The Effect of Preheating Temperature on Joint Improvement in Friction Drilling of Dissimilar Sheet Metals (AA6061/AISI304L)

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ADVANCED JOINING PROCESSES UNIT

Introduction

Simultaneous friction drilling process was used to join two dissimilar metal sheets, AA6061 and AISI304L using a tungsten carbide drilling tool coated with AlCrN. The impact of preheating temperatures of 250°C, 300°C, and 350°C on the joint quality obtained through this method was analyzed and compared to the joint created in a drilling sample at room temperature (39°C).

The findings show the positive effect of preheating on reducing the gap between sheet metal layers in the vicinity of the joint and the negative effect on the joint mechanical strength.

Methodology

- **Sheets of AISI304L and AA6061 with thicknesses of 3 mm and 1 mm, respectively, were subjected to testing.**
- **An 8mm diameter tungsten carbide drill tool coated with AlCrN on a cobalt matrix was utilized for friction drilling.**
- **To achieve the necessary preheating temperature, two 400 W cartridge heaters were utilized and to ensure a consistent temperature level, a closed-loop controller featuring a thermostat, a type-K thermocouple, and a contactor was employed.**
- **Simultaneous friction drilling was performed at four different temperatures, including room temperature, 250°C, 300°C, and 350°C (Figure 1)**
- **Study was done by optical microscopy, tensile-shear strength test, micro hardness tests, field-emission scanning electron microscope(SEM)**

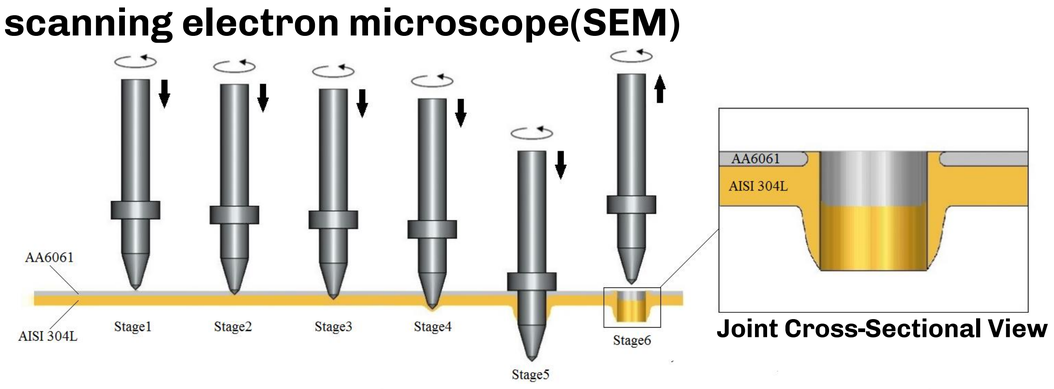


Figure 1. Schematic of Simultaneous Friction Drilling of AA6061 and AISI304L Sheets

Results and Discussion

- **Figure 2 displays a bar chart of the results from the tensile-shear strength test, along with a schematic of the procedure used to conduct the test.**
- **Preheating reduced joint strength by 13% to 32.5% compared to non-preheated samples.**
- **The strength reduction of two preheated samples is linear up to 250°C and 300°C. However, the sample preheated up to 350°C shows less reduction in strength compared to the sample preheated up to 300°C.**

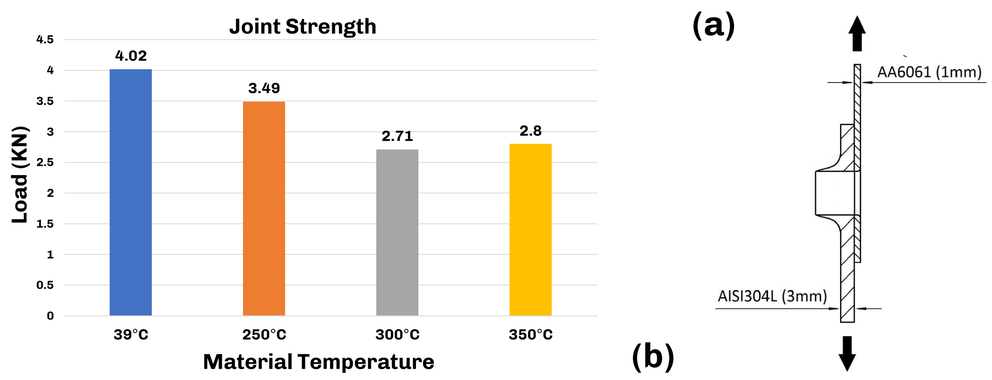
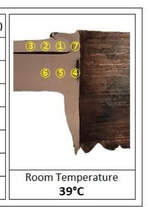


Figure 2. Bar chart of tensile-shear strength test results Schematic illustration of the procedure for conducting the tensile testing.

