Arc Cleaning for Increased Electrode Life—Process Parameters

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ABSTRACT

Even before the present energy crisis and ever-spiralling petroleum products prices, auto makers were busy meeting the various statutory requirements which added to the weight and operating charges of vehicles resulting in increased fuel consumption. One of the means to reduce vehicle weight was through the use of Aluminium alloys in both structural and body parts. A gage-to-gage substitution of Aluminium for steel leads to a 65 percent weight saving.

The widely used technique of joining viz resistance welding, when applied to Al, gives rise to problems because of the high conductivity of Aluminium, rapid contamination of copper electrodes by Al and presence of oxide layer on Al alloys, besides tendency of Al for solidification cracking.

This paper deals with aspects to reduce Al pick up by the electrodes and also to reduce surface splashing observed during welding of Al alloys. Arc cleaning is a recent method in which the sheet is cleaned immediately prior to welding, on the welding machine itself.

The parameters influencing the arc-cleaning process have been investigated and the results of the investigation indicate that—

(1) *The main process parameters are arc gap, gas flow rate and arc time.*
(2) *The optimum arc gap is 0.7 to 0.9 mm Higher gaps result in melting of the sheet itself.*
(3) *At higher gas flow rates, cleaning efficiency reduces.*

The process appears to be very useful in increasing the life of the electrodes thereby contributing to increased productivity.

1. INTRODUCTION

Although resistance welding of Al-alloys was initiated for aircraft industries, the advent of TIG and MIG welding processes obscured resistance welding of Al-alloys. Requirement of stringent cleaning techniques and machines with sophisticated controls have rendered the process inapplicable to mass production of vehicles, for economic reasons. Little information is given as to how far surface techniques and machine characteristics can be relaxed whilst maintaining adequate weld quality, and also the frequency of electrode dressing is not specified.

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The problems (1,2,3) in resistance spot welding of Aluminium alloys are : high current requirements due to high thermal conductivity, splashing and explusion due to refractory oxide layer and particular "strength—temperature" characteristics of these alloys, electrode pick up due to easy alloying nature between copper and Al, and cracking and porosity in the nuggets. These problems have necessitated a need for very sophisticatted resistance welding machines with very high power capacity and low inertia heads with dual-force-program.

Along with research programs to solve the above problems, investigations have also been going on for development of alloys having good weldability. This has resulted in development of a series of alloys requiring fairly simple welding schedules.

Since electrode pick up not only affects mechanical properties of the electrodes but also electrical conductivity and hence the weld quality, the investigations in this area have been centred around i) methods of minimizing contact resistance between the electrode and sheet surface ii) electrode materials having better mechanical properties and low affinity for Al. A loaded electrode affects the welding schedule resulting in erratic nugget formation and frequent electrode changes affecting productivity.

The oxide removal accompanying TIG and MIG welding with DCEP and AC operation have led to the possibility of using "arc cleaning" as a technique to minimize electrode pick up and surface expulsion problems (4-6) Since the cleaning is accomplished in situ, just prior to welding, it has the advantage of minimum time available for re-formation of the oxide film and extends electrode life, especially in case of copper based alloy electrodes.

Although the arc cleaning technique has been discussed, the parameters influencing the process and their effects have not been reported.

2. EXPERIMENTAL

The sheets to be welded are cleaned on the welding machine immediately prior to welding using an electric arc in an inert gas atmosphere. The schematic arrangement of cleaning is shown in fig. 1.

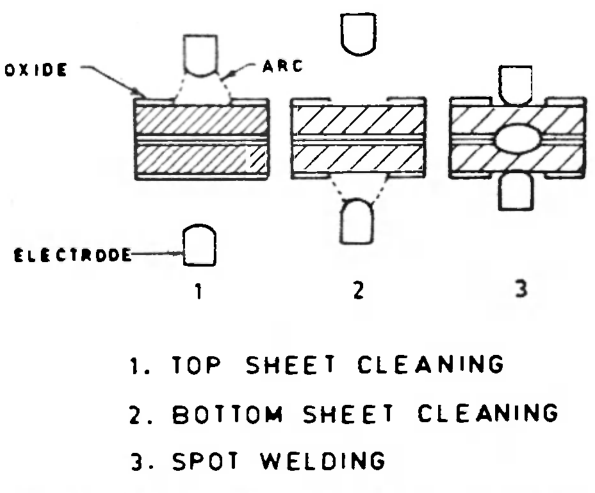

Fig. 1. Schematic illustration of the arc cleaning process.

