International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 1, No. 3, October 2012

Research Paper

TO STUDY THE MECHANICAL BEHAVIOUR OF FRICTION WELDING OF ALUMINIUM ALLOY AND MILD STEEL

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Friction welding is a solid state joining process used to join similar and dissimilar metals, not possible with other available welding techniques. Now a day's Friction welding is most commonly used in industry that is aeronautical engineering, automobile engineering, submarine industry and heavy industry. In this research work, friction welded joint of dissimilar metals was made to evaluate the mechanical properties of mild steel and aluminium alloy bimetallic joint.

Keywords: Friction welding, Ultimate tensile strength, Micro hardness, Scanning electron microscope, Chemical composition

INTRODUCTION

Friction welding is defined by the different authors by adopting various definitions of friction welding. The friction welding is a Solid state welding process or the method of manufacturing for joining different types of metals, i.e., ferrous metals and non ferrous metals (dissimilar metals). In the friction welding there are two components, the rapid rotation of one component at high rpm and other component is brought into contact at high forging pressure to get upset. As the market trends of heavy industries, locomotives, shipyard engineering, three dimensional engineering, automobile, and in welding research engineering, bimetallic joints are most needed for light, tough, strong, economical corrosion resistant parts and components. All these requirements cannot be fulfilled by one metal or alloy. Joints of similar and dissimilar metal combinations are employed in different applications requiring some special combination of various types of mechanical properties as hardness, tensile strength, brittleness, malleability etc. and also to save cost incurred towards costly and scarce materials (Ozdemir, 2005). In friction welding, heat is generated by friction when the

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two materials joined together (one is rotate and another specimen is stationery) the temperature and pressure increase so the mechanical energy convert into thermal energy. then it is (friction welding) so easy to join ferrous metal and non ferrous metal, there are some parameter used in friction welding as forging (upset) time, forging (upset) pressure Friction time, friction pressure, Temperature measurement, Burn off length and rotation speed (Vill, 1962). Here are some advantages and disadvantages of solid state friction welding, viz., low heat input, ecofriendly, and low cost are some advantage and disadvantages of friction welding is the high heat input, initially high cost to set up process and non-matching filler wire. The friction welding based on some parameter that is pressure, temperature, weld time, and burn off length (Ananthapadmanaban *et al.*, 2008). It is to know that the properties of hot rolled iron based super alloy friction pressure effect has been investigated (Hakan *et al.*, 2007). The friction welding is more challenging than other conventional welding processes there are many problems faced because of the dissimilar metals to be weld each other the, hardness, strength, and other parameter which is not same as the similar metal not only these parameter but also some other parameter like brittleness, malleability and melting point are also create problem while welding time (Fomichev, 1980). To investigate the selection of material at desirable conditions in all situations as used in friction welding (solid state welding process) for the friction welding of high speed steel to carbon steel has been carried out (Mumim, 2007). For the sake of friction welding it is to know that the mechanical, chemical and metallurgical Properties of friction welded steel-aluminium and aluminium-copper bar using factorial analysis has been investigated (Yilbas, 1995).

MATERIAL AND METHODS

Material

The material used in this experiment was aluminium alloy and mild steel (al-alloy and C/Fe). All the specimens were made in cylindrical form having 12 mm diameter and 75 mm length as shown in Figures 1 and 2. A vertical milling machine was used for friction welding process as shown in Figure 3.

