Hardness of Rotary Friction Welding for Similar and Dissimilar Metals

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ABSTRACT

Aim of this paper is to determine the hardness of rotary friction welding for similar and dissimilar materials. Rotary friction welding is one of the important welding method to joined the various rods of materials and alloys etc. the work carried out on modified lathe machine attached with two self chuck, one is in rotational and another one is fixed. The material used to carry out this work 10 & 14 mm in diameter rods of Aluminium, Copper, Brass and Mild Steel. It is observed that the value of hardness at HAZ was lower; the hardness for copper and brass materials were higher compared to the other metals joints.

KEY TERM: Lathe Machine; Rotary Friction; Process Parameters; Welding; Hardness.

INTRODUCTION

Friction welding is a solid state joining technique by applying rotational speed and pressure at motion less work piece to join metal without any defect, porosity and no cracks propagation in the weld zone with fine grain structure etc due to thermo mechanical effect [1]. It has wide number of application such as automobile, aerospace, nuclear, electrical, chemical, cryogenic and marine etc [2]. The advantages like no material waste, production time is less and low energy expenditure in it [3]. The factor affecting the weld includes various rotational speeds, frictional load and weld duration [4]. In this process the conversion of mechanical energy to thermal energy and no other source is required [5]. A novel and energy efficient rotary friction welding technology can be achieved a high production rate; it was introduced and developed in Oak Ridge National Laboratory (ORNL) at south wire company by W. Thomas of the institute of welding (TWI) [6,7]. While developing this technique to join various alloys, other metals can be fabricated into useful components and many investigations to exploit their excellent high temperature mechanical properties and oxidation resistance [8]. Where as in conventional fusion welding, the use of carbon electrode results in very hard formation, crack susceptible structure on steel side of dissimilar metal welded joint and along the fusion line of ferrite side of the joint discontinuous brittle and hard zones gets formed [9]. In solid state welding process to restrain the form of inter metallic compound to increases the bond strength and nodular cast iron composites can be join [10]. In the present work the results were reported at and near the HAZ have measured.

EXPERIENTAL WORK

Rotary friction welding is a novel technology to join the metal rods of similar and dissimilar materials such as Aluminum alloy, Copper, Brass and Mild Steel of two diameters i.e. 10 and 14 mm round rods with 100 mm length shown in Fig.4. The various combinations materials like MS-MS, MS-Al, Cu-Brass and Al-Al have been carried out at rotational speeds of 1250 and 2350 rpm on modified lathe machine shown in Fig.3. The process parameters that influence the weld formation while performing welding operations such as Friction load, Temperature, Time of welding and Diameter of specimens etc. The normal lathe machine have been modified to rotary friction welding lathe machine setup by changing the 3phase induction motor 1.8 KW power and 2800 rpm in order to achieve higher speeds for rotary friction welding and a disc plate with disk brake attached to chuck plate to stop suddenly after getting weld joint as shown in Fig.1and Fig.2. The experiment was carried out on modified lathe machine at two different speeds with various material combinations as shown in Fig.4. After joining the materials, hardness test have been carried out on Rockwell Hardness tester.

Fig.1. Disc Brake

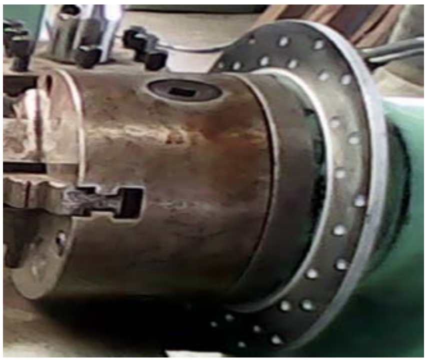

Fig.2. Disc Plate

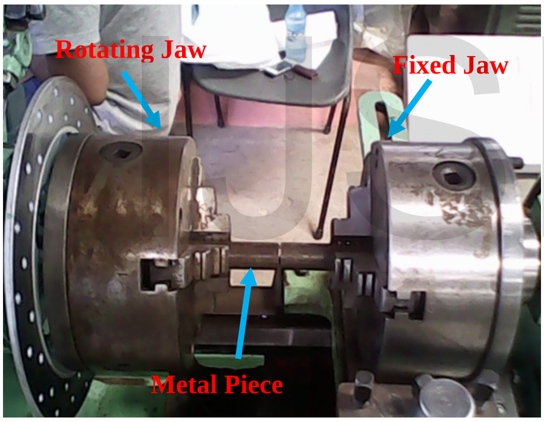

Fig.3. Modified Lathe machine Setup

Fig.4. Metal pieces with different diameter

Fig.5. Rotary Friction Welded specimen for similar and dissimilar

RESULT AND DISCUSSION

The Specimens of different materials combination and sizes are shown in table.1. The work carried out at two different speeds (1250 & 2350 rpm) of rotation at 1 kN frictional load. The hardness was carried out on Rockwell Hardness tester (RHN) for the welded specimens shown in Fig.5.

Table.1. Rotary Friction welded specimens at 1250 rpm tested on Rockwell hardness tester.

