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INVESTIGATION ON FRICTION STIR WELDING OF COPPER

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ABSTRACT

Friction stir welding (FSW) is primarily used for aluminium also used for copper in certain industrial application. In the present study FSW of 5mm pure copper plates is done on vertical machining center with cylindrical H13 material tool. Surface temperatures are measured using pyrometer. Temperature graphs are plotted. The welded Joint at 950 RPM tool rotational speed and at 7mm/min tool traverse speed found satisfactory in visual inspection.

Index Terms: Friction Stir Welding, Copper, Temperature

I. INTRODUCTION

Friction stir welding (FSW) was invented at The Welding Institute (TWI) of the United Kingdom in 1991. FSW is a solid state welding process. In this process the joint is formed due to the rotational and translational motion of tool shoulder, plunged pin and forging pressure exerted by tool shoulder on the metal pieces without fusion and filler material.

Dhananjayulu Avula et al. studied the feasibility of joining the commercial pure copper plates by friction stir welding. They found the efficiency of joint 94.03 % as compared to base material, Hardness of weld zone was higher than the base material and in microstructure examination, they found stirred zone (SZ) exhibited primary two phases namely, recrystallized grains and fine precipitates in matrix of copper.

Park Hwa Soon et al. studied friction stir welding of oxygen free copper and 60% Cu- 40% Zn copper alloy (60/40 Brass). They varied spindle rotational speed from 500 RPM to 2000 RPM and Tool traverse speed from 500mm/min to 2000mm/min. They obtained defect free joints over a wide range of welding conditions of tool rotational speed 1000 RPM to 2000 RPM and tool traverse speed from 500mm/min to 2000mm/min. They showed the hardness (Hv.) and tensile strength increases as tool traverse speed increases.

Y.M. Hwang et al. investigated on Friction Stir Welding of pure copper C11000 in butt joint configuration. They used K-type thermocouples to record the temperature history at different locations on workpiece. They found appropriate temperatures to be between 460 °C and 530 °C for a successful FSW process.

The process is primarily used for aluminium also has many industrial applications for copper. In this study experiment is conducted at 7 mm/min tool traverse speed and 950 RPM tool rotational speed.

II. METHODOLOGY

A. Workpiece Material

The pure copper material is used. The material was cut into a number of pieces. With help of lathe machining and filing operation edges are made perpendicular to each other.

Workpiece Dimensions: Plate Length=100mm, Plate Width=50mm, Plate Thickness=5mm

B. Tool Material

The design of the tool is important as a good tool can improve the quality of the weld. There are many tool designs eg. Straight cylindrical, Threaded, Triflute, among that Straight cylindrical tool is used.

It is desirable that the tool material is sufficiently strong, tough, and hard wearing at the welding temperature. Further, it should have a good oxidation resistance and a low thermal conductivity to minimize heat loss and thermal damage to the machinery further up the drive train. Hot-worked tool steel such as AISI H13 has proven perfectly acceptable for welding aluminium alloys within thickness ranges of 0.5 – 50 mm. H13 tool material is used. On raw material all the machining operations were performed using lathe machine and grinding machine. Hardening of the tool is done, hardness number is 55HRC. Dimensions of tool are as follows:

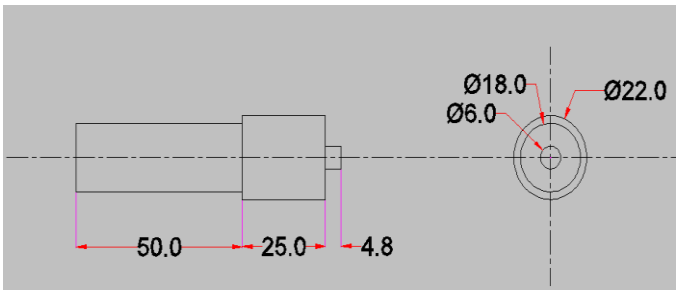

Fig. 1. Design of straight cylindrical pin

C. Experimental Setup

The experiments are done on the VMC (Manufacturer: HAAS) at Datta Tools Karad.

Convenient tool rotational and tool traverse speed is selected. The relationship between the welding speeds and the heat input during welding is complex but, in general, it can be said that increasing the rotation speed or decreasing the traverse speed will result in a hotter weld. In order to produce a successful weld it is necessary that the material surrounding the tool is hot enough to enable the extensive plastic flow required and minimize the forces acting on the tool. If the material is too cold, then voids or other flaws may be present in the stir zone and in extreme cases the tool may break. In this experiment tool rotational speed of 950 RPM and tool traverse speed of 7mm/min is selected.

