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Study of the Effect GMAW and SMAW Welding Combination with WAAM Method

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Abstract

The development of technology and science is multiplying, so it affects the industrial sector in Indonesia, namely the industry that manufactures machine elements, especially in the automotive sector, which commonly uses metal as raw material. The manufacturing sector's production in the automotive industry tends to increase annually. The need for metal as raw material is constantly increasing. The WAAM welding method be utilized as one of the innovations in the industrial world that potentially reduces the use of raw metal materials by replacing them with the results of the WAAM process. In this study, a combination of GMAW and SMAW welding using the WAAM method was carried out by adding material in layers and switching between the two types of welding. The welding process is carried out by varying the current (high, medium, and low). Then, a tensile test was carried out to determine the mechanical properties of the combination results. Based on the tensile test results, it is known that the high current variation gives the best results, the increasing current lead to an enhancement of the mechanical properties. Finally, using high currents will give the best result for application in the engineering and automotive sector.

Keywords: GMAW, SMAW, WAAM, Manufacturing

Abstrak

Perkembangan teknologi dan ilmu pengetahuan yang semakin pesat, sehingga mempengaruhi sektor industri di Indonesia, yaitu industri yang memproduksi elemen-elemen mesin, khususnya pada sektor otomotif yang umumnya menggunakan bahan baku logam. Produksi sektor manufaktur pada industri otomotif cenderung meningkat setiap tahunnya. Kebutuhan logam sebagai bahan baku terus meningkat. Metode pengelasan WAAM dimanfaatkan sebagai salah satu inovasi dalam dunia industri yang berpotensi mengurangi penggunaan bahan baku logam dengan cara menggantinya dengan hasil proses WAAM. Pada penelitian ini dilakukan kombinasi pengelasan GMAW dan SMAW dengan metode WAAM dengan menambahkan material secara berlapis dan berganti-ganti antara kedua jenis pengelasan tersebut. Proses pengelasan dilakukan dengan memvariasikan arus (tinggi, sedang, dan rendah). Kemudian dilakukan uji tarik untuk mengetahui sifat mekanik dari hasil kombinasi tersebut. Berdasarkan hasil uji tarik, diketahui bahwa variasi arus tinggi memberikan hasil terbaik, peningkatan arus menyebabkan peningkatan sifat mekanik. Akhirnya, dengan menggunakan arus tinggi akan memberikan hasil yang terbaik untuk diaplikasikan pada bidang teknik dan otomotif.

Kata Kunci: GMAW, SMAW, WAAM, Manufaktur

1. Introduction

Welding joins two metals by melting some parent and filler metals with or without pressure to produce a continuous connection (Bakhori, 2017). There are two commonly used welding processes, namely GMAW SMAW and GMAW welding is a welding process using a wire roll, and an electric motor regulates its movement. This connection process uses a heat source from electrical energy converted into heat energy. (Ketaren, 2019). GMAW welding has advantages and disadvantages. Some advantages of this welding process are that it has good weld results (weld strength), does not produce slag, and is very efficient for fast processing. However, this welding has a high price.
In addition to GMAW welding, Shield Metal Arc Welding (SMAW) welding is also commonly used. SMAW welding is welding with an electric arc as a heat source to melt the parent metal. An electric arc is formed between the shielded electrode and the base metal (Azwinur, 2019). SMAW welding has advantages and disadvantages. SMAW's advantages are that it can be used anywhere, welding various materials, electrodes are readily available with various sizes, simple equipment, and welding. In comparison, the disadvantages of SMAW welding are that the welding is limited only as long as the electrode is used. When connecting the welding, remove the slag from the previous welding.
Of the two weldments that have different mechanical strengths, according to research conducted by (Winardi, 2020), the tensile test results of SMAW welding with E7018 electrodes amounted to 419 MPa. Moreover, according to research by (Bayu, 2016), the tensile test results of GMAW welding amounted to 479.3 MPa. So that in this study will combine GMAW - SMAW welding using the Wire Arc Additive Manufacturing (WAAM) method to obtain better tensile strength results.
The WAAM method is an arc welding method considered one of the 3D printing technologies. The WAAM process is carried out by depositing electrodes layer by layer using an electric arc as an energy source (Israr, 2018). WAAM produces a deposit in the form of layers from the weld bead, resulting in a metal wall with a minimum width of 1 - 2 mm. WAAM can produce high deposition rates of 1 - 4 kg/hour (Ding, 2015). With deposition, tensile testing can be carried out on the welding results without being influenced by the base metal.

