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MINI SPOT WELDING MACHINE

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ABSTRACT

This research paper focuses on the development of a 2-D axisymmetric electro-thermo-mechanical simulation model for resistance spot welding (RSW) process. Resistance spot welding is widely used in sheet metal fabrication, particularly in the automotive industry, due to its simplicity and cost-effectiveness. The specific objectives include studying and understanding the RSW process, creating a 2-D axisymmetric geometry in ANSYS, developing an electro-thermo-mechanical coupled field model, validating the simulation results with published work, validating the simulation results with experimental data, and analyzing the obtained results. By developing an accurate simulation model for resistance spot welding, this research aims to contribute to the optimization and improvement of the welding process. The findings of this study can potentially be utilized in the automotive industry and other sheet metal fabrication applications to enhance the quality and efficiency of resistance spot welding.

INTRODUCTION

The resistance spot welding process has the benefits of being quick, highly productive, and automation-friendly. The features of this process are a lot of energy can be delivered to the spot in a very short time. Hence for industrial significance, first a quick overview of resistance spot welding has been covered here.

BASIC OF RESISTANCE SPOT WELDING

One of the many ways to join two or more pieces of metal together is by resistance welding. The following list of techniques demonstrates how resistance welding is different from the others.

1. Bolting

2. Riveting

3. Soldering

4. Arc welding

5. Resistance Welding

All metals being attached together must have some additional material added before using arc welding or soldering. Resistance welding doesn't need any extra materials or holes in the metal, unlike bolting and riveting, which both require the metal to be drilled in order for the rivets or bolts to fit.

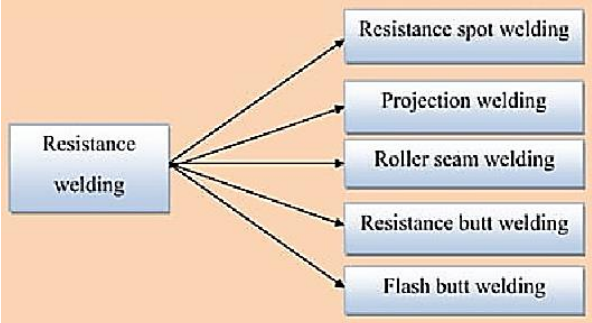

Fig 1: Classification of Resistance Welding Process

WORKING PRINCIPLE

Resistance welding is based on the Joule heating theory. In order to heat the work pieces by Joule heating, an electric current must first pass through the top and bottom electrodes and clamp the work pieces between them. When the welding current is turned off, the molten nugget that formed when the temperature at the contact reached the material's melting point solidified to create the weld that connects the work components.

The following equation can be used to determine how much heat is produced.

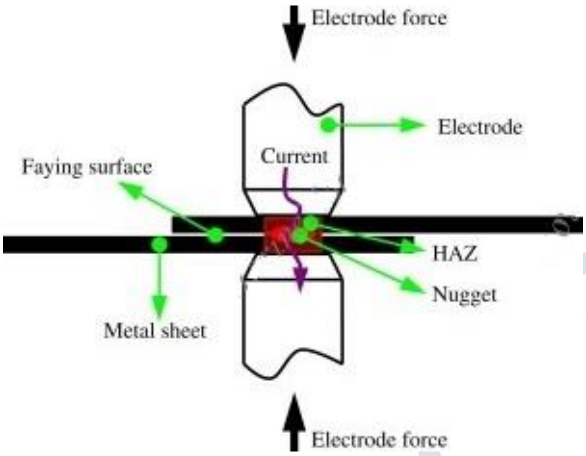

Fig 2 : Principle of Resistance Spot Welding

The amount of heat generated can be given by the following equation.

$$H \propto I^2 * R * T$$

where,

H - Heat generated in joules

I - Current flow in amperes

R - Resistance in ohms

T - Time for the welding process

FACTORS INVOLVED IN RESISTANCE SPOT WELDING

The quality of weld largely depends on the formation of the molten area which later becomes nugget.

1. Current: A current that is too low will not generate enough heat to form a nugget, but a current that is too high will cause ejection and even temperatures over the boiling point.

