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Converting the pneumatic to servo-based system in resistance spot welding: Analyzing the electrode caps deformation

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Abstract

In this experimental research, the electrode caps are investigated for deterioration under the resistance spot welding technology. The research was fundamentally conducted using two different electrode actuation systems to understand the wear and tear factors of electrode caps. A Japanese model 75 kVA pedestal, alternating current waveform of spot welder, was engaged to carry out the welding processes up to 900 welding attempts on pneumatic system. Subsequently, it was converted into servo-based electrode actuating systems and repeated the entire welding processes. The carbon and stainless steel sheets are primarily used to weld in this experiment. The electrode caps are then sharpened by CDK-R dresser to remove the mushroom growth which has regularly been induced for every 400 welding attempts. As for the macrograph and micrograph observations, the electrode caps are measured for diameter growth of electrode caps as well as the copper-to-chromium ratio. The chromium content has been significantly reduced at the electro tip areas due to the direct expose of heat generation which becomes a regular phenomenon in both the systems. However, the results from servo-based system are deemed to be offering lower tendency of wear and tear factors when compared to the pneumatic-based system.

Keywords

Spot welding, pneumatic system, servo system, electrode actuation

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Introduction

A pure copper is naturally soft, has very low tendency of corrosive effect and fails prematurely in demanding applications.[1] However, it can be strengthened by various methodologies including, but not limited to, alloying, precipitation hardening, cold work, solid solution and dispersion strengthening.[2] A mixture of copper alloys is a good choice for the manufacturing of spot welding electrode caps due to its physical properties. As such, most of the welding experts often prefer to use the copper alloys which contain substances such as chromium, beryllium, zirconium and the like for resistance spot welding (RSW) application.[3] Figure 1 shows the copper and chromium phase diagram for copper-based alloys as this research uses such combination of electrodes.[5] It shows that chromium is easily soluble in the liquidus of copper when heated above 1076 °C and below 1860 °C. Once solidified, it requires equal amount of heat to re-melt it again completely. Hence, this factor gives drawback on the copper–chromium alloy to handle the carbon and stainless steel welding process, because the carbon steel melting point falls between 1426 °C and 1539 °C, whereas the stainless steel melting point falls between 1400 °C and 1450 °C.[4] The copper and chromium solubility phases are actually of the eutectic type. The face-centered cubic (FCC) will be formed in copper, whereas body-centered cubic (BCC) will be formed in chromium when solidification process is concerned in copper–chromium alloy.

As the number of welding processes is repeatedly carried out on carbon and stainless steels, the mushrooming effect at the edge of electrodes grow in outward direction, enlarging the tip diameters apparently,

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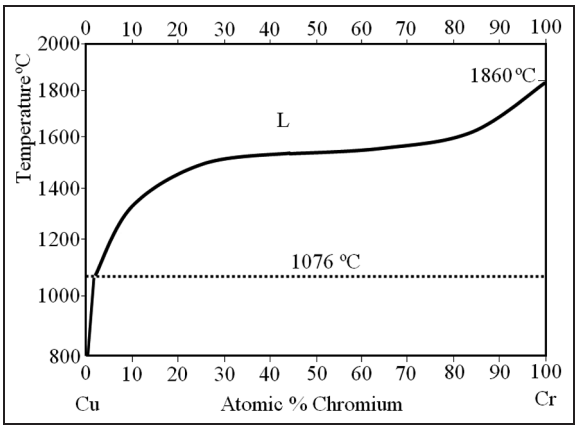

Figure 1. Copper and chromium phase diagram.[4]