2. Methods

2.1. Welding Process
The welding process in this study uses three variations of current, as follows:

Table 1: Welding Current Variation

Current Variation	GMAW	SMAW
A	120A	90A
B	140A	100A
C	160A	110A

There are several welding steps in this research, first welding the first layer on the substrate metal using GMAW, second cleaning the GMAW welding results using a steel brush, and third welding the second layer using SMAW. The welding process is carried out in a stacked and alternating manner until the dimensions are 230 mm, 15 mm wide, and 100mm high. The following is a schematic drawing of the WAAM combination of GMAW - SMAW and a sample of the welding results:

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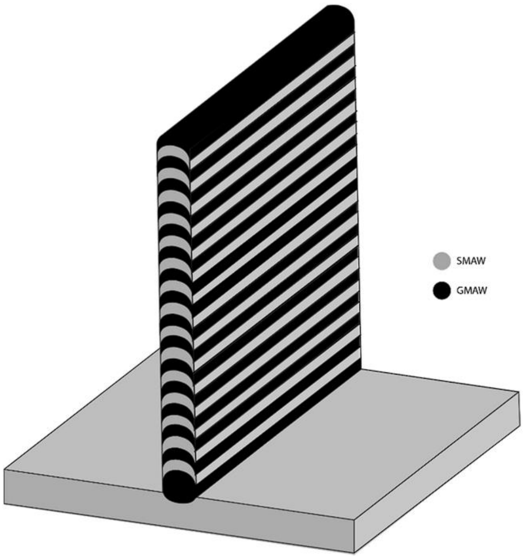

Figure 1: GMAW-SMAW Welding Layer Scheme with the WAAM Method

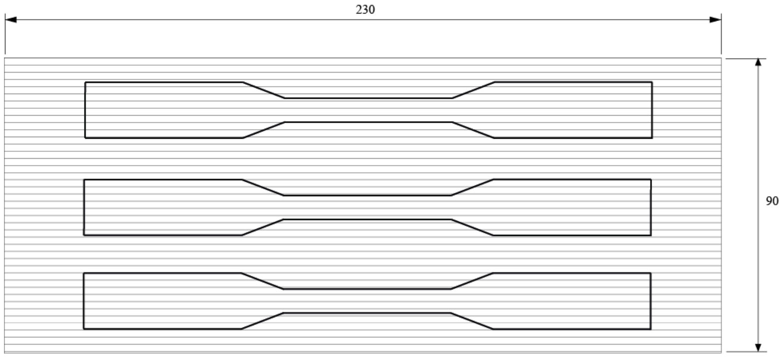

Figure 2: Schematic of GMAW-SMAW Tensile Test Samples with WAAM Method

Figure 3: GMAW-SMAW Weld Metal with WAAM Method

2.2. Preparation of Tensile Testing

The WAAM results were then cut according to ASTM E8 standards with dimensions, as shown in Figure 3. The test samples for each variation amounted to 4, so the total number of tensile test samples was 12. The following is a picture of the dimensions and tensile testing samples after being cut.

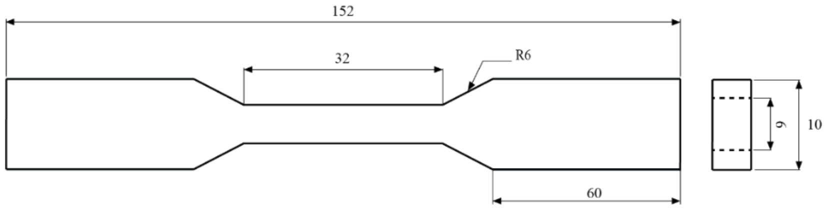

Figure 4: ASTM E8 Standard Tensile Test Sample Size Dimensions

Figure 5: Tensile Test Samples

3. Result and Discussion

3.1. Analysis Of Tensile Strength Results

The experiment results shown that the tensile strength increase correspondingly with increase in welding current. The highest tensile strength was 537.7 MPa in the GMAW 160 A and SMAW 110 A variations. The increase in welding current can be a strong factor affecting the increase in tensile strength. As in research conducted by (Syahrani, 2013) which examines the effect of variations in welding current on tensile strength using the SMAW process where the results of his research show that with increasing current strength given it will increase the tensile strength. The reason for these results is that a low current can cause an unstable welding arc, which may be less effective. This can result in less deep penetration and insufficient heat input to melt the electrode, leading to low tensile strength.