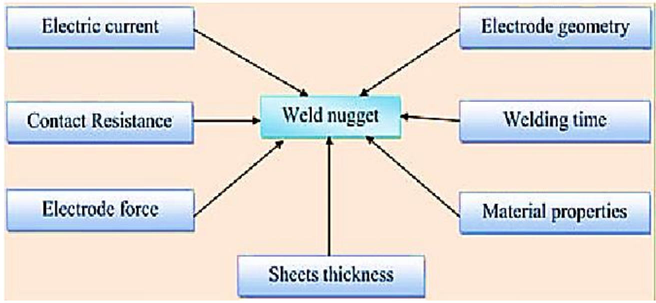

Fig 3 : Various factors responsible for quality of weld nugget

2. Resistance: The total value of the electrical resistance affects the current output or the resistance spot welding machine and consequently the heat generation of the circuit.

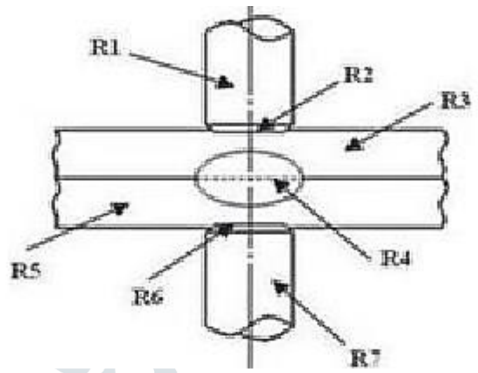

Fig 4: Various Resistance locations

3. Time: The heat generation is directly proportional to the welding time. In the majority of single impulse resistance spot welding applications, time is the only variable that can be controlled. By increasing the time, heat generation will also increase.

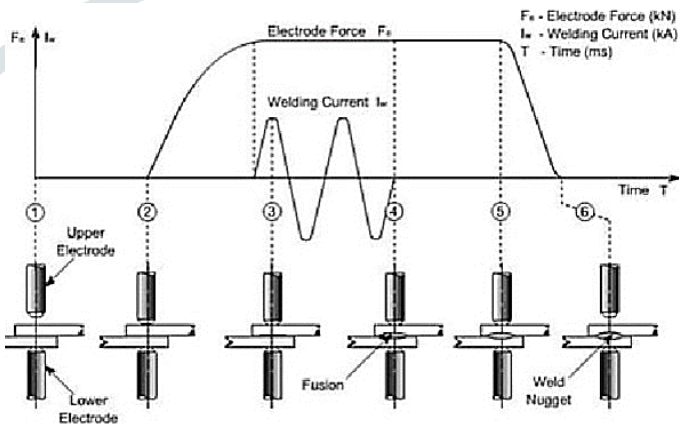

Fig 5 : Cycles of Resistance Spot Welding

4. Pressure: If the pressure applied by the electrode is too small then the sheets the electrodes will not contact properly. This will cause high contact resistance and may result in the surface burning or pitting the electrodes tips.

If excessive pressure is applied by the electrode during the hold time, then softened metal may be expelled from the metal-to-metal contact surface which will produce a nugget of smaller dimension.

5. Surface condition: The surfaces to be joined by this process should be clean, free of oxides and chemical compounds, and have a smooth surface.

6. Electrode Geometry: the weld nugget diameter should be slightly less than the diameter of the electrode tip point. The weld nugget will be small and weak if the electrode tip diameter is too small for the application. However, there is a risk of overheating the base metal and the formation of voids and gas pockets if the electrode tip diameter is too large.

LITERATURE REVIEW

Hessamoddin Moshayedi et al, had represented a 2D axisymmetric electro-thermo-mechanical finite element method to study the effect or welding time and current intensity on the nugget size in resistance spot welding process of AISI type 3041.

