The Influence of Difference Quenching Technique on Bobbin Tool

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ABSTRACT – Bobbin friction stir welding (BFSW) tool is important for the friction process. The reason is because the tool required to resist high force and torsion when fully penetrate through the material to be welded. AISI H13 tool steel is the most common material used for fabricating the bobbin tool when welding Aluminium Alloy. In order to improve mechanical properties of the bobbin tool, hardening process that involves quenching step is required. This is important for increasing the tool strength in preventing tool breakage during the welding. Therefore, in this study the tool steel H13 samples that were hardened are quenched in two different approaches that are in an oil bath and air blast. Then the samples are subjected to X-ray fluorescence to identify the presence of the substance. Finding on different medium quenching process shows that the sample which quenched via air blast indicated highest hardness value and consequently reducing the formation of sludge and scale on the sample. The scale is not favourable because it caused slipping tool when hold by the tool holder during welding. Thus, a post-processing to clean the scale is intensive. The XRF result revealed that although there is a different chemical composition that potentially affect the tool strength but the differences are small.

1. INTRODUCTION

Bobbin friction stir welding (BFSW) is a solid state welding that creates frictional heat generated by the full penetrate tool to develop weld. The tool, namely bobbin tool is composed of a pin and two shoulders that generate sufficient heat at both top and bottom of the welded material. The common material used for making the bobbin tool based on previous studies to weld Aluminium Alloy is the AISI H13 tool steel [1–3] due to the characteristics of fatigue resistance and high toughness.

The success of the join in BFSW depends on the strength of bobbin tool to resist the force and torsion during the welding. Traditionally, the conventional friction stir welding (CFSW) process required a full contact of the tool plunge to the material introduces the axial force (vertical force) [4]. These axial forces found to be minimal using BFSW [5], but replace by the compression force (gap) produce by the two shoulders. Higher shoulder compression generates high force based on the previous study in [6]. During the BFSW, the sudden high force obtained when the bobbin tool begins to touch the material and this force becomes stable once the bobbin tool traverses along the weld line. This high force may lead to the tool breakage (see Figure 1 (a)).

A proper alignment and positioning of the bobbin tool are required so that the material to be welded is in line with the gap between the shoulders (see Figure 1). Although the proper position of bobbin tool has been through, however the concern on tightening the bobbin tool to the tool holder becomes a major factor to the success of welding. This is because of the presence of unwanted material around the tool holder of bobbin tool known as scale. This issue is related to the process of heating and cooling during hardening.

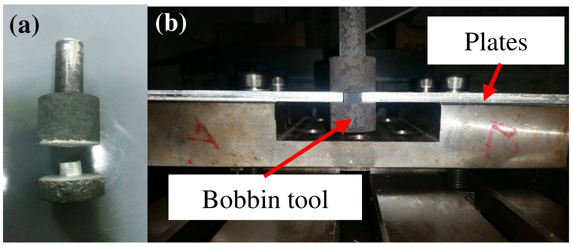

Figure 1 (a) bobbin tool breakage and (b) setup

The hardening process refers to the heat treating the sample above the normalizing temperature. The temperature is held for a certain time, so that the sample can evenly heat treated throughout before undergo rapid cooling by means of quenching process. The quenching medium can be either be water, oil or air. This quenching process is important so that the desired hardness can be achieved. Conversely, this quenching technique introduces the formation of sludge and scale to the bobbin tool. This sludge and scale should be avoided as it influences the performance of the bobbin tool during BFSW. The bobbin tool should have higher hardness than the plate to be welded to guarantee the success of joining. Thus, in this study, two quenching techniques which are the quenching via oil bath and air blast is carried out in order to produce the high strength of bobbin tool.

2. METHODOLOGY

The circular AISI H13 tool steels with a diameter of 25 mm were cut into 20 mm thickness. The samples were hardened at 1010°C for 30 minutes soaking time based on findings in [7]. After the soaking time, the samples were taken out from the furnace and were cooling suddenly by quenching process using two different types of medium which are the in the oil bath and the air blast. This quenching process was conducted until the samples reach the room temperature.

The as received and hardened samples were ground and polished before undergoing the microhardness test using a semiautomatic Vickers (Mitutoyo) hardness machine. The polished samples were indented with the load 200 g for 15 seconds dwell time and the hardness of each of the samples was recorded. The elemental composition of all samples was determined through the x-ray fluorescence (XRF).

3. RESULT AND DISCUSSION

Based on Figure 2, the oil quenching sample is darker due to the presence of sludge and scale compared to the air blast quenching sample. This sludge and scale formed due to the oxidation of the oil during the quenching process [8]. This is unwanted because it will cause the slip of bobbin tool from the tool holder and consequently creates cutting effect instead of forming the weld during the welding. On the other hand, the air blast quenching sample had less scaling due to the pressure of the air that peel off the scale from the sample.

Air blast quenching sample	Oil quenching sample

Figure 2 Quenching samples

Although the quenching via oil bath provides the fastest and uniform cooling rate compared to the quenching via air blast, however the hardness value is not improved. The average hardness of the tool as received and the quenching samples are tabulated in Table 1. The hardness of as received H13 sample was approximately 208HV. The hardened sample which quenched with air blast exhibit approximately 228HV higher than the sample quenched in an oil bath. Based on [5], the differences in microhardness value were due to the carbon content whereby the air blast quenching sample has higher carbon content than the oil quenching sample. Additionally, the chemical composition of the samples that undergo some changes during hardening and quenching process also influences the hardness value of both samples. The XRF result in Table 2 indicates that the air blast quench sample revealed high content of manganese, Mn and silicone, Si which increase the hardness value [9].

Table 1 Average hardness of the H13 samples

Sample	Average microhardness (Hv)
As received	208
Oil quenching	389
Air blast quenching	617

Table 2 Chemical composition of the three samples

Element	Concentration (wt %)		
	As received sample	Oil quench sample	Air blast quench sample
Fe	91.633	90.652	91.148
Cr	4.775	4.814	4.806
V	0.922	0.950	0.941
Mn	0.511	0.458	0.508
Si	0.362	0.591	0.625
Co	0.164	0.066	0.160
Al	0.016	0.736	0.408
S	0.097	0.110	0.097
Mg	0.000	0.000	0.000
P	0.000	0.000	0.000

4. CONCLUSIONS

The bobbin tool is one of the major important things in BFSW. In this study, it can be concluded that the air blast technique helps to increase the hardness of the AISI H13 as well as reducing and removing the formation of scale through the blast of air pressure. On the other hand, the oxidation occurred when the sample is quenched in oil bath leads to the formation of the sludge and scale on the outer surface of the sample.

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