

## Temperature distribution study in resistance spot welding

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This paper presents effect of sheet thickness and current density on cooling speed and temperature distribution in resistance spot welding. Thicker sheets have higher temperatures in weld zones. Temperatures are higher in sheets having various thicknesses under higher weld current. Weld current is more effective than material thickness on cooling rate and temperature distribution.

**Keywords:** Sheet thickness, Spot welding, Temperature distribution

### Introduction

Electric resistance spot welding (RSW) has an extensive application in joining of sheet metals in mild and stainless steels, heat resisting alloys, aluminium and copper alloys and reactive metals. RSW has high speed of operation, ease of mechanization, self jiggling nature of lap joint and absence of edge preparation or filler metal<sup>1,2</sup>. In RSW, work pieces are joined to each other by using pressure and heat. Heat is generated by the resistance to passage of current according to Joule's law. Temperature is the highest at contact surface between the pieces. In RSW, cooling speed is very high. Current density and sheet thickness affect heat generation in welding region. Veenstra & Hults<sup>3</sup> used thermal method to measure temperatures between electrodes. Bentley & Greenwood<sup>4</sup> studied temperature distribution in RSW using metallographic method.

This paper presents effect of sheet thickness and current density on cooling speed and temperature distribution in RSW.

### Experimental Studies

Material used was steel sheet having low carbon, circular shape and three different thickness (0.5 mm, 1 mm and 1.5 mm). Sheets were matched to each other as upper and bottom pieces. A groove was machined on upper sheet of each specimen to measure temperature values under electrode region. Depth of groove equals

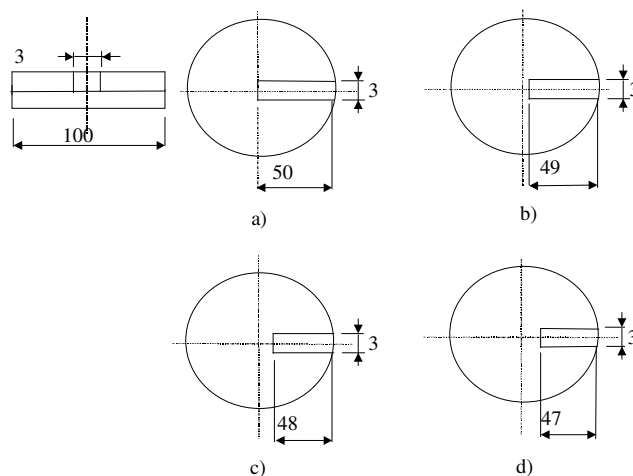


Fig. 1—Specimens with groove and matched each other

to sheet thickness. Groove length was extended by 1 mm. from weld center to sheet edge step by step in each identical welding specimen (Fig. 1). A digital thermometer that determined temperatures in the welding zone can measure three values in seconds and record results (Fig. 2). Electrode force was applied during spot welding while keeping welding current constant. Welding conditions were as follows: electrode force, 3400 N; welding time, 15 cycles; welding current, 11 kA; squeezing time, 25 cycles; and cooling time, 20 cycles. Same procedure was accomplished for 1 and 1.5 mm sheet thickness welding specimens.

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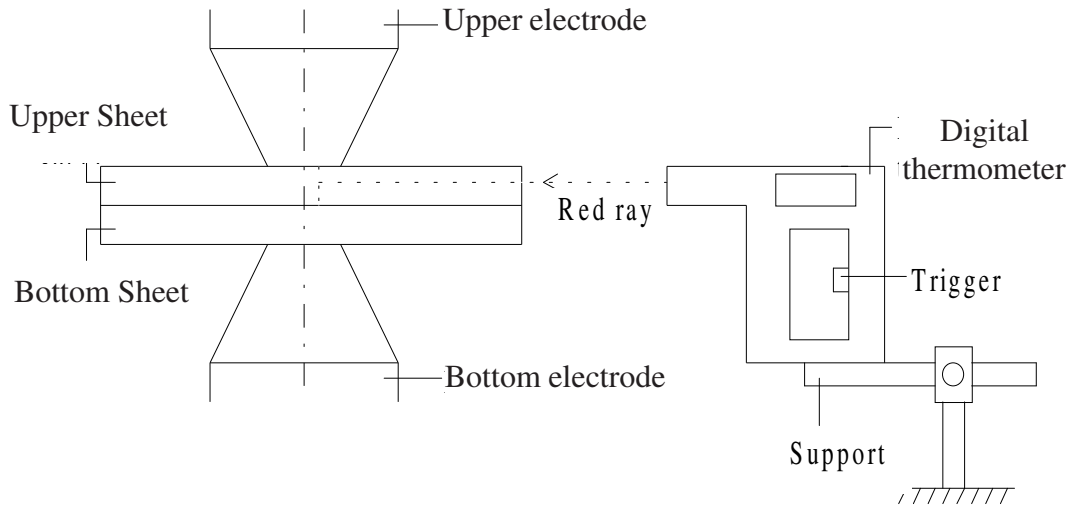