Table 2: Tensile Strength of Welding Products

Sample Name	Welding Current(A)	Tensile Strength (MPa)	Deviation Standard
A	GMAW 120A – SMAW 90 A	488,184	14,239
B	GMAW 140A – SMAW 100 A	498,445	14,670
C	GMAW 160A – SMAW 110 A	537,708	12,216

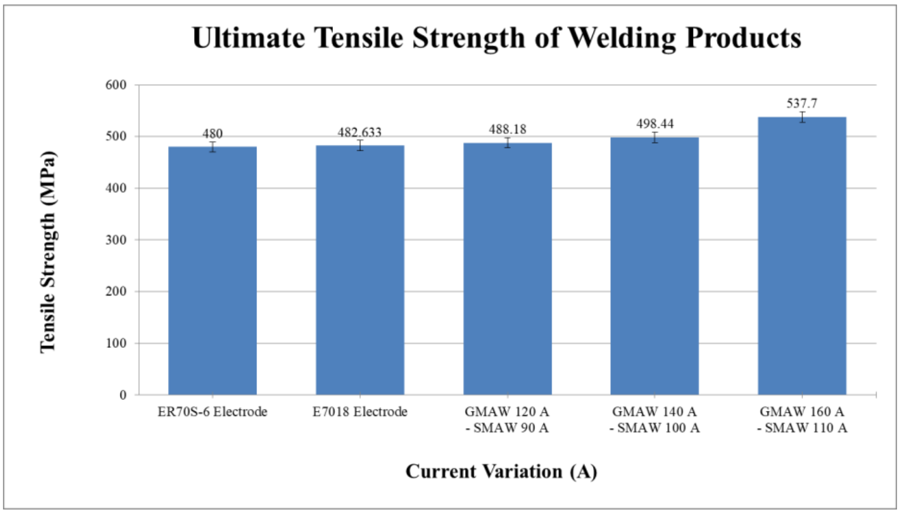

Figure 6: Tensile Strength Graph of The Welding Products, ER70S-6 and E7018 Electrodes

Figure 6 illustrates that the yield strength increases as the welding current used increases. The variations of GMAW 160 A and SMAW 110 A produced the highest yield strength of 433.86 MPa. According to (Wibawa, 2019). Yield strength is the strength of the material to withstand the load before experiencing plastic deformation. This means that when the load is still below the yield strength, the material can return to its original shape. Yield strength is important to know as an early indication of material failure.

Table 3: Yield Strength of Welding Products

Sample name	Welding Current (A)	Yield Strength (MPa)	Deviation Standard
A	GMAW 120A – SMAW 90 A	405,77	25,44
B	GMAW 140A – SMAW 100 A	416,326	21,422
C	GMAW 160A – SMAW 110 A	433,86	18,472

