International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 03 | Mar 2019 www.irjet.net p-ISSN: 2395-0072

CHARACTERIZATION OF 904L SUPER AUSTENITIC STAINLESS STEEL BY FRICTION WELDING

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Abstract - The quality of the joint can be defined in terms of mechanical properties, generally, all welding processes are employed with the aim of obtaining a welded joint with the desired characterization. The purpose of this study is to propose a method to decide near optimal settings for the welding process parameter in friction welding of (AISI 904L) super austenitic stainless steel by using non conventional techniques. The main objective of this work is to be determine the friction welding process parameters to maximize the fatigue life and minimize the width of the partial deformation zone (lift & right) and welding time. This study describes how to obtain near optimal welding conditions over a wide search space by conducting relatively a smaller number of experiments.

Key Words: friction welding, super austenitic stainless steel 904L, tensile test, bending test, hardness test and macro & micro structure.

1. INTRODUCTION

Friction welding is a solid-state welding process that generates heat through mechanical friction between work pieces in relative motion to one another, with the addition of a lateral force called "upset" to plastically displace and fuse the materials. Because no melting occurs, friction welding is not a fusion welding process in the traditional sense, but more of a forge welding technique. Friction welding is used with metals and thermoplastics in a wide variety of aviation and automotive applications.

In friction welding the heat required to produce the joint is generated by friction heating at the interface. The components to be joined are first prepared to have smooth, square cut surfaces. One piece is held stationary while the other is mounted in a motor driven chuck or collet and rotated against it at high speed. A low contact pressure may be applied initially to permit cleaning of the surfaces by a burnishing action. This pressure is then increased and contacting friction quickly generates enough heat to raise the abutting surfaces to the welding temperature. As soon as the required temperature is reached, rotation is stopped and the pressure is maintained or increased to complete the weld.
The softened material is squeezed out to form a flash. A forged structure is formed in the joint. If desired, the flash can be removed by subsequent machining action. Friction welding has been used to join steel rod up to 80 mm in diameter and rod with outer diameter upto 100 mm.

1.1 OBJECTIVE OF PROJECT

To study the characterization of Super austenitic stainless steel by friction welding such as hardness test, tensile test, micro structure, bending test

2. EXPERIMENTAL PROCEDURE

2.1 Material selection

Grade 904L stainless steel is a non-stabilized austenitic stainless steel with low carbon content. This high alloy stainless steel is added with copper to improve its resistance to strong reducing acids, such as sulphuric acid. The steel is also resistant to stress corrosion cracking. Grade 904L is non-magnetic, and offers excellent formability, toughness and weldability.

Grade 904L contains high amounts of expensive ingredients, such as molybdenum and nickel. Today, most of the applications that employ grade 904L are replaced by low-cost duplex stainless steel 2205

Table 1 Chemical Composition

Nickel	23.0 min. – 28.0 max.	Silicon	1.00
Chromium	19.0 min. – 23.0 max.	Phosphorus	0.045
Molybdenum	4.0 min. – 5.0 max.	Sulfur	0.035
Copper	1.0 – 2.0 max.	Iron	Balance
Manganese	2.00		

2.2 Experimental of 904l super austenitic stainless steel

The welding process used in this project is solid state welding process friction welding, which is used to weld the 904L stainless steel of diameter 16 mm, length of 80mm, spindle speed of 1400 rpm.

12 specimens were prepared under different friction load and forging load along with friction time and forging time. Above diagram describes the friction welding of 904l stainless steel, the welding has to be started from 81 mm length and facing before 1 mm at the weld length of 80mm.

2.3 APPLICATIONS

some of the major applications of grade 904l stainless steels include:

oil refinery components, seawater cooling devices, watch case, gas scrubbing plants, paper processing industries, acetic, phosphoric and sulphuric acid processing plants

3. Welding process

the friction is used to generate heat at the interference surface. This heat is further used to join two work pieces by applying external pressure at the surface of work piece. In this welding process, the friction is applied until the plastic forming temperature is achieved. It is normally 900-1400 degree centigrade for steel. After this heating phase, a uniformly increasing pressure force applied until the both metal work pieces makes a permanent joint. This joint is created due to thermo mechanical treatment at the contact surface

Fig 1 specimen dimension

4. Welded Specimen

Fig 4. welded specimen

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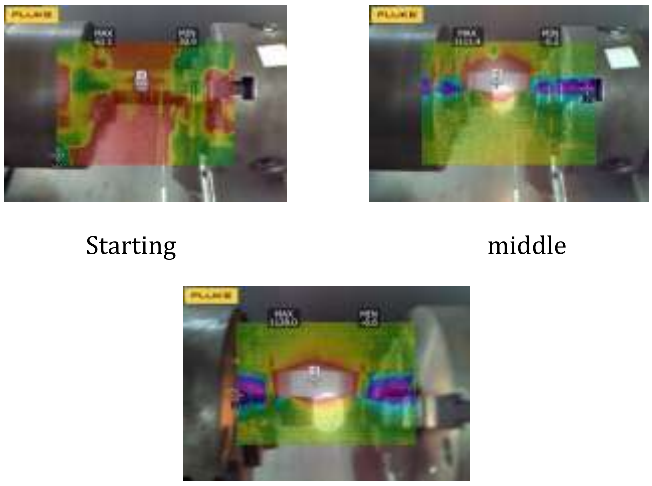
4.1. Thermal imaging camera