Figure 1: A Photograph of Material Sample of Mild Steel

Figure 2: A Photograph of Material Sample of Aluminium

Figure 3: Continuous Drive Friction-Welding Setup

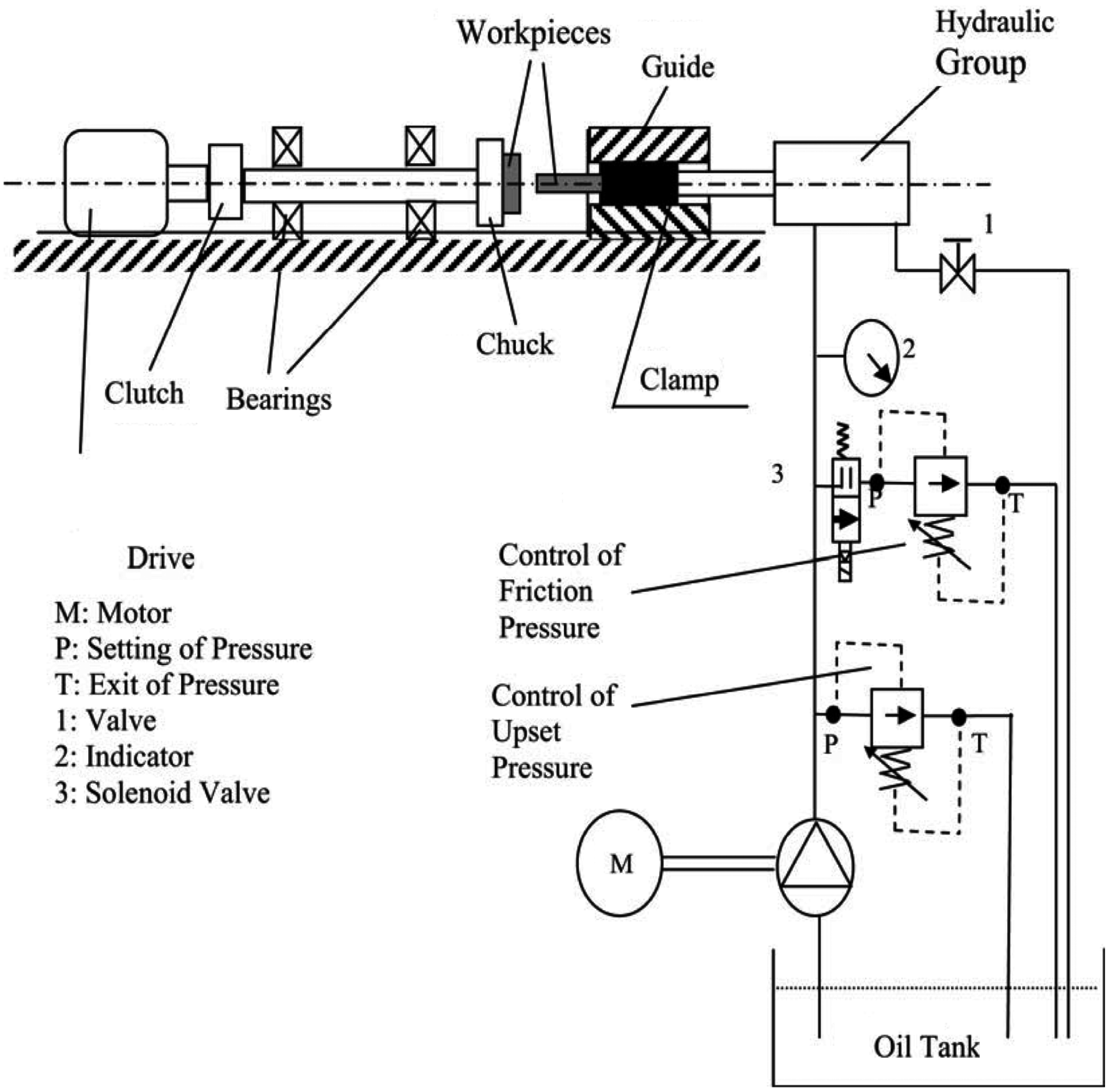


Table 1: Chemical Composition of Base Metal (Aluminium)

Elements	Al	Cu	Mg	Si	Fe	Ni	Mn	Zn	Pb	Sn	Ti	Cr	V
Percentage	98.56	0.015	0.482	0.630	0.217	0.007	0.009	0.018	0.014	0.016	0.018	0.009	0.005

Table 2: Chemical Composition of Base Metal (Mild Steel)

Elemsents	Fe	C	Si	Mn	P	S	Cr	Mo
Percentage	97.68	0.150	0.240	1.46	0.016	0.0260	0.031	0.012
Elements	Ni	Al	Co	Cu	Nb	Ti	V	W
Percentage	0.010	0.047	0.004	0.226	0.057	0.022	0.001	0.007

The chemical composition of aluminium alloy and mild steel is shown in Tables 1 and 2. The vertical milling machine was used because its stability and less vibration as compared to lathe machine. After friction welding, specimens were polished by grinding on various grades of emery paper and then were etched with natal solution. The vertical milling machine (sallsons) used was of three phase, 2.5 horse power and RPM was up to 1440.

Experiment Set Up

Vertical milling machine was used for joining of aluminium alloy to mild steel. A friction welding set-up as shown in Figure 3 was designed by modifying vertical milling machine and constructed according to the principles of continuous drive-welding machines. A Drive motor with 2.5 kW power and 1,440 rpm was selected for friction welding.

Procedures

Aluminium alloy and mild steel were used for friction welding. All the experiments were conducted in Shitla industries at Rohtak. One of the components (Al alloy) was rotated at given RPM and other (mild steel) was fixed. Heat was generated due to the friction between the materials while applying friction force. For the measurement of temperature, a non-contact type temperature gun (laser temp.gun) was used to measure the temperature at the interface while processing, stop watch was used to measure the time friction time. A total of eight experiments were done by varying three parameters, viz., RPM, Burn off length and friction time at two levels as shown in Table 3.

