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EFFECT OF ROOT FACE HEIGHT AND WIDTH OF THE ANVIL HEATING PLATE OF HOT-GAS WELDING ON BENDING STRENGTH OF HDPE SHEET

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ABSTRACT

Hot-Gas Welding is a welding process that is widely used in plastic materials. In previous studies, there was a phenomenon that occurred, namely the connection of the base material before the welding process which affected the bending strength of HDPE sheets. The purpose of this study was to determine the effect of variations in root face height and width of the anvil heating plate on bending strength, and also to determine the interaction of the two variables. The method used in this study was experimental. The hot-gas welding process, by varying two independent variables, namely root face height 0 mm, 0.8 mm, 1.6 mm, 2.4 mm and anvil heating plate width of 10 mm, 15 mm, and 20 mm, with controlled variables HDPE material with 5 mm thick, HDPE filler with 4 mm thick, hot gas temperature 250 ℃, single v bevel shape, anvil plate temperature 150 ℃ and v grove angle 60º. The results of this study indicate that the root face height and width of the anvil heating plate affect the bending strength of hot-gas welding HDPE sheets. The maximum value of bending strength is 47.14 Mpa or 85.32% of the bending strength of the parent material. The maximum bending strength value is obtained from the interaction of root face height of 2.4mm and anvil heating plate width of 20mm. Weld defects in the highest bending strength results were identified the least.

Keywords : hot-gas welding, bending strength, heater width, hdpe sheet, root face height

1. INTRODUCTION

Based on the query about hot-gas welding, the abstracts provide relevant information about various welding processes and techniques, including hot wire gas tungsten arc welding (HW-GTAW) and gas metal arc welding (GMAW) with hot-wire feeding technology.

Hot Wire Gas Tungsten Arc Welding (HW-GTAW), HW-GTAW involves heating the filler metal prior to entering the weld pool, resulting in increased deposition rate and welding speeds [1]–[3]. This process offers benefits such as metallurgical control, energy efficiency, and lower heat input, making it suitable for welding various novel materials [4], [5]. Gas Metal Arc Welding (GMAW) with Hot-Wire Feeding Technology. GMAW processes can be combined with an auxiliary hot wire to increase productivity and decrease heat input [6], [7]

The use of an additional wire allows for high melting rates while maintaining sufficient penetration depth and wetting behavior [8], [9].

Optimization of Gas-Metal Arc Welding

- The use of CO2 shield gas with hot-wire feeding technology can provide a welding process with high efficiency and low heat input, resulting in sound joint properties [10]–[12].

High-Speed Welding with Compensatory Gas Jet Blow

A method involving compensatory gas jet blow molten pool can improve weld appearance, macroscopic morphologies, microstructures, and hardness, resulting in high-quality welds without defects [13], [14].

Unfortunately, there is no specific information on "hot-gas welding" in the provided abstracts. However, the information on hot wire techniques in gas tungsten arc welding and gas metal arc welding, as well as the optimization of welding processes, can provide insights into related welding methods and technologies [15]–[17].

Plastic is a material that we can find in almost every object in our daily lives. Plastic is a polymer that has unique and extraordinary properties. Polymer is a material consisting of molecular units called monomers. If the monomers are of the same type it is called a homopolymer, and if the monomers are different it will produce a copolymer [18], [19]. Plastics are generally difficult to be degraded (decomposed) by micro-organisms. In this increasingly rapid technological development, there are many methods for joining plastic materials, one of which is using the hot gas welding method. The importance of plastic welding in the industrial and automotive world is one of them being able to support the economic value of plastic materials and reduce plastic waste itself [20], [21]. One of the factors in the application of plastic welding to the industrial and automotive world is that not all machine tools can make or print a plastic item with Therefore, on a large scale, this plastic welding is applied to the industrial and automotive world to overcome this problem [22], [23]. The use of the base plate as a heater during the welding process can improve the quality of the joint and increase the homogeneity of HDPE sheet welded joints [24]–[26]

Nowadays, many plastic welding methods are used by hot gas welding, because this method is the most reliable and technically advantageous from a research and production point of view [27], [28].

In previous studies, there was a phenomenon that occurred, namely the joining of the base materials during the Hot-Gas Welding process which affected the value of the bending strength of welding HDPE sheets [29], [30].

