The Effect of Root Face Height and Width of Hot-Gas Welding Plate Heater on Tensile Strength of HDPE Sheet

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Article Information

Manuscript Received 2023-07-21
Manuscript Revised 2025-06-25
Manuscript Accepted 2025-06-27
Manuscript Online 2025-06-30

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 early connection of the parent material before the welding process which affected the tensile 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 tensile strength, and also to determine the interaction of the two variables. The welding process of Hot-Gas Welding, by varying two independent variables namely root face height 0 mm, 0.8 mm, 1.6 mm, 2.4 mm and the width of the anvil heating plate 10 mm, 15 mm, and 20 mm. The controlled variables include HDPE material 5 mm thick, HDPE filler 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 anvil plate width affect the tensile strength of hot-gas welding HDPE sheets. The maximum value of tensile strength is 27.09 Mpa or 85.32% of the tensile strength of the parent material. The maximum tensile strength value is obtained from the interaction of the root face height of 2.4 mm and the width of the heating plate of 15 mm. Distortion and linear misalignment weld defects at the highest tensile strength results were identified the least.

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

1. INTRODUCTION

The use of plastics in daily life and industry has increased, this happens because plastic materials have the advantage of not rusting, strong, lightweight, recyclable and relatively cheap prices. Plastic materials are often found in everyday life and household life, including for food wrappers, mineral water bottles, paralon pipes and many more. Plastic in general is easily broken and cracked, it can be repaired by connecting plastic, one of the plastic connections that can be used is the plastic welding method [1]–[3]. The lack of research on plastic welding makes the industry rarely use plastic welding methods as an alternative, therefore the process of connecting plastic components using welding must be considered further [4], [5].

Meanwhile, research highlights the influence of temperature and pressure parameters on the tensile strength of HDPE welded using the hot-gas welding method. The results of this research provide a deeper understanding of the factors that influence the tensile strength of HDPE material in the welding process [6], [7]. In addition, research explores the use of variations in filler material in hot-gas welding to increase the tensile strength of HDPE joints. The findings from this study provide insight into ways to improve the welding performance of HDPE through the addition of appropriate filler materials [8], [9]. In addition, factors such as cooling time and cooling pressure can influence the tensile strength of HDPE joints produced by hot-gas welding [10], [11]. The results of this study provide a more comprehensive view on optimizing the cooling process in hot-gas welding to increase the tensile strength of HDPE joints. Furthermore, research investigates the effect of HDPE material thickness on the tensile strength of joints produced by hot-gas welding. The findings from this study provide valuable information about the relationship between material thickness and HDPE welding performance [12], [13]. Additionally, studies explored the use of gas flow variations in hot-gas welding to increase the tensile strength of HDPE joints. This research shows that proper regulation of the gas flow can produce stronger joints in HDPE [14], [15]. In addition, there are also studies that discuss the influence of surface preparation and environmental conditions on the tensile strength of HDPE joints produced by hot-gas welding. The findings from this study provide valuable insight into the importance of surface preparation and environmental control in achieving strong joints in HDPE [16], [17]. Furthermore, research investigated the effect of varying welding pressure on the tensile strength of HDPE joints in hot-gas welding. The findings from this study provide a better understanding of the optimal pressure settings to achieve strong HDPE joints [18], [19]. Furthermore, the study explored the use of temperature variations in hot-gas welding to increase the tensile strength of HDPE joints. The results of this study show that careful temperature control can produce stronger HDPE joints [20]. There are also studies investigating the effect of varying welding speed on the tensile strength of HDPE joints in hot-gas welding. Findings from this study provide insight into optimal speed settings to achieve strong HDPE joints [21], [22]. Meanwhile, research discusses the influence of joint geometry on the tensile strength of HDPE in hot-gas welding. The results of this research show that appropriate geometric design can improve the performance of HDPE joints in hot-gas welding [23], [24].

In plastic welding, there are efforts to provide characteristics and joint properties that resemble the properties of the parent material, but what happens is that many existing plastic welds produce relatively lower or weaker mechanical strength compared to the mechanical strength of the material without welding [25], [26].

One of the welding methods that can be used is hot-gas welding. Hot-Gas Welding is a manual process for connecting thermoplastic materials, using a stream of hot air pressure which is directed to heat and melt the thermoplastics material with the welding rod (plastic welding rod / wire) simultaneously [27], [28].

In the welding process, a preheating process is often used or what is often referred to as a preheating process, where the preheating process aims to stabilize the temperature of the specimen before welding so that no defects or damage occur and improve the mechanical properties of the material to be welded [29], [30].

