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Optimization and Analysis of Mechanical Properties for SS410 with EN19 Welded Joints using Spot Welding

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Abstract - Joining dissimilar metals has recently become very popular in industries because of the advantages associated with the weld joint. This experimental focus on an investigation of mechanical, material properties and the optimization of mechanical properties in resistance spot welding methods in lap configurations between SS410 stainless steel and carbon steel. The Taguchi method has to be used to design experiments. Welding was conducted using a spot welder. Tensile and hardness test specimens has to be prepared from the welded sheets in appropriate dimensions and tensile and hardness tests has to be performed for each specimen. The depth and width of weld nuggets were investigated. It can be concluded from the investigation that the welding joint in this method can offer moderate strength In order to improve significant mechanical and metallurgical properties of the joint, other variable parameters like voltage; electrode tip diameter etc. can also be introduced and has to be investigated.

Keywords: Optimization, Mechanical Properties, SS410, EN19, Spot Welding.

I. INTRODUCTION SPOT WELDING

Resistance spot welding is the resistance welding method more widely used by the industry. While in arc welding processes, electric current is used to maintain an arc between the torch and the surface of the work piece, in resistance welding methods, electric current produces heat in the piece by its flow through the work piece. The maximum amount of heat is produced where the electric resistance is maximum, which is at the surface between the sheets being joined, producing a molten nugget. Force is applied before, during and after electric current. This force is necessary in order to maintain the electric current continuity and to assure the pressure necessary to avoid defects in the joint. In spot welding the joint is produced by local fusion caused by the flow of electric current between cylindrical electrodes. The size and shape of individual spot welds are determined by the area of contact between the electrodes and the work piece. These electrodes are normally made of cooper alloys. This process deliver a big amount of energy to the spot in a very short time, thus the rest of the sheet does not have an excessive heated up. Compared with other welding process, such arc processes, resistance spot welding is easily automated, maintained and fast. Regarding the power density achieved and equipment is relatively inexpensive, the cost of each welding is one of the cheapest within all the welding processes. Resistance spot welding is widely used in assembling automobile body parts, made of thinner-gauge metals, and for manufacturing pipe, tubing and smaller structural sections. Although resistance spot welding has been used widely by the industry, this process may be difficult to control. There are

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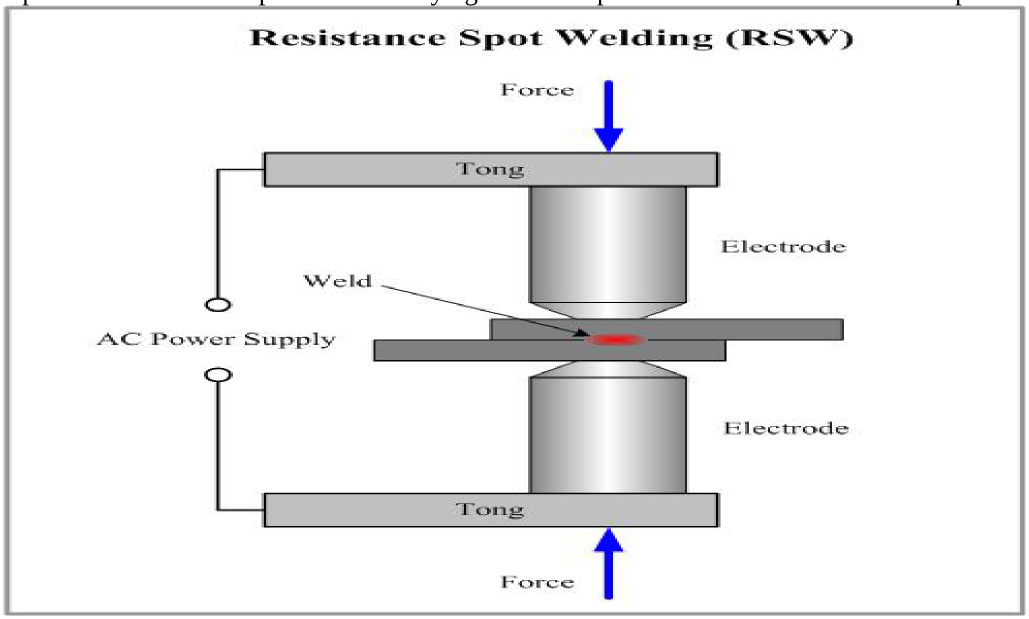
also strong interactions between the electrical, mechanical and thermal parts of the process. Because of that there are significant difficulties in modeling the spot welding process. These difficulties produce problems to know about the quality of resistance of spot welds Thus in the practice are carrying out more spot welds than are needed for keep structural integrity.



