Investigation of Transient Thermal Analysis on SS316L and Inconel 718 using Pulsed Nd: YAG Laser

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Abstract - Welding of dissimilar materials used to enhance the mechanical properties in engineering applications. The engine component is made using combinations of Inconel and stainless-steel (SS) materials in aerospace application. In dissimilar welding condition, uneven heat distribution is generated during welding processes which may leads to material property degradation on one side of the weld zone. A three-dimensional finite element-based model developed using COMSOL code to simulate welding process for two different laser spot positions of dissimilar welding of Inconel 718 and stainless steel 316L. A Pulsed Nd: YAG laser beam spot is initially focused symmetrically on butt joint on both sides of material and later the laser beam spot is offset-ted to the side of Inconel with respect to dissimilar material property. Thus, a significant symmetric zone is achieved by offset the laser spot position, which possess good quality of weld.

Key words: Dissimilar materials; Pulsed laser welding; Thermal distribution

1. Introduction

Austenitic nickel based super compounds, for example, Inconel 718 are widely utilized in air motor hot segment segments, aviation structures, fluid rocket parts including cryo-genic motors and gas turbines. These composites show broad properties at high temperatures regarding higher quality, corrosion obstruction, durability and protection from warm exhaustion (1). One of the most significant issues, if there should be an occurrence of unique weldments, is the appraisal of legitimate filler materials for welds between super amalgams and austenitic hardened steels (2). Austenitic hardened steels and nickel-based combinations are for the most part welded utilizing regular Shield Metal Arc welding (SMAW), Gas Tungsten Arc welding (GTAW), or gas metal Arc welding (GMAW) forms (3). Customarily, welding is utilized with a set up welding technique named highly contrasting welding, where a filler material is for the most part of an extra metal combination that has a middle person coefficient of warm extension of the two sections to be joined. The welding of metals will frequently leave a microstructural engrave with defined highlights, for example, a combination zone , un-dissolved zone, heat influenced zone and a thermo-precisely influenced zone, which should be present weld heat rewarded on limit precipitation or isolation of stages that could decrease the mechanical or destructive obstruction of the material (4).

The important to consider various factors before attempting to join two different metals, as this will determine not only how successful the welding will be, but also how long your newly joined components are likely to last. Firstly, the solubility that is the chemical properties of a substance that determines its ability to dissolve in a solvent, of the two dissimilar metals must be mutual. If the metals cannot be dissolved together, then the welding process will fail. successfully welded without resulting in cracks or any other kind of negativity. Laser welding is utilized all the more regularly in mechanical procedures since it has more extensive application than conventional welding as less warmth is made in light of the fact that the pillar is so engaged. This implies heat move to the workpiece is significantly less and the metallurgical structure is less influenced and the nature of the weld is a lot higher than with customary types of welding (5). Laser pillar welding is profoundly ideal for joining divergent metals. Up until this point, the microstructural and mechanical properties of unique welded Inconel 625 and SS 316 by high force laser have been not considered (6).

The dissimilar welding of Inconel and SS joints are highly sensitive due to the very low weldability of Inconel alloy and therefore the welding method should be associated with minimal distortion and microstructure changes (7). Nd: YAG laser welding process with high penetration depth and very narrow heat-affected zone is one of the fusion welding methods that can be used in highly sensitive joints. (8). Evaluation of various sources in the field of dissimilar materials welding indicates that no

systematic research has been reported regarding the dissimilar welding between Inconel and SS (9,10).

The purpose of this study is to investigate the influence of transient thermal analysis on the weld quality in pulsed Nd: YAG laser welding of SS 316L and Inconel 718. The heat distribution is modeled using a multi physics COMSOL software.

2. Modelling approach

For this demonstrating a couple of 3 mm thick Inconel 718 and AISI 316L tempered steel sheet examples are considered as appeared in Figure 1. The warm properties and substance creation of both AISI316L Stainless Steel sheets and Inconel 718 are appeared in Table 1 and Table 2 separately

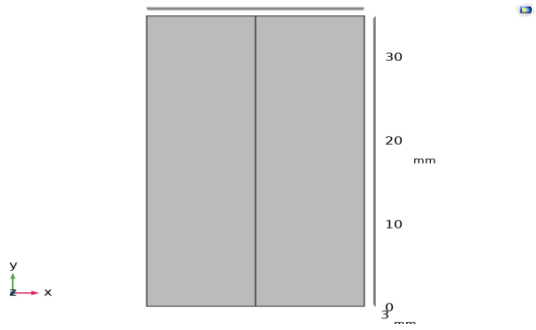

Figure 1: Model of AISI 316L stainless steel sheets and Inconel 718

Table 1: Thermal properties of Inconel 718 and AISI 316L stainless steel

Physical Property	Density (g/cm^3)	Melting Point (°C)	Thermal conductivity (W/m-k)
Inconel 718	8.22	1370-1430	6.5
316L SS	0.799	1,371–1,399	16.2

Table 2: Chemical Composition of Inconel 718 and AISI 316L stainless steel

Base Metal	Ni	Si	N	Al	Cu	P	Ti	Mn
Inconel 718	50.00-55.00	0.35 max	-	0.20-0.80	0.30 max	0.015 max	0.65 - 1.15	0.35 max
316L SS	10.00 - 14.00	0.75 max	0.10 max	-	-	0.045 max	-	2.00 max
Base Metal	Cr	Mo	Cb	C	S	Nb	B	Fe
Inconel 718	17.00 - 21.00	2.80-3.30	1.00 max	0.08 max	0.015 max	4.75-5.50	0.006 max	Balance
316L SS	16..0 - 18.0	2.0 – 3.0	-	0.03 max	0.03 max	-	-	Balance

The AISI 316l hardened steel and Inconel 718 steel are framed as association in butt joint at relative fix resistance around 1 μm and by utilizing predefined free tetrahedral strategy it is coincided. Marginally progressively exact forecasts of pinnacle temperature are accomplished by utilizing this strategy.

3. Results and discussion

The laser beat produces the warmth by changing over light vitality to warm vitality once the fixed objective was begun to illuminate by laser beats. The correlation between the dissemination of temperatures of disparate 316L austenitic treated steel and Inconel 718 sheet joints for two unique places of centered laser spot during the procedure of a beat laser weld. Almost an equivalent conveyance of warmth was seen on the two sides of weld when the laser is counterbalanced to the side of Inconel. Be that as it may, there is some expansion seen on 316L hardened steel when it is evenly engaged. This is because of the higher warm conductivity of 316L hardened steel than Inconel 718. By the method of limiting the laser communication region and by giving diminished warmth contribution to the side of 316L hardened steel, the temperature circulation is controlled. n dissimilar weld joints, this may cause drastic and undesirable changes in metallurgical and mechanical properties. It has to be noted that 316L stainless steel is having higher thermal conductivity than the Inconel 718.

4. Conclusion

In this work, utilizing COMSOL code a three-dimensional limited component-based displaying is created and the welding procedure is mimicked for two diverse situations of laser spot. Contrasted with Inconel 718 side high temperature saw in the side of hardened steel is accounted for. So as to get balanced appropriation of temperature in both side it was chosen to counterbalance the side of Inconel 718 rather than evenly engaged across butt joint. By utilizing beat Nd: YAG laser pillar is utilized to made disparate weld joints of 316L hardened steel-Inconel 718. Along these lines, for various mix of materials the choice made for counterbalancing the situation of laser spot for disparate welding joint will be valuable by limiting the corruption of material and have adequate quality.

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