For bevel angle variations that have the highest tensile strength value results in the 60 ° v-groove angle variation, while the lowest tensile strength value results in the 40 ° v-groove angle variation, this is because the small bevel angle affects the lack of welding penetration to cause weld defects in the form of incompelete penetration [31], [32].

In previous studies, there is a phenomenon that occurs, namely the connection of the parent material during the preheating process before the hot-gas welding process which affects the tensile strength value of HDPE welding joints [33].

2. RESEARCH SIGNIFICANCE

the increase in the use of plastics in the manufacturing industry makes a lot of research on plastic splicing, one of which is the hot gas welding method. the main purpose of this study is to obtain the maximum tensile strength of plastic splicing so that the characteristics increase. utilization in the industrial field is often plastic splicing used for water pipes.

3. RESEARCH METHODS

3.1 Research Installation Schematic

Figure 1 is a schematic of the Hot-Gas Welding (HGW) research installation for HDPE sheet material.

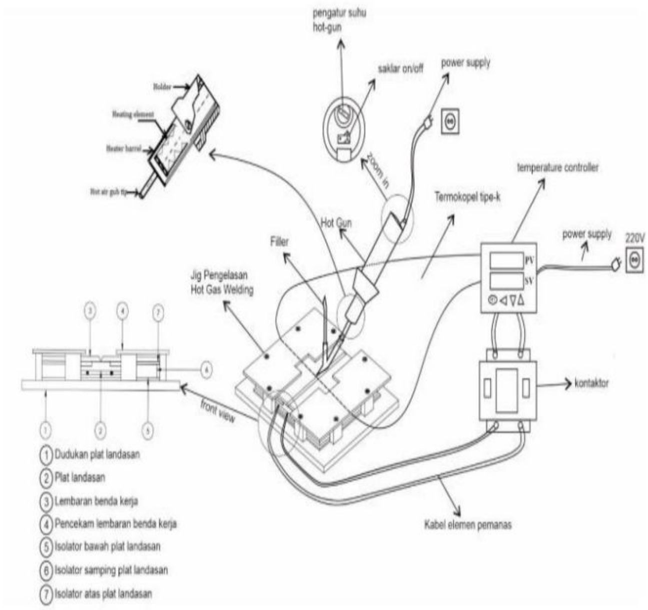

Figure 1. Research Installation schematic

The installation scheme is clarified in Figure 2 to Figure 4. Figure 2 is the HGW jig with the addition of heating elements at the base of the anvil 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 welding process of specimens gripped on the hot-gas welding (HGW) jig.

