EXPERIMENTAL INVESTIGATION OF RESISTANCE WELDING PROCESS FOR THE THIN STAINLESS STEEL MATERIAL

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Abstract

The resistance welding is mostly used in automobile, aircraft and railways industries. In the industry, there are different types of stainless steel used so the research work on the resistance welding is very important and require careful study. The austenitic steel is preferred in most of the research areas for stainless steel. In this paper, the thin stainless steel having low thermal and electrical conductivity is used. The phase transformations are studied under the thermo-electrical part and welding characteristics are studied under the effects of different welding parameters. The Scanning Electron Microscope (SEM) images are used to explore the in-depth views of the material and finite element model has been developed to study the effects of welding parameters. The main purpose of our research work is to develop the optimized model to promote the quality research in the field of resistance welding for the thin stainless steel material using mechanical, thermal and electrical methods.
Keywords: *Resistance welding, Resistance spot welding, Scanning Electron Microscope (SEM), Stainless Steel.*

Introduction

Resistance welding is basically a welding process to join two or more pieces of metal together. Most of the welding processes require additional material to be added to the metal for joining and also require holes to me made into the metal for fitting bolts or rivets into the metal, but, the

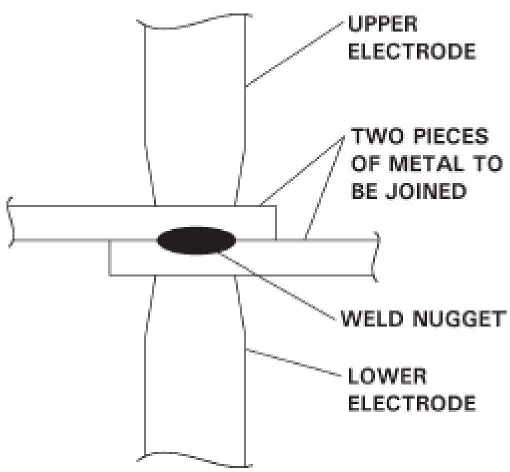
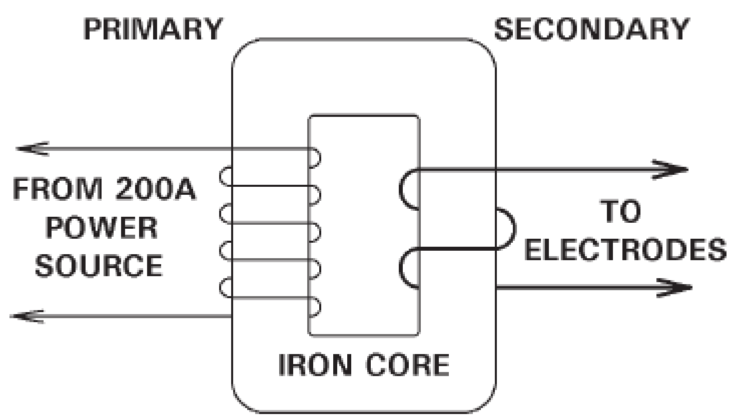


Fig. 1

Resistance Spot Welding

resistance welding do not require any additional material for joining and also do not require any holes to be made for fitting bolts or rivets into the metal. In the resistance spot welding, two metal pieces are joined together using upper and lower electrode as shown in the figure 1. The heating is obtained by passing the electric current through them till the stage they began to melt at the spot where they are in contact with each other. After this, the electric supply is turned off and the molten metal flowing gets solidified. The welding transformer usually consists of primary and secondary coils of wire. Power flows from primary to secondary coil in the fig. 2 shown welding transformer. The “turn ratio” is obtained by dividing the turns of the primary coil to the turns of secondary coil.



SIMPLIFIED DIAGRAM OF
A WELDING TRANSFORMER

Fig. 2

Welding Transformer

The one of the most important factors in resistance welding is the electrode force/squeezing force for joining the metal pieces together. The most commonly compressed air is used to generate the electrode force as shown in the fig. 3. The compressed air develops a pressure on the piston in the cylinder-piston arrangement. Due to this pressure, the electrode force/squeezing force is developed for joining the metal pieces together.

When the current required, I = 10,000 amp.

