode of failure on the load direction with respect to the layer direction in conjunction with the heat treatment. At elevated temperature of 750° all specimens broke in the base material of 2.4630 in ductile fracture mode. Strength measured supersedes the values of either of the base materials.

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1. Introduction

With view to functional integration a combination of functional parts with load carrying substructure produced by LAM and joined by LBW becomes possible. An additional aspect is the possible replacement of casting by laser or arc additive manufacturing, especially for complex parts in terms of design or material combination in applications for limited lot sizes. In all these cases joining of similar and dissimilar materials is required.

Laser Additive Manufacturing (LAM) offers a huge potential in terms of design opportunities as well as new material combinations. A disadvantage of LAM is the usually small build-up rate, so that parts are typically very

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expensive compared to their volume. Joining of parts made by additive manufacturing to wrought and forged parts could enable industry to fully exploit design and material combination benefits and being simultaneously economically attractive.

Additively produced materials have specific properties in terms of microstructure, texture, and residual stresses which differ from those of wrought materials. There is also a difference to cast parts which show more or less isotropic material properties due to their equiaxed solidification structure. For a successful industrial implementation of the proposed combination of LBW and LAM, joining knowledge about the above mentioned properties as well as the complete processing route and mechanical properties are required.

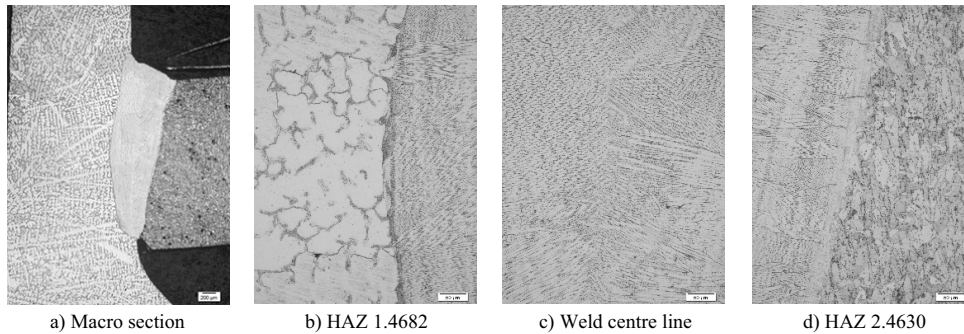


Fig. 1. Cross sections of a welded joint between a cast 2.4680 (Stellite 31) and a wrought 2.4630 (Nimonic 75).

At the example of a turbine component operated at 750°C a typical dissimilar material joining of 2.4682 (Stellite 31) produced by Laser Metal Deposition (LMD) to a wrought 2.4630 (Nimonic 75) will be demonstrated. In general the combination is suitable for welding as demonstrated in figure 1 at the example of a joint between cast and wrought part. The heat input has to be controlled meticulously.

Table 1. Composition of the alloys in weight-percent.

	C	Mn	Si	Cr	Ni	Fe	Co	W	Ti
2.4630	0.12	0.4	0.24	19.75	bal.	4.34	0.09	-	0.33
2.4682	0.5		1.0	25.5	10.5	< 2	bal.	7.5	

Throughout the study the Stellite 31 part simulates a cast structure – or its replacement. The study pursues a couple of aims. Firstly, learning about the weld metallurgy of dissimilar welds and a comparison to a cast partner. Secondly, an understanding of the boundary condition for welding of LMD produced parts and the effect of the building strategy on the mechanical properties of the welded joints. This will be highlighted by an assessment of the strength and the deformation behaviour of the welded structure. Thirdly, attaining insight in the weld metallurgy with view to mixing of the material and the resulting microstructures, and related to this, accessing the fracture modes of the parts welded.

The results are not restricted to turbine manufacturing. They are applicable for welding of components for the application in hot and/or harsh environments, guided by the materials selected.

2. Experimental

2.1. Materials

The 2.4630 (Nimonic 75) is delivered as cold rolled sheet materials of 2.5 mm thickness in annealed state. It is a nickel-chromium alloy with controlled content of carbon and titanium (Special Alloys Corporation). Material 2.4682 (Stellite 31) is a cobalt-base, high-temperature superalloy made for casting, which is often used in gas turbine

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