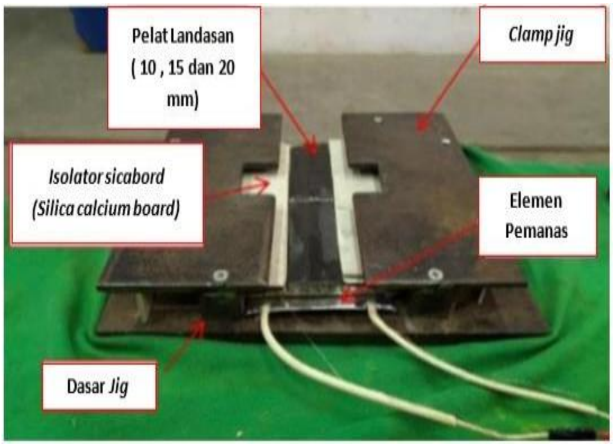

Figure 2. Hot-Gas Welding Jig

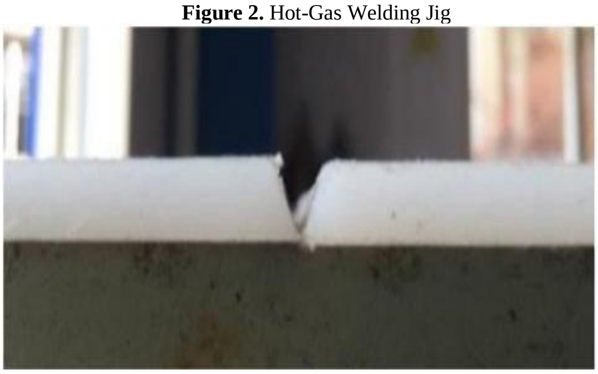

Figure 3. Preparation of the V-Groove

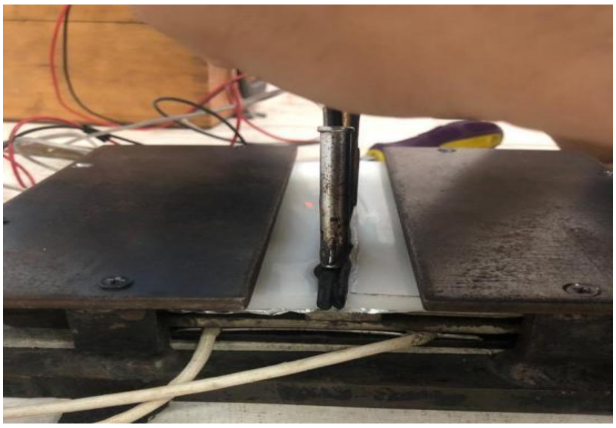

Figure 4. The Hot-Gas Welding Procces

3.2 Research Methodology

The material joined by the Hot-Gas Welding (HGW) welding process is High Desity Polyethylene (HDPE) white color with a size of 165 x 100 x 5 mm each, where the mechanical specifications of the material are shown in table 1. [7] 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 placed inside the HGW jig plate. The heating wire serves as a specimen heater at the beginning and during the HGW welding process. The two variations used in this study are the root face height: 0 mm, 0.8 mm, 1.6 mm, 2.4 mm, and the width variation of the heating plate used 10 mm, 15 mm and 20 mm. The tensile test standard uses the astm d 638-01 standard. [8] Which can be seen in Figure 5.

Table 1. Mechanical Specifications

Mechanical Properties of HDPE Plastic	
Specific gravity (kg/m3)	0,95-0,96
Melting point (ºC)	124o
Degree of Crystallinity (%)	85-95
Tensile strength (kgf/cm2)	245
Tensile strength (Mpa)	28

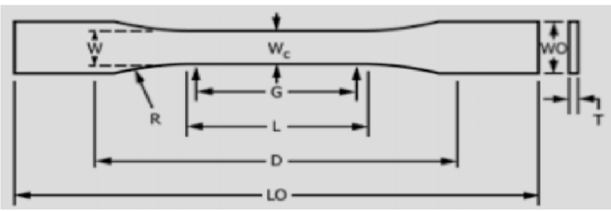

Figure 5. Tensile test standard ASTM 638-01

The description of Figure 5 for the dimensions of the tensile test specimens is provided in Table 2.

Table 2. Dimensions of the tensile test specimens

Width (w)	13 mm
Length (L)	57 mm
Overall Width (Wo)	19 mm
Overall Length (Lo)	165 (<) mm
Gauge Length (G)	50 mm
Distance between grips (D)	115 mm
finger (R	76 Mm
Thickness (T)	≤ 7 mm

4. RESULTS AND DISCUSSION

Table 3 is the tensile test data of HDPE sheet welding connection specimens with variations in root face height and width of the heating plate according to ASTM 638-01 standards.

Table 3. The Tensile tes Data of HDPE

Heating plate width	Root face height (mm)	Tensile Strength (Mpa)
No connection		31,72
10 mm	0	18,59
	0,8	19,43
	1,6	20,58
	2,4	21,44
15 mm	0	22,84
	0,8	25,23
	1,6	26,71
	2,4	27,09
20 mm	0	21,56
	0,8	23,25
	1,6	24,2
	2,4	25,3

The effect of root face height and heating plate width on the tensile strength of HDPE joints can be seen in Figure 6 main effect plot and in Figure 7 interaction plot, respectively.

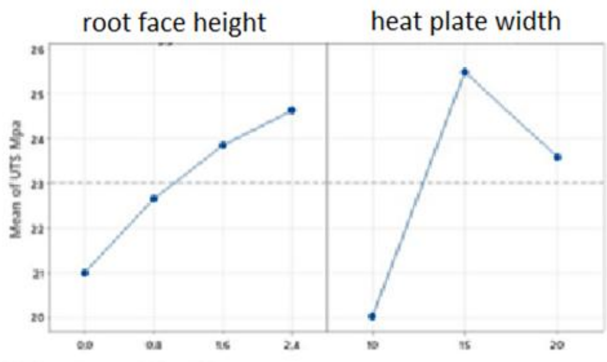

Figure 6. Main Effect Plot

Figure 6 shows the graph of root face height variations affecting tensile strength, it is known that the average tensile test has increased in variations in root face height. In the variation of root face height o mm, the highest value is obtained, namely with an average of 20,99 MPa, at a root face height of 0.8, the highest value is obtained with an average of 22,63 MPa, at a root face height of 1.6, the highest value is obtained, namely with an average of 23,83 Mpa and at a root face height of 2.4, the highest value is obtained with an average of 24,60. root face height variation with the lowest value is with an average of 20,99 MPa.