Then, primary turns = 100

Secondary turns = 2

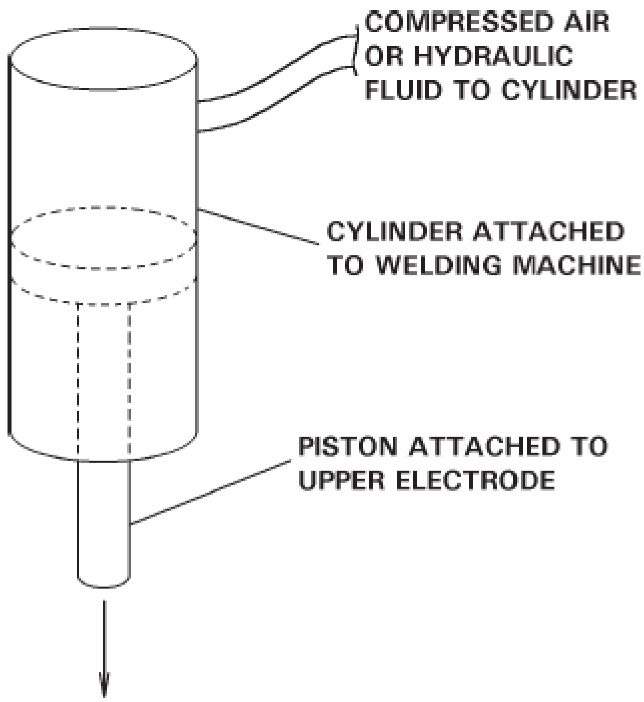
As, Turn ratio = Primary turns / Secondary turns

So, Turn ratio = 100 / 2 = 50

The resistance welding has the advantages over following welding processes:

a. Bolting
b. Riveting
c. Soldering
d. Arc welding

The time interval between the initial application of the electrode force and initial application of current is called squeeze time. The duration/length of time the welding current flows through the two metal pieces is an important factor.



SIMPLIFIED DIAGRAM OF
THE WELD FORCE SYSTEM

Fig. 3

The Electrode Force System

The martensitic stainless steel is least used in resistance welding due to brittleness of the welding joint. The stainless steel offers corrosion resistance and can also be recycled. Under the impact loading, high strength stainless steel offers very good energy absorption in relation to strain rate.

Literature Review

Kadam and Basu [1],focused on to determine the generalized relationship of cutting speed and surface roughness depending upon variable input process parameter using adequate mathematical models of regression and ANOVA in electrical discharge cutting process. Bhosle and Kadam optimized [2] the grinding process with variable process parameters like feed depth of cut against surface roughness and material removal rate. To Optimize the Resistance Spot and Seam welding process for specimen made from two dissimilar non-ferrous materials is the main aim of Mr. Elangovan and Venkateshwaran [3]. Kadlag and Kawade [4], determined generalized relationship of cutting speed and surface roughness dependent on variable machining parameters of wire cut electrical discharge machining. Bhatti and Quisse [5], optimized the resistance spot welding process to design the spot in structure. Reddy and Suresh Kumar predicted the surface roughness model of P20 graded steel by using genetic algorithm [6].

Experimental Procedure

The resistance welding was performed using a welding gun fitted with hemispherical electrodes. The lap joint configuration was setup and the electrode force of 4 kN was fixed for the welding. The range of input current setup from 7 kA to 8 kA. The welding current cycle duration is 370 ms. The force cycle duration is 310-480 ms. The welded steel were 2 mm thick. The electrical resistivity of austenitic stainless steel is 70 μΩ-cm and the low carbon steel is 13.2 70 μΩ-cm. The thermal conductivity of austenitic steel and low carbon steel is about 16.2 $Wm^{-1}K^{-1}$ and 52 $Wm^{-1}K^{-1}$ respectively. Light microscopy, micro hardness measurements were analyzed across welded joints. The weld joints quality is tested using peel testing. The macrostructure of the welded joint is obtained by welding current of 7.5 kA. As per the microstructure indication, the welding joint is asymmetrical. The size of fusion zone is larger on austenitic steel than low carbon steel. Almost similar results were obtained when using the welding current of 7 and 8 kA. The Heat Affected Zone (HAZ) in case of low carbon steel is higher due to higher thermal conductivity. Using the macrostructure experimentation, it is concluded that higher the welding current, larger will be the fusion zone.

Sample code	Welding current [kA]	Welding current cycle duration [ms]	Force [kN]	Force cycle duration [ms] [ms]
1	8.0	370	4.0/3.4	310/480
2	7.5	370	4.0/3.4	310/480
3	7.0	370	4.0/3.4	310/480

Table 1

Parameters for resistance spot welding

The microstructure characteristic of low carbon steel is ferritic. Some pearlites were also present in low carbon steel. Grain becomes coarser in low carbon steel in the region of Heat Affected Zone (HAZ). The Scanning Electron Microscopy (SEM) is also performed for the low carbon and austenitic stainless steel.