II. MATERIALS USED

2.1 SS410

Grade 410 is the basic martensitic stainless steel; like most non-stainless steels it can be hardened by a "quench-and-temper" heat treatment. It contains a minimum of 11.5 per cent chromium, just sufficient to give corrosion resistance properties. It achieves maximum corrosion resistance when it has been hardened and tempered and then polished. Grade 410 is a general purpose grade often supplied in the hardened, but still machinable condition, for applications where high strength and moderate heat and corrosion resistance are required. Martensitic stainless steels are optimized for high hardness, and other properties are to some degree compromised. Fabrication must be by methods that allow for poor weld ability and usually the need for a final heat treatment. Corrosion resistance of the martensitic grades is lower than that of the common austenitic grades, and their useful operating temperature range is limited by their loss of ductility at sub-zero temperatures and loss of strength by over-tempering at elevated temperatures.

2.2 EN19

EN 19 steel is a high tensile alloy steel and wear resistance properties and also where high strength properties are required. EN 19 is used in components subject to high stress and with a large cross section. This can include aircraft, automotive and general engineering applications for example propeller or gear shafts, connecting rods, aircraft landing gear components.

II. EXPERIMENTAL RESULTS

3.1 HARDNESS VALUES (kgf/mm2)

SAMPLES	S1	S2	S3	S4	S5	S6	S7	S8	S9
SS 410	75	75	78	78	77	73	78	81	70
EN19	95	87	95	86	82	94	90	90	97

3.2 TENSILE STRENGTH VALUES

Sl. No	Current KA	Electrode Force Kg/cm^2	Weld Cycle	Tensile Strength N/mm^2
1	4	2	6	113.00
2	4	2.5	8	129.00
3	4	3	10	133.50
4	4.5	2	8	122.25
5	4.5	2.5	10	140.00
6	4.5	3	5	150.50
7	5	2	10	135.75
8	5	2.5	6	124.50
9	5	3	8	118.25

III. PROCESS PARAMETER OPTIMIZATION FOR TENSILE STRENGTH

After finding all the observation as given in table 3.2, S/N ratio and means are calculated and also various graphs for analysis is drawn by using Minitab-16 software.

4.1 S/N Ratio Values:

Trial no.	Designation	Current KA	Electrode Force Kg/cm^2	Weld Cycle	Tensile Strength N/mm^2	S/N Ratio Value
1	$A_1B_1C_1$	4	2	6	113.00	44.0824
2	$A_1B_2C_2$	4	2.5	8	129.00	49.0664
3	$A_1B_3C_3$	4	3	10	133.50	33.9794
4	$A_2B_1C_2$	4.5	2	8	122.25	16.9020
5	$A_2B_2C_3$	4.5	2.5	10	140.00	43.6938
6	$A_2B_3C_1$	4.5	3	5	150.50	46.4029
7	$A_3B_1C_3$	5	2	10	135.75	47.2722
8	$A_3B_2C_1$	5	2.5	6	124.50	40.7485
9	$A_3B_3C_2$	5	3	8	118.25	44.0824

4.2 Taguchi Analysis:

4.2.1 Response Table for Signal to Noise Ratios:

Level	Current	Electrode Force	Weld Cycle
1	42.38	36.09	44.86
2	35.67	44.50	35.57
3	44.03	41.49	41.65
Delta	8.37	8.42	9.28
Rank	3	2	1

4.2.2 Response Table for Means:

Level	Current	Electrode Force	Weld Cycle
1	125.2	123.7	129.3
2	137.6	131.2	123.2
3	126.2	134.1	136.4
Delta	12.4	10.4	13.2
Rank	2	3	1

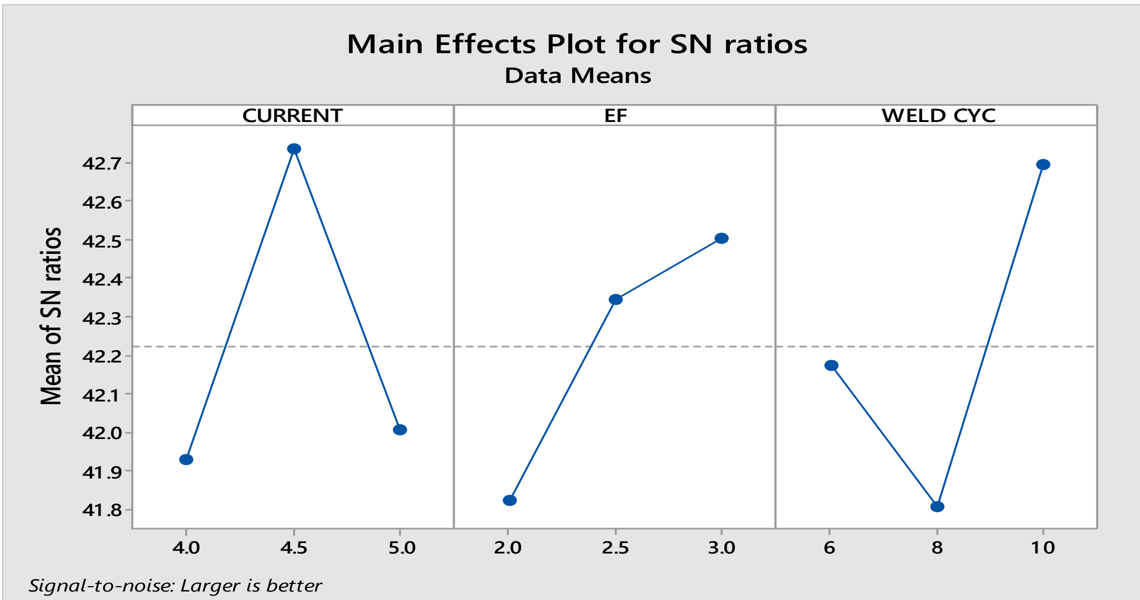
4.2.3 Factors Information:

