To Study the Mechanical Behavior of Friction Welding of HSS M_{33} & SS 316

Gourav Sardana[1], Ajay Kumar[2]

[1]*M.tech Student, Mechanical Department, O.I.T.M, Hissar, Haryana, India,* ***gourav.sardana@yahoo.com***
[2]*Asst. professor, Mechanical Department, O.I.T.M, Hissar, Haryana, India,****apkumar12@gmail.com***

Abstract

The purpose of this work was to join and assess the development of solid state joints of dissimilar material HSS M_{33} and AISI 316 stainless steel, via continuous drive friction welding process, which combines the heat generated from friction between two surfaces and plastic deformation. Experiments performed on manually lathe machine with different three rpm (1700, 2700, and 3700) & different position of work pieces Tests were conducted with different welding process parameters. The strength of the welded joint was determined by Breaking Point load. Micro hardness values of the joints were also obtained with the HV hardness scale. The microstructures of welded joint also study with the help of Optical Microscope.

Index Terms: *Friction welding, welding parameters, Mechanical characterization, Metallographic.*

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1. INTRODUCTION

Welding technology is used in manufacturing development of New welding method. Welding of different metal and their alloys is a common application in engineering. "Friction welding" (FW) is a group of solid-state [welding] processes using heat generated through mechanical friction between moving work pieces, with the addition of an upsetting force to plastically displace material. This technique, which we refer to as "friction welding" provides a very simple method of joining a probe to a work piece. Friction welding is a type of forge welding, i.e. welding is done by the application of pressure. Friction generates heat, if two surfaces are rubbed together, enough heat can be generated and the temperature can be raised to the level where the parts subjected to the friction may be fused together. The principle of this process is the changing of mechanical energy into heat energy. One component is gripped and rotated about its axis while the other component to be welded to it is gripped and does not rotate but can be moved axially to make contact with the rotating component. At a point fusion temperature is reached, then rotation is stopped and forging pressure is applied. Then heat is generated due to friction and is concentrated and localized at the interface, grain structure is refined by hot work.

Material and Method used in friction welding: The material used in experiment was HSS & SS .All the specimen were made in cylindrical shape having diameter10mm & length 130mm. Experiments performed on manually lathe machine & special type of fixture is used on the lathe machine to estimate the manually forge pressure.

1.1 Continuous Drive Friction Welding

The present study utilized a continuous drive friction welding machine. In continuous drive friction welding one work piece is rotated at nominal constant speed in action alignment with the second part under an applied pressure. The rotation and pressure are maintained for the specific period to ensure adequate thermal and mechanical conditioning of the interface region. Thereafter, the rotation is stopped often with forced braking and at the same time pressure is increased to upset parts together. The application of an axial force maintains intimate contact between the parts and causes plastic deformation of the material near the weld interface.

Fig.1 (Friction Welding of HSS & SS)

2. EXPERIMENTAL SETUP DETAIL

Manually Lathe machine is used for the friction welding operation. Machine setup is done as per the principle of continuous drive friction welding machine & to measure the forge pressure hydraulic jack with pressure gauge is used in the tail stock. So that manually effort can be measured. The main condition of machine that work pieces must be ideal alignment as shown in Figure.2 otherwise work pieces may be damage.

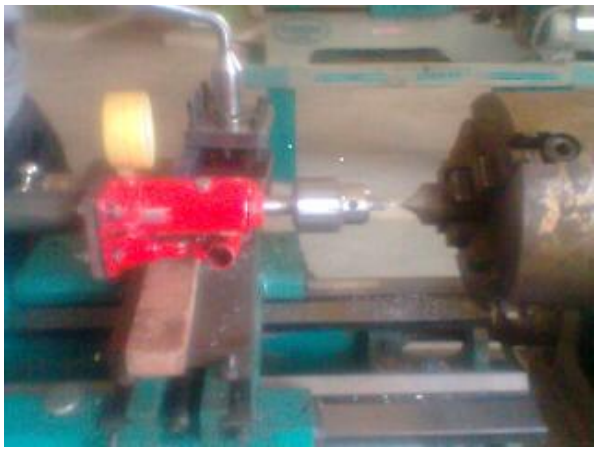


Fig.2 (Ideal alignment of Fixture)

2.1 Chemical composition of Base Metal

Element	%
Fe	74.23
C	1.07
Si	.520
Mn	0.277
P	0.0230
S	0.006
Cr	3.85
Mo	9.37
Ni	0.224
Al	< 0.01

Table1: (Chemical composition of HSS)

Element	%
Fe	68.41
C	0.022
Si	0.550
Mn	1.37
P	0.0350
S	.022
Cr	16.54
Mo	2.07
Ni	10.39
Al	0.015

Table2: (Chemical composition of SS)

