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

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Abstract

Welding is a crucial technology in modern manufacturing processes, widely applied in automotive, oil refineries, and other industries. This study focuses on two standard welding techniques: Gas Metal Arc Welding (GMAW) and Shielded Metal Arc Welding (SMAW). GMAW uses argon gas as a shielding gas, and the ER70S-6 electrode has a 1.0 mm diameter, while SMAW employs the E7018 electrode with a 2.6 mm diameter. Both methods are tested on ASTM 106 Grade B steel, a commonly used material in various industries. The primary goal of this research is to evaluate the tensile strength of steel specimens welded using MIG and SMAW. The tensile strength of raw material, as well as the welded materials, is measured to assess the quality of the welds. The results show that the tensile strength of the raw material is 648.26 kgf/mm². After welding, the tensile strength for the MIG-welded material is 540.79 kgf/mm², while the SMAW-welded material achieves a higher tensile strength of 616.17 kgf/mm². These values highlight the significant difference in performance between the two welding techniques. SMAW welding provides the best joint quality among the two methods, with a tensile strength value of 616.17 kgf/mm². This study underscores the importance of selecting the appropriate welding technique based on the desired strength and application, with SMAW proving superior for this particular material. These findings contribute valuable insights into material technology and welding, offering a reference for future industrial applications.

***Keywords**: SMAW, MIG, Tensile Test.*

1. In.troduction

Welding is a critical technology for modern manufacturing processes, such as in industrial fields such as automotive and oil refineries. Welding is also defined as a metallurgical bond in metal joints that is carried out when the metal melts and can also be interpreted as a metal union that occurs due to heat (whether or not there is a pressure influence) Deutsche Industrie Normen (DIN). The welding process is the process of connecting several metal rods using heat energy. Metal properties are one of the factors that affect the quality of welding results, and welding is the connection of two or more materials based on the principles of the diffusion process, causing the union of more parts of the material to be joined. The development of metal welding technology provides convenience in human life[1], [2] [3].
Metal Inert Gas (MIG) welding is an arc welding process in which additional material is fed by a coil of electrode wire and melted by the joule effect and electric arc. An inert gas, generally argon-based gas (MIG welding), or active gas, usually CO-based gas (MAG welding), is used as a plasma for arc initiation and shielding gas for metals at high temperatures to avoid contamination with oxygen and nitrogen. The joining process in construction and machining currently leads to low operating costs in the manufacturing process[4], [5].
Shielded Metal Arc Welding (SMAW) is the union of metal objects that are melted through electrodes using electricity as the primary source. This welding is effective and practical because it only requires simple tools, namely welding machines and electrodes in use, so this type of welding is very well applied in the industrial and household world, for example, welding production machinery, heavy equipment, vehicles, making fences, canopies or others. In general, welding is used as a powerful metal connection and as a construction machine maintenance tool[6][7], [8].
MIG and SMAW welding are mostly chosen for their ease of processing, economy, good mechanical and physical properties, and low investment costs. However, the shortcomings of these joint products are highly dependent on several factors. These factors include the welder, electrode, current strength, and welding speed, which affect the structure and stability of the material[9][10]–[12].
The benefits of this research are that it will add knowledge in the field of material technology and welding to the world of education, especially in the field of shipping and welding science. This research is used to improve the quality of steel welding joints after the welding process with the right type to be used as a reference in selecting materials and the right kind of welding. For this reason, it is neces-

sary to conduct a tensile test; the purpose of conducting a tensile test on welding is to determine the quality of the weld results based on different welding methods; the purpose of testing and inspection is to ensure quality and provide confidence that will be welded.

Fig 1. Tensile test process

2. Research Methodology

2.1. Research Materials and Tools

This research was carried out at the Material Test Laboratory of the Department of Mechanical Engineering, Medan State Polytechnic, using customized conditions and equipment. This research uses a steel tube pipe with chemical requirements, as shown in the table below.

Table 1. Chemical Requirements Tube Pipe ASTM 106 Grade B[13]

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

The welding technique in this study uses Gas Metal Arc Welding (GMAW) welding with argon gas protective gas, ER70S-6 electrode electrode diameter 1.0 mm, and Shielded Metal Arc Welding (SMAW) with welding electrodes used E7018 electrode diameter 2,6 mm and using a V camp[14], [15].

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 30°.
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. After welding, the material that has been welded will be cut into the shape of a test specimen by a grinding machine. This tensile testing process aims to obtain flexural strength on the welding material.

