Investigation of the Effect of Spot Welding Process Parameters on Mechanical Properties of Spot Welds Made on Ass 304 and ASS 202 Steels _ a Comparative Study

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Abstract— The objective of this work is to report a comparative study of effect of welding process parameters on mechanical properties of resistance spot welds made on ASS 304 and ASS 202 stainless steel sheets. The process input parameters include welding current, electrode force and welding time, to determine their effect on the weld strength quality characteristics (tensile strength and hardness). This investigation was aimed at finding the optimum values for the process parameters for joining pairs of strips of 0.5 mm each , in combination of ASS 304 to ASS 304 ; ASS 202 to ASS 202 and finally joining ASS 304 to ASS 202 and comparing the result.

Key words: Resistance spot welding, weld nugget strength, stainless steel sheet joining

I. INTRODUCTION

Spot welding is a commonly used process for joining metal sheets in industries like automobiles , aircrafts , fighter planes, space crafts , truck cabins , rail vehicles and home appliances , due to its efficiency , suitability and ease of adaptability to high speed automation with strict cycle time using shaped copper alloy electrode to apply the required extenet of pressure and to pass a predetermined amount of current between the two work pieces for a precise period of time . The material between the electrode yields and is squeezed together. It then melts destroying the interface between the parts, forming a weld nugget at interface.

II. LITERATURE REVIEW

Pandey, Khan and Moeed [1] worked on optimization of resistance spot welding parameters using taguchi method , response of S/N ratio with respect to tensile strength indicates the welding current to be the most significant parameter that controls the weld tensile strength whereas the holding time and pressure are comparatively less significant in this regard . Atzori B.et al [2] Investigated the effect of nugget diameter, heights of nucleus, nucleus size on mechanical properties i.e. tensile shear and tensile peel strength in electrical resistance spot welding of galvanized chromided micro alloyed steel sheets . Hirch Rogar B [3] has studied on the resistance spot Weldability of galvanized interstitial free steel sheets with austenitic stainless steel sheets. In micro hardness measurements, the maximum hardness values were in the middle of the weld nugget . Darwish S.M and Al-Dekhial [4] developed a mathematical model to study the influence of spot welding parameters (welding current, welding time, electrode force and sheet thickness) on the strength of spot welded Stainless steel sheets with commercial purity . Vural M., Akkus A and Eryurek B [5] investigated the effect of nugget diameter on the fatigue strength of resistance spot welded joints of galvanized steel and austenitic stainless steel(AISI 304) welded as lap joints . Bouyousfi B. Sahraoui T., Guessasma S. and Chaouch K.T. [6] have studied the effect of spot welding process parameters (are intensity, welding duration and applied load) on the mechanical properties and characteristics of the spot joints between two stainless steel sheets (304 ASS) having the same thickness. Micro hardness and tensile test results have shown that the weld resistance is important and highly correlated to the value of the process parameters especially the applied load.

III. EXPERIMENTAL METHOD AND CONDITION

A. Material:

The grade and chemical composition of materials used in this study are shown in Table 1. It includes ASS 202 and ASS 304 steel 0.5 mm sheet.

AISI/ASTM	Steel eq no to DIN EN	C Max	Mn Max	P Max	S Max	Si Max	Cr Max	Ni Max	Other elements
TP 202 (ASS-202)	1.4373	0.150	7.5-10	0.060	0.030	1.00	17-19	4-6	N-O.25 Max
TP 304 (ASS 304)	1.4301	0.080	2.0	0.045	0.030	1.00	16-20	8-11	

Table 1: Showing composition of ASS 202 and ASS 304 Steel sheet.

Steel sheets of ASS 202 and ASS 304 are welded with spot welding machine with following details with current and electrode force as welding process parameters.

B. Welding Equipment and Parameters:

Resistance spot welding machine (5 KVA, PHASE 2, DUTY CYCLE 50 %)
Max weld Amps: 200: oil/air cooled
Universal Testing Machine (Measuring range 0-400 kN)
Leica DMLM Metallurgical Microscope, special objective (1.6x to 250 x) with 20,22 and 25 mm fields of view.

C. Process Parameters Used For This Are:

*Weld current and *Electrode force

D. Hardness Test Using Rockwell Hardness Machine:

The result have been recorded as shown in (Table 2) on Steel sheets, and corresponding Hardness value is noted carefully.