2.2 Experiment Procedure

First of all machine is set up as per requirement of Friction welding i.e. Fixture is arranged on the machine. High speed steel and stain less steel is used for the friction welding. Experiments performed with three different rpm (1700, 2700, and 3700). One of the component (HSS) is at rpm & other (SS) stationary in the fixture. Heat is generated during the friction between the two materials (HSS & SS). Temperature gun is used to measure the temperature during the friction welding process. Stop watch is used to measure the Friction time of welding operation of two different materials (HSS & SS).total Six experiments performed on three different rpm (1700, 2700, 3700) & different position of work pieces(HSS rpm –SS constant) as shown in table.3 & sample in figure .3

sample	Rpm	Position	Forge pressure (kg/cm 2)	Friction Time (sec)	Forge Time (sec)	Temp (˚C)
S_1	1700	HSS(rpm) SS(cnst)	100	7	35	850

S_2	2700	HSS(rpm) SS(cnst)	150	7	30	880
S_3	3700	HSS(rpm) SS(cnst)	180	7	24	920
S_4	3700	HSS(cnst) SS(rpm)	330	14	48	965
S_5	2700	HSS(cnst) SS(rpm)	210	14	75	895
S_6	1700	HSS(cnst) SS(rpm)	110	14	150	870

Table .3(Experiment record)

Fig.3 Samples (S_1-S_6)

3. RESULTS & DISCUSSION

3.1 Breaking Pont Test: The Breaking point Test of friction welded specimens was performed on the Universal Testing Machine 50 ton U.T.M Breaking point value given in Table no.4:

Sample No	Breaking Load (KN)
S_1	9.96
S_2	9.10
S_3	3.30
S_4	3.54
S_5	2.92
S_6	3.82

Table.4 (Breaking load value)

When rpm is increased from 1700 to 2700 (HSS rpm & SS constant) breaking load value is decreased from 9.96 - 9.10(KN).& when further rpm is increased from 2700 to 3700 then breaking load value simultaneously decreased up to 3.30 (KN).

When rpm is increased from 1700 to 2700 (HSS constant & SS rpm) breaking load value is decreased from 3.82 -2.92 (KN) & when further rpm is increased from 2700 to 3700 then breaking load value is increased up to 3.54 (KN).

3.2 Micro Hardness Measurements of Friction Welded Joints: Micro hardness measurement of the specimens was done along the weld and at the cross section of base metal. Stainless steel and High Speed steel was taken along the weld hardness. On High Speed Steel and on stainless steel hardness was taken at a constant distance of 0.10mm from the interface in all samples. Total of 12 readings were taken, one on intersection, 6 on High Speed Steel side and 6 on Stainless Steel side as shown in table 5&6.

Sample No	Distance From SS Side(mm)	Hardness(HV.3)
S_1	.10	312-316
S_2	.10	300-305
S_3	.10	310-315
S_4	.10	326-335
S_5	.10	325-330
S_6	.10	320-325

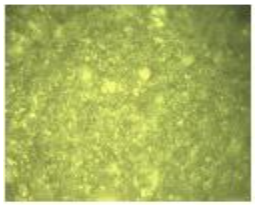
Table.5

Sample No	Distance From HSS Side(mm)	Hardness(HV.3)
S_1	.10	440-450
S_2	.10	390-400
S_3	.10	290-300
S_4	.10	270-280
S_5	.10	260-270
S_6	.10	240-250

Table.6

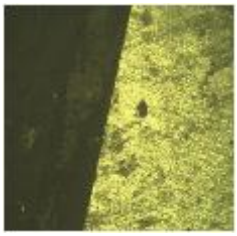
Higher Hardness values are observed next to interface but they dramatically decreased with increase distances. As rpm is increases temp is also increases & hardness is also increases. But hardness is decreases with increases the upset time. Micro hardness value in the weld zone was much higher then the parents' material. Hardness increase with decreasing particle size.

3.3 Microstructure Examination of Friction Welded Joints: Microstructure of the specimens was captured on an Optical Microscope at 500X magnification with the help of a camera along the weld. Images were captured at different places along the weld, on interface, very near to the interface on High Speed steel side, very near to the interface on Stainless Steel side, on High speed steel and on Stainless Steel as shown in Fig.3



Micro structure of HSS

Micro structure of SS



Micro structure of HSS & SS

Fig.3

The micro structure of base metal consists of austenitic grain structure. Micro photograph shows that Stainless steel was greatly deformed with grains elongated & refined near the weld inter face. Micro structure of stainless steel consists of austenitic grains & High speed steel structure consists of carbide particles in marten site matrix.

4. CONCLUSION

In general terms, the present invention is dependent on continuous drive (one piece in rotation & other in linear motion) where both faces of the weld joint are in motion during the heating phase of the operation, which motions are brought into phase when the conditions of the joint are appropriate. The change of phase of the motions of the mating parts can be accomplished with highly precision and speed than are possible when alignment of the parts is dependent on stopping the motion of one or both the parts. Friction welding has been successfully employed to weld dissimilar metals. Strength of the joints obtained was good. As we increases the rpm (HSS rpm & SS constant) of job then breaking point load is decreases but when rpm (HSS constant & SS rpm) of job then breaking point load is increases at high rpm.

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