Fig 2. ASTM 106 Grade B steel pipe specimens

2.2. Dimensions of Welding Test Objects

The tensile test is one form of testing that visually determines the quality of a material. In addition, tensile tests are used to measure the strength or toughness of the material due to loading and the weld joints' elasticity in the weld metal and HAZ [13], [16]. In giving loads

and determining dimensions, several factors must be considered, namely: The standard dimensions of a tensile test experiment or test are as follows:

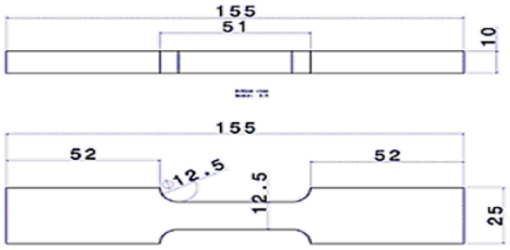

Fig 3. Tensile test specimen [17]

3. Results and Discussion

The test specimen consists of tensile testing for the quality of the tensile strength of ASTM 106 Grade B steel, the results of SMAW and MIG welding of the tensile strength of the ASTM 106 Grade B steel region[7], [13], [18]. Figure 3 to 4 is a picture of the tensile test specimen. The tensile test data on the welding group and raw material obtained are then entered into the existing equation. The data can be seen in Table 2.

Table 2. Tensile Testing Results of ASTM 106 Grade B Steel Tube Pipe.

Parameters	Specimen		
	Raw material	**MIG**	**SMAW**
σmax (kgf/mm²)	608,94	296,27	672,03
	677,13	666,02	582,16
	658,71	529,10	637,23
	-	626,79	582,21
	-	585,77	607,22
Avarage	**648,26**	**540,79**	**616,17**
ε (%)	12,17	2,77	13,88
	16,93	8,13	15,02
	14,47	5,49	14,16
	-	13,13	9,30
	-	4,98	11,91
Average	**14,53**	**6,90**	**12,85**

The tensile test results can also be presented with a graph, as shown in Figure 4.

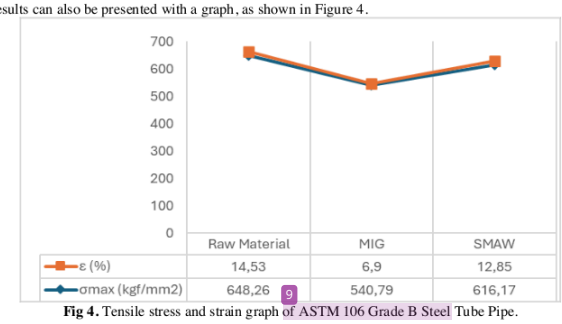

Fig 4. Tensile stress and strain graph of ASTM 106 Grade B Steel Tube Pipe.

The tensile strength value for raw materials is 648,26 kgf/mm² . The tensile strength value for the MIG group is 540,79 kgf/mm², the tensile strength value for the SMAW group is 616,17 kgf/mm² which means a decrease from the raw material group and when compared to MIG welding with SMAW on MIG welding shows a better value [19] .

The elongation for the raw material grouping is 14,53%. The elongation value of the MIG welding group is 6,9%, and the welding group has an elongation of 12,85%. This elongation value is still below the raw material, where the elongation value has decreased by 2,32% in MIG welding and 7,63% in SMAW welding [20].

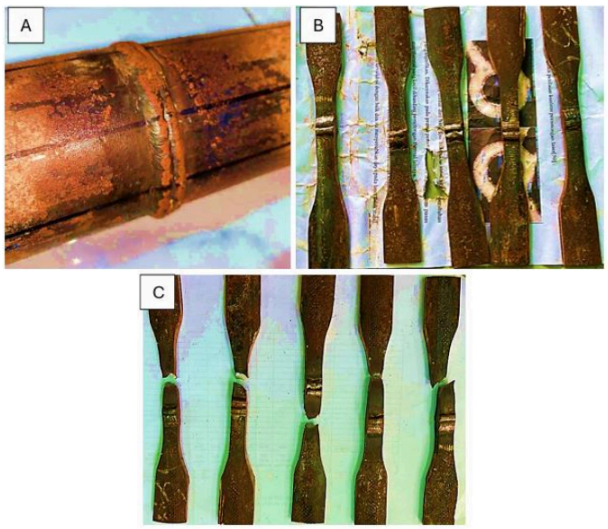

Fig 5. a) welding specimen, b) specimen forming, c) Tensile testing results

4. Conclusion

The conclusions that can be drawn after tensile testing of MIG and SMAW welding joints with a welding current of 140A are as follows:

1. The tensile strength of raw material and weld metal is:
   a. The tensile strength value for the raw material was 648,26 kgf/mm^2.
   b. Tensile strength value for MIG welds of 540,79 kgf/mm^2.
   c. The tensile strength value for SMAW welding is 616,17 kgf/mm^2.
2. The best connection between MIG and SMAW welding is SMAW welding with a tensile strength value of 616,17 kgf/mm^2.

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