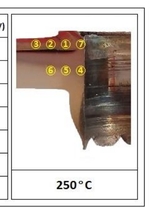
Results and Discussion

- **The results of hardness testing on four samples (Figure 3) show that all three preheated specimens have lower hardness than the sample produced by friction drilling at ambient temperature. This decrease in hardness is most noticeable in the joint area.**

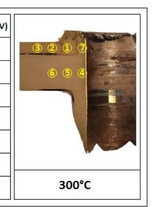
Tested Points	Hardness (HV)
Point No 1	89.5
Point No 2	75.9
Point No 3	64.1
Point No 4	275
Point No 5	240
Point No 6	205
Point No 7	286



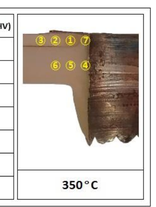
Tested Points	Hardness (HV)
Point No 1	64.8
Point No 2	63.7
Point No 3	60.7
Point No 4	273
Point No 5	220
Point No 6	203
Point No 7	285

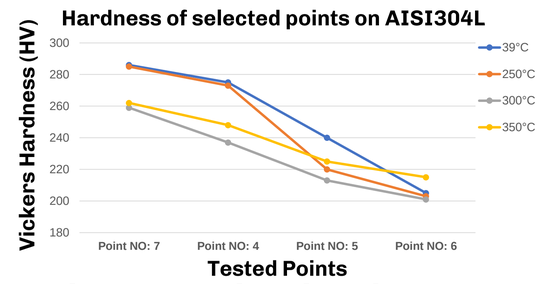


Tested Points	Hardness (HV)
Point No 1	53.0
Point No 2	50.2
Point No 3	47.3
Point No 4	237
Point No 5	213
Point No 6	201
Point No 7	259



Tested Points	Hardness (HV)
Point No 1	54.1
Point No 2	51.2
Point No 3	48.4
Point No 4	248
Point No 5	225
Point No 6	215
Point No 7	262





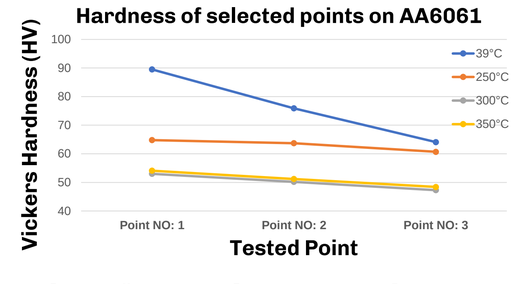


Figure 3. Microhardness Test Results of Samples Tested at Different Preheating.

- **SEM image in figure 4 shows a crack has initiated but not propagated in the sample drilled at ambient temperature samples drilled at 250°C and 300°C have developed cracks throughout the thickness of the aluminum sheet, while the sample drilled at 350°C has no cracks.**

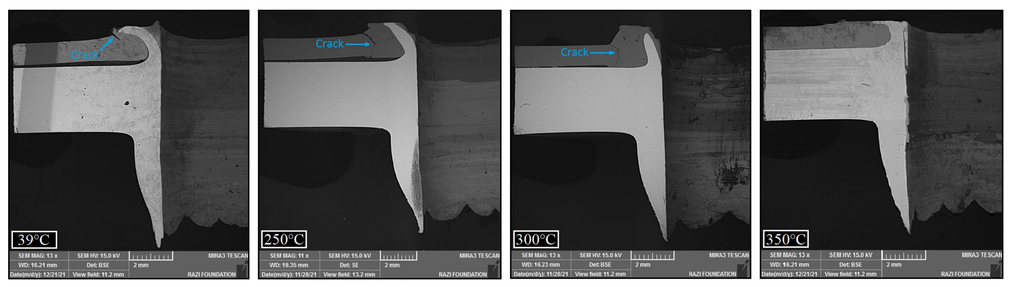


Figure 4. SEM images of cross-sectional surfaces of 4 drilled samples with varying preheating temperatures

- **SEM image in figure 5 demonstrate that as the preheating temperature increases, the degree of separation between the aluminum and stainless-steel sheets near the joint in this area decreases and eventually becomes zero in the sample preheated to 350 °C.**

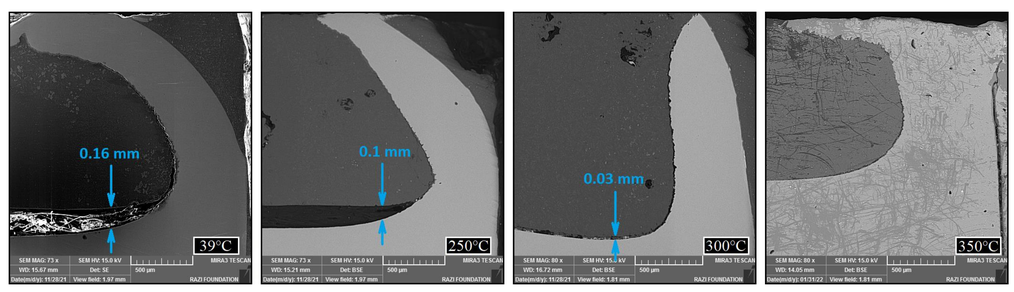


Figure 5. SEM images of the joint region at high magnification

Conclusions

- **Preheating to 350°C improves the formability of the aluminum sheet, resulting in the elimination of the gap in the joint area.**
- **Preheating to 350°C causes a 30% decrease in the joint failure threshold, which can be attributed to changes in the joint area's microstructure and reduced hardness.**
- **preheating at a temperature lower than 350 °C, while reducing the gap between the two sheets in the joint vicinity, does not have the desired effect on the joint created because it does not prevent the formation of cracks in the sheet.**