Fig. 2—Schematic view of welding procedure

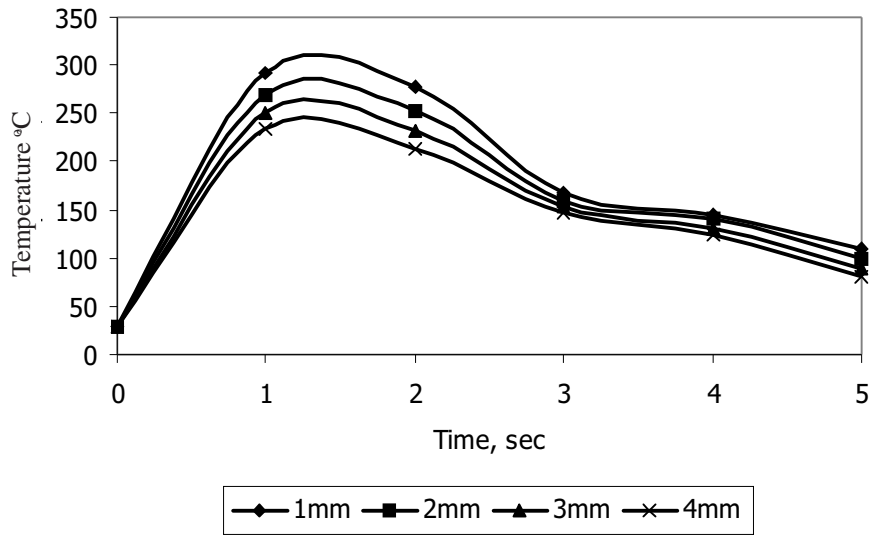


Fig. 3—Time depending temperature distribution of 1 mm sheet thickness

**Results and Discussion**

**Effect of Sheet Thickness and Distance from Weld Center**

Time depending temperature distribution on different points of welding zone starting from 1 mm distance are shown (Fig. 3) for 1 mm sheet thickness. In first step of welding, especially in 0-1 sec, temperature increases rapidly and when welding current is stopped, it decreases in 2-3 sec, indicating that cooling rate is very high because of high temperature difference between welding zone and environmental conditions. While temperature decrease

as depends on time, temperature difference and cooling rate decreases rapidly, especially in time interval after 3 sec.

Temperature values obtained are periodical (Fig. 4) according to distance from weld center (weld nugget). In all time divisions, temperature decreases while distance from nugget increases. For higher sheet thickness, current way becomes longer than that of thin sheet, and that's why temperature values also increase. There is a linear relation between sheet thickness and