Figure 8 shows that the width of the heating plate the results of tensile strength can be known to also have a significant effect can be seen in the graph in the variation of the width of the heating plate 10 mm has a tensile strength value with an average of 20,01 MPa, in the variation of the width of the heating plate with a value of 15mm the highest result is obtained with an average of 25,46 MPa, but in the variation of the width of the heating plate 20 mm has a decrease from the variation of 15 mm and the highest average value of 25,57 MPa is obtained.

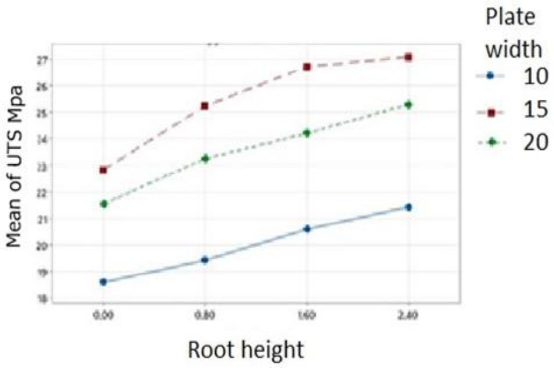

Figure 7. Interaction plot

Figure 7 shows that the interaction graph between the height of the root face and the width of the heating plate has a significant effect on the tensile strength value. In the variation of heating plate width of 10 mm, the lowest tensile strength value is obtained in the root face height variation of 0 mm, then it increases linearly in each root face variation of 0.8 to 2.4 and has the highest tensile strength with an average of 21.44 MPa.

In the variation of the width of the heating plate of 15 mm, the lowest value was obtained in the variation of the root face height of 0 mm with an average value of 22.84 MPa, then experienced a linear increase in value at each variation of the root face height of 0.8 1.6 mm 2.4 mm and had the highest tensile strength at a height of 2.4 with an average value of 27.09 MPa.

In the variation of the heating plate width of 20 mm, the lowest value is obtained in the root face height variation of 0 mm with an average value of 21.56 MPa, then linearly increases in value at each variation of the root face height of 0.8 1.6 mm 2.4 mm and has the highest tensile strength at a height of 2.4 with an average value of 25.30 MPa.

5. CONCLUSIONS

After the discussion above, the following conclusions are:

1. The variation of root face height in welded joints during the hot-gas welding process has a significant effect, it is found that the tensile strength results in hot-gas welding welded joints that are almost the same or close to the parent material without welding are variations with a root face height of 2.4 mm, with the highest average strength value to the low, namely 2.4 mm with a value of 27.09 Mpa or 85.32%, 1.6 mm with a value of 26.71 Mpa or 84.12%, 0.8 mm with a value of 25.23 Mpa or 79.46%, 0 mm with a value of 22.84 Mpa or 71.93%.
2. The width variation of the anvil heating plate on the welding joint during the hotgas welding process has a significant effect on the tensile strength of HDPE sheets. Where each variation has a different tensile strength value, at a width of 15 mm anvil heating plate, the highest strength value is obtained with an average value of 27.09 Mpa or 85.32%.
3. The interaction between the variation ofroot face height and the width of the anvil heating plate obtained the maximum value of tensile strength of HDPE sheet welding joints is highest in the combination of root face height 2. 4 mm and the width of the anvil heating plate of 15 mm with a value of 27.09 Mpa or 85.32% of the strength of the material without connection, namely 31.72 Mpa, while the lowest HDPE sheet welding connection tensile strength value is obtained in the combination of variations in root face height of 0 mm and width of the anvil heating plate of 10 mm with a tensile strength value of 18.59 Mpa or 58.55%, this value is obtained because the root face height and width of the anvil heating plate are small, making the parent material connected or the fusion becomes small.

6. ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to all those who have helped in this research. Their participation in sharing their time and experience was invaluable in providing the data needed to carry out this research. providing the data needed to carry out this research.

7. AUTHOR CONTRIBUTIONS

•Conception and design: Mochammad Shohib Salam, Agus Setiawan
•Methodology:Mochammad Shohib Salam, Agus Setiawan
•Data acquisition: Mochammad Shohib Salam
•Analysis and interpretation of data: Mochammad Shohib Salam, Agus Setiawan
•Writing publication: Mochammad Shohib Salam, Agus Setiawan
•Approval of final publication: Agus Setiawan
•Resources, technical and material supports: Mochammad Shohib Salam, Agus Setiawan
•Supervision: Mochammad Shohib Salam

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