Sr No	AISI/ ASTM	Electrode force (Newton)	Hardness at nugget (HRC) at 25 Amp	Hardness at nugget (HRC) at 50 Amp	Load
1	ASS 304-	90	45	86	100 kgf

	ASS 304				
2	ASS 202-202	90	40	75	100 kgf
3	ASS 304-202	90	36	73	100 kgf

Table 2: Showing hardness values at 25 amp and 50 amp

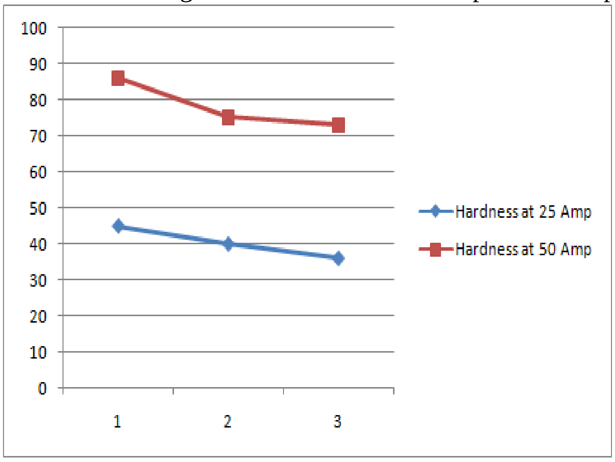

Fig. 1: Hardness at 25 Amp and 50 Amp

We can see from Figure 1. that hardness increases when current is changed from 25 Amp to 50 amp. It means that ASS 202 AND ASS 304 are material which becomes harder at weld nugget when the temperature during welding increases. Actually, Austenite stainless steel changes its phase at high temperature. It transforms into martensite . Hardness is increased also due to the ratio between the main elements of stainless steel chemical composition: Cr, Ni, and Mo.

E. Tensile Test Done on UTM Machine:

Weld steel sheets welded at 25 Amp current and electrode force of 90 Newton were tested on UTM machine which gave Max.Load (kN) and Disp at Fmax(mm) which is shown in table 3.

Sr No	**AISI/ ASTM**	**Disp in (mm) /**								**Disp at Fmax(mm)**
		load (kN)								**Max. Load (kN)**
1	ASS202-ASS202	0.5	1.0	1.5	2.5	3.0	3.5	4.0		4.00
		1.23	1.4	1.6	1.72	2.16	2.2	2.40		2.40
2	ASS304-ASS202	.05	1.5	2.0	2.5	3.0	3.5	4.0	4.5	4.50
		1.4	1.6	1.8	2.0	2.2	2.3	2.4	2.6	2.60
3	ASS304-ASS304	0.5	1.0	1.5	2.5	3.0	3.5	4.5	5.0	5.20
		1.15	1.4	1.56	1.8	1.9	2.1	2.08	2.4	2.90

Table 3: Tesile test with 25 Amp current and electrode force of 90 Newton

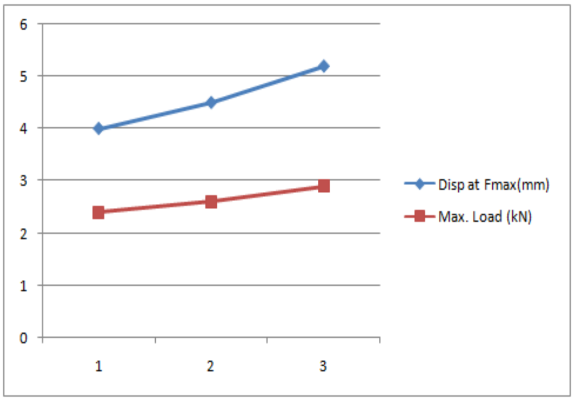

Fig. 2: Showing Max load (kN) and Disp at Fmax(mm) during tensile test

F. Study of Heat Affected Zone:

To understand the effects of microstructure on the mechanical performance of welds, it is important to recognize microstructural differences at the various weld regions. These include the base metal (BM), heat affected zone (HAZ) and fusion zone (FZ). S. J. Hu, J. Senkara and H. Zhang [9] The FZ is created by heating above the melting point, while the surrounding HAZ material itself consists of several regions which experience thermal cycles with progressively decreasing peak temperature from the fusion boundary. S. Kou [7] In some of these regions post-weld microstructure depends heavily on the BM structure, while in other regions the BM effects are less clear because peak temperatures during the weld thermal cycle are well above the critical temperature (Ac3).Thus, it is important to first develop a clear understanding of the thermal history in these regions and their effects on the resulting micro-structure. [H. Zhang and J. Senkara] 8 BM temperatures during welding typically remain below 200 C remote from the weld, so no transformations are activated and the microstructural constituents are left unaffected . Hardness values in the base metal depend mainly on alloying levels and processing methods.

As we can see in figure (3) the HAZ can be divided into four subregions: the sub- critical (SC), intercritical (IC), fine grained (FG) and coarse grained (CG) heat affected zones .Peak temperatures in the FG and CG HAZ exceed Ac3 , resulting in a fully austenitized local structure. In the FG HAZ the short time above Ac3 limits grain growth, producing an ultra-fine structure upon cooling. However, temperatures in the CG HAZ are well above Ac3 , and growth of austenite grains is facilitated with the extended time spent at elevated.

