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OPTIMIZATION ON FRICTION WELDING OF DUPLEX STAINLESS STEEL-S31803

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Abstract - Friction welding is now well established as one of the most economical and highly productive methods in joining similar and dissimilar metals. It is widely used in automotive and aerospace industrial application. Friction welding is often the only viable alternative in this field to overcome the difficulties encountered in joining the materials with widely varying physical characteristics. The duplex stainless steel is superior to austenitic stainless steel in corrosion resistant and strength. The aim of this study is to do optimization on duplex stainless steel 2205 welded specimens by using friction welding process. Based on the trial weld run parameter values welding is done and then the microstructure analyses, hardness testing, were carried out. The mixture of re-crystallized grain in the weldment was observed by microstructure analysis. Hardness test was used to find the hardness for the trial weld run parameter welded specimen and it reveals that the hardness of the weld metal zone of S31803 is less than that of the base metal zone.

***Key Words*:** friction welding, Duplex stainless steel S31803, tensile test, bending test, hardness test and macro & micro structure.

1. INTRODUCTION

Solid state welding is a group of welding processes which produces coalescence at temperatures essentially below the melting point of the base materials being joined, without the addition of brazing filler metal. Pressure may or may not be used. These processes are sometimes erroneously called solid state bonding processes: this group of welding processes includes cold welding, diffusion welding, explosion welding, forge welding, friction welding, hot pressure welding, roll welding, and ultrasonic welding.

In all of these processes time, temperature, and pressure individually or in combination produce coalescence of the base metal without significant melting of the base metals.

Solid state welding includes some of the very oldest of the welding processes and some of the very newest. Some of the processes offer certain advantages since the base metal does not melt and form a nugget. The metals being joined retain their original properties without the heat-affected zone problems involved when there is base metal melting. When dissimilar metals are joined their thermal expansion and conductivity is of much less importance with solid state welding than with the arc welding processes.

Time, temperature, and pressure are involved; however, in some processes the time element is extremely short, in the microsecond range or up to a few seconds. In other cases, the time is extended to several hours. As temperature increases time is usually reduced. Since one of these processes is friction welding will be described 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 Duplex stainless steel by friction welding such as hardness test, tensile test, micro structure, bending test

2. EXPERIMENTAL PROCEDURE

2.1 Material selection

Duplex 2205 is a duplex stainless steel, with a chemical composition of nearly equal proportions of austenite and ferrite. This combination allows the alloy to be stronger and tougher than standard austenitic steels, they are much more resistant to stress corrosion cracking than standard austenitic steels. It is also the strongest Duplex in welded tubular products. Duplex 2205 grade has very high mechanical strength and excellent seawater corrosion resistance for use in some of the most demanding oil and gas, chemical process, desalination and geothermal power applications

Table 1 Chemical Composition

ELEMENTS	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Fe
% Wt	0.03	1.0	3.0	0.01	0.01	23.00	3.50	4.5	0.24	Bal

2.2 Experimental of S31803 Duplex stainless steel

The welding process used in this project is solid state welding process friction welding, which is used to weld the

S31803 stainless steel of diameter 20 mm, length of 80mm, spindle speed of 1100 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 S31803 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 S31803 stainless steels include: seawater cooling pipes, oil transportation pipes, gas scrubbing plants, paper processing industries, acetic, phosphoric and sulphuric acid processing plants oil refinery components, paper processing industries

3. Welding process

The duplex stainless steel are cut into 54 pieces with above 80 mm length pipe by grinding wheel cutting. All the samples are subjected to facing operation in centre lathe machine on both sides for better surface finishing. The welding process chosen here is friction welding. At present duplex stainless steel are welded using friction welding.

Fig 1 specimen dimension

4. Welded Specimen

Fig 4. welded specimen

The welding process used in this project is solid state welding process friction welding, which is used to weld the S31803 stainless steel of diameter 16 mm, length of 80mm, spindle speed of 1100 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 S31803 stainless steel, the welding has to be started from 81 mm length and facing before 1 mm at the weld length of 80mm.

5. Welding parameter

Exp no	Friction load kg	Friction time sec	Forging load kg	Forging time sec
1	1200	22	1300	4
2	1100	20	1200	3
3	1000	18	1100	2
4	1200	22	1300	4
5	1100	20	1200	3
6	1000	18	1100	2
7	1200	22	1300	4
8	1100	20	1200	3
9	1000	18	1100	2
10	1200	22	1300	4
11	1100	20	1200	3
12	1000	18	1100	2

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.

Base metal	156VHN
Heat affected zone	146VHN
Welding zone	136VHN

Table: 6.1 Vickers hardness

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	489
2	1300	20	1400	4	496
3	1300	25	1300	4	535
4	1400	20	1300	4	574
5	1400	20	1400	4	561
6	1450	20	1300	4	538

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 S31803	SPECIMEN NO	LOAD (MPa)	Length (mm)	Time (min)
1	5	956	15	1.56
2	6	1040	14	1.32
3	10	1125	12	1.45

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

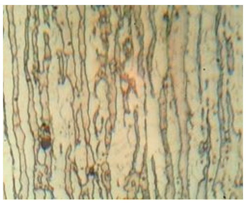
GRADE S31803	SPECIMEN NO	Parameter	Toughness at (RT)
1	7	Test result (joules)	145
2	8		146
3	9		148
		Average (joules)	145

Table 6.4 impact test

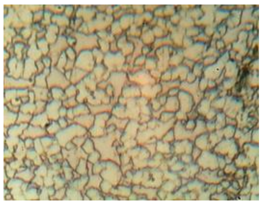
6.5 Microstructure of S31803 stainless steel

Micro structural evaluation ranges from simple determination of certain parameters such as grain size or coating thickness through porosity and pore structure to full characterization of multi-component systems or evaluation of degradation or failure mechanisms.

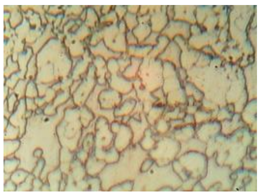
Here we use the micro structural for the determination of grain boundaries on the following three zones. Micro examination is performed for a number of purposes most commonly it is carried out to assess the structure of material for quality purposes: Ensures correct heat treatment is employed Detects unwanted phases and inclusions Identifies where excessive grain boundaries



Base metal



fusion zone



HAZ zone

Fig 6.5 microstructure of S31803 Duplex stainless steel

7. CONCLUSIONS

In this study, Friction welding process parameters were optimized by using response surface methodology. The friction welding process was carried out as per the design of experiments by central composite design. Tensile test was carried out for friction welded samples and the results of the tests are recorded. Based on the experimental results, regression analysis has conducted. Based on the experimentation and optimization the following conclusions are stated:

[1] Specimen having high burnoff length has the high Tensile strength

[2] The Microstructure of the specimen shows the originated grain boundaries over Weld zone, HAZ, Base metal the continuation on the welded area has the high hard

[3] The empirical relations were developed to predict the tensile strength of the friction welded super duplex stainless steel incorporating process parameters at 85% confidence level.

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

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