Material Combinations	Scale used	Indenter used	Minor load (kg)	Major load (kg)	RHN		
					At weld zone	5 mm from weld zone	10 mm from weld zone
Friction Welded Ø10 mm Specimens At 1250 rpm Speed							
1.MS-MS	C	Diamond cone, 120◦	10	140	24	32	37
2a.MS	C	Diamond cone, 120◦	10	140	28	32	38
2b.Al	B	1/16” ball indenter	10	90	17	19	22
3a.Cu	B	1/16” ball indenter	10	90	55	48	41
3b.BRASS	B	1/16” ball indenter	10	90	44	69	82
4.Al-Al	B	1/16” ball indenter	10	90	18	19	21
Friction Welded Ø14 mm Specimens At 1250 rpm Speed							
1.MS-MS	C	Diamond cone, 120°	10	140	21	29	33
2a.MS	C	Diamond cone, 120°	10	140	26	28	29
2b.Al	B	1/16ball indenter	10	90	16	18	23
3a.Cu	B	1/16” ball indenter	10	90	61	49	45
3b.BRASS	B	1/16” ball indenter	10	90	42	66	82
4.Al-Al	B	1/16” ball indenter	10	90	17	19	20

Table.2 Rotary Friction welded specimens at 2350 rpm tested on Rockwell hardness tester.

Material Combinations	Scale used	Indenter used	Minor load (kg)	Major load (kg)	RHN		
					At weld zone	5 mm from weld zone	10 mm from weld zone
Friction Welded Ø10 mm Specimens At 2350 rpm Speed							
1. MS-MS	C	Diamond cone, 120°	10	140	36	48	56
2a.MS	C	Diamond cone, 120°	10	140	38	40	42
2b.Al	B	1/16” ball indenter	10	90	14	14	15
3a.Cu	B	1/16” ball indenter	10	90	53	44	40
3b.BRASS	B	1/16” ball indenter	10	90	44	69	84
4.Al-Al	B	1/16” ball indenter	10	90	13	12	11

Friction Welded Ø14 mm Specimens At 2350 rpm Speed							
1.MS-MS	C	Diamond cone, 120◦	10	140	24	32	36
2a.MS	C	Diamond cone, 120◦	10	140	25	26	37
2b.Al	B	1/16” ball indenter	10	90	15	16	20
3a.Cu	B	1/16” ball indenter	10	90	58	46	42
3b.BRASS	B	1/16” ball indenter	10	90	45	68	85
4.Al-Al	B	1/16” ball indenter	10	90	12	16	17

From the above table it is observed that the hardness value of brass is higher then the other material joints and least values of hardness are for aluminium alloy at weld zone. However, as the distance increase from the center of weld zone then the hardness values increases. Where as in copper and aluminium are the hardness values were decreases.

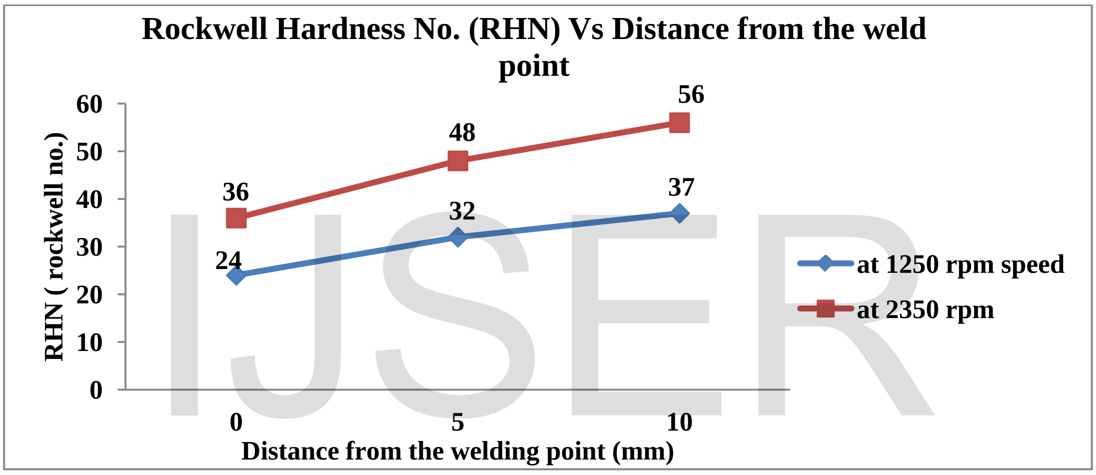

Fig.6. Hardness of MS-MS Ø10 mm Materials Vs Distance from weld

From the graph the as the speed increase the hardness value increases. The hardness value is higher for 2350 rpm of speed and lower value of hardness for 1250 rpm of speed.

CONCLUSIONS

1. The work carried out on the modified conventional lathe machine setup was design and fabricated.
2. It is observed that the hardness gradually increased from the weld zone. However, for aluminum material it is vice versa.
3. It is concluded that the hardness value of brass is higher then the other welded joints and least is value of hardness is for aluminium at weld zone.
4. As the distance increases from the weld zone then the hardness value increases. Where as in copper and aluminium it is vice versa.
5. As the speed increases the hardness value was increases and higher for the speed of 2350 rpm and lower value of hardness for 1250 rpm.

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