Comparative Analysis of Compressive Strength of Steel Tubing Pipe Welding Results Using SMAW and MIG Welding with 140A Current

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Comparative Analysis of Compressive Strength of Steel Tubing Pipe Welding Results Using SMAW and MIG Welding with 140A Current

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Abstract

The welding process plays a crucial role in manufacturing and is inseparable from its advancement. Deutsche Industrie Norman (DIN) defines welding as creating a metallurgical bond at the joint of metal or alloy metals in their molten state. This process is essential for constructing strong, durable materials like plates, steel, and pipes. Bending tests, including face bend and root bend, are often conducted to evaluate the quality of welded joints. These tests assess welded materials' toughness, strength, and resistance under specific loading conditions. This study employed two welding techniques: Gas Metal Arc Welding (GMAW) and Shielded Metal Arc Welding (SMAW). GMAW, called Metal Inert Gas (MIG) welding, uses argon or helium as protective gases and a continuously fed electrode wire. On the other hand, SMAW relies on flux-coated electrodes to create the weld seam, with molten metal from both the electrode and parent material filling the joint. The results revealed distinct advantages for each method. The highest bending test value for the root bend was achieved with MIG welding at 982,55 Kgf/mm², demonstrating its effectiveness in creating durable root joints. Conversely, SMAW exhibited superior performance in face bend tests, achieving a bending strength of 104111 Kgf/mm², making it ideal for surface-level joint applications. Both techniques displayed no visible cracks in their welds, ensuring compliance with industry standards and confirming their reliability for various manufacturing needs. These findings highlight the importance of selecting appropriate welding methods based on specific application requirements.

Keywords: *Metal Inert Gas, SMAW, Bending Test.*

1. Introduction

With the development of the manufacturing process, the welding process is one of those parts that cannot be separated from the manufacturing process. Products such as plates, construction steel, and pipes are made by forming processes with strict and meticulous qualifications with manufacturing processes, and in welding work, one must pay attention to the suitability of the weld construction to achieve optimal results. For this reason, welding needs to pay attention to several important things, including welding efficiency, labor savings, and energy savings [1][2].

Deutsche Industrie Norman (DIN) states welding is a metallurgical bonding of metal or alloy joints in a molten state. Thus, welding is the local connection of several metal rods using focused heat energy. Welding is the process of joining materials (both metal and non-metal) using heat energy to produce quality construction so a method is needed to combine two materials with good technology [3][4][5]. Many studies have been carried out in welding, including the analysis of the bending strength of SMAW welding using various variations of electric current and the effect of strong current on the results of GMAW welding [6][7].

Metal Inert Gas (MIG) welding is a part of the development of Gas Metal Arc Welding (GMAW), which has two protective gases, namely inert gas and active gas, which we often hear as Metal Inert Gas (MIG) and Metal Active Gas (MAG). Metal Inert Gas (MIG) welding is a gas arc welding that uses welding wire and electrodes. The electrode is a roll of wire (roller) whose movement is regulated by an electric motor. This weld uses argon and helium gas to protect the arc and melting metal from atmospheric influences. In SMAW welding (shielded metal arc welding) in this welding, the parent metal is melted due to heating from the electric arc that arises between the tip of the electrode and the surface of the workpiece. The existing electric arc is generated from a welding machine. The electrode is wrapped in a protective flux; the welding electrode is sometimes called a welding wire. During welding, this electrode will experience melting with the parent metal, which becomes part of the weld seam. With this melting, the weld seam will be filled with liquid metal from the electrode and parent metal [8][9].

Therefore, this study compares the compressive strength of steel tubing pipe welding results using SMAW and MIG welding with a current of 140A.

2. Research Methodology

The method used in this research is an experimental method used to analyze the compressive strength of ASTM A106 Grade B steel material welding joints with a diameter of ø 10 inches, thickness of 7,11 mm, and length of 200 mm[10]. An experiment is to make observations under artificial conditions deliberately arranged and made by researchers. Before conducting research, several stages must be fulfilled, including the following:

2.1. Material

This research was carried out at the Material Test Laboratory of the Department of Mechanical Engineering, Medan State Polytechnic, using customized conditions and equipment. The steel tube pipe with chemical requirements is used for this research in the table below.

Table 1. Chemical Requirements Tube Pipe ASTM 106 Grade B[11]

Carbon max %	Manganese %	Phosphorous max %	Sulfur max %	Silicon min %
0.30	0.29-1.06	0.025	0.025	0.10

2.2. Tools

The welding technique in this study uses Gas Metal Arc Welding (GMAW) welding with argon gas protective gas, ER70S-6 electrode diameter 1.0 mm, and Shielded Metal Arc Welding (SMAW) with welding electrodes using E7018 electrode diameter 2,6 mm and using a V camp[12]–[14].

