A Review on Spot Welding with Dissimilar Materials
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Abstract— The paper deals with using of welding current as the most necessary parameters in resistance spot welding (RSW) on the surface of welded materials. Many values of welding current were used in this experiments and consequently the results represent that increase of the welding current tends to increase the size of weld spot, and also raises the shear force. Whereas the shear force increased inversely with the time of welding.

Key words: resistance spot welding, welding current, welding time

I. INTRODUCTION
It has been used in many industrial applications, especially those, which need high corrosion resistance, since there are many aggressive mediums responsible for the corrosion of that alloy in chemical, petrochemical industries.[2] This technique is widely used in automotive industry due to its high efficiency in manufacturing thin metal sheets. The aim was to determine the spot welding parameters for the dissimilar metal joints and to characterize the mechanical properties of the joints. [4] Welding is a metallurgical process—all aspects of a welding process can be, more or less, related to metallurgy of the materials involved in welding, either the base metal or the electrodes. After spot welding, important changes occur in mechanical and metallurgical properties of the spot welded areas and heat affected zones. The investigation of these changes is very important for the safety strength of the welded joints [1].

There are three parameters to influence the welding of the surface quality of spot resistance welding in all aspects: applying force, welding time and welding current.

II. WORKING PRINCIPLE OF RESISTANCE SPOT WELDING PROCESS (RSW)
Resistance Spot Welding (RSW) is one of the oldest process of joining two two metal pieces overlapped together by flowing current through a small area (spot) relatively contact to each other when the pressure is applied for a given amount of time shown in Fig. 1.

When the two metal sheets comes into contact due to the forced applied between electrodes, the alternating current passes through the electrodes in the presence of electrical contact resistance between the two metal sheets. In this process, the electrical energy is transformed into Heat energy on the faying surface between the sheets which is welded. In this process, due to the fast rate of welding current increases the temperature rapidly and the result metal sheets is going to melt at the point being welded. [1]

In resistance spot welding, the heat energy is necessary to generate the coherence by applying an electric current through the overlapped of sheets between the two electrodes. Thermal and Electrical properties of the plates or sheets and some coating materials are responsible for the formation of a welded joint, nugget size and the heat-affected zone (HAZ). A weld’s formation can be included to the thermal and electrical welding processes. The electrical and thermal parameters are controlled by a common experimental practice in resistance spot welding.

Fig. 1: Principle of resistance spot welding
After the solidification of heat effected zone, a weld nugget is created and hence two metal sheets are joined together. Usually, the water-cooled electrodes are used to protect the sheet surface from sticking.[1]

The usual expression of heat produced by an electric resistance can be written as

\[ H = I^2Rt \]  (1)

where \( H \) is heat, \( I \) is current in Ampere, \( R \) is resistance in ohm in the circuit, and \( t \) is the time for which the current is flow in the circuit. When the resistance or current is not constant, the result will come for the heat created in a time interval \( t \) integrating the above expression is obtained [4].

Resistance spot welding is a welding process in which the coalescence is created by the heat gained from resistance to supply the electric current through the workpieces held together by electrodes under pressure. The shape and size of welds individually made are primarily limited by the size of the electrodes. The welding machine control function defines the welding cycle. The particular steps are controlled by squeeze time, weld time, holding time and off time [5].

A. Literature Review
Various authors show the light on the spot weld parameter optimization and influence on different materials by processes.

M. I. Khan, K. M. Moed, K Pandley “Investigation of the Effect of Current on Tensile Strength and Nugget Diameter of Spot WELDS Made On AISI-1008 Steel Sheets”. At the present time researcher were inspected that the weld current is most influence factor for controlling the nugget diameter as well as the weld tensile strength. They used 0.8mm mild steel sheets (low carbon cold rolled). It has good strength, better corrosion or erosion resistance, toughness and ductility properties. According to the taguchi method, the orthogonal array will selected. In the
experimental results, it will indicate that Signal to Noise(S/N) ratio to nugget diameter and tensile strength represent the welding current to be most influence factor for controlling the nugget diameter (weld time and pressure are less) and tensile strength (pressure and hold time are less). [6]

Dheeraj Sagar, Gyanendra Singh, Nishant Singh, Rajeev Arora “Effect of weld current and time on hardness of spot weld”. After studying this paper, they focused on weld time and weld current on the basis on heat affected zone spot weld hardness. The qualitative properties of spot welds were assessed Heat Affected Zone for measuring the hardness. different grade of Austenitic stainless steel 304, 304L, 304H they used. The austenitic structure shows excellent toughness, down to cryogenic temperatures in these grades. The results after the experimental work, to enhance the reliability of response surface methodology (RSM) technique. Five levels and four variables is selected for a orthogonal blocking with central composite design. The results in last indicates that due to increase in weld time and weld current the hardness of heat affected zone (HAZ) decreases. The influence of weld time and weld current on diameter of weld nugget, width of HAZ and degree of penetration by electrode can be inspected. [7]

M. Subramaniam, and V. Subramanian has given that the optimization of the welding time and welding current setting for achieving a maximum tensile shear force and minimize nugget diameter with the use of regression analysis. For this purpose SPRC35 steel sheet was used. The author gave the result that with the increase in welding current would be increased tensile shear strength and the nugget diameter [8]. They were used genetic algorithm (GA) and artificial neural network (ANN) to optimize in subassemblies the parameters of spot welding required to minimize gaps or dimensional deviations. The ANN was useful for producing the relation between some parameters of welding and their respective created assembly gaps. Genetic algorithm was used to obtain the optimum parameters of welding which was used to the minimize dimensional deviation.

