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Effect of Speed on Hardness in Rotary Friction Welding Process

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Abstract

Aim of this paper was to determine the hardness in rotary friction welding by varying speed. It is a solid state welding technology to join material by applying linear force to join the materials. The work was carried out on modified conventional lathe machine attached with two self chucks, one is in rotational and another one is fixed. The material diameter was used 10 & 14 mm in diameter rods of similar and dissimilar material with four combination of set (MS-MS, MS-Al, Cu-Brass, and Al-Al). It was observed that the value of hardness at HAZ is softer and harder away from the HAZ.

Key Term: Lathe Machine; Rotary Friction; Speed; 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 were measured.

EXPERIMENTAL WORK

Rotary friction welding is solid state welding technology to join the metal rods of similar and dissimilar materials such as Aluminum alloy, Copper, Brass and Mild Steel of 10 and 14 mm round rods with 100 mm length was used as shown in Fig.1. The various combinations of materials such as MS-MS, MS-Al, Cu-Brass and Al-Al were carried out at a rotational speed of 1600, 2000 and 2700 rpm on modified conventional lathe machine as shown in Fig.2. 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 conventional lathe machine was modified to rotary friction welding machine setup by changing the 3-Phase induction motor, 1.8 KW power and 2800 rpm, in order to achieve higher speed of 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.3. The experiment was carried out on modified conventional lathe machine at various speeds with various material combinations as shown in Fig.4. After welded joint, hardness test was carried out on Rockwell Hardness tester.

Figure.1: Types of Materials with different diameters

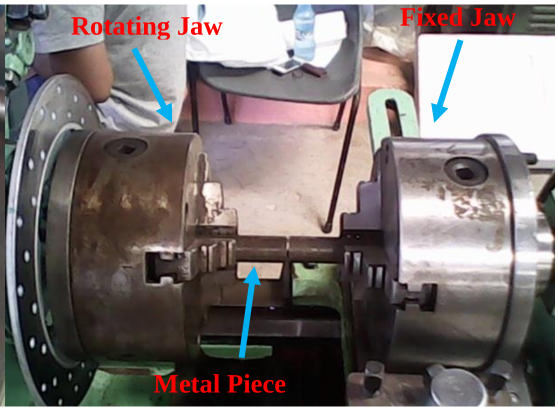

Figure.2: Modified Conventional Lathe machine Setup

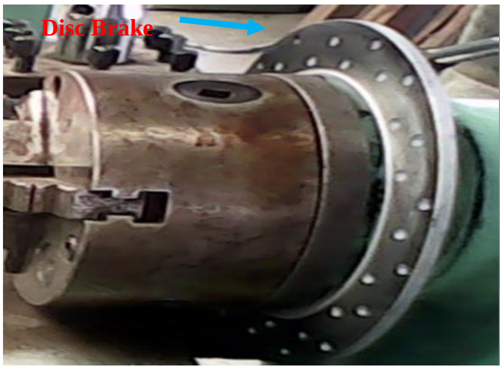

Figure.3: Disc Plate to stop the moving jaw

Figure.4: Welded specimens for similar and dissimilar metals

RESULT AND DISCUSSION

The Specimens of different materials combination and sizes are shown in table.1. The work carried out at various speeds (1600, 2000&2700 rpm) of rotation at 1kN frictional load. The hardness was carried out on Rockwell Hardness tester (RHN) for the welded specimens tabulated below table.

Table.1: Rotary Friction welded specimens at 1600 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 1600 rpm Speed							
1.MS-MS	C	Diamond cone, 120◦	10	140	28	36	43
2a.MS	C	Diamond cone, 120◦	10	140	32	35	39
2b.Al	B	1/16” ball indenter	10	90	16	17	20
3a.Cu	B	1/16” ball indenter	10	90	54	47	41
3b.BRASS	B	1/16” ball indenter	10	90	41	66	81
4.Al-Al	B	1/16” ball indenter	10	90	16	17	19
Friction Welded Ø14 mm Specimens At 1600 rpm Speed							
1.MS-MS	C	Diamond cone, 120˚	10	140	22	30	34
2a.MS	C	Diamond cone, 120˚	10	140	25	28	32
2b.Al	B	1/16ball indenter	10	90	15	17	22
3a.Cu	B	1/16” ball indenter	10	90	60	48	44
3b.BRASS	B	1/16” ball indenter	10	90	42	67	83
4.Al-Al	B	1/16” ball indenter	10	90	15	18	19

Table 2: Rotary Friction welded specimens at 2000 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 2000 rpm Speed							
1. MS-MS	C	Diamond cone, 120°	10	140	32	41	49
2a.MS	C	Diamond cone, 120°	10	140	35	37	40
2b.Al	B	1/16" ball indenter	10	90	15	16	17
3a.Cu	B	1/16" ball indenter	10	90	53	45	40
3b.BRASS	B	1/16" ball indenter	10	90	44	69	83
4.Al-Al	B	1/16" ball indenter	10	90	14	15	16
Friction Welded Ø14 mm Specimens At 2000 rpm Speed							
1.MS-MS	C	Diamond cone, 120°	10	140	23	31	35
2a.MS	C	Diamond cone, 120°	10	140	25	27	35
2b.Al	B	1/16" ball indenter	10	90	15	17	21
3a.Cu	B	1/16" ball indenter	10	90	59	47	43
3b.BRASS	B	1/16" ball indenter	10	90	43	67	84
4.Al-Al	B	1/16" ball indenter	10	90	14	17	18