The steps taken in the welding process are as follows:

1. Prepare SMAW and MIG welding machines according to DCEP (Direct Current Electrode Positive) polarity.
2. Prepare electrodes E7018 (SMAW welding) and ER70S-6 (MIG welding).
3. Prepare two pieces of ASTM A106 Grade B steel pipe with a diameter of ø10 inch, length of 200 mm, and thickness of 7,11 mm, both sides of which have been beveled 30º.
4. Make a 3 mm broad root face using a hand grinder that is equally large and flat.
5. Turn on the welding machine, then the electrode is clipped to the electrode holder, and the mass on the welding machine is clipped to the welding table.
6. Set the root gap between the pipes to be welded at 3 mm.
7. The ampere meter is set at 140 Amperes.

Furthermore, welding for ASTM 106 Grade B steel pipe specimens starts with welding the root pass, fill pass, and cover pass[15], [16]. After the following welding process, the material that has been welded will be cut into the shape of a test specimen with a grinding machine. This tensile testing process aims to obtain flexural strength on the welding material.

2.3. Bending Test

A bending test is one form of testing that visually determines the quality of a material. In addition, the bending test is used to measure the strength or toughness of the material due to loading and the welded joints' elasticity in the weld metal and HAZ[17], [18]. In giving loads and determining dimensions, several factors must be considered, namely: The standard dimensions of arch trials or tests are as follows:

1. Root Bend

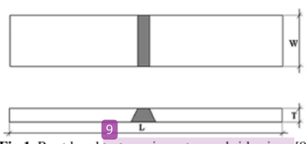

Fig 1. Root bend test specimen top and side views[9]

2. Face Bend

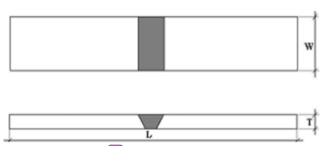

Fig 2. Face bend test specimen top and side views[9]

3. Results and Discussion

The following is the value of the data results from the compressive test of welding specimens, which can be seen in Table 2 below:

Table 2. Raw material, SMAW, and MIG compressive test results

Welding Methode	Sample	Righ. Bending σb (Kgf.mm^2)	Average σb (Kgf.mm^2)	Methods	Description
RAW Material	1	1011,39	1050,65	Root Bend	No Cracks

	2	1125,45		Root Bend	No Cracks
	3	1015,10		Root Bend	No Cracks
	4	1039,17	1020,63	Face Bend	No Cracks
	5	1002,09		Face Bend	No Cracks
SMAW	1	964,62	941,38	Root Bend	No Cracks
	2	935,25		Root Bend	No Cracks
	3	924,27		Root Bend	No Cracks
	4	1077,30	1041,11	Face Bend	No Cracks
	5	1004,92		Face Bend	No Cracks
MIG	1	998,23	982,55	Root Bend	No Cracks
	2	1005,74		Root Bend	No Cracks
	3	943,69		Root Bend	No Cracks
	4	1050,42	1014,57	Face Bend	No Cracks
	5	978,72		Face Bend	No Cracks

The bending test results of the specimens shown in Table 2 get results that are poured in graphical form on each specimen. The results obtained from the compressive test results vary from specimen to specimen. Where the data for each test is shown in the graph in Figure 5 below:

Bending testing is carried out to see the toughness and resistance of a material to a given static load. The bending tests carried out include face bend and root bend, as the results of the bending tests can be seen in Figure 3.

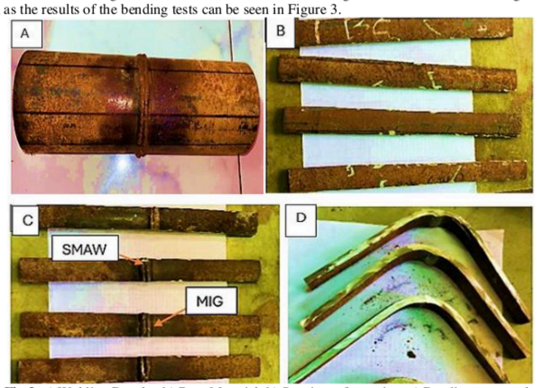

Fig 3. a) Welding Results, b) Raw Material, b) Specimen formation, c) Bending test results

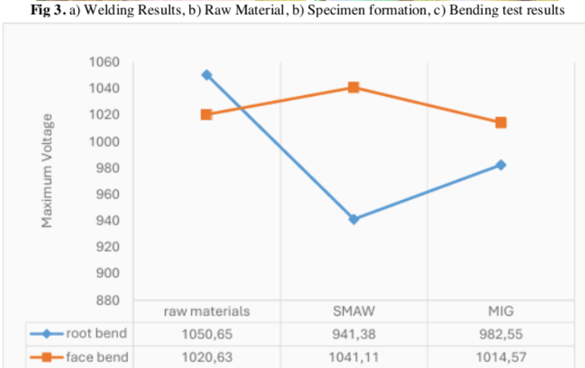

Fig 4. Maximum stress graph of bending test

Based on Figure 4 shows that the highest value of bending testing at the root bend is in MIG welding of 982 ,55 Kgf.mm^2 and then followed by SMAW welding of 941,38 Kgf.mm$^{2.}$ and this value shows a value not much different from the raw material value which has a value of 1050,65 Kgf.mm^2[19], [20].

