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EFFECT OF FRICTION TIME ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF FRICTION WELDED INCONEL718 AND SS410 DISSIMILAR JOINTS

[1]Anitha P*, [2]Manik C. Majumdar, [3]Saravanan V and [4]Rajakumar S

[1,2]Department of Mechanical Engineering, National Institute of Technology Durgapur, Durgapur, India.
[3]Department of Engineering, Mechanical Section, Higher College of Technology, Muscat , Oman.
[4]Department of Manufacturing Engineering, Annamalai University, Annamalai Nagar, India.

ABSTRACT

This paper illustrates the influence of friction time on microstructure and mechanical properties of the friction welded Inconel 718 and SS 410 dissimilar joints. The experiments were conducted by varying the friction time 6 sec to 10 sec at 1500 RPM rotational speed and 189 MPa of friction pressure. A total of five experiments were conducted and the corresponding tensile strength and Vickers micro hardness were recorded. A detailed macro and microstructural analysis were performed at the interface for all the joints and presented. It was found that the friction time plays major role on the mechanical properties of the joint and the ultimate tensile strength and hardness was found to be 679 MPa and 406 HV.

Key words: *Friction welding, Friction Time, Microstructure, Tensile strength, Hardness.*

1. Introduction

The joining of conflicting materials grants to accomplish the advantages of divergent materials over and over given that average disclosure to numerous modern applications. The main objective to join dissimilar metals is owing to the combination of favorable properties of mechanical and microstructure of one object and either extensive corrosion resistance or low specific weight of the other substantial metals [1]. However, it is exceptionally hard to deliver a solid joint on account of their poor metallurgical similarity and disparity in mechanical properties [2]. Conventional fusion welding can not be achievable to make a solid joint because of the formation of stress concentration, chemical segregation and development of secondary intermetallic phases. Thus solid state welding procedures like diffusion bonding, explosion welding, friction welding and friction stir welding are the prominent joining techniques in the advanced manufacturing filed[3]. Alloy IN718 is a nickel-iron based super alloy widely used in components for chemical plant equipment and nuclear power plant equipment, aircraft, due to its excellent corrosion resistance and good mechanical properties at high temperatures. Steels are most reliable high strength and less cost structural material. Hence bimetallic joint of IN718 with SS410 are required to investigate in the current manufacturing technology.

Friction welding process is a solid state welding technique by which significant heat is produced on the faying surface of two components under a certain combination of pressure, time, speed and surface roughness of weld face [4]. Heat is produced by the friction, which makes the metal to become soft and forms the joint before reaching plastic deformation. After the interface plastic deformation a metallurgical bond is developed by axial forging immediately due to relative movement. Since the filler material is not used, friction welding eliminates the undesirable effects of low temperature eutectic segregation and problems associated with the selection of filler materials [5]. The significance of this friction welding technique has been extended the noticeable quality in the manufacturing business.

The strength of friction welding influencing the best welding technique for similar and dissimilar metals for the most extreme economical and higher production rates and extraordinarily proficient joints, higher in imitate, less fabrication time and low imperativeness input [6]. The greatest benefits of friction welding compared with other conventional method are less power consumption and short duration of the process. The major parameters influences these processes are rotational speed, friction pressure, friction time, forging pressure and forging time [7].

V.V. Satya Narayana *et al.* investigated the main parameters such as friction pressure, forge pressure and burn-off length. They observed that the weld interface region consists of fine grains compared to the peripheral region. They concluded

**Corresponding Author - E- mail: anithavlr@yahoo.com*

that forge pressure forms fine grains while friction pressure forms the coarse grains [8]. R. Palnivel *et al*. studied the influence of process parameters of rotational speed, friction pressure and burn-off length of friction welded titanium tubes. They observed that lower values of process parameter formed the weak joints because of pores and insufficient consolidation of plasticized material. Similarly higher ranges of parameters also produced lower strength of joints due to the emission of excessive hot material from the interface zone [9]. The effect of friction pressure on the properties of hot rolled iron based super alloy has been investigated by Afes. Haken. They examined that the impact of friction time on microstructure and tensile strength of the friction welding of dissimilar metal combinations [10]. The published information on the effects of process parameters (rotational speed, friction time and forging pressure) on the microstructure and mechanical properties of the friction-welded joints is very significant to produce the quality joint. Hence, the aim of the present work is to find out the effect of friction time on the mechanical properties of joint as well as the microstructural characterization of the interface for friction welded IN718 with SS410.