A thermal imaging camera (colloquially known as a TIC) is a type of thermographic camera used in firefighting. By rendering infrared radiation as visible light, such cameras allow firefighters to see areas of heat through smoke, darkness, or heat-permeable barriers. A thermal imaging camera consists of five components: an optic system, detector, amplifier, signal processing, and display. Fire-service specific thermal imaging cameras incorporate these components in a heat-resistant, ruggedized, and waterproof housing



Starting middle

Ending

Fig 4.1 thermal imaging of during operation on welding peocess

5. Welding parameter

Exp no	Friction load kg	Friction time sec	Forging load kg	Forging time sec
1	1300	20	1300	4
2	1300	20	1400	4
3	1300	25	1300	4
4	1300	25	1350	4
5	1400	20	1300	4
6	1400	20	1400	4
7	1400	25	1350	4
8	1400	25	1400	4
9	1400	25	1450	4
10	1450	20	1300	4
11	1450	25	1400	4
12	1450	25	1450	4

Table -5 welding parameter

6. RESULTS AND DISCUSSION

Hardness, Tensile Test, Impact Test, Bending Test, Microstructure And Scanning Electron Microscopy (Sem)

6.1 VICKERS HARDNESS

hardness is a characteristic of a material, not a fundamental physical property. it is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation.

Table:6.1 vickers hardness

Base metal	146VHN
Heat affected zone	132VHN
Welding zone	136VHN

Fig 6.1 hardness test on surface

6.2 Tensile test

The welded joints are machined to the dimensions as per ASTM guidelines are followed in preparing the tensile test specimens. Tensile test is carried out on a 100 kN electromechanical controlled universal testing machine. The specimen is loaded at the rate of 1.5 kN per minutes according to the ASTM specifications.

The tensile strength values are given with corresponding friction welding process parameters in the Table 4.

Table -6.2: welding input parameters and corresponding tensile strength

Exp no	Friction load kg	Friction time sec	Forging load kg	Forging time sec	Tensile strength (TS) N/mm^2
1	1300	20	1300	4	463
2	1300	20	1400	4	500
3	1300	25	1300	4	482
5	1400	20	1300	4	489
6	1400	20	1400	4	512
10	1450	20	1300	4	494

Table 6.2 friction welding parameter

6.3. Bending test

A bend test is a method for measuring stiffness and yield properties of certain materials. Bend tests for ductility provide a simple way to evaluate the quality of materials by their ability to resist cracking or other surface irregularities during one continuous bend

Table -6.3: welding input parameters and corresponding tensile strength

GRADE 904L	SPECIMEN NO	LOAD (MPa)	Length (mm)	Time (min)
1	4	1000	14	1.48
2	7	1300	14	1.26
3	9	950	10	1.22

Table 6.3 bending test

6.4 Impact test

Impact Testing of metals is performed to determine the impact resistance or toughness of materials by calculating the amount of energy absorbed during fracture. The impact test is performed at various temperatures to uncover any effects on impact energy

GRADE 904L	SPECIMEN NO	parameter	Toughness at (RT)
1	8	Test result (joules)	158
2	11		160
3	12		168
		Average (joules)	162

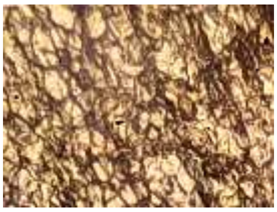
Table 6.4 impact test

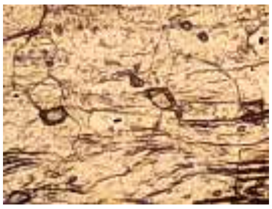
6.5 Microstructure of 904l stainless steel

Samples for observation by Optical Microscope, including the embedded powders, were ground and polished to a mirror finish using a final alumina suspension of 0.05 õm and electro-etched in a solution of 20 ml HCl, 10 ml glycerol, and 15 g nitri acid for 10–20 sec at room temperature.

Micro examination is performed for a number of purposes most commonly it is carried out to assess the structure of material for quality purposes:

Ensures correct heat treatment is employed
Detects unwanted phases and inclusions
Identifies where excessive grain boundaries


Base metal


fusion zone

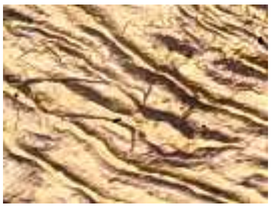

HAZ zone

Fig 6.5 microstructure of 904L super austenitic stainless steel

7. CONCLUSIONS

The tensile tests showed that the friction processed joints exhibited comparable strength with the base material and joint strength decreased with an increase in the friction time. In-situ monitoring of acoustic emission during tensile testing is useful in predicting the fracture mechanism of the joint

The process parameters have a significant effect on tensile strength and friction time was found to have greater influence on tensile strength of the joints followed by forging load, forging time and friction load

The fusion zone of rotating side has more width than the stationary side. This will lead the higher hardness than the stationary side of the welded specimen

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