Table 3: Rotary Friction welded specimens at 2700 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 2700 rpm Speed							
1. MS-MS	C	Diamond cone, 120°	10	140	40	55	65
2a.MS	C	Diamond cone, 120°	10	140	40	43	44
2b.Al	B	1/16" ball indenter	10	90	13	12	11
3a.Cu	B	1/16" ball indenter	10	90	54	43	40
3b.BRASS	B	1/16" ball indenter	10	90	45	69	85
4.Al-Al	B	1/16" ball indenter	10	90	13	11	11
Friction Welded Ø14 mm Specimens At 2700 rpm Speed							
1.MS-MS	C	Diamond cone, 120°	10	140	25	33	37
2a.MS	C	Diamond cone, 120°	10	140	24	26	39
2b.Al	B	1/16" ball indenter	10	90	14	16	19
3a.Cu	B	1/16" ball indenter	10	90	57	45	42
3b.BRASS	B	1/16" ball indenter	10	90	46	70	86
4.Al-Al	B	1/16" ball indenter	10	90	10	14	16

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

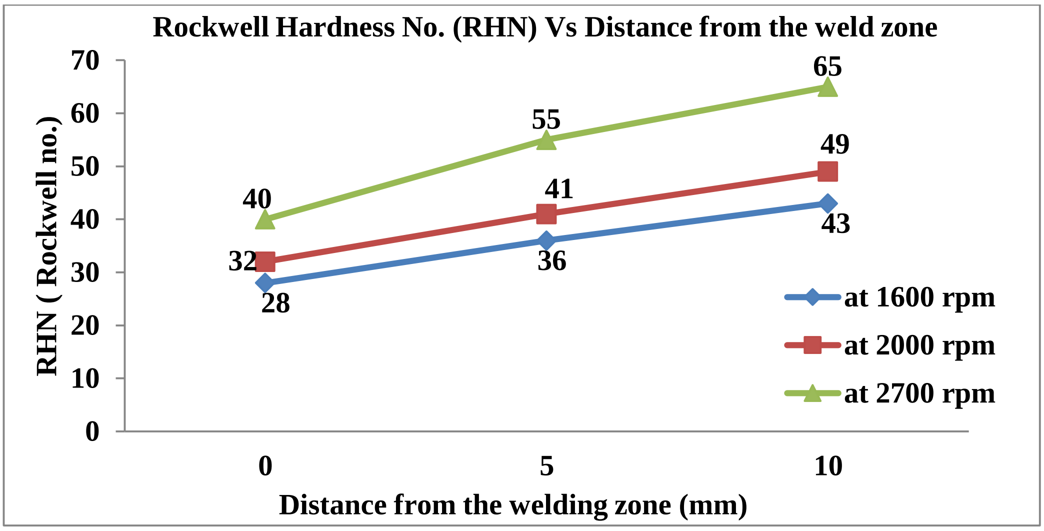

Figure.5: Hardness of MS-MS Ø10 mm Materials Vs Distance from weld zone

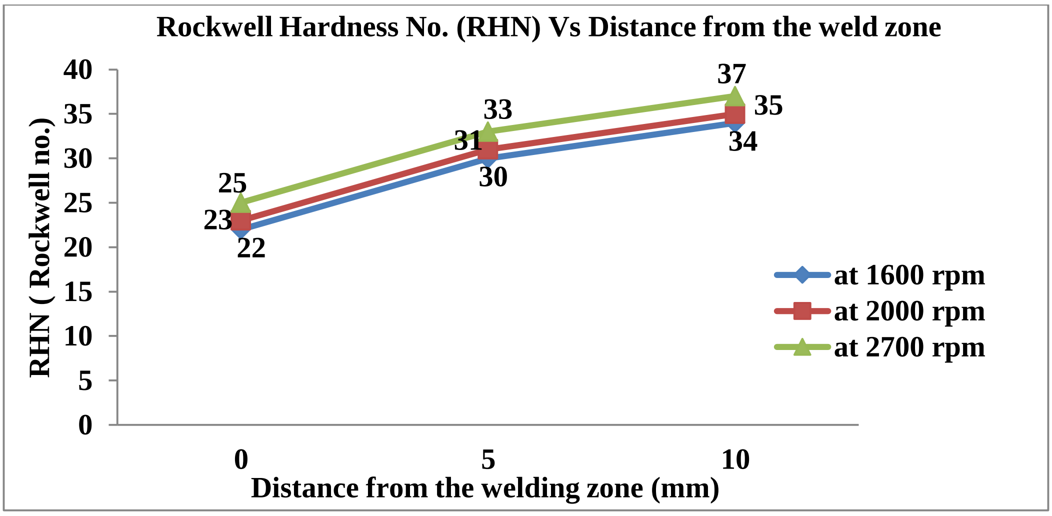

Figure.6: Hardness of MS-MS Ø14 mm Materials Vs Distance from weld zone

From the graphs (Fig.5 & Fig.6) as the speed increases the value of hardness increases. The hardness value was higher for 2700 rpm of speed and least value of hardness for 1600 rpm of speed. It was observed that the hardness of Ø10 mm rod is higher than the Ø14 mm rod.

CONCLUSIONS

1. The work was carried out on the modified conventional lathe machine setup has been design and developed shown in Fig.2.
2. It was observed that the hardness values were gradually increased from the weld zone. Where as in aluminum material it vice versa.
3. The hardness value of brass was higher than the other welded joints and least value of hardness was for aluminium at welded zone.
4. The hardness value was increases as the distance increases from the welded zone. Where as in copper and aluminium at welded zone hardness values were decreased.
5. As the speed increases the hardness values were increases and higher values of hardness for the speed of 2700 rpm and least value of hardness for 1600 rpm.
6. It was observed that the hardness value of Ø10 mm rod is higher as compared with Ø14 mm rod.

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