A study on the microstructures of resistance spot welded Al 6063 T6 and SS 304

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Abstract. The micro structural and mechanical activity of resistance spot welds (RSW) conducted on 6063-T6 aluminium alloy sheets and SS 304 stainless steel welded at various welding parameters is investigated in this report. In order to determine the effect of welding parameters on the efficiency of the welds, micro structural examinations and hardness assessments were carried out. In order to define their strength and the microstructures of the base and welded components, the welded joints were subjected to static tensile-shear testing. Present work focused on evaluating the mechanical properties for RSW welding aspects of SS 304 and AL6063 T6 materials of 1 and 1.5 mm thick.

1. Introduction
Welding is the method of becoming game member of two metals completely via the software of a appropriate mixture of temperature, pressure, and metallurgical stipulations locally. Fabrication and restore works of metallic merchandise in each industry, welding is the essential means. In the car sector, welding is used significantly in basic fields of use. RSW is the most normally used welding strategies for car applications. The new applied sciences in the welding place made viable the considerable discount The weight of the vehicle and its expansion as an economic system and efficiency. The light-weight vehicles ketch and development have appreciably accelerated and in the closing decades, unique options have been developed primarily based on the intensive use of Aluminium as modified or new alloys. RSW is a procedure of becoming a member of metallic factors through the entrance of distinct spots at the interface regarding the work pieces. It is certain concerning just good and realistic techniques for the creation about incidence metal assemblies [1].

![Micrograph of RSW in two sheets of mild steel](image)

Figure 1. Micrograph of RSW in two sheets of mild steel

This specification is used to transform low carbon steel, stainless metal, then nickel, aluminium or titanium alloy elements into a part, but is then exceptionally aged [2-5]. A regular body-in-white (BIW) contains about 5000 welds; thus, the energy yet toughness concerning the automobile is mostly based concerning the attribute on resistance point welding. Over the remaining 20 years, the utilizes of arrest drop welding over lined steels...
has allowed manufacturing regarding constantly response welds at quotes more 20 million by week.

2. Research methodology
Two uncooked substances have been used in it lesson namely stainless metal (SS 304) then 6063 aluminium alloy (Al 6063). Because of each material, the sample measurements of one hundred seventy five mm x 25 mm x 1.5 mm were once organised due to tensile cut control in compliance with the AWS C1.1. The parameters old for dot welding are proven within ‘Table 2’. The suture geometry because obturcaneous power check is proven into configuration 1 because of warmth handled non-heat dealt with samples. The quantity concerning the pattern was proven specifically among ‘Table 1’.

| Sl.No | Parameters | Unit         |
|-------|------------|--------------|
| 1     | Current    | 4 kA, 5 kA, 6 kA |
| 2     | Overlap    | 30 mm        |
| 3     | Force      | 1500 N       |
| 4     | Dimensions | 175 x 25 x 1.5 mm |

Figure 2. Dimensions of the plate

Welding technique requires the fundamental detail such namely welding parameter. In it study the welding parameter shad been as sorted in term over welding currents then welding times, while the ignoble parameters have been fixed such as electrode forces, (1.8 KN) and welding cycles (10 cycles). The welding parameters have been shown among ‘Table 2’ or welding joint(lap joint) design was once shown into ‘figure 3.2’.

Figure 3. RSW with overlap of two materials

| Material | Dimensions |
|----------|------------|
|          | Length | Width | Thickness |
| Al 6063  | 175    | 25    | 1.5       |
| SS 304   | 175    | 25    | 1.0       |
Later then the welding is done the samples are tested because theirs microstructures because findings. The microstructures execute stand present the usage of the standard microscope, SEM yet TEM snap shots obtained.

3. Results and discussions

3.1. Weld Morphology

Given the significant set of parameters evaluated, the spot welds were lovingly visible even though they used to be variable in spot and in dot diameter with variations procedure parameters. The parameters of the procedure are different. Radio graphic examination confirmed the welds have been fair over intestinal defects, certain so pores yet voids. Subsequent metallographic evaluation was on ceafter dimension the accurate dimensional traits over the welds, primarily the altar on the weld nugget, yet according to signify the microstructure, as much nicely to ensure so much welds had been totally broad on defects, parley ‘figure 4’.

![Figure 4. macrostructure of RSW nugget Microstructure](image)

The spot welding method of the resistance is thermal, metallurgical and mechanical, as results in a thin field, currently called the nugget, or a warmed area around the nugget. The volume and form of microstructures in these areas is greatly determined by the warmth feedback between the systems. ‘Figure 5’ indicates the metallographic views of etched SS 304 illustrating a everyday equiaxed austenitic corn structure as consists of the alloy fellow boundaries namely a end result concerning growth calamity for the duration of there crystallization. Besides, the microstructure of the Al 6063 T6 in ‘figure 6’ shows the microstructure regarding Al 6063.

The structure consists mostly of pancake wound grains stretched into the direction of rolling, which have shown that they exist between the average part and the figure, while incomplete grains with equilibrium exist within the structure.

![Figure 5. Microstructure of base material ss304](image)

The use of welding conditions, the main soldering cutting edge or current time of float influences this microstructure extensively. ‘Figure 7’ expound the microstructures over the
mass of welds performed the usage of 23.5kA yet 28.7kA, each because of 2 cycles on contemporary flow era yet with 3237 N about electrode force.

Figure 6. Microstructure of base material AL 6063 T6

Figure 7. Microstructure of AL 6063 during the RSW

Figure 8. Microstructure of welded material
‘Figure 8’ demonstrates the effects on reduction of joints thickness and welding indentation of different welding parameters. With the rise in soldering current and welding time, the number of thickness decreases in welded joints improved, of which a maximums value was 40.15% at 9 kA for 200ms. Different behavioural patterns of welding nugget diameter and indentation depth are considerably depending on the feedback of the welding thermal. As the heat input improved by increasing the welding current and weld time, more aluminium alloy and steel melted were obtained at higher temperatures and this led to a higher diameter and indentation size.

The activities during the heating process are explained in Figure 8 b,c, d, and the molten nugget was produced at the melting temperature. On the outside of the nugget was an internal austenitic stainless steel and half molten base metal due to its high resistivity. In the cooling process, the liquid overheating metal was produced by non-spontaneous nucleation near the semi-molten metal, with the grain developing crystalline Concordia characteristics perpendicular to the fusion side. In the course of a high temperature austenitic transformation took place in stainless steel / aluminium interface which led to an austenitic growth during a temperature that was then refreshed into coarse ferrite grains.

A new phase centre may have been formed by grains on the surface of the base material around the edge of the weld pool, as energy requirements were minimal, and crystal mesh and lattice constants were in near alignment with the new phase.

4. Conclusions

We welded austenitic stainless steel SS 304 to Al alloy 6063-T6 by intermediate frequency RSW and studied the microstructure before and after the welding joint. This analysis produces the following results:

- This layer consists of fe2al5 phase, with an aluminium alloy nugget, with a tight-like morphology beside the steel, and a feal3 phase with a tongue-like morphology which depends greatly on the location in the welding region and the welding region and the welding parameters of the alloy.
- The IF RSW joint consist of molten aluminium alloy nuggets and heat-impacted stainless steel materials and aluminium alloy. An inter metallic compound film formed at the interface between steel and aluminium.
- Cracks initiated at the interfacial layer of the tensile shear specimens and propagated predominantly through the aluminium alloy fusion zone near the interface and partial through the intermetallic compound layer.

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