2. RESEARCH SIGNIFICANCE

The importance of plastic welding in the industrial and automotive world is one of them being able to support the economic value of plastic materials and reduce plastic waste itself. One of the factors in the application of plastic welding to the industrial and automotive world is that not all machine tools can make or print a plastic item with Therefore, on a large scale, this plastic welding is applied to the industrial and automotive world to overcome this problem.

Currently, plastic welding uses a lot of hot gas welding methods, because this method is the most reliable and technically advantageous from a research and production point of view [31].

3. RESEARCH METHODS

3.1 Research Installation Schematic

Figure 1 is a research installation scheme for Hot-Gas Welding HDPE sheet material.

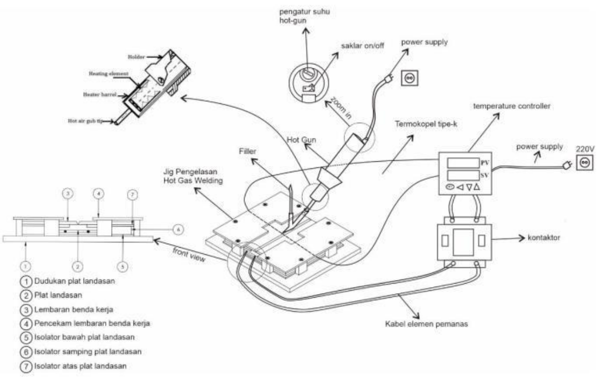

Figure 1. Research Installation Schematic

The installation scheme is clarified in Figures 2 to 4. Figure 2 is the HGW jig with the addition of a heating element to the base plate of the HGW jig, Figure 3 is the preparation of the V-groove angle with variations in root face height, and Figure 4 is the clamped specimen welding process on a Hot-Gas Welding (HGW) jig.

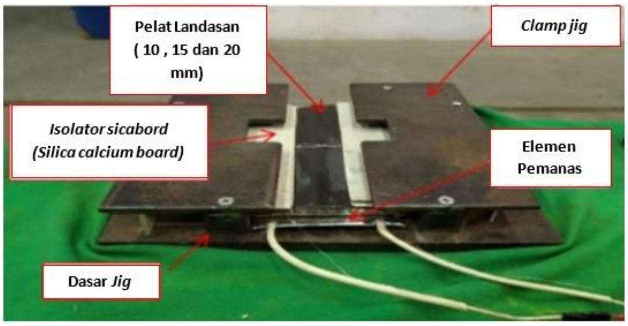

Figure 2. *Jig Hot-Gas Welding* (HGW)

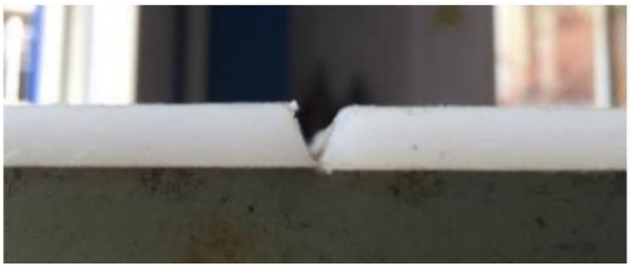

Figure 3. Root Face Height Preparation

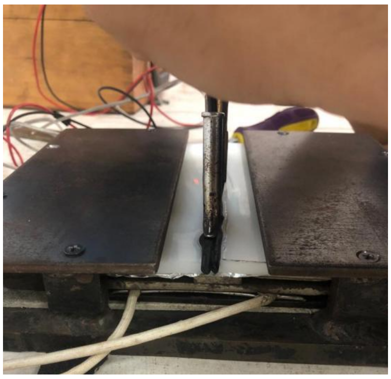

Figure 4. Specimen Welding Process with HGW

3.2 Research Methodology

In this study the material that was joined by the Hot-Gas Welding (HGW) welding process was white High Desity Polyethylene (HDPE) with a size of 175 x 100 x 5 mm each, where the mechanical specifications of the material are shown in Table 1. [32] The HGW process uses a hot-gun welding tool with a power of 1050 Watt, where the hot air temperature parameter is set at 250º. The added material used is black HDPE rod with a diameter of 4 mm. The heater used for specimen heating is a 500-Watt heating wire element housed within the HGW jig plate. The heating wire functions as a specimen heater at the start and during the HGW welding process. Two variations were used in this study, namely root face height: 0 mm, 0.8 mm, 1.6 mm, 2.4 mm, and variations in the width of the heating plate used

10 mm, 15 mm and 20 mm. The bending test standard uses the DIN EN 12814-1, 1999 standard. [33], [34] What can be seen in Table 1 using the three point bending test method can be seen in Figure 5.