2. EXPERIMENTAL WORK

Friction welding was carried out by using continuous rotary friction welding with constant speed of 1500 RPM as shown in Fig.1. The materials used in the experiment were IN718 and SS410 of rolled cylindrical rod with 12mm in diameter and 75 mm length. IN718 rod was clamped securely in a rotating spindle wherein SS410 was fixed in stationary clamp as represented in Fig.2.

The base metals were tested to examine the physical and mechanical properties and are shown in the Table1 and 2. A several number of trial runs were carried out using IN718alloy to SS410 to find out the feasible working limits of friction welded process parameters. Fabrication of five defect free-welded joint was obtained by varying the friction time from 6 sec to 10 sec. These working parameters was derived by inspecting macro structure of joint without having any visible defects.

Fig.1 Friction welding Machine

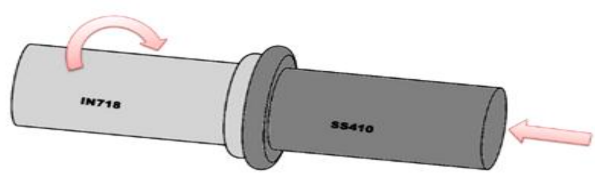

Fig. 2 Friction welded joint of IN718/SS410

The friction pressure and rotational speed were kept constant 189 MPa and 1500 RPM respectively. Fig.3. shows the friction-welded sample. The tensile specimens were turned from these joints as per ASTM E8 standards. The ultimate tensile strength for all the joints were evaluated in universal testing machine and further macro and microstructural studies are carried out optical microscope at the welded interface region. The chosen values of the friction-welded parameters are presented in Table3.

Table 1. Chemical composition (wt. %) of IN718 and SS410

Materials	Ni	Cr	Mo	C	Mn	Si	S
IN 718	53	19	3	0.06	0.32	0.31	0.13
SS410	0.7	12.3	-	0.13	0.83	0.8	0.03

Table 2. Mechanical Properties of base metals

Material	Tensile Strength (MPa)	Yield Strength (MPa)	% Elongation	Micro Hardness (HV)
IN 718	1035	1025	30	521
SS 410	657	595	23	221

Table 3. Friction welded parameters Values

Specimen	Rotational Speed (RS) (RPM)	Friction Pressure (FS) (MPa)	Friction Time (FT) (sec)
S1	1500	189	6
S2	1500	189	7
S3	1500	189	8
S4	1500	189	9
S5	1500	189	10

3. RESULTS AND DISCUSSION

A defect free dissimilar joint of Inconel 718 and SS410 were made by friction welding procedure by varying the friction time speed and keeping other parameters as constant. The friction welded specimen of five different timings are shown in Fig .3.

Fig. 3 Sample welded specimen

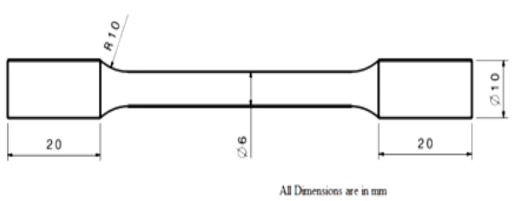

Fig. 4 Tensile specimen

The effect of friction time on tensile strength, hardness, macro, and microstructure in the friction surface were discussed in detail and presented.

3.1 Effect of Friction Time on Tensile strength

The dimensions of the tensile specimen was shown in Fig.4. Tensile specimen were prepared from the five different specimen and tested as per ASTM E8 standards for its ultimate tensile strength using UTM of 1000KN capacity. There are various parameters which can affect the tensile strength of joint but friction time has the significant influences on friction tensile strength [11]. The test reveals that if the friction time increases then the tensile strength also increases to attain maximum strength then declines with the further escalation in friction time. This decrease in tensile strength associated with the longer friction time causes a broad diffusion zone with intermetallic phases. Therefore, to attain a high strength, the friction time should be kept for shorter friction times. However the friction time is very low the bond have a defects such as cracks, pores, distortions, isolated areas, etc. Fig 5 shows the tensile strength obtained at different friction time by keeping other parameters constant. Among the five different friction time, the joint fabricated at the friction time of 8 Sec achieved high tensile strength of 679 MPa.

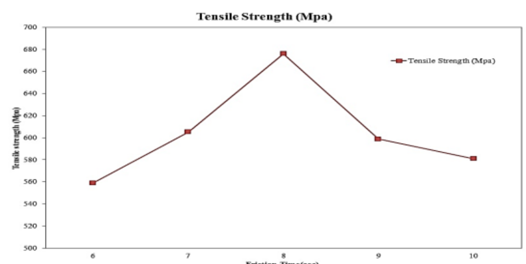

Fig. 5 Effect of friction time on tensile strength

3.2 Effect of Friction Time on Hardness

From the Fig.6, it is observed that as friction time increases, the hardness also increases at the interface of the joint. There is a maximum value of the hardness attained with the friction time of 8 sec. After the optimum level of 8 sec, hardness begins decreasing with the increasing friction time. The optimum friction time is 8 sec at which maximum hardness of 406 HV was obtained. The maximum hardness in the interface region was mainly a due to friction and oxidation process, which takes place during joining process and leads to the formation of brittle intermetallic layer.

