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THE EFFECT OF FRICTION TIME VARIATIONS ON DISSIMILAR MATERIAL WELDING JOINTS AND HARDNESS VALUE USING A BAR-PLATE ROTARY FRICTION WELDING MACHINE

(*PENGARUH VARIASI WAKTU GESEK TERHADAP SAMBUNGAN LAS MATERIAL DISSIMILAR DAN NILAI KEKERASAN MENGGUNAKAN MESIN LAS GESEK ROTARY TEGAK BAR-PLATE*)

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ABSTRACT

This research aims to determine the effect of variations in friction time on welded joints of dissimilar materials and hardness values. The method used is the friction welding method. One of the materials widely used in industrial products is mild steel AISI 1037 and stainless steel 304. One of the tools used is a bar-plate upright rotary friction welding machine. The parameters used are friction time variations of 25-35 seconds, 55-65 seconds and 115-125 seconds with a rotational speed of 2,484 rpm, friction pressure of 0.5 MPa, forging pressure of 0.7 MPa, forging time of 10 seconds. From the results of the connection several tests were carried out, namely liquid penetrant , macro observation and hardness test. The results of liquid penetrant testing and macro observations showed no influence on the welding area. The results of hardness testing have an influence on the hardness value. In the interface area, the friction time variation of 120 seconds has the highest hardness value of 161.67 VHN. The lowest hardness value in the interface area with a friction time variation of 30 seconds is 152.90 VHN. Where the longer the friction time, the hardness value also increases.

Keywords: bar-plate, dissimilar, friction welding, swipe time

ABSTRAK

Penelitian ini bertujuan untuk mengetahui pengaruh variasi waktu gesek terhadap sambungan las material *dissimilar* dan nilai kekerasan. Metode yang digunakan adalah metode *friction welding.* Salah satu bahan yang banyak digunakan pada produk industri adalah *mild steel* AISI 1037 dan *stainless steel* 304. Salah satu alat yang digunakan yaitu mesin las gesek *Rotary* tegak *bar-plate*. Parameter yang digunakan adalah variasi waktu gesek 25-35 detik, 55-65 detik dan 115-125 detik dengan kecepatan putar 2.484 rpm, tekanan gesek 0,5 MPa, tekanan *forging* 0,7 MPa, waktu *forging* 10 detik, dari hasil penyambungan tersebut dilakukan beberapa pengujian yaitu *liquid penetrant*, pengamatan makro dan uji kekerasan. Hasil

pengujian *liquid penetrant* dan pengamatan makro tidak terdapat pengaruh pada daerah pengelasan. Hasil pengujian kekerasan terdapat pengaruh pada nilai kekerasan. Pada daerah *interface* variasi waktu gesek 120 detik memiliki nilai kekerasan tertinggi sebesar 161,67 VHN. Nilai kekerasan terendah pada daerah *interface* variasi waktu gesek 30 detik sebesar 152,90 VHN. Dimana semakin lama waktu gesek maka nilai kekerasan juga semakin meningkat.

Kata kunci: *bar-plate, dissimilar*, las gesek, waktu gesek

INTRODUCTION

Friction welding is categorized as a type of solid state welding, where the connection process is carried out in a solid state between two surfaces at temperatures below the melting point of the parent material without the addition of materials or filler metals and can also be carried out using or without the use of pressure. Friction welding is a joining process that is generated through heat derived from mechanical friction and combined with pressure between two surfaces, one of which is subjected to rotation and the other to rest in the presence of pressure. The friction that occurs is carried out continuously until the welding temperature is reached, followed by the forging process by applying axial force after the rotation is stopped and the connection between the two parent materials occurs (Rachnaldy Putra 2020). Friction welding can also join round and non-round materials. While the decisive process parameters are variations in friction time, friction pressure, forging time, forging pressure, rotating speed and variations in chamfer angle on the forging surface.

From the research conducted by Rachnaldy Putra, (2020) said that the longer friction time variation parameter will cause an increase in hardness value. From the results of research conducted by Meipen (2022) with the thesis title of the effect of rotating speed on the weld joint area and hardness value using a bar-plate upright rotary friction welding machine. In macro observations there is an influence on each given rotational speed, where a large enough cavity occurs at a speed of 2,484 rpm with a cavity length of 4.76 mm, then getting smaller at a speed of 2,613 rpm with a cavity length of 2.63 mm, then at a speed of 4,335 rpm no voids were found. In hardness testing, variations in rotational speed affect the hardness value in each region, where the interface area has a high hardness value, this is due to the heat input that occurs during welding where the interface area has fine grains that affect the hardness value, where the highest hardness is at a speed of 4,335 rpm with a hardness value of 148.10 VHN, while the lowest hardness value in the rotary speed variation of 2,484 rpm has a hardness value of 140.44 VHN (Meipen 2022). To solve the problem of cavity defects in the rotary speed variation of 2,484 rpm. So that the author is interested in taking the title "Effect of Variation of Friction Time of Dissimilar Materials Using Bar-

Plate Upright Rotary Friction Welding Machine". The problem formulation of this research is how the effect of variations in the friction time of disimilar materials using a bar-plate upright rotary friction welding machine. The purpose of this study is to determine the effect of variations in friction time on dissimilar material welding joints using a bar-plate upright rotary friction welding machine.