Table 1. Sample Dimensions and Test Arrangements

Prosedur pengelasan	Benda Uji			Da (jarak antara poros roll)	*d* diameter mandrel)
	a (Tebal Sampel)	*b* (lebar sampel)	*L* *(panjang sampel)*		
Pengujian *face* dan *root bend*	3≤ a < 5	30	150	80	4
	5≤ a < 10	30	200	90	8
	10 ≤ a < 15	30	200	100	12,5
	15 ≤ a < 20	30	250	120	16
	20 ≤ a < 30	30	380	160	25
Uji bending samping	10 + 0,5	a	200	90	8

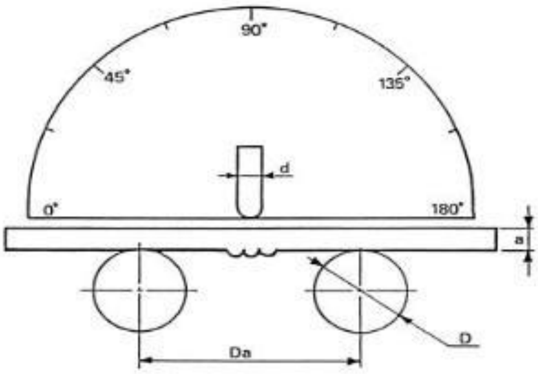

Figure 5. Structure of the Three-point Bending Test

4. RESULTS AND DISCUSSION

Table 2 is the result of testing the bending of plastic welded joints. In this sub-chapter, the raw data will be processed and then statistical tests will be carried out.

Table 2. Bending Test Results

Lebar Pemanas	Tinggi Face Root	Kekuatan Bending (Mpa)				
		I	II	III	IV	Rata - rata
Tanpa Sambungan		55,15	56,55	55,20	56,10	55,75
10 mm	0 mm	22,94	22,65	22,78	20,49	22,22
	0,8 mm	26,62	26,22	26,43	23,84	25,78
	1,6 mm	28,31	28,20	26,64	28,55	27,93
	2,4 mm	30,90	30,08	30,79	28,56	30,08
15 mm	0 mm	32,58	31,65	31,76	31,53	31,88
	0,8 mm	35,02	33,63	32,71	35,82	34,30
	1,6 mm	36,90	36,80	36,11	37,08	36,72
	2,4 mm	37,57	37,47	37,48	37,22	37,43
20 mm	0 mm	37,64	38,37	37,87	37,67	37,89
	0,8 mm	39,61	38,74	38,63	39,91	39,22
	1,6 mm	41,92	46,30	45,08	43,22	44,13
	2,4 mm	47,24	47,03	46,85	47,46	47,14

The main effect plot values for the bending test values for the width of the base plate heater and the variations in root face height are taken from the average data for each variable. This analysis is used to read the value of each base plate temperature variable and the variation of additives as shown in Figure 6.

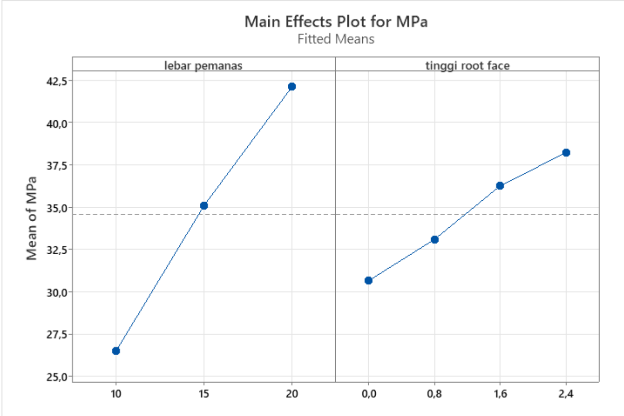

Figure 6. The Main effect Plot Graph of the Bending Test

Based on Figure 6 on the graph of variations in the width of the base plate heater affecting the bending strength, it is known that the average bending test experienced an increase in variations in the width of the base plate heater. In the variation of the 10 mm base plate heater, the highest value was obtained, namely with an average of 30.08, in the 15 mm wide base plate heater, the highest value was obtained with an average of 37.43 MPa, and in the 20 mm wide base plate heater, the highest value was obtained, namely -average 47.14 MPa.