2.1 Circuit

The basic approach in developing the set-up was to provide a means of producing an inert gas shielded arc between spot welding electrode and an aluminium sheet without damaging the solid state components of the machine control unit. The circuit employed is shown in fig. 2.

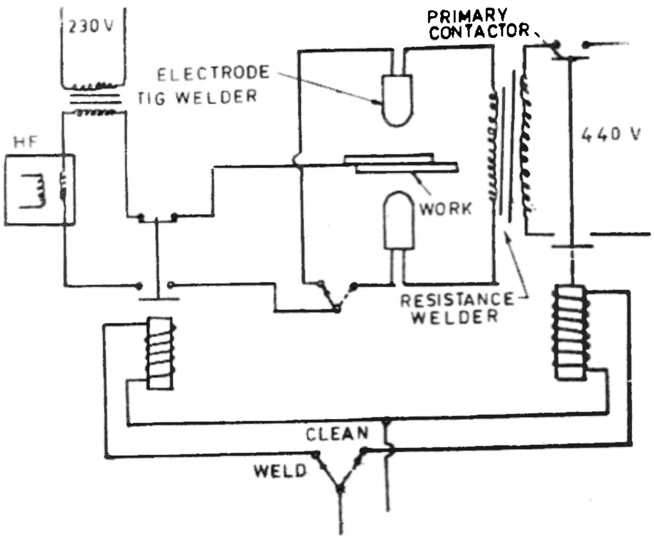

Fig. 2. Diagram of circuit used in arc cleaning.

2.2 Cleaning Set Up

To provide effective gas shielding during arc cleaning, a set-up, as shown in fig. 3 was fabricated.

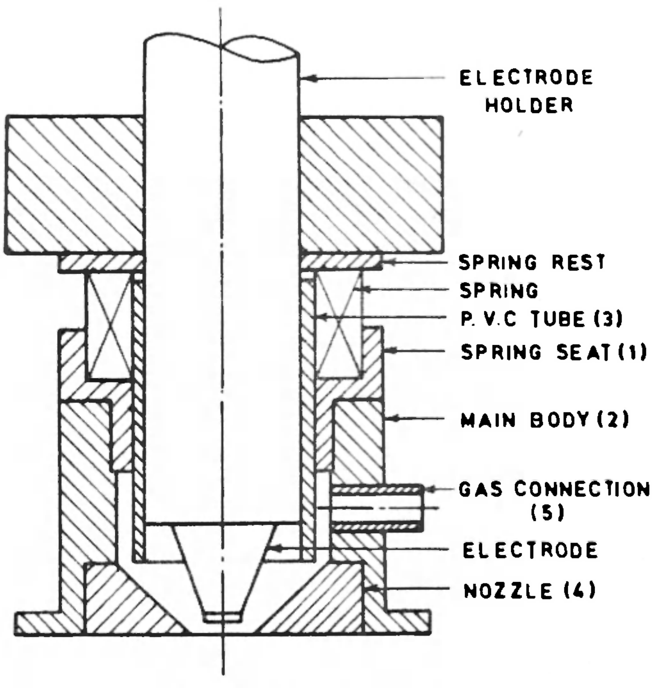

Fig. 3. Gas flow nozzle.

The cups and the sheet are electrically disconnected by introducing an insulation sleeve between them.