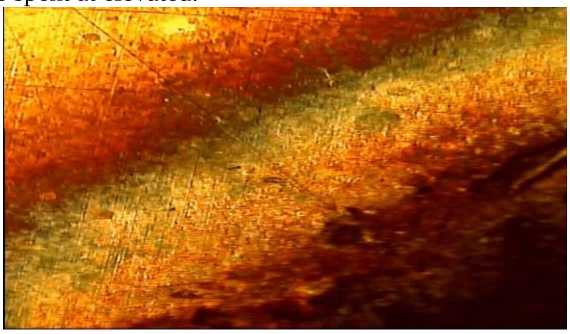

Fig. 3: (100 x) H.A.Z. of a ASS 202-ASS 202- 202- 45 N Electrode force before breaking of nugget

Fig. 4: Leica Microscope used in experiment

Top left corner shows yellow colour that is of base metal (BM).In HAZ : Subcritical (SC) the orange colour i.e 2nd layer from top Intercritical (IC) red colour 3rd layer from top . Fine grained (FG) green colour 4th from top . Coarse grained (CG) yellow colour above the dark brown Fusion zone (FZ) we see that as we go closer to the FZ (fusion zone) the dark brown colour in right (bottom) increase as heating is done above the melting point .

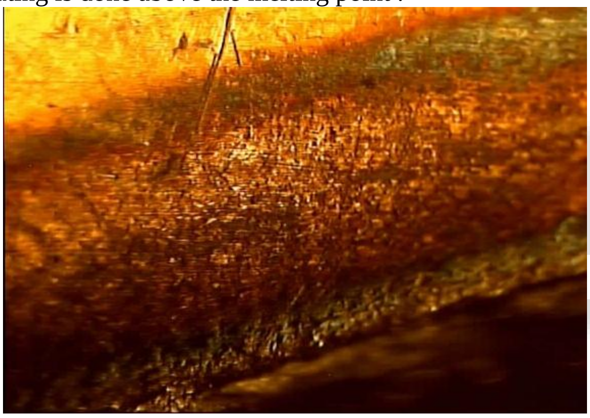

Fig. 5: (100x) H.A.Z. OF 202-202 -25 Amp 45 N electrode force , after rupturing of nugget.

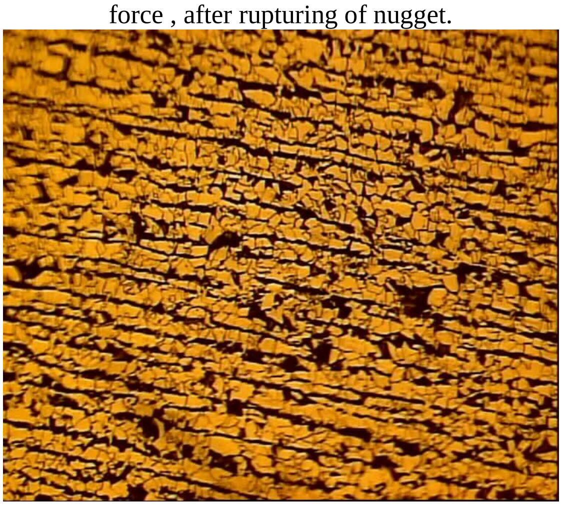

Fig. 6: 200x grain structure of ASS202

Deduction from FIgure 5.

- Top left corner showing yellow colour is the base metal
- H.A.Z. has merged into allmost one layer , no distinct colours are visible .
- Rupture of the Fusion zone (FZ) can be seen by eroded grain in layer near nugget (left corner)

IV. Results

It can be seen from Table 2 and Figure 1 that Hardness of steel sheets at nugget increases as the current increases from 25 Amp to 50 Amp , and maximum hardness is of ASS 304-ASS 304 steel sheet. As we can see in Table3. the tensile test shows that ASS 304-ASS 304 steel sheet shows maximum bearing load (Max. Load (5.20 kN) with Disp at Fmax(2.90 mm) . Microscopic examination of nugget shows how different layers of HAZ before welding and after ruputure of weld. In Figure 5. We can see that eroded layer in right corner of HAZ due to rupture of the weld nugget after tensile test.

V. Conclusion

The current study are to detail study an compare the microstructure and mechanical properties two type of Austnitic Stainless steel.The examined steels include an: ASS304 and ASS202 (0.5mm in thickness)

So we can see that there is a great difference in composition of (C-Mn-P-Cr-Ni) and by welding these two material together i tried to get a new weld composition at nugget and examined how HAZ (heat affected zone) and mechanical propereties will be changed .

As most work have been done on ASS316,AISI304, SAE 1010 but in current study both the metal ASS304 & ASS202 are quite different , ASS202 has low Ni and high Mn and weak in corrosion resistance and ASS304 is low in Mn , i will study how does these variation in compositon affects the HAZ (heat affected zone) and mechanical properties by first welding

(a)ASS304 & ASS202

(b)ASS304 & ASS304

(c)ASS202 & ASS202

The current experimental will be optimizing the process parameter in resistance spot welding.

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