STUDY OF DYNAMIC RESISTANCE CURVES IN RESISTANCE SPOT AND SEAM WELDING

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ABSTRACT

Resistance welding involves complex interactions between material characteristics, thermal mechanical and electromagnetic phenomena. The occuring during spot weld formation (break down of surface asperitics, molten nugget formation negget growth and mechanical collapse) can be understood through dynamic resistance curves. In seam welding speed and current are very improtant the limiting factor of welding speed is the surface splash. In practical terms, the significance of dynamic resistance curves lies in their possible use in monitoring weld quality. These can be very effectively utilised for the initial selection of the welding variables. In a welding such curve is characterised by initial peak of resistance followed by resistance drop, secondary peak, and ultimately stable condition. Studies are made in mild steel.

INTRODUCTION

Good spot welding practice requires that the following three parameters can be controlled.

(1) The welding current that passes through the joint to provide the heat.

(2) The pressure between the electrodes that serves to keep the two or more sheet components in intimate contact.

(3) The weld time during which the current is allowed to flow.

The varying electrical resistance of the weldment during a spot welding is termed as dynamic resistance and is modulated by the process itself. The process of nugget formation in resistance spot welding is treated as a sequence of events resulting from electrical heating of a number of metallic constrictions. Dynamic resistance curves can be very effectively utilized for the initial selection of welding variables when setting the machine as well as for monitoring the quality of weld produced subsequently. Resistance seam welding is used in many applications including radiators, drums and petrol tanks. In seam welding a rather complex control system is required (1). This involves the travel speed as well as sequence of current flow to provide for overlapping welds. The available welding current range decreases as the welding speed increases. This paper related to the interpretation of the characteristics shape of the Dynamic resistance curves of Mild Steel in spot welding and general model of weld formation in resistance seam welding.

Literatures Review

Bhattacharya and Andrews (2) introduced the concept of constriction resistance responsible for electrical heating in resistance spot welding. They also observed that the fitting of surface films in a metallic contact is a complex phenomena but its consequences are of great significance in understanding the electrical behaviours of the work piece during the brief period immediately after initiation. The principle of monitoring based on dynamic resistance characteristics has been verified for spot welds in mild steel. The theory of fritting or electrical breakdown of surface films advanced by Holm (3) who suggested that a finite thres hold voltage must be applied across the contact before any appreciable current flow can be established across the interface. It has been found experimentally that the dynamic resistance curves of mild steel exhibit a regular pattern of changes when variables such as current, time, tip diameter, electrode force etc. are varied. Numerous problems are faced in mass production of spot welding of sheet metal components. The more common ones are electrode tip deformation, scale on tip surface, poor matching of work pieces, fluctuation of input power, shunting effect etc. All these factors lead to unacceptable quality of spot welds (4). In this paper it is reported that a programmed automatic control unit monitors quality of spot welds. In doing so it makes use of change in resistance between the electrodes' tips during the formation. This ensures that the desired spot weld quality is achieved. Any model of weld formation and growth must reflect the physical and metallurgical changes which take place during the welding process. Yamatorno and Okuda (5) studied resistance seam welding and observed that with ac current the weld structure can exhibit distinct banding in transverse section which corresponds to steps in the conical shaped solidification from as indicated by the chevrons in the longitudinal direction. In resistance spot welding the final shape of the dynamic resistance curve depends on the relative contribution of a number of factors (6). For example break down of surface asperites and films results in a decrease in the resistance where as an increase in temperature increases the resistivity of the base steel and increase the resistance. Waddle and williams (7), obtained dynamic resistance curve for seam welding showing an initial peak secondary peak followed by steady state condition. They also observed various physical states in the weld zone giving rise to number of resistance in parallel. They found that at both low and high welding speed the majority of the heat is developed at the point of highest resistance i.e. the faying surface. However at low welding speeds there is sufficient time available between weld formation and exit from the electrodes, to allow significant heat abstraction from the surface of the weld through the electrodes. Current increase of 50% to 100% in the case of narrow seam welding of coated steel compared to mild steel has been reported by them. They found at high welding speeds nugget is formed towards the exit side and suggested narrow seam welds for increasing welding speed.

Designers and production personnel often include additional welds to those really demanded by strength calculations. However, additional welds are wasteful from every point of view and reflect an engineering situation which should not be tolerated (8).

Analysis of dynamic resistance curves

Dynamic resistance is computed from instantaneous values of weld voltage and current. An electronic divider circuit is used to compute weld voltage and current, additional electronic circuits are needed for signal processing both before and after the division operation. Fig. 1 shows resistance voltage and current variation during formation of a good weld in mild steel. A sharp drop in resistance immediately after initiation and also linear rise to a peak are observed. Stage-I corresponds to break down of contact insulation or fritting. In Stage-II there is increasing dynamic resistance due to temperature coefficient of constriction resistance Stage-III shows growth of fused metallic bond and diminishing dynamic resistance. It is suggested that the welded joint tends to reach a thermal equilibrium soon after reaching the peak. The slope of the dynamic resistance curve after the peak depends upon the rate of mechanical collapse. Fig. 2 shows delta R, which defined as

Delta R = Rp - Re

= Drop in resistance from the maximum value. Minimum weld time is important. The weld current does not stop till the minimum weld cycles are finished though the case may be that Delta R is attained much before the minimum values. On the other hand maximum weld time refers to the maximum weld cycles upto which weld time can get extended if required to obtain the set value of delta R. Heavy duty high production spot welding gun capable of welding speeds in excess of 1000 welds an hour is available. The electrode arms have been specially designed allowing access to all spot weld positions. Also a self contained measurement instrument for auditing spot welding electrode forces and seam welding forces are available. The electrode arms have been specially designed allowing access to all spot weld positions. Also a self contained measurement instrument for auditing spot welding electrode forces and seam welding forces are available. There is a need to maintain a constant electrode tip geometry during spot welding of coated steels. The dynamic resistance curve obtained in seam welding are characterized by an initial peak followed by a steady state condition and can be defined when welding uncoated mild steel in four stages as shown in Fig 3. Stage one growth - an initial resistance peak is attained between one and four cycles of current flow. Stage two growth - after the initial peak in resistance the resistance falls steadily over the next few cycles of current flow the No of which depends on sheet thickness and the welding conditions used. During this phase the effect of current shunting out weighs any increase in resistance. Stage III growth secondary resistance peak. This stage of weld formation corresponds to the development of a small secondary resistance peak which is considered to result from changes in the available shunt paths before a steady state condition is attained where the resistance level and current flow paths remain relatively constant. Compared to mild steel, all coated steels require much higher welding currents for weld formation. The necessary current increase can be 50 to 100% in case of narrow seam welding. The effect of different coatings will depend on how the coating changes the relative distribution of resistance and current paths. Current flow through the weld zone is related to different resistance paths at different welding speeds. At high welding speed nugget is formed towards exit side.

CONCLUSIONS

Significance of dynamic resistance curves lies in their possible use in monitoring weld quality. A prototype version of a weld quality monitor utilizing dynamic resistance as the process parameter has been in operation at the production plant. The system enables the user to detect defective welds and in many cases the fault can be traced back to their origin.

Again four stages of weld growth have been identified relative to dynamic resistance characteristic developed in the weld zone of resistance seam welding. Factors which encourage current flow towards the exit side of the electrode arc of contact include higher welding speeds, thicker steels, and the presence of a surface coating.

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