

C. Electrical Resistance Hot Upset Welding Of Aluminum Alloy 5454 *by F. Feng, Alcan International Limited*

Introduction

Hot upset welding is one of the welding processes that has long been utilized in human welding civilization. Yet, very limited work has been carried out in qualitatively understanding the effect of welding parameters on the weld integrity created by this process, especially for aluminum alloys. Hot upset operation is still used in manufacturing some important aluminum parts in modern industry, such as sheet fabricated aluminum wheels and friction welded aluminum parts that generally involves upset (forge) stages. Therefore, more in depth investigation about the joining mechanism of this process is necessary in improving the process reliability and developing an automatic welding process control methodology.

Procedure

Alloy 5454 sheets were used to study the mechanism of aluminum hot upset welding process. Hot upset welding operations were conducted on a Gleeble 2000 machine to simulate both of the actual welding thermal process and mechanical material forging operation. Optical microscopy and scanning electronic microscopy were used in characterizing the material behavior at different welding conditions. Tensile testing was also used to evaluate the strength of the welds made with various welding parameters.

Results and Discussion

A test matrix including both welding temperatures and holding times were used to explore the effect of the welding parameters on the weld integrity. The temperatures were measured with embedded thermal couples and continuously monitored through the whole welding cycles. A whole welding cycle generally involves the following sequences - the two aluminum sheets to be welded are firstly put against to each other with very low force just enough to close the gap and make the surfaces fully contact, then an electric current was let flow through the joint and the contact surfaces were thus thermally heated up through the electrical resistance heating. It starts with a temperature ramp-up and then the temperature will be held for the duration specified in the program once it reaches its expected value. Almost instantaneously, a forge force was applied to the joint while the electrical current was reduced to zero. The cross sections of the welds thus produced were then polished, etched and examined to analyze the weld quality. The major observations are: (1) the most important factor affecting the joint quality is the temperature; (2) Below 500 degree C, no weld was formed. (3) When temperature reaches 500-550 degree C, welds with very low strength (cold weld) were created and all the welds failed along the original faying surface. (4) As temperature increased to 560 degrees, the weld strength raised significantly and a totally new material flow mechanism was noticed which was defined as "hot weld". This temperature is the minimum temperature required to achieve satisfactory upset welds. (5) Microscopically, whether the oxides along the faying surface were effectively broken played a decisive role in the weld strength. At temperatures below 550, the oxides still existed continuously. However, in the cases above 560 degree C, the mechanism of material flow close to the faying surface was majorly through the grain boundary weakening and sliding, and the oxides were thus removed and strong welds were obtained.

Conclusions

To successfully hot upset weld 5454 aluminum alloys, the temperature in the weld area has to be above 560 degree C. This is due to the change in the mechanism of material flow in the welded areas including the weld flash, which will in turn affect the effectiveness of surface oxides removal and the final weld strength .