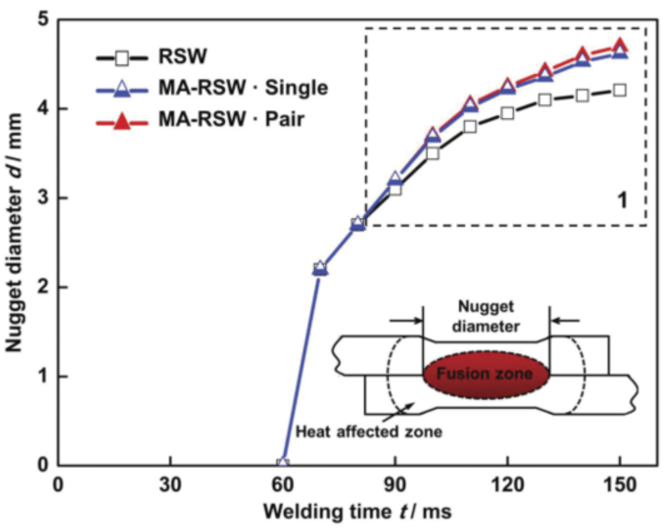

Fig 6: Time vs Nugget diameter

During the entire Resistance Spot Welding (RSW) process, it has been found that the center of the faying surface is always the location with the maximum temperature. Weld nugget formation requires a welding current greater than 6 KA, and current ejection happens at 8.5 KA.

HAMID EIZAZADEH et al, has studied on current intensity, welding time sheet thickness ad material geometry of electrodes, electrode force and current shunting are the most effective parameter on the spot-welding process. If the electric current flow is more than what is required for nugget growth, the nugget will expand quickly. The nugget growth rate decreases as the current flow increased but the nugget size rise until melt spattering occurs.

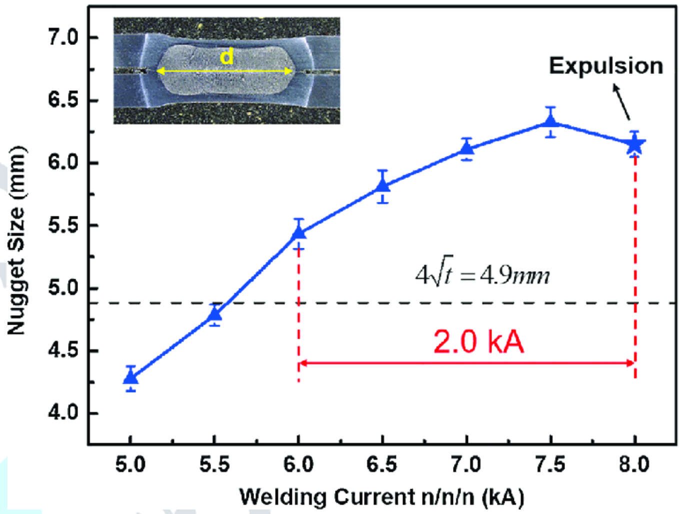

Fig 7: Welding current vs Nugget Thickness

METHODOLOGY

1. Researching and comprehending the resistance spot welding procedure.

2. To create in ANSYS 2D axisymmetric geometry,

3. To create an ANSYS model for an electro-thermal-mechanical coupled field.

4. To validate the simulation result with published work.

5. Validate the simulation result with experimental work

6. To analyze the result

MODELLING OF RESISTANCE SPOT WELDING PROCESS

ANSYS and COMSOL, two commercially accessible analysis programmes were used to simulate this process.

The simulation analysis has been done in two stages. One is structural analysis and other is coupled electrical - thermal and structural analysis. The flow diagram of the simulation process is shown in the following figure.

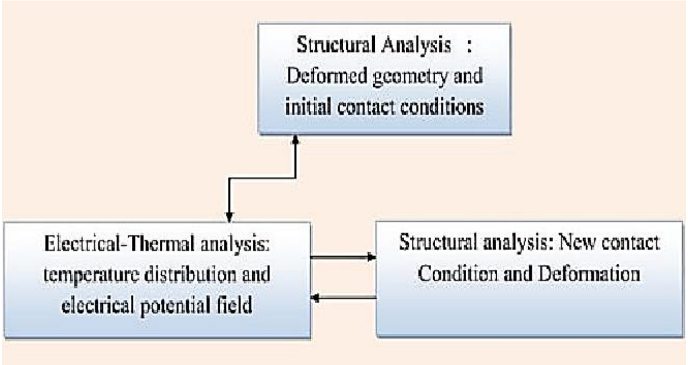

Fig 8 : Stages of simulation process

Geometry for Simulation Model

To simulate resistance Spot welding process, we have to first develop 2D axisymmetric model. Dimensions or geometry is given below.