Table 3: Observation Data for Al-Alloy and c/fe During the Process

No. of Experiment	Parameters			Maximum Temp. in Degree Centigrade
	RPM (R)	Burn Off Length (L) in mm	Weld Time in Sec.	
1.	1440	2.5	30	98
2.	1440	2.5	20	106
3.	1440	1.5	20	104
4.	1440	1.5	30	110
5.	1800	1.5	20	126
6.	1800	1.5	30	130
7.	1800	2.5	20	84
8.	1800	2.5	30	94

RESULT AND DISCUSSION

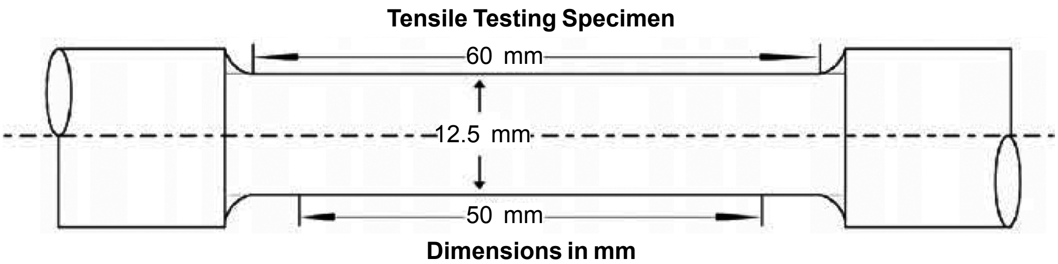
A photograph of welded material was shown in Figure 4. Peak temperature recorded during the experiments is shown in Table 3. Tests were also conducted to obtain micro hardness and tensile strength data.

Tensile Test

Tensile testing was done on a Universal testing machine (UTM) of 400 kN capacity. The geometry of the test specimen is as shown in Figure 5. Mechanical properties of the weld material were also considered.

Figure 4: A Photograph of Welded Material

Figure 5: Geometry of Test Specimen



Tensile strengths of aluminium alloy and mild steel at the fusion (the point where friction welding of these two material) joint of the specimen, where fracture occurs was recorded and was shown in Figure 6. Ultimate tensile strength and ultimate tensile load at which the fracture occurs is shown in Table 4.

As it can be seen from Table 4 that maximum value of UTS is found for specimen no. 8 where all the parameters are at higher level. RPM has very little effect on UTS, Burn off length and friction time are more responsible for change in UTS values. As seen from previous papers burn off length has major effect on UTS, same is the case here where burn off length is more UTS is more.

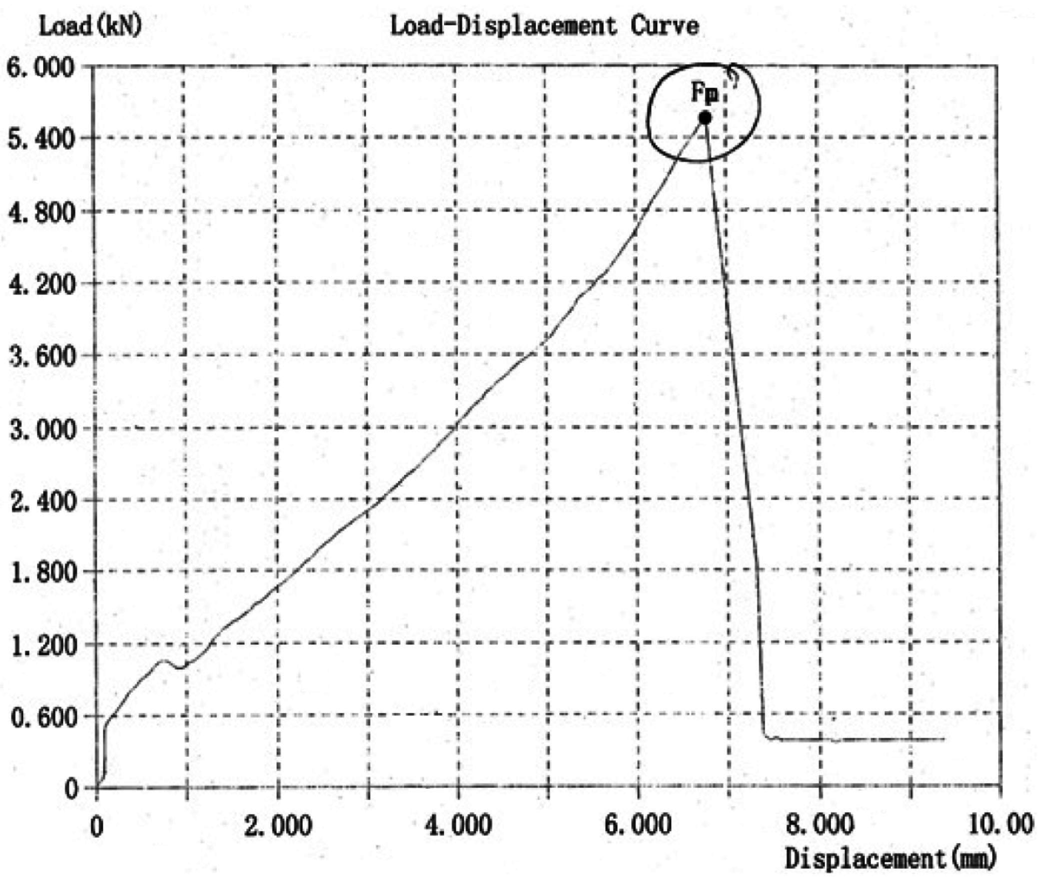
Scanning Electron Microscope

The scanning electron microscope test was also obtained by the SEM test machine of the