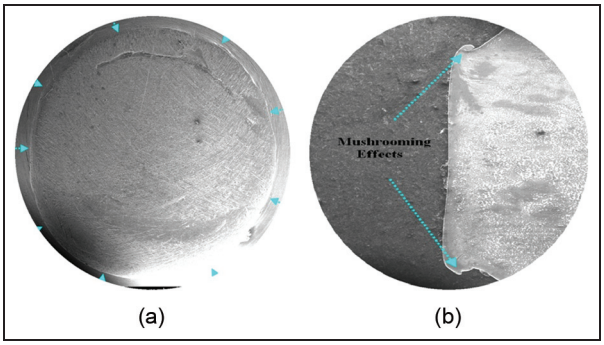

Figure 2. Mushroom growth of electrodes due to deterioration: (a) top view and (b) cross-sectional view.

as shown in Figure 2 for the surface in addition to the cross-sectional views.[6,7] The electrode tip cleaning procedures are therefore carried out for every 400 welding attempts as to maintain the truncated shapes from the electrode tip with regard to mushroom growth. This is absolutely necessary to avoid any drastic changes in resistive components due to the imbalanced surfaces or enlarged contact points between electrodes to sheets or vice versa.[8–10] The mushrooms grown for every 400 welding attempts are therefore well cleaned using dresser, so almost an acceptable flat surface is retained throughout the entire welding process. However, the electrode compressing mechanism is certainly subjected to the consistencies of force profiles that are supplied during welding process in RSW.[11] So, the two different compressing mechanisms are inspected for wear and tear factors of electrodes. In this research, around 900 welding attempts were carried out for two dissimilar types of electrode actuation systems to characterize the welding performance.

Experiment

The carbon and austenitic stainless steels were prepared in a rectangular shape as follows: the length of specimen, 200 mm; the width, 25 mm and two thicknesses, 1 and 2 mm, as exactly shown in Figure 3. Two pairs of water-cooled copper–chromium electrodes with 30° truncated round tips (5 mm in diameter) were used to accomplish the entire welding processes. The test samples were initially welded with pneumatically controlled 75-kVA alternating current (AC) waveform system, and later, the electrode actuation was mechanically converted to servo-assisted system with similar electrical specification. With such arrangement, around 900 welding attempts were carried out for each system to understand the electrode's wear and tear factors. The committed electrode caps are subsequently analyzed for deterioration and also checked for the internal micro- and macrostructural orientation. It should be noted here that the Class 2 spot welding electrodes are made

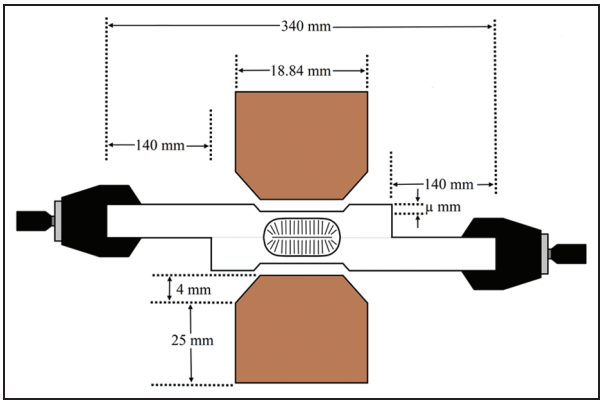

Figure 3. Alignment of electrodes and base metals.

of copper and chromium chemical elements, according to the Resistance Welding Manufacturing Association, America (RWMA) classification (Table 1).

Results and discussion

Electrode deformation in pneumatic-based system

The original size of electrode tip on both sides was just 5 mm in diameter, and it has been widened up to 7.458 mm (49% mushroomed) on upper electrode side and up to 7.238 mm (44%) on lower electrode side after accomplishing almost 900 weld attempts. The imbalanced deformation on both sides must not be interpreted as Peltier's effects (high electrode deformation on anode side than cathode side in direct current (DC) spot welder) because of the very small percentage of deformation that took place at the tips (the difference is just about 5%). The electrode on upper side has slightly higher deformation rate due to the regular impact produced by the squeezing moment of electrode onto the base metals. On the same circumstance, the unmovable lower electrode has very smooth touch between electrodes to base metals as it was regularly handled by human hand.[12,13] The base metals that occupied the top of lower electrode are gently handled by human hands before commencing any of the