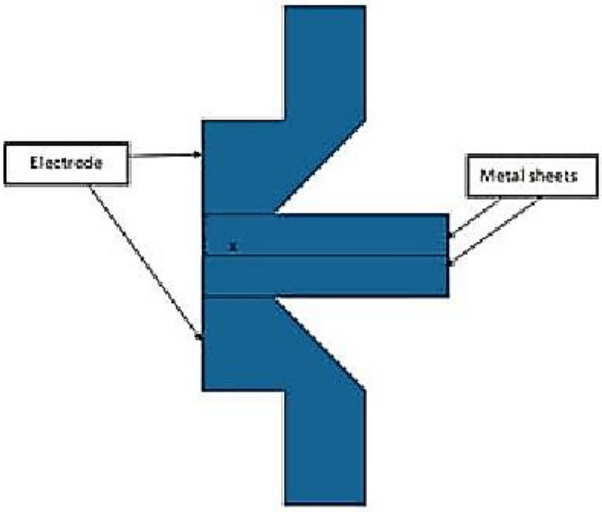

Fig 9 : Geometry Used for Modelling

Table 1 : Dimension Used for Modeling

Specimen size	Width	30 mm
	Thickness	1.5 mm
	Length	40 mm
Electrode size	Length	12 mm
	Diameter	16 mm
	Ti diameter	7 mm

Meshing

For various locations, the mesh is formed in coarse and fine mesh sizes as indicated.

Fig 10: Mesh generated FEA Geometry

The element used in this analysis is coupled field element PLANE223, to simulate the structural-thermal-electrical coupled field analysis.

PLANE223 : This element is two dimensional 8-nodel coupled -field solid element. This element has 8 nodes with up to 4 degrees of freedom per node. The geometry, node locations and co-ordinate system for this element as shown in the figure.

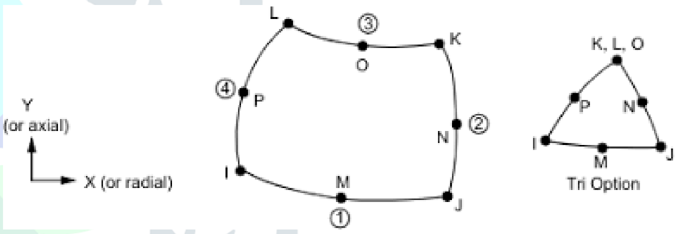

Fig 11: Geometry of PLANE 223 Coupled field elements

EXPERIMENTAL WORK

Machine Specification

For this experiment a press type resistance spot welding machine with 16KVA capacity was used.

Fig 12: Press Type Spot Welding Machine

Material used for specimens and electrodes

The material used for test specimens was stainless steel-304.

Fig 13: Actual photograph of Electrode

RESULT

The maximum temperature of 1680 °C is obtained at the end of weld cycle as mentioned in the published result whereas its value was around 1647 °C obtained by the developed model in holding cycle. at the end of hold cycle the temperature reached was 792.16 °C. In the Off-cycle temperature reached to 449.69 °C. The figure indicates that due to the convection heat losses in the cycle, the temperature decreases. The diameter of the weld nugget obtained was 3.4mm and height obtained was 2.9 mm.

The overall deviation calculated was 14%. This deviation occurred in the result due to various reason such as the types of meshed applied for number for elements and nodes generated.

CONCLUSION

1. Most of parametric study has been done by considering the process parameters such as applied force, weld time, squeeze time, from that weld quality has been predicted.

2. According to the literature review, it is necessary to investigate how different process variables affect the weld quality.

3. For this purpose the simulation model can be used for resistance spot welding process. Additionally, this strategy is now helpful for giving industries the most trustworthy cost-reduction solution.

4. The developed axisymmetric model for resistance spot welding process totally based on the geometry of electrode and specimens.

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