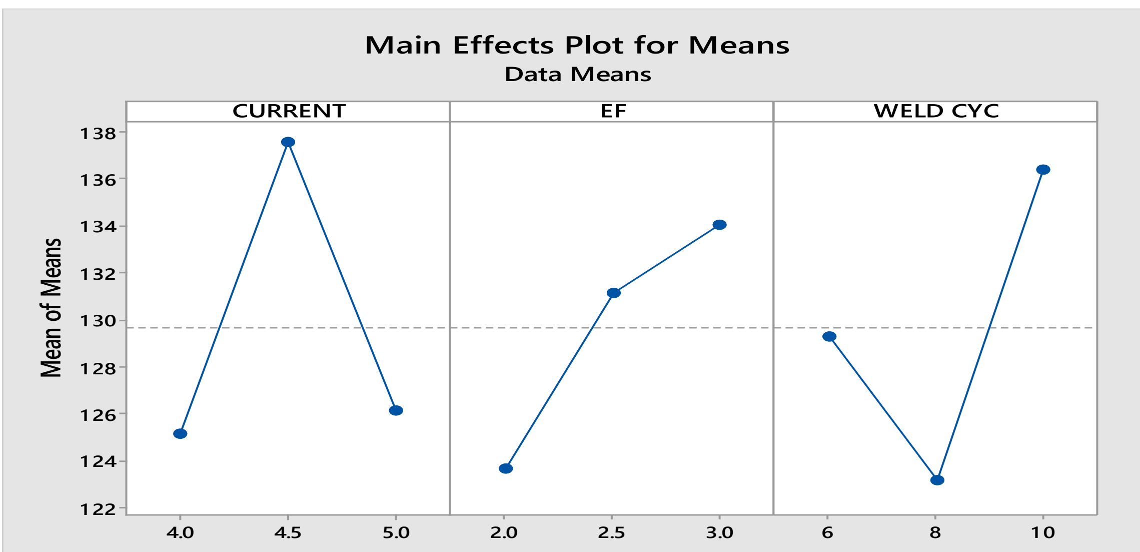
FACTOR	TYPE	LEVELS	VALUES
Current	FIXED	3	4.0, 4.5, 5.0
Electrode Force	FOXED	3	2.0, 2.5, 3.0
Weld Cycle	FIXED	3	6,8,10

4.2.4 Analysis of Variance:

Source	DF	Seq SS	Adj SS	F	P	% OF CONTRIBUTION
AMPS	2	285.5	142.76	0.79	0.558	26
VOLT	2	173.3	86.63	0.48	0.675	17

Gas Pressure	2	263.8	131.88	0.73	0.577	24
Error	2	360.2	180.11			33
Total	8	1082.8				100





IV. CONCLUSION

The following conclusions can be inferred from the experimental study carried out:

1) The two dissimilar metals, i.e., SS 410 and EN19 Medium carbon steel can be spot welded together, producing a good weld joint with reasonably good strength.

2) In the Spot weld joint between SS 410 and EN 19 carbon steel, the weld Strength increases with Increasing welding Current.

3) In the Spot weld joint between SS 410 and MS, the weld Strength increases with Increasing Electrode force.

4) In this experimental investigation we found good mechanical strength Current 4.5 KA, Electrode force 3 kg/cm2 and weld cycle of 5.

5.1 Optimal Control Factor

1. TENSILE STRENGTH- A2 (Current -4.5) B3 (Electrode force -3 Kg/cm2) C1 (Weld cycle 6)

5.2 Percentage of Contribution of Process Parameter

1. Tensile strength – Amps- 26%

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