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Exploration of Diffusion Welding Of AISI 304 Stainless Steel Plates

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Abstract: Diffusion bonding method is an alternate method to join similar and dissimilar materials with minimum dimensional tolerance. It is one of the solid-state process in which two metallic surfaces are made to contact at the elevated temperature and pressure. Diffusion bonding process provides elevated quality joints without post-weld machining. The main process parameters of diffusion bonding include temperature, pressure and holding time. In diffusion bonding technique microstructural changes were fashioned in the base metal which determines the mechanical properties of the bond at the boundary. Diffusion bonding method can be used to weld the dissimilar materials with different chemical and mechanical properties. The present work determines the control of process parameters on diffusion bonded joints of AISI 304 stainless steel plates. Experimental investigation on the microhardness, lap shear test was made for diffusion bonded couples and outcome are summarized.

Keywords: Stainless steel, Diffusion Bonding, Microhardness, Lap Shear Test.

1. INTRODUCTION

Diffusion bonding is a solid-state joining process in which two sparkling metallic surfaces are brought into contact at eminent temperatures under low pressure [1] Diffusion bonding produces high-quality joints without post weld machining [2] Diffusion bonding can be accomplished. In order to produce a high-quality joint by diffusion bonding, the two contact surfaces of the materials to be joined should be smooth, which increases the atomic diffusion between the surfaces [3, 4]. Similar and dissimilar materials can be joined by diffusion bonding technique. To produce metallurgical joint between dissimilar metals faster diffusion rate between the materials is necessary, which is accomplished by higher bonding temperature and longer holding time [5-7]. Diffusion bonded plates of stainless steel play a vital role in nuclear industries.

2. EXPERIMENTAL INVESTIGATION

The surfaces of both plated are refined with various grades of emery paper and cleaned. AISI 304 Stainless Steel plates were cut into dimensions of 50mmx50mm square samples acetone. Both the plates are placed one above the other and stacked in a die. This setup is kept in a vacuum chamber at a pressure of -29mm of Hg. Based on the literature review, parameters like temperature, holding time and pressure are selected. The specimens were heated, using a furnace at a heating rate of 20°C/min at a pressure of 5MPa. Generally, the levels of temperature selected will be in the range of 0.6 - 0.7 Tm (Tm is the absolute melting temperature). After diffusion bonding, the samples were cooled to the room temperature in the furnace.

Table: 1 Chemical Composition of AISI 304 Stainless steel

C	**Si**	**Mn**	**Cr**	**Ni**	**Cu**	**V**	**S**	**P**	**Fe**
0.04	0.524	0.829	18.761	8.765	0.195	0.013	0.014	0.011	Remainder

3. RESULTS AND DISCUSSION

3.1 **Assessment of Lap Shear Test Results**

The lap shear tensile specimen is prepared using wire cut electrical discharge machine. Lap shear test for all the joints has been carried out in the universal testing machine with a capacity of 100tons.The lap shear test results of the joints are tabulated in table 3.It is pragmatic that highest strength of 20.415KN was obtained for the joint No:6 bonded at 825^{0}C for 90min at 5MPa. At squat joining temperatures and holding times, the bonding strength is lower, owing to the incomplete coalescence of the mating surfaces. The diffusion layer twisted at the interfacial regions confirms the formation of intermetallic compounds, which give high strength to the joints. When the temperature is elevated, the atoms relocate from either side of the materials to each other. When the temperature is not adequate the movement of atoms on either side takes place at a low level and hence the strength of joints is very low down and thereby the quality of the joint is also low.

Table: 2 Process Parameters

Joint number	Parameters
1	700^{0}C, 40mins, 5MPa
2	750^{0}C, 60mins, 5MPa
3	780^{0}C,90mins,5MPa
4	800^{0}C, 40mins, 5MPa
5	820^{0}C, 60mins, 5MPa
6	825^{0}C, 90mins, 5MPa

Table 3: Lap shear test results

S.NO	**Particulars**	**Joint No:1**	**Joint No:2**	**Joint No:3**	**Joint No:4**	**Joint No:5**	**Joint No:6**
1	Break load (KN)	5.615	7.302	8.200	10.915	12.105	20.415
2	Max Displacement(mm)	1.500	3.300	2.900	4.500	4.500	7.300
3	Area(mm^{2})	300	300	300	300	300	300
4	Ultimate stress(KN/mm^{2})	0.016	0.013	0.016	0.017	0.015	0.015
5	Elongation %	12.667	13.451	14.667	13.997	15.667	16.125
6	Yield stress(KN/mm^{2})	0.026	0.013	0.017	0.018	0.014	0.015
7	YS/UTS Ratio	1.057	1.300	0.898	0.9	0.9	0.828