RESEARCH METHODS

Observation and Literature Study

Observations were made at the Production Process Technology Laboratory, Department of Mechanical Engineering, Riau University. Observations are made directly on the machine by observing how the machine works. Literature study in this research by collecting data from books, journals and the internet that discuss the welding process in the form of bar-plate upright friction welding, welding on specimens, welding that occurs on the material, and so on related to this research. The machine used is a bar-plate upright rotary friction welding machine made by Utamar, F. and Siswanto in 2014. There are 3 variations of rotational speed which are 2,484 rpm, 2,613 rpm, and 4,335 rpm that can be adjusted using a pulley. The maximum pressure that can be applied is 1 MPa or 10 bar generated by a pneumatic cylinder. The diameter for the maximum bar workpiece is 12 mm. The data obtained from this literature study will be used as a reference for conducting research.

Tools and workpieces

The tools used in research on the effect of variations in friction time on dissimilar material welding joints and hardness values using a bar-plate upright rotary friction welding machine are, 1). Bar-plate upright rotary friction welding machine, 2). Compressor, 3). Hand grinding, 4). Jig and fixture, 5). Scope, 6). Protractor, 7). Stopwatch, 8). Tachometer, 9). Optical microscope, 10). Hardness testing machine.

Materials

The materials used in the study of the effect of variations in friction time on dissimilar material welding joints and hardness values using a bar-plate upright rotary friction welding machine are as follows, 1). Mild steel AISI 1037 and stainless steel 304, 2). Remover, penetrant, dan developer, 3). Sandpaper, 4). Solution etsa.

RESULTS AND DISCUSSION

Welding Results

The welding results of three variations of friction time using a bar-plate upright rotary friction welding machine with a variation of friction time of 30 seconds, 60 seconds, and 120 seconds can be seen in Figure 1.

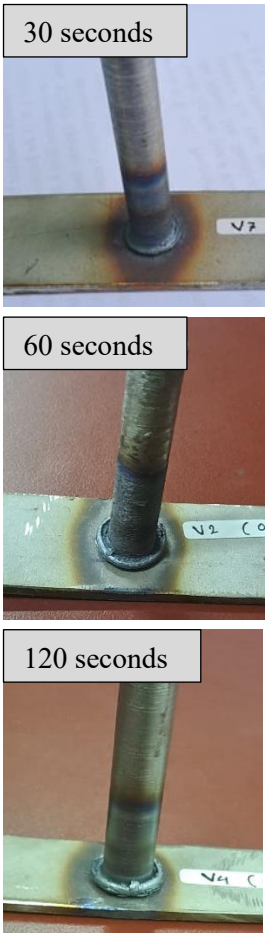

Figure 1. welding result

Non Destructive Testing (NDT)

The results of NDT testing carried out on dissimilar material welding joints using a bar-plate upright rotary friction welding machine, in Figure 2 (a) variation of friction time 30 seconds can be seen in the circled interface area is not found the emergence of red penetrant indicating the presence of cracks in the weld joint, in Figure 2 (b) variation of friction time 60 seconds can be seen in the circled interface area is not found the emergence of red penetrant indicating the presence of cracks in the weld joint, in Figure 2 (c) the 120 second friction time variation at the circled interface area also did not find the onset of red penetrant which indicates that there is a crack defect in the welded joint. All test specimens of the 30-second, 60-second and 120-second friction time variations were subjected to penetrant testing but no weld defects were found in the welded joints.

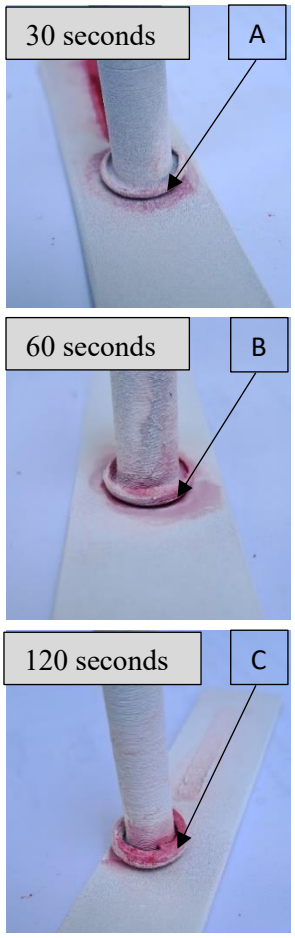

Figure 2. Liquid penetrant testing (ASME 2010 section V article 6)

Macro Observation

Figure 3. shows photos of macro observations at the interface area. In Figure 3. (a) shows a macro observation of the 30 second friction time variation specimen which does not show any voids. Figure 3. (b) shows a macro observation of the 60 second friction time variation specimen which does not show any

voids. Figure 3. (c) shows a macro observation of the 120 second friction time variation specimen which also has no visible voids.

