Optimization in Performance Parameters of Frictionally Welded Mild Steel [AISI - 1018]

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***Abstract*–An attempt has been made to optimize the process parameters like speed (rpm), forging pressure and friction time in friction welding of AISI 1018 mild steel. The experiments were performed, which were based on design matrix of L8 orthogonal array to obtain high quality weld strength for various engineering applications having minimum burn off length and maximum ultimate tensile strength.**

Keywords - Friction welding, Solid state welding, Ultimate Tensile Strength, Burn off length.

I. INTRODUCTION

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.

Mild steel is preferred engineering material for automobile, mineral processing industries, metal joining for pipes and various high performing components that are being used for varieties of applications owing to their lower weight and excellent thermal conductivity properties. [4]

Orthogonal arrays are special standard experimental design that requires only a small number of experimental trials to find the main factors effects on output.

II. SUMMARY OF LITERATURE & RESEARCH GAP

Almost every study involves various parameters like rpm, friction time, temperature distribution, burn off length, ultimate tensile strength, study of microstructures etc. Different materials joined by friction welding results in different properties from the parent material.

Most of the research work regarding friction welding has been done on dissimilar metals. Friction welding is capable process of joining similar metals also, like mild steel with mild steel, aluminum with aluminum alloys, tungsten with tungsten etc. But, limited data related to friction welding of mild steel over mild steel joint has been reported. The present work is objected to the study of 'Optimization in performance parameters of frictionally welded mild steel AISI-1018'. The measurement and study of mechanical properties like ultimate tensile strength and burn off length of the joint has been studied.

III. EXPERIMENTAL DESIGN FOR PRESENT WORK

The setup mainly comprises of central lathe. For measuring the forging pressure, a hydraulic cylinder with gauge is used. The cylinder with gauge, which can read upto 100 kg/cm^2 is fixed in between two tailstocks. A specially fabricated tool holder which can hold rod of 12 mm dia. and 100 mm length is used to hold one piece in it and other piece is fixed in rotating chuck.

The work material chosen for the study is mild steel (AISI - 1018) rod of dia. 12 mm. The material was purchased from local market and cut into pieces of 100 mm length. The spectroscopy test of material was performed at CTR, Ludhiana, Punjab. The chemical composition of the material is as per table I. The material resembles with AISI – 1018 type of steel.

TABLE 1: CHEMICAL COMPOSITION OF WORK MATERIAL

Element	Carbon (C)	Manganese (Mn)	Silicon (Si)	Phosphorus (P)	Sulphur (S)
Amount wt. (%)	0.18	0.80	0.23	0.042	0.032

Friction welding was performed on conventional lathe at central workshop of MIMIT, Malout. Fig. 1 shows the complete setup used for experimentation. To get the required speed, the pulley and belt arrangement has been changed on the conventional lathe. When the chuck starts rotating at higher speed, the friction pressure was applied, until the red hot layer isn't visible. Then brakes were applied to stop the machine immediately and at that very moment required forging pressure was applied.

The input process parameters which affect the output responses like burn off length and ultimate tensile strength, have been selected from literature and are friction time, forging pressure and speed (rpm). Other parameters like friction pressure and forging time were kept constant. After selecting the process parameters, the range and level values of each process parameter was selected from literature and by performing trial runs on the setup and are listed in the Table II. For the design matrix L8 orthogonal array was chosen. The L8 orthogonal array was selected using minitab 18 software to conduct the experiments as per the level combinations. The burn off length was noted for each experimental run for analysis. The ultimate tensile strength

test was performed by machining the welded specimen according to the standard dumble shape by keeping the weld nugget at centre and performing the test on Universal Testing Machine at R and D centre for bicycle and sewing machine, Ludhiana.

Fig. 1 Experimental Setup

TABLE II: RANGE OF PROCESS PARAMETERS

Sl. No.	Parameters	Range
1.	Speed	938-1320 rpm
2.	Forging pressure	40-60 kg/cm^2
3.	Friction time	10-12 sec.

IV. RESULTS AND DISCUSSION

A. Burn Off Length Observation

Table III shows the observed values for burn off length. Main effect plot, surface plot and contour plot were drawn by using the values obtained.

TABLE III: BURN OFF LENGTH OBSERVATION

Sl. No.	Friction time (sec.)	Forging pressure (kg/cm^2)	Speed (rpm)	Average Burn off length (cm)
1.	10	40	938	0.85
2.	10	40	1320	1.30
3.	10	60	938	1.16
4.	10	60	1320	1.62
5.	12	40	938	1.10
6.	12	40	1320	1.51
7.	12	60	938	1.38
8.	12	60	1320	2.04

Analysis of Burn off length:

(a) The burn off length is the "smaller the better" type quality characteristic. From the main effects plot for means as shown in Fig. 2 the first level of RPM, the first level of forging pressure and the first level of friction time results in lower value of burn off length. Consequently, the optimal level combination is first level of RPM, the first level of forging pressure and the first level of friction time.