3.2 Hardness measurements

The microhardness measurements were performed using micro Vickers hardness tester. Readings were taken at regular intervals on both sides of the interfacial regions. The figure (a-f) shows the hardness profiles of all the joints. It is experimental that the hardness values increases considerably in the diffusion region due to the arrangement of the intermetallic compounds. Hardness material of the Stainless steel is 256HV. It is observed that the hardness value in the diffusion region is almost same as that of parent material.

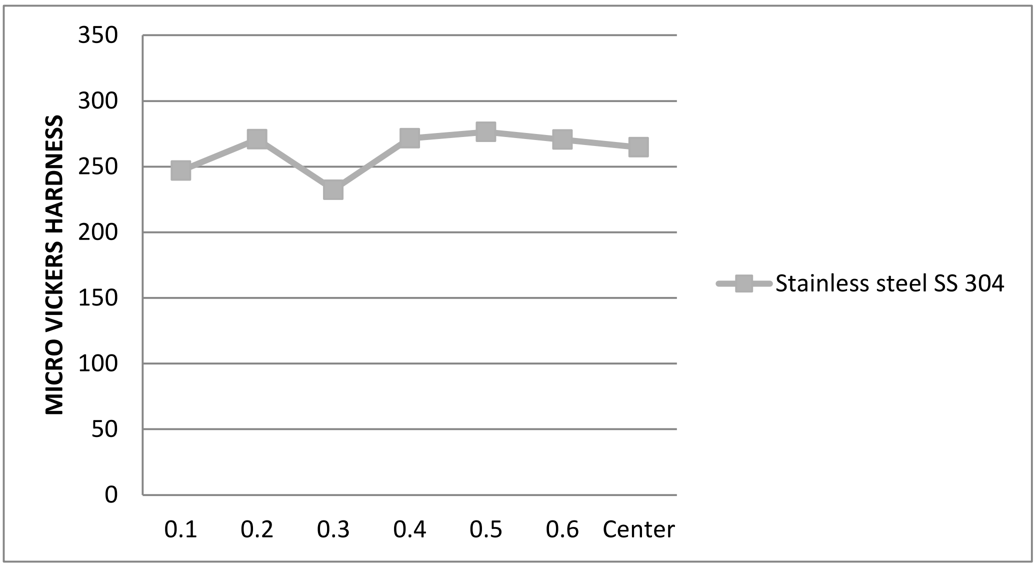


Fig a. Joint No:1

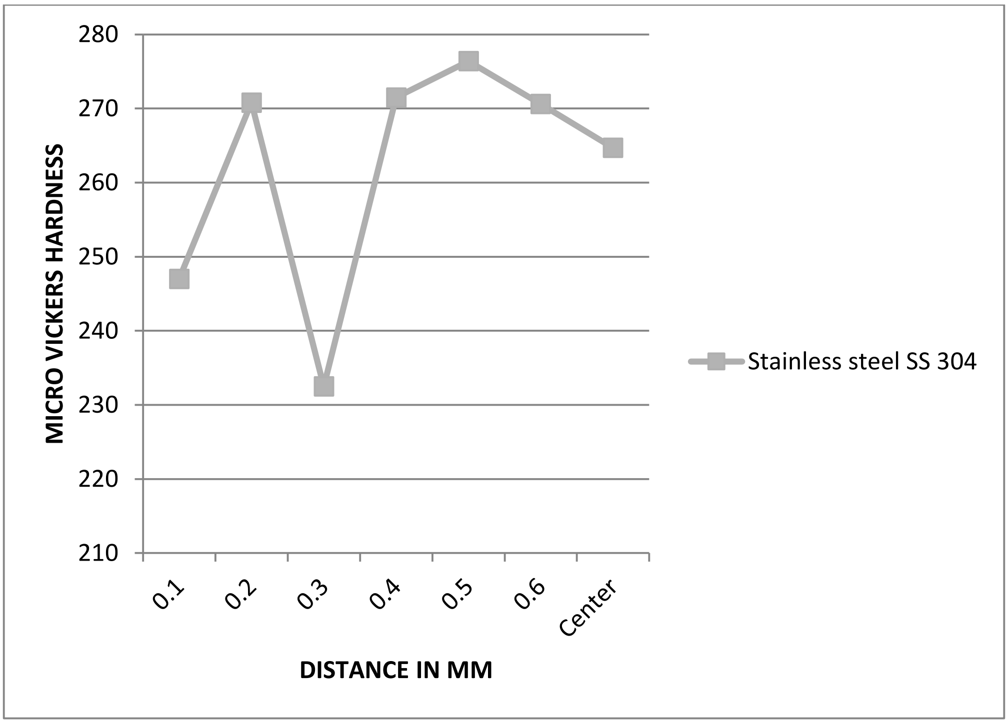


Fig c: Joint No: 3

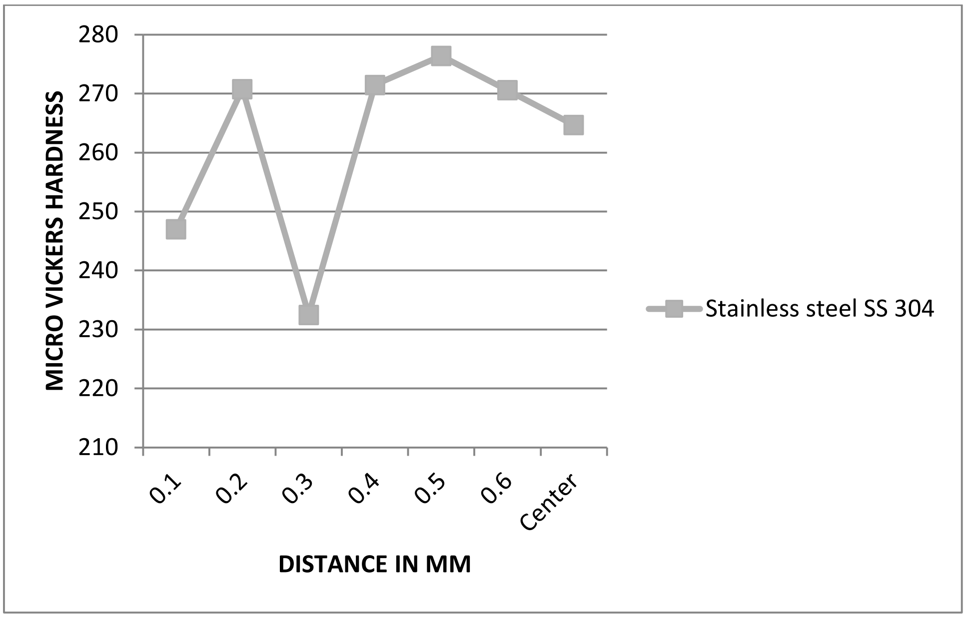


Fig d: Joint No: 4

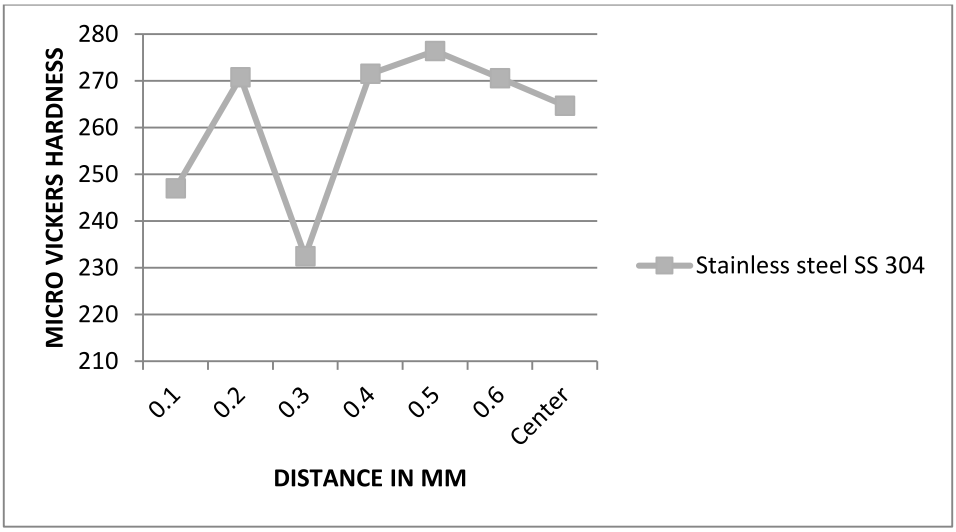


Fig 4e.Joint No :5

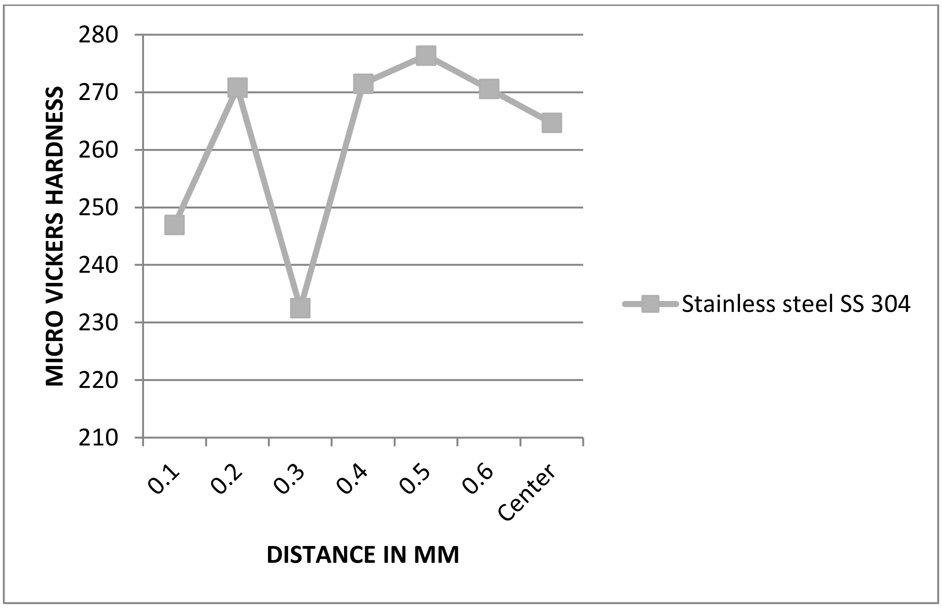
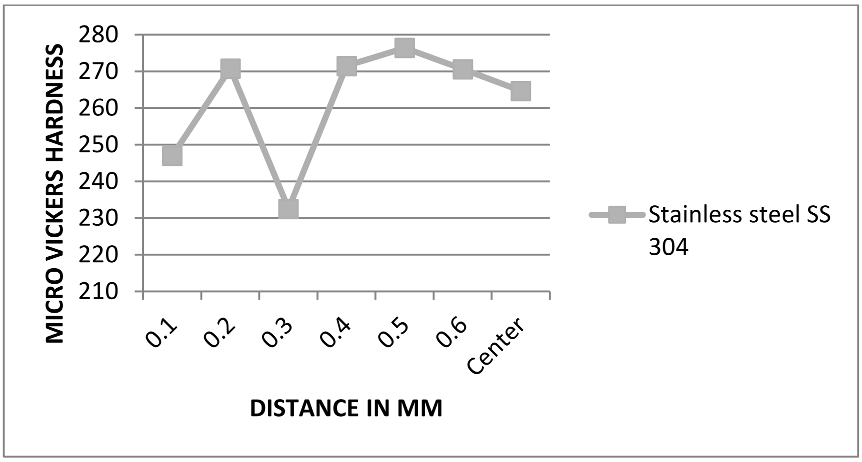


Fig 4f: Joint No : 6



CONCLUSIONS

In the present study, the properties of diffusion bonded AISI 304 Stainless Steel were investigated. Bonding was carried out at temperatures from 700°C to 850°C for holding times of 40, 60 and 90 minutes under 5 MPa load in a Vacuum atmosphere. Based on the experimental investigation and testing, following conclusions are drawn.

Joints fabricated at 825°C, 90min and 5MPa have the maximum lap shear strength, due to better coalescence of the mating surfaces. The bonding strength is high at the interface due to the formation of intermetallic compounds. However, the bonding strength decreases after 825˚C because the width of the brittle intermetallic compounds increases noticeably which acts as a barrier for the quality of the joint.

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