Table 4: Tensile Strength Data

No. of Experiment	Parameters			UTM Result	
	RPM (R)	Burn Off Length (L) in mm	Weld Time in Sec.	UTS (N/mm²)	UTL(KN)
1.	1440	2.5	30	135	6.24
2.	1440	2.5	20	130	5.98
3.	1440	1.5	20	104	5.56
4.	1440	1.5	30	110	2.56
5.	1800	1.5	20	108	2.54
6.	1800	1.5	30	112	2.56
7.	1800	2.5	20	131	5.88
8.	1800	2.5	30	136	6.28

Figure 6: A Tensile Strength Graph of Spacemen



fusion joint was shown in Figure 7. The main purpose of the SEM test is to show the fusion joint correctly between the two dissimilar metals that is al-alloy and mild steel.

Figure 7: SEM at Fusion Joint of Al-Alloy and Mild Steel

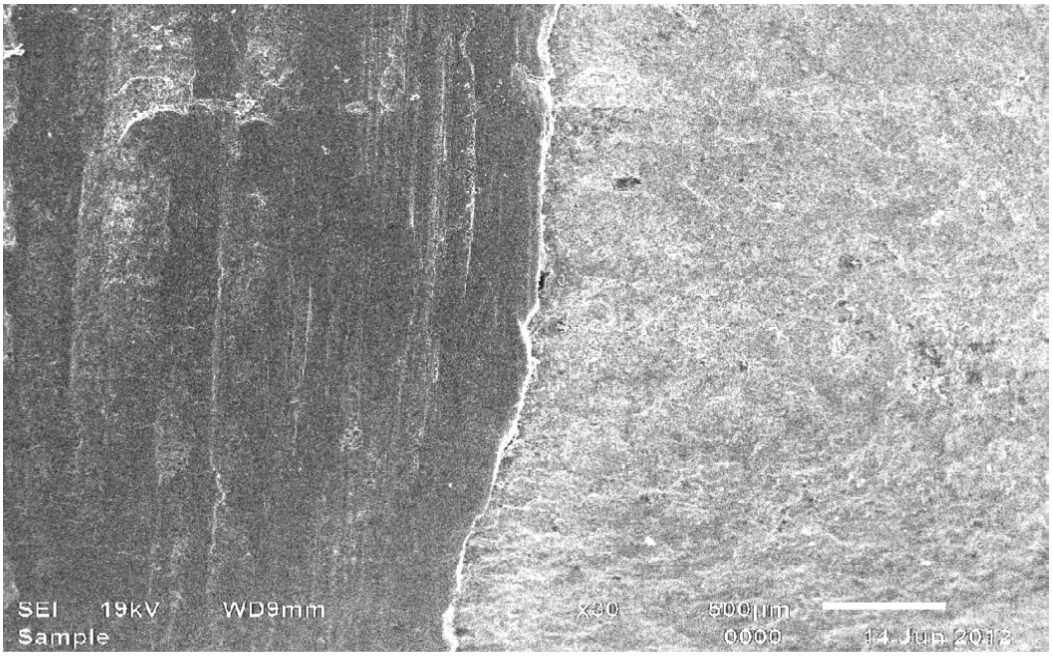


Table 5: Micro Hardness Data

No. of Experiment	Parameters			UTM Result
	RPM (R)	Burn Off Length (L) in mm	Weld Time in Sec.	UTS (N/mm^2)
1.	1440	2.5	30	71
2.	1440	2.5	20	68
3.	1440	1.5	20	64
4.	1440	1.5	30	65
5.	1800	1.5	20	64
6.	1800	1.5	30	65
7.	1800	2.5	20	70
8.	1800	2.5	30	72

Micro Hardness

Micro hardness for Al1: Alloy and Mild Steel was 47 VHN and 190 VHN respectively. Micro hardness data of fusion welding between Aluminium Alloy and Mild Steel was shown in Table 5.

CONCLUSION

Friction welding has been successfully employed to weld dissimilar metal. Tensile strength and micro hardness of both of the material were good and fusion joint of the material were also in good condition and the ductility was reasonable. Chemical composition of the mild steels and aluminium used for welding played an important role in deciding the properties of the weld.

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