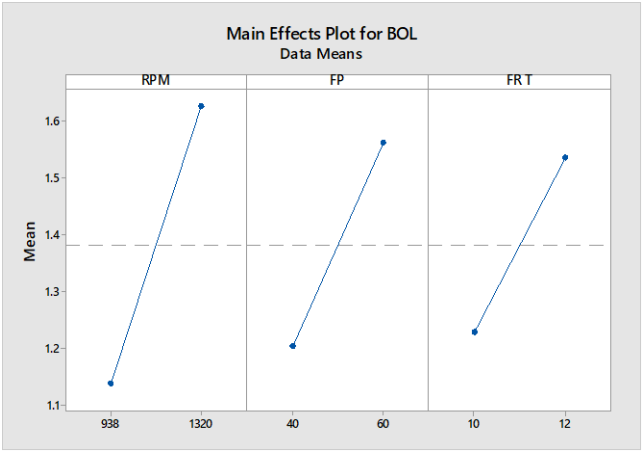

Fig. 2 Main effect plot for means of burn off length

TABLE IV: RESPONSE TABLE FOR S/N RATIO

Level	SPEED	FP	FRT
1	-0.8757	-1.3187	-1.5867
2	-4.0603	-3.6174	-3.3494
Delta	3.1846	2.2988	1.7627
Rank	1	2	3

(b) Table IV shows the ranks of selected parameters. From the table, it is clear that speed has rank 1, FP has rank 2 and FRT has rank 3. Therefore surface plot and contour plot (Fig. 3 and Fig. 4) has been drawn between BOL and the most two influencing factors, and it has been concluded that for low speed, the burn off length obtained is minimum. It is so because at lower speed, the friction between the workpieces was minimum and hence had resulted in lower burn off length. For lower value of forging pressure, the burn off length obtained was minimum. This is due to that at lower forging pressure less fusion takes place and causes lower burn off length.

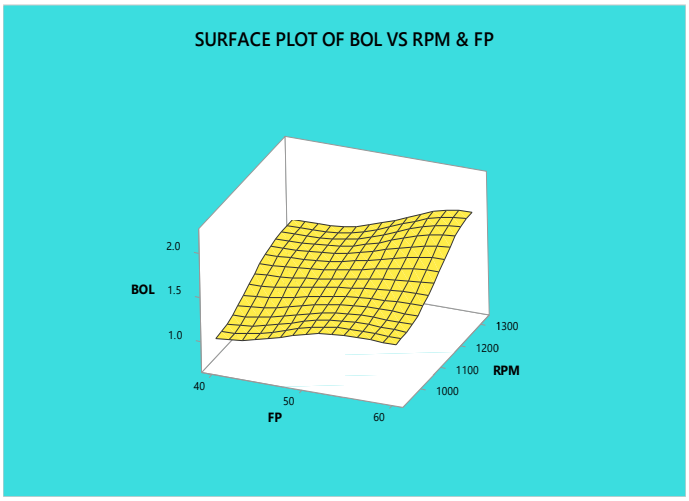

Fig. 3 Surface plot for burn off length

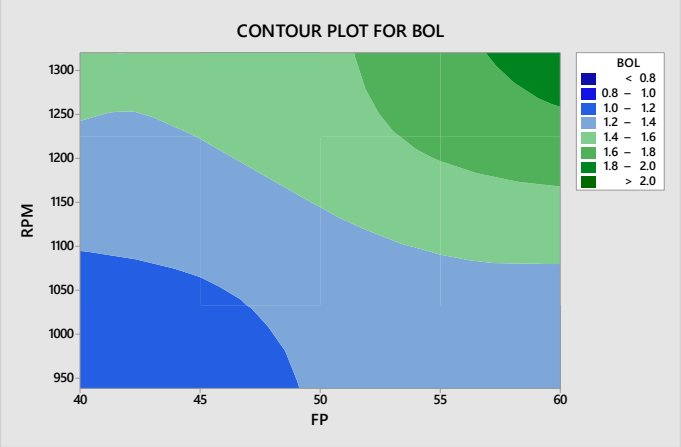

Fig. 4 Contour plot for burn off length

B. Ultimate Tensile Strength Observation

Table V shows the observed values for Ultimate Tensile Strength (UTS). Main effect plot, surface plot and contour plot were drawn by using the values obtained.

Analysis of Ultimate Tensile Strength:

(a) The Ultimate tensile strength is the "larger the better" type quality characteristic. From the main effects plot for means as shown in Fig. 5 the first level of RPM, the first level of forging pressure and the first level of friction time results in higher value of UTS. Consequently, the optimal level combination is first level of RPM, the first level of forging pressure and the first level of friction time.