2.3 Process Sequence

The cup springs will be adjusted so that as the welding unit comes out of the retract stage, the cups are in position to arc clean the top sheet. After the top sheet is cleaned, the cleaning cup and sheet on the other side will be manually pushed down to obtain the pre-set electrode-bottom sheet gap. Now the bottom sheet outer surface will be cleaned. Immediately following this, the spot weld will be made.

The process is amenable to automatic sequencing thus achieving high production rates.

2.0 Parameters Effect

The parameters investigated are

(a) Arc Voltage (10-16 V)
(b) Arc gap (0.6-1.7 mm)

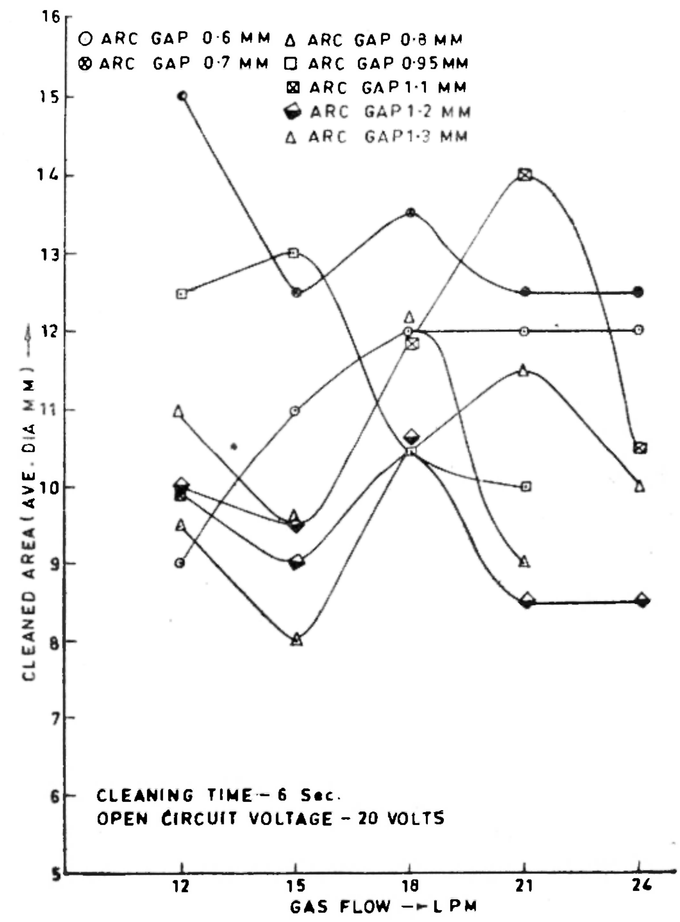

Fig. 4. Cleaned area Vs gas flow

(c) Arc time (2,4,6,8 secs)
(d) Shielding gas flow rate (12-24 LPM)
Electrodes were Cu—1 % Cr alloy.

The diameter of the electrode tip used was 9.5 mm. The studies were carried out on 1.6 mm thk. 54S Aluminium alloy sheets.

3. RESULTS AND DISCUSSION

The result of arc cleaning was expressed in terms of size of the cleaned spot (average dia.) and visual inspection of the cleaned surface quality.

Arc cleaned area was lesser than or just equal to the electrode tip dia for arc times less than two seconds.

Also, excessive arc times have no effect on the cleaned area but rough surface is formed due to excessive arcing (perhaps due to pitting). Optimum results are obtained with arc time of 6-8 secs.

The maximum cleaned area is about 1.752 sq. cm for 0.7 mm arc gap 12 LPM gas flow.

From fig. 4 it can be seen that in general, better results are obtained for arc gaps of 0.7-0.9 mm. No particular pattern is followed between gas flow rate and cleaned area size. However, it appears that cleaning efficiency drops at higher gas flows, as indicated by decreasing size of cleaned area.

Arc gaps greater than 1.5 mm require higher open circuit voltage (ocv). This gives an arc sufficiently strong to melt the sheet surface.

Fig. 5 shows the optimum arc time for different arc gaps.

3.1 General Remarks

Size and material of the electrode affect the behaviour of the arc. The area of cleaned spot appears to be directly proportional to size of electrode tip.