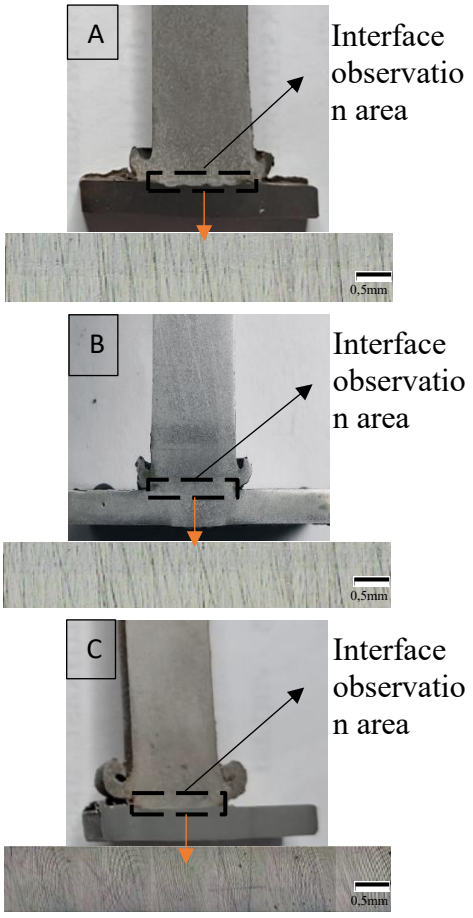

Figure 3. Macro structure testing

Hardness Testing

The results of hardness testing obtained from variations in friction time of 30 seconds, 60 seconds and 120 seconds can be seen in Figure 4. graph of average hardness value:

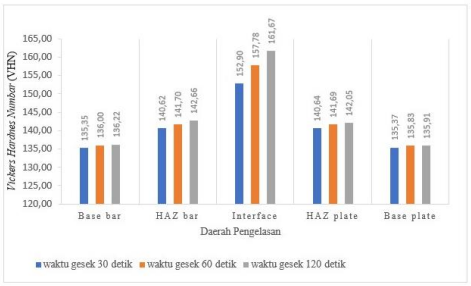

Figure 4. Graph of average hardness value (ASTM E92)

Figure 4. shows the graph of the average hardness of the specimen. Overall, the highest hardness test results in the WM (weld metal) area are found in the 120 second friction time variation with an average hardness value of 161.67 VHN at the interface area. While the lowest hardness test results are found in the 30 second friction time variation with an average hardness value of 152.90 VHN at the interface area. As for the HAZ area, the hardness test results show that the hardness in the HAZ area is higher than the base metal area. The hardness test results show that the use of longer friction time variations will produce optimal hardness values. This can occur because the heat input that occurs during the welding process will affect the hardness value of the material. Where the longer the friction time is given the heat obtained will increase.

Where the higher heat will require longer time for the cooling process which allows the appearance of pearlite grains which result in the weld joint itself becoming harder, that variation in friction time affects the results of the hardness test , this was also found by Rachnaldy Putra, (2020). In research conducted by A.W. Nugroho, et al (2016) also said that with an increase in friction time, the deformation (strain) becomes greater so that the hardness value increases again. This shows that the friction time greatly influences the hardness properties of the joint area which in turn influences the quality of the friction welded joint.

CONCLUSIONS

The conclusion from the results of the research on the effect of variations in friction time using a bar-plate upright rotary friction welding machine, the most optimal friction time variation parameter is the 120 second friction time variation, where the NDT test results and macro structure testing found no welding defects or voids in the welded joints, with the highest average hardness value of 161.67 VHN at the interface area. In the 60 second friction time variation where the NDT test results and macro structure testing also found no welding defects or voids in the welded joints and obtained an average hardness value of 157.78 VHN at the interface area. And the lowest average hardness value is found in the 30 second friction time variation with a hardness value of 152.90 VHN at the interface area. Where the results of NDT testing and macro structure testing also found no welding defects or voids in the weld joints. In research conducted by A.W. Nugroho, et al (2016) also said that with an increase in friction time, the deformation (strain) becomes greater so that the hardness value increases again. This shows that the friction time greatly influences the hardness properties of the joint area which in turn influences the quality of the friction welded joint.

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