(b) Table VI shows the ranks of selected parameters. From the table, it is clear that speed has rank 1, FP has rank 3 and FRT has rank 2. Therefore surface plot & contour plot (Fig. 6 and Fig. 7) has been drawn between UTS and the most two influencing factors. From the surface plot & contour plot (Fig. 6 and Fig. 7), it has been concluded that for low speed, the UTS obtained will be maximum and for the lower value of friction time, the ultimate tensile strength will be maximum.

TABLE V: OBSERVATION FOR UTS

Sl. No.	Friction time (sec.)	Forging pressure (kg/cm^2)	Speed (rpm)	Average U.T.S. (N/mm^2)
1.	10	40	938	504
2.	10	40	1320	493.7
3.	10	60	938	455.9
4.	10	60	1320	456.05
5.	12	40	938	502.55
6.	12	40	1320	377.7
7.	12	60	938	468.4
8.	12	60	1320	411.55

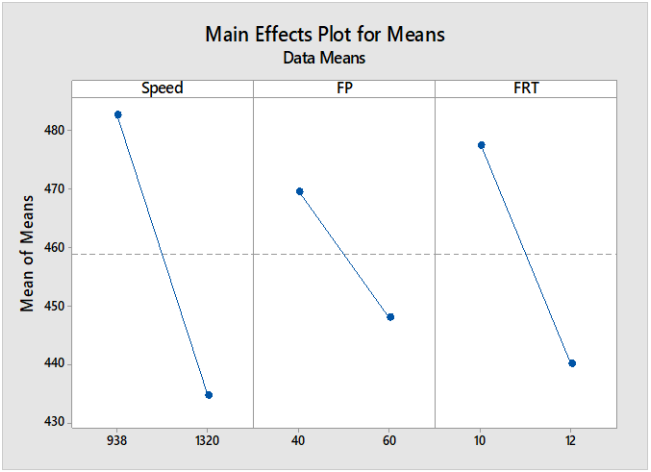

Fig. 5 Main effect plot for means of UTS

TABLE VI: RESPONSE TABLE FOR S/N RATIO

Level	Speed	FP	FRT
1	53.67	53.37	53.57
2	52.72	53.01	52.82
Delta	0.95	0.36	0.75
Rank	1	3	2

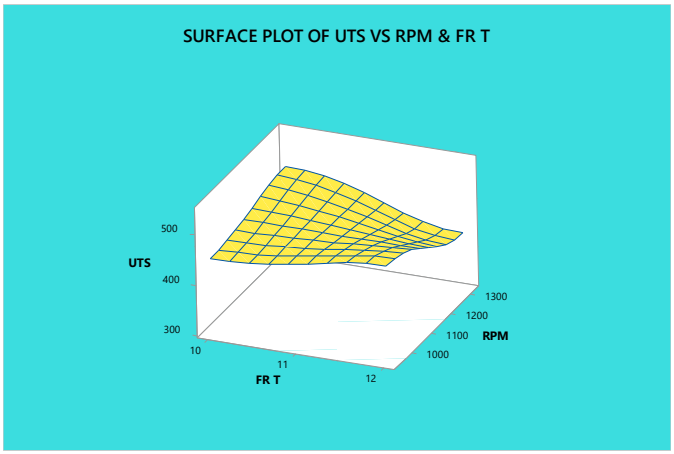

Fig. 6 Surface plot for UTS

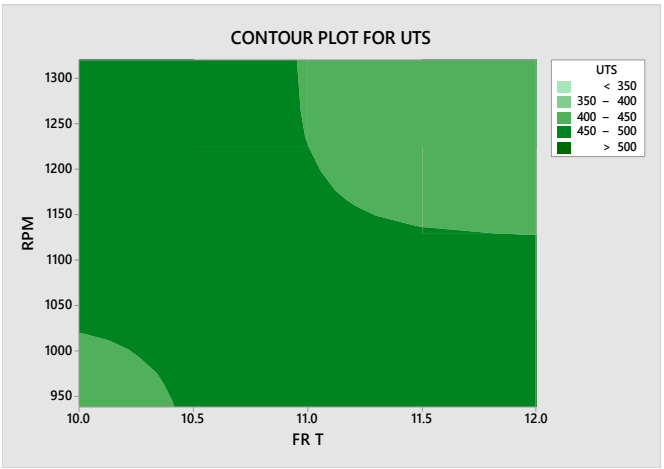

Fig. 7 Contour plot for UTS

V. CONCLUSION

The optimal parameters have been found by successful friction welding of mild steel AISI-1018 for the purpose of minimization of burn off length and maximum tensile strength. The following conclusions can be drawn from experimental results.

- The minimum burn off length found was 0.85 cm at speed (938 RPM), forging pressure (40 N/mm^2) and friction time (10sec.).
- The maximum UTS found was 504 N/mm^2 at speed (938 RPM), forging pressure (40 N/mm^2) and friction time (10sec.).

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