J.B. Shamsul and M.M. Hisyam “Study of Spot Welding of Austenitic Stainless Steel Type 304”. In this research they had concluded that the austenitic stainless is being welded by resistance spot welding. The experiment gave the relationship between welding current and the diameter of nugget and at the welding zone it shows the Hardness distribution. They carried out Austenitic SS304 of 3.5mm thickness. After experiment the results indicate, that the changes of the current, the nugget diameter were differ, it shows that with the increasing of welding current the weld nugget increases. By the micro hardness testing concluded on the cross section samples across the vertical & horizontal of the nugget, they were studied by plotting the graphs to indicate that the result due to the varied welding current with respect to the weld nuggets. Due to its better corrosion resistance, good strength, high toughness and ductility, the austenitic stainless steel AISI-304 is an very important commercial alloy. The results indicates that the nugget size increases with increasing the welding current. The hardness distribution does not effect the nugget size. With addition, increasing welding current does not arise the hardness distribution. [9]

Norasiah et.al was lighted on weld parameters for using Response Surface Methodology optimizing spot in order to obtain smaller heat affected zone (HAZ) and a nominal weld diameter. [8]

Norasiah Muhammad, Yupiter H. P. Manurung, Sunhaji Kiyai Abas, Roselleena Jaafar, Ghalib Tham, Esa Haruman “The Development of Model For Quality Features Of Resistance Spot Welding Using Multi-objective Taguchi Method And Response Surface Methodology”. The parameters which effect the Resistance Spot Welding (RSW) on the welding zone produced was inspected by using Taguchi Method. RSM was used to predict the weld zone development creating the mathematical model. To identify the predetermined model, the confirmation test of experiment was conducted for plate thickness of 8 to 1.3 mm (Low mild Steel). On the Basis of the experimental results, for improving the welding performance and quality in RSW to predetermined the size of welding zone the designed model can be efficiently effective. For detecting important parameters in multi-tasking optimization for width of HAZ and radius of weld nugget has been employed the ANNOVA technique. This analysis, concluded that welding current was important to contribute the percentage of various control parameters on characteristics of multiple quality (width of HAZ and radius of weld nugget). For the greatest influence to growth of weld nugget In RSW, the contact surface and welding current are significant. Performance in RSW and the welding quality can be used to determine size of weld zone by using confirmation test. On the results, they said that developed model can be extensively to determine the weld zone size and the welding quality and RSW performance. [6]

Lin et.al was used Taguchi Method and ANN for optimizing the parameters of spot weld. The optimum settings of four parameters; electrode force, welding current, electrode tip diameter and weld time can be identified by Taguchi Method. For various welding schedules to achieve the weld strength measurement, the of model ANN was employed. [10] The above work consist of steels with the same type thickness. Furthermore many work was only looked into single weld characteristic the strength of weld except for Norasiah [8] and Subramaniam [6]. This work was inspected the optimum setting of weld for different thicknesses and dissimilar steel. The existing data for welding do not allow parameter setting for different thicknesses and dissimilar steel. The most automotive body parts are made up of different steel and different thicknesses. For determining the welding joints of dissimilar steels with dissimilar thickness optimum parameter of welding schedule is much complex. In the automotive industry, current practice is to be recommended for the thinner steel, the welding schedule for the steel which is to be welded with two dissimilar thicknesses or the medium thickness joining the steels with three dissimilar thicknesses. This work concluded that the three different weld parameters namely the weld nugget diameter, tensile shear strength and the weld penetration. These three weld parameters play important roles in enhancing the spot weld quality. No any of the above authors. Finally used Grey based Taguchi Method was not reported for the weld parameters optimization.
III. EXPERIMENTS

This work will be carried at robotics and automobile part manufacturing industry, space craft using a spot resistance welding. The following low carbon steel sheet and high strength alloy steel will be used for experiments: HSLA with the variable thickness in mm, low carbon steel with different thickness in mm.

Welding current, weld time and electrode force will have been using the control parameters having each three levels. The squeeze time, electrode tip diameter and holding time will have constant. Weld times, welding currents and electrode forces will be ideal factors by making the weldability characteristic by the welding gun.

The samples with dimensions of 100 x 30 mm and 3 mm lapping according to STN 05 1122 standard will be used for the experiments (Fig. 2).

![Fig. 2: Tensile shear test sample](image)

<table>
<thead>
<tr>
<th>Steel Type</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low mild steel</td>
<td>0.18</td>
<td>0.5</td>
<td>0.06</td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>HSLA</td>
<td>0.04</td>
<td>0.13</td>
<td>0.08</td>
<td>0.04</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Table 1: COMPOSITION OF METAL

IV. RESULTS

The coalescence is formed by resistance spot welding electrode pointed tips. The penetrations was inspected at the surfaces of the samples made with the parameters of higher value of welding time, current and the penetrations were at the both surfaces of steels to be welded for all observed samples with the least value of welding current were prepared. With the variation of the values of welding current effected the welding electrode indentation at the surfaces of materials of the weld.

V. CONCLUSION AND DISCUSSION

The work represents an overview of latest works on experiment of Resistance Spot Welding process and further references. From the above review it will be concluded that:

1) Resistance Spot welding is very fast and easy process, no required to use any filler metal or fluxes to generate the joint and also it does not have any hazard with open flame.

2) This process (RSW) mainly depends on the process parameters (e.g. electrode force, weld time, welding current), and material parameters (e.g. thickness, types).

3) The most statically study was done by considering the three process parameters like applied force, weld time and squeeze time. The quality of weld was evaluated to the individual properties like tensile peel strength, tensile shear strength etc.

4) The above discussion of literature survey refers that it is necessary to study the influence of all welding parameters for the weld strength and weld quality in detail. At the most of the research papers concluded that current is the major. In the most of the research papers finally landed that for the influence of the weld strength and weld quality depends upon the welding current with increasing or decreasing the others factors.

REFERENCES