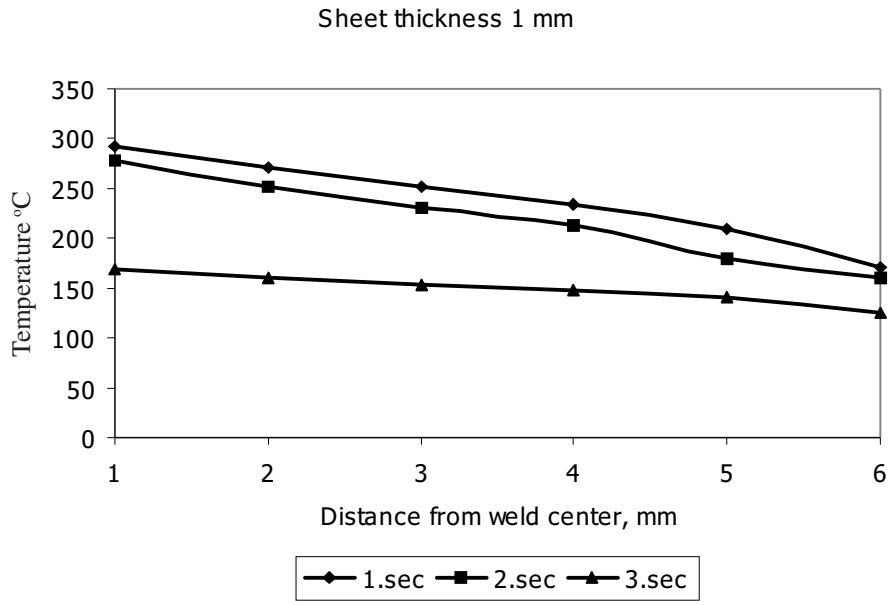


Fig. 4. Temperature values according to distance from weld nugget

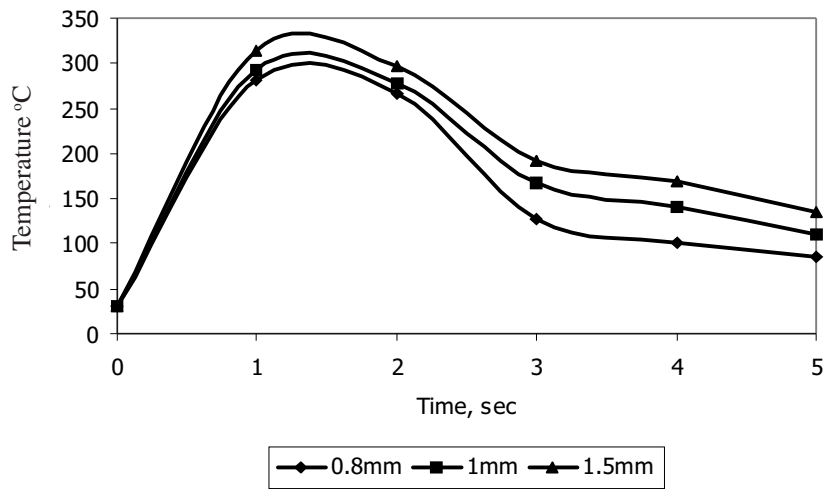


Fig. 5—Temperature distribution in weld center according to sheet thickness

material resistance. It is known that, when material resistance against weld current is increased, heat formation also increases. But, as differences between sheet thickness and temperatures are not very high, a high change is not observed in cooling rates. Thicker sheets have higher temperatures in weld zones (Fig. 5).

**Effect of Weld Current**

By changing weld current (8,10, 12 and 14 kA), temperature values were measured using three different

types of sheet thickness, keeping other welding parameters constant. Because groove had been not machined in upper sheet of specimens, measured temperature are surface temperatures. As weld current is increased, temperatures dramatically increase (Fig. 6). For constant electrode contact surface, parameter affecting material resistance is sheet thickness. Increasing sheet thickness increases material resistance, and heat input is rapidly increased in weld zone. But, obtained results in this study shows that effect of sheet

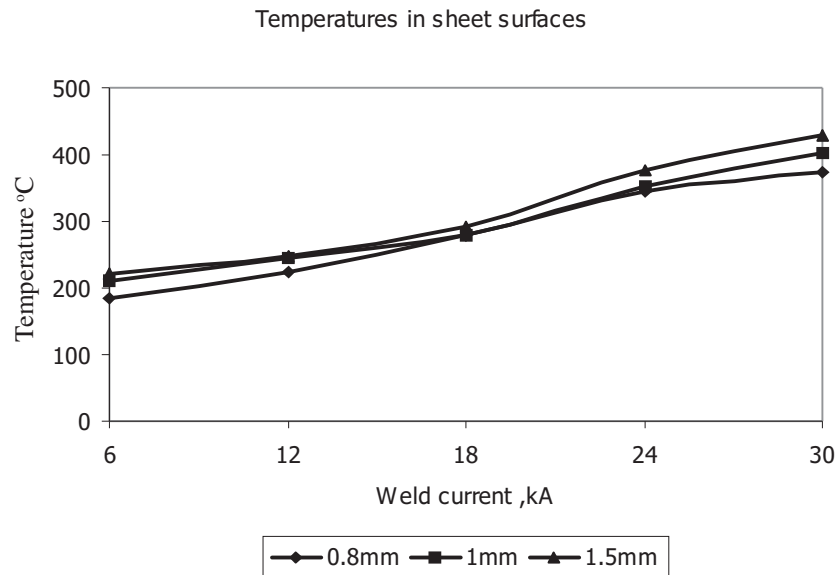


Fig. 6—Effect of weld current on temperature values

thickness and material resistance on heat occurring is dramatically less than that of weld current. By changing current, temperature values change. As environment temperature is constant, difference of temperatures and cooling rate rapidly increases. Weld current is found more effective than material thickness on cooling rate and temperature distribution.

### Conclusions

Temperatures in weld zones increase by weld current. Because there is a linear relation between sheet thickness and electrical resistance of sheet metal, heat appearing between sheets increases and temperatures become more. Temperature values decrease linearly from weld center.

Weld current is more effective than material resistance and sheet thickness on the heat occurring between sheets. By reducing temperature differences, cooling rate can decrease.

### References

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