The highest bending test value on the face bend is at SMAW welding of 1041,11 Kgf.mm^2 and not much different from the raw material value, which has a value of 1050,65 Kgf.mm^2, then followed by MIG welding of 1041,11 Kgf.mm^2 and not much different from the raw material value which has a value of 1020,63 Kgf.mm^2

Based on the bending test results, no cracks were found in the welds, both in SMAW and GMAW welding. These results show that the weld results meet the standard[10], [16].

4. Conclusion

From the results of the bending test research, the following conclusions can be drawn:

1. The average value of the bending strength of the root bend specimen group is the highest in MIG welding, which is 982,55 Kgf.mm^2, compared to the SMAW welding specimen group.
2. The average value of the bending strength of the face bend specimen group is the highest in SMAW welding, which is 1041,11 Kgf.mm^2, compared to the MIG welding specimen group.
3. When comparing SMAW and MIG welding, SMAW welding is recommended for producing a face bend that is better efficient and has a low economic value compared to MIG.

References

[1] Sonawan H dan Suratman R, *Pengantar untuk Memahami Proses Pengelasan Alumunium*, Cetakan ke. Bandung: CV. Alfabeta, 2006.

[2] A. Sebayang, E. Tarigan, and L. Tarigan, "Pengaruh Variasi Arus Pengelasan 120 A , 130 A , 140 A , dan 150 A terhadap Kekuatan Tarik pada Material ST 37 dengan Metode Pengelasan Metal Inert Gas (MIG)," vol. 2, no. 1, pp. 118–124, 2024.

[3] E. Tarigan, T. A. Sianturi, and R. A. Sihombing, "Pengaruh Arus Pengelasan terhadap Gaya Tarik Pelat Baja Aisi 1040 Pengelasan Metal Inert Gas (MIG)," *J. Pendidik. Tambusai*, vol. 7, pp. 1575–1582, 2023, [Online]. Available: https://www.jptam.org/index.php/jptam/article/view/6021%0Ahttps://www.jptam.org/index.php/jptam/article/download/6021/5043

[4] R. Siswanto, "Teknologi Pengelasan," *Tek. Mesin Univeristas Lambung Mangkurat*, pp. 1–20, 2018.

[5] Deutsche Industrie Norman (DIN), "Definisi dan Standar Proses Las".

[6] Juwanda, Saifuddin, and Marzuki, "Analisa pengaruh kuat arus hasil pengelasan GMAW terhadap kekerasan material ASTM A 36," *J. Weld. Technol.*, vol. 3, no. 1, pp. 6–11, 2021.

[7] O. D. Nata, M. Hidayat, and S. A. Rohman, "Analisis Kekuatan Uji Bending Pengelasan Shielded Metal Arc Welding (Smaw) Material Ss400 Menggunakan Kawat Las E6013 Berbagai Variasi Arus Listrik," *Hexag. J. Tek. dan Sains*, vol. 2, no. 1, pp. 12–15, 2021, doi: 10.36761/hexagon.v2i1.871.

[8] S. M. Kejuruan et al, ""Welding With Gas Tungsten Welding Process,"," 2004.

[9] DIN Standards Committee, "Arc Welding and Metallurgical Processes," 2021.

[10] Department of Petroleum Engineering, "Testing and Application of ASTM A106 Grade B Steel in Industrial Welding," *Riau Univ.*, 2023.

[11] ASTM, "Specification A106 for Seamless Carbon Steel Pipe for High-Temperature Service".

[12] American Welding Society (AWS), "Welding Handbook: Fundamentals of Welding".

[13] International Organization for Standardization (ISO). ISO 5173:, "Destructive Tests on Welds in Metallic Materials.".

[14] S. M. Kejuruan, ""Flexural Strength Test on Welded Materials," *Polytech. Medan*, 2023.

[15] J. Weld. Tech.," 'Analysis of Strength in Welding with Argon Protection,'" vol. Vol. 2, 2022.

[16] Sebayang, Alexander, "'Development of Gas Metal Arc Welding Methods Using Inert Gas Protection.'".

[17] L. Tarigan, "'Implementation of SMAW Welding Using E7018 Electrodes,'" *Polytech. Medan*, 2019.

[18] Marzuki, "'Effectiveness of Gas Shielded Welding on Steel Plate Materials,'" *J. Mech. Eng.*, 20121.

[19] A. Sebayang, ""Comparative Study of Welding Current Impact on SMAW and MIG Welding Results," *IJESTY*, 2024.

[20] Fitriani, "'Analysis of Welding Efficiency Between SMAW and GMAW Techniques,'" *Univ. Riau,* 2020.

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