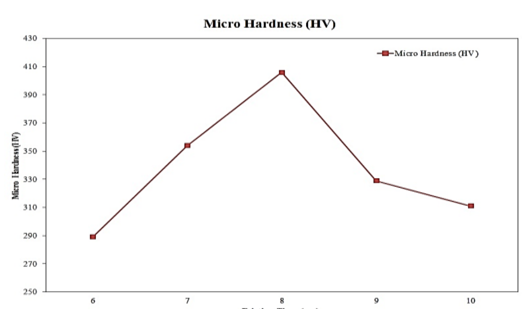

Fig. 6 Effect of friction time on hardness

3.3 Structural characterization

The following observations were remarked from the macroscopic and microscopic analysis made for the joint for different friction time of dissimilar joint of IN 718 with SS410.The macro image reveals the occurring of weld flash of assorted material at different friction time as shown in Fig.7 (a) & (b). The resulted friction weld joints exhibits that low friction time forms less amount of flash wherein longer friction time emits higher amount of flash.

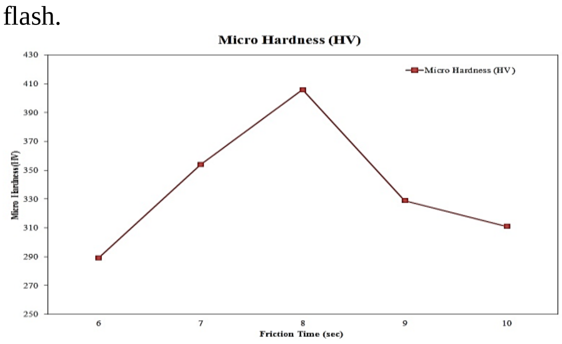

Fig. 6 Effect of friction time on hardness

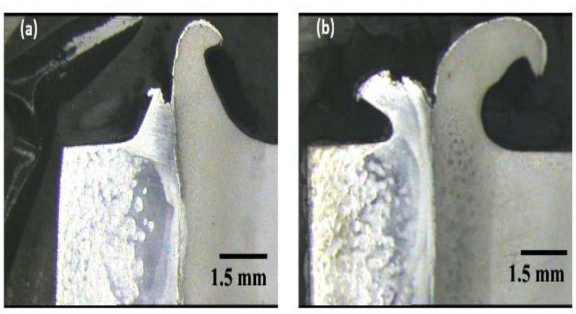

Fig. 7 Macro Structure of the joint welded at (a) 6 sec (b) 8 sec

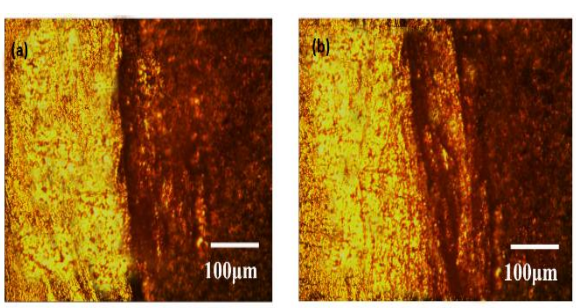

Fig. 8 Micro Structure of the joint welded at (a) 6 sec (b) 8 sec

The microstructure view of interface of the joint at different friction time has shown in Fig. 8 (a) & (b). The variations of the weld zone are clearly visible. The size of weld zone increases with increasing friction time due to high amount of heat generation during the friction time [12]. But less friction time formed narrow interface region.

4. CONCLUSIONS

In this study, a trial has been made to investigate the effect of friction time on tensile strength of dissimilar IN 718 and SS 410. From this investigation, the following inferences were arrived:

1. The maximum tensile strength of 679 MPa achieved at the friction time of 8 sec with the rotational speed of 1500 RPM and friction pressure of 189 MPa.
2. Tensile strength increases with the increase in friction time to attain a peak value and declines with further increasing of friction time, which observed at friction time of 10 sec.
3. Micro hardness test revealed that, the trend of hardness values increased with increase in friction time up to maximum and reduced in hardness value of further increasing friction time. The maximum hardness of 406 HV recorded at 8 sec of friction time.
4. Longer friction time forms a well degree weld zone and with refined grain structure, but shorter friction time forms the narrow weld zone.

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