A sharp pointed electrode constricts the arc and consequently causes melting of the Al sheet surface. A flat tipped electrode (truncated cone type) caused cleaning over a wider area. Observations made with three different electrode configurations (fig. 6) support this.

If the tip size is increased beyond certain limits, the arc splits and the arc current is maintained through a

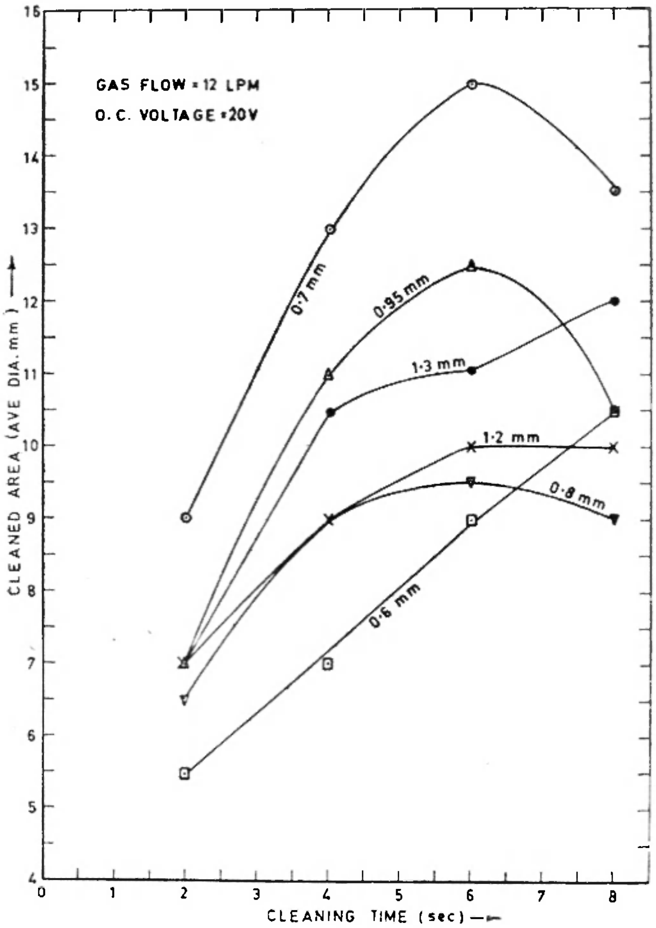

Fig. 5. Cleaned area Vs cleaning time.

number of small arcs, thus bringing out the interesting aspect that the cleaning action is obtained by wandering of the cathode spot. This spot under the oxide layer, due to its explosive action, bursts the oxide layer out.

Electrode life studies with and without arc cleaning can be made. However, since the number of welds to be made are very large, it has not been possible to investigate this aspect. However, contact resistance measurement of arc cleaned spots showed contact resistance values of the order of 60-90 M compared with 2000 M of as received sheets. This shows that arc cleaning would result in almost elimination of surface splashing during spot welding.

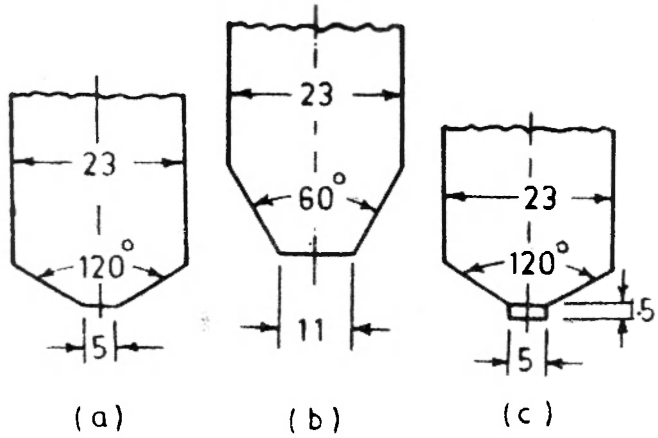

Fig. 6. Electrode configuration.

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