Formation of joint: The joint is formed as shown in the figure below:

Fig. 2. Photograph of Friction stir welding of Copper

Friction stir welded joint of pure copper found satisfactory in visual inspection

III. TESTING AND ANALYSIS

For temperature measured pyrometer is used. The technology for Infrared Radiation Pyrometer is based on the principle that all objects emit radiation at wavelengths in the infrared region of the electromagnetic radiation spectrum.

Specifications:

Model: Metrix+ MT 14

Temperature range : -50°C~1350°C (-58 TO 2462F)

Accuracy: ±1. 5% or ±1. 5°C

Temperature measurement is made by the Pyrometer at various locations on the workpiece as shown in following figure:

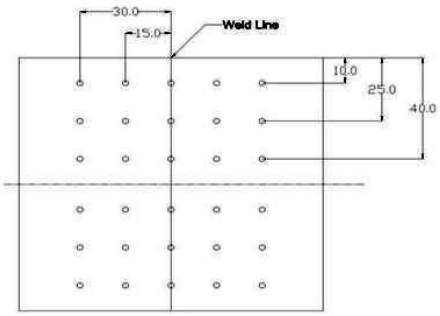

Fig. 3. Temperature location on workpiece plates

Following are the measured temperature values during friction stir welding of copper at various workpiece locations:

Table1:

Distance	10	25	40	60	75	90
-30	85	140	110	105	170	144
-15	120	220	135	135	245	232
0	125	225	160	140	260	258
15	100	175	144	107	167	150
30	75	100	95	90	110	107

Graph: Following figure shows graph of measured temperature values verses distance.

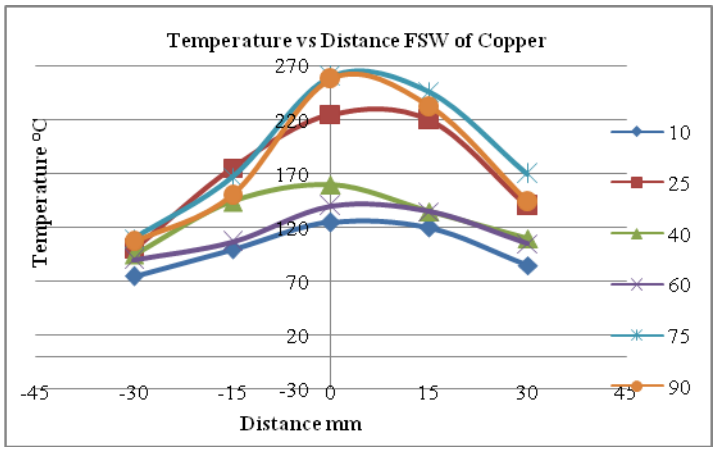

Fig. 4. Temperature Verses Distance

From above graph it can be concluded that as distance from weld line increases temperature decreases.

Following figure shows surface plot of temperature values throughout the workpiece calculated by iterative calculations:

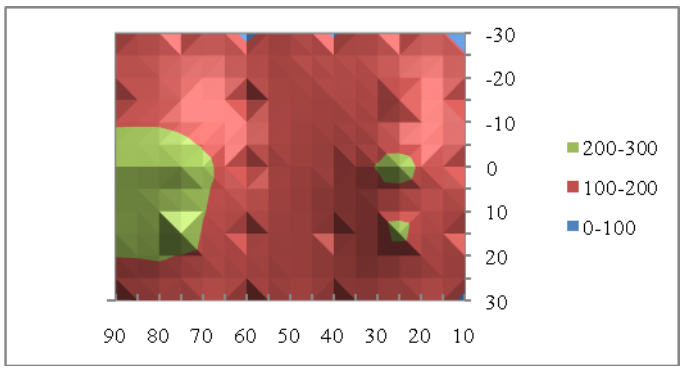

Fig. 4. Surface plot of temperature values throughout the workpiece

In above figure: (0 to -30) and (0 to 30) are vertical distances from weld line of advancing and retreating side respectively. (0 to 90) are horizontal distances from workpiece.

IV. CONCLUSION

1. Friction stir welded joint of pure copper found satisfactory in visual inspection.
2. Higher temperature found nearer to weld line. Temperature decreases as distance from weld line increases.
3. Pyrometer measures surface temperature due to this temperature values found lower than measured by Y.M. Hwang et al.

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