In figure 6 the graph of variations in the height of the root face as a result of bending strength can be seen that it also has a significant effect. It can be seen in the graph that the root face height variation of 0 mm has the highest bending strength value with an average of 37.89 MPa, the root face height variation of 0.8 obtains the highest value that is, with an average of 39.22 MPa, for a variation of root face height of 1.6 mm it has an average bending strength value of 44.13, and for a variation of root face height of 2.4 mm the highest value is obtained with an average of 47.14 MPa. The root face height variation with the lowest value is with an average of 22.22 MPa.

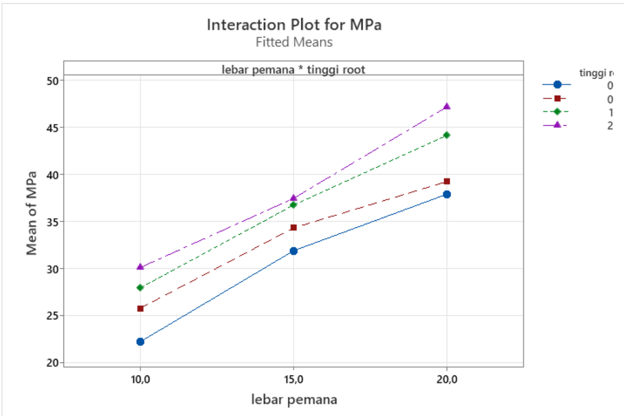

Figure 7. Graphic Interaction Plot for Bending Strength

Figure 7 is a graph of the interaction between the height of the root face and the width of the anvil heating plate. It can be seen that it has a significant effect on the bending strength value. For variations in the width of the anvil heating plate of 10 mm, the lowest bending strength value was obtained at the root face height variation of 0 mm with a value of 22.22 MPa, then it increased linearly for each variation of the root face from 0.8 to 1.6 to 2.4 and had a strength highest bending with an average of 30.08 MPa. For variations in the width of the anvil heating plate of 15 mm, the lowest value was obtained for the variation of root face height of 0 mm with an average value of 31.88 MPa, then the value increased linearly for each root height variation. face 0.8 1.6 mm 2.4 mm and has the highest bending strength at 2.4 in height with an average value of 37.43 MPa. For variations in the width of the anvil heating plate of 20 mm, the lowest value was obtained for the root face height variation of 0 mm with an average value of 37.89 MPa, then the value increased linearly for each root face height variation of 0.8 1.6 mm 2.4 mm and has the highest bending strength at a height of 2.4 with an average value of 47.14 MPa.

5. CONCLUSIONS

After conducting research and processing on the data that has been obtained, several conclusions are obtained based on the research objectives that have been made, namely:

1. Variations in the height of the root face on the welded joints during the hot-gas welding process have a significant effect, the bending strength results on the welding joints of the hot-gas welding are almost well close to the strength value of the parent material without welding is a variation with a root face height of 2.4 mm, with an average value of the highest strength towards the low of 2.4 mm, 1.6 mm, 0.8 mm, 0 mm.

2. Variations in the width of the anvil heating plate at the welded joints during the hot-gas welding process have a significant effect on the bending strength of HDPE sheets. Where each variation in the width of the anvil heating plate has a different bending strength value, at a 20 mm wide anvil heating plate, the highest strength value is obtained with an average value of 47.14 MPa.

3. The interaction between variations in the height of the root face and the width of the anvil heating plate obtained the maximum bending strength value of the highest HDPE sheet welded joints in the combination of the root face height of 2.4 mm and the width of the anvil heating plate of 20 mm with a value of 47.14 Mpa of material strength without joints, namely 56.59 Mpa, while the value of the bending strength of HDPE sheet welded joints is lowest in the combination of variation of root face height of 0 mm and 10 mm of base heating plate width with a bending strength value of 22.22 MPa, this value is due to the height of the root face and the width of the base heating plate is small so that the parent material that is connected or the occurrence of fusion becomes small.

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7. AUTHOR CONTRIBUTIONS

- Conception and design: Ahmad Fikri Fahruddin, Agus Setiawan
- Methodology: Ahmad Fikri Fahruddin, Agus Setiawan
- Data acquisition: Ahmad Fikri Fahruddin
- Analysis and interpretation of data: Ahmad Fikri Fahruddin, Agus Setiawan
- Writing publication: Ahmad Fikri Fahruddin, Agus Setiawan
- Approval of final publication: Agus Setiawan
- Resources, technical and material supports: Ahmad Fikri Fahruddin, Agus Setiawan
- Supervision: Ahmad Fikri Fahruddin

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