The general expression of heat generated in an electric circuit can be expressed as,

$Q = I^2RT$

Where, Q= Heat (Joule), I= Current (Ampere),

R= Electrical resistance of the circuit (ohm, Ω) and T= Time (second).

Fig. 4

The Experimental Setup

The EDX analysis was used for a more broad study for the welding joint. Vickers microhardness measurements were performed on each sample.

From the experiment, it is obtained that, Welding current α Fusion zone.

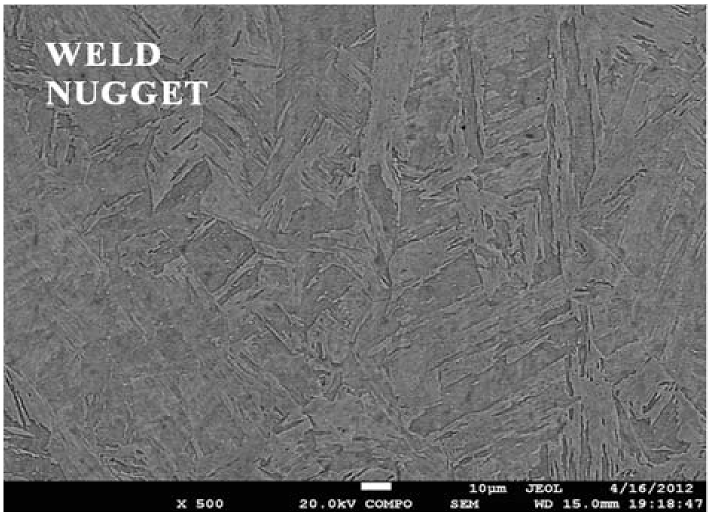


Fig. 5

Scanning Electron Microscope (SEM) image of dissimilar steel weld nuggets

The observation parameters are following:

a. Accelerating Voltage = 20 keV
b. Probe current = 2 nA
c. Working distance = 15 mm

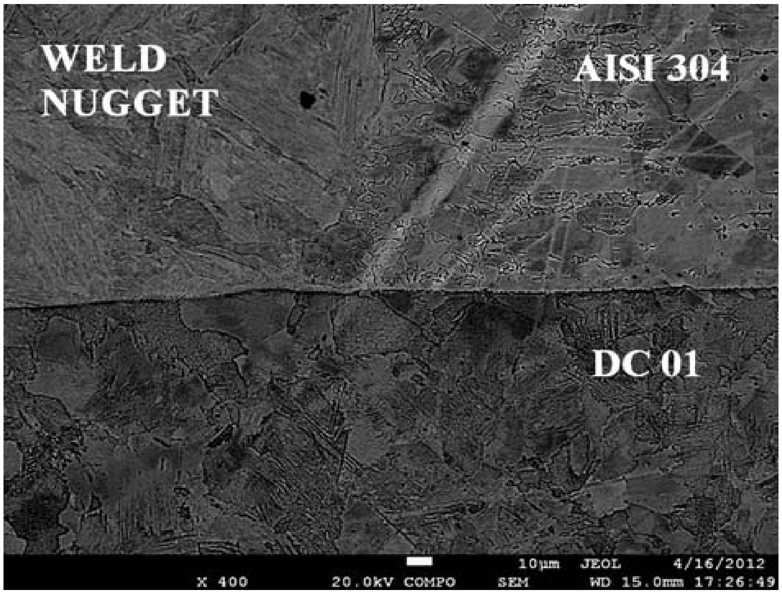


Fig. 6

Scanning Electron Microscope (SEM) image of base materials and welded joint

Result and Discussions

Weld cycle and welding current are the most significant factors for welding to obtain good strength of weld. For obtaining the qualitative result, strength of weld should be $290N/mm^2$. Resistance spot welding is comparatively fast process and quality of weld keep on increasing with sheet thickness and increase in operating pressure.

Conclusion

The size of weld metal increases with welding current. The Heat Affected Zone (HAZ) for low carbon steel is higher than austenitic steel due to high thermal conductivity of low carbon steel. The microstructure of low carbon steel is ferritic. In the fusion zone, hardness goes on increasing. Grain becomes coarser in low carbon steel in the region of Heat Affected Zone (HAZ).

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