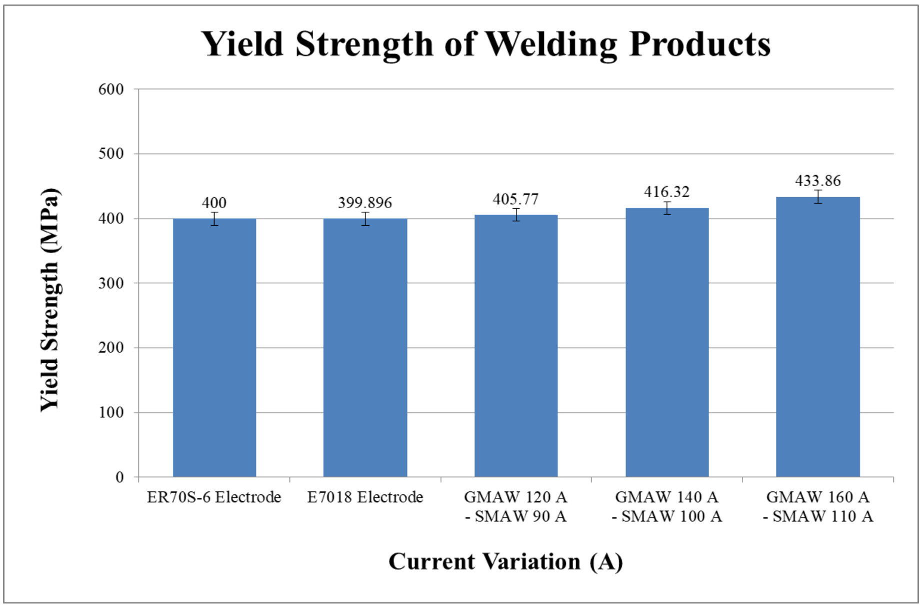

Figure 7: Yield Strength Graph of Welding Products, ER70S-6 and E7018 Electrodes

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The rise in tensile strength observed in this study is attributed to the synergistic effect of using GMAW and SMAW welding techniques alongside an increase in the current applied. This study uses 2 types of electrodes that affect the tensile strength. The ER70S-6 electrode used in GMAW welding has a tensile strength of 480 MPa, while the E7018 electrode used in SMAW welding has a higher tensile strength of 482.633 MPa (AWS A5.1). It can be observed that the combination of GMAW and SMAW welding techniques has led to an increase in the tensile strength compared to the standard strength of each electrode.

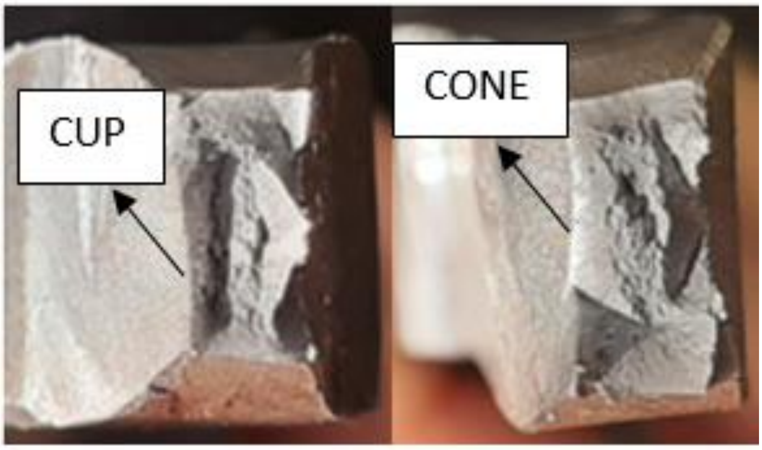

Figure 8: Fracture shape of Tensile Specimen

The fracture shape formed in this study is a ductile fracture pattern, ductile fracture is a fracture that undergoes plastic deformation before failure which can be characterized by the formation of cup and cone in the tensile test specimen. Cup and cone fault patterns generally occur in metals that experience necking. According to (Callister, 2014), the cup and cone fault process begins with the appearance of microvoids during necking. Then as the deformation continues, the microvoids will spread and enlarge and then join to form cracks whose long axis is perpendicular to the stress. Then the crack will propagate and break in the necking area. The center of this type of fracture is irregular and fibrous, indicating plastic deformation (Callister, 2018).

4. Conclusion

Welding current can affect the tensile strength. Increasing the applied current will result in a higher tensile strength. In this study, the tensile strength obtained was higher than the tensile strength of each electrode used. The highest tensile strength is in the GMAW 160 A - SMAW 110 A current variation, which is 537.708 MPa. Additionally, the welding current can affect the microstructure as well. The higher the current used will have an increasing number of ferrite phases, and form a larger grain size.

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References

AWS, (2001), “Welding Handbook Ninth Edition, Volume 2 Welding Provesses arc and Gas Welding and Cutting, Brazing, and Soldering”, Florida: American Welding Society.

Azwinur, A. and Muhazir, M., 2019. Pengaruh jenis elektroda pengelasan SMAW terhadap sifat mekanik material SS400. Jurnal Polimesin, 17(1), pp.19-25.

Bakhori, A. (2017). Perbaikan Metode Pengelasan SMAW (Shield Metal Arc Welding) Pada Industri Kecil di Kota Medan. Buletin Utama Teknik, 13(1), 14-20.

Bayu Kartiko Aji dan Wijoyo, 2016. Pengaruh Kuat Arus Listrik Terhadap Ketangguhan Impak Dan Kekuatan Tarik Sambungan Las MIG Baja Karbon Tinggi, Mechatronic AT-AUB Surakarta.

Callister Jr, W.D. dan Rethwisch, D.G. (2018), Materials Science and Engineering - An Introduction 10th Edition, John Wiley & Sons, Inc., United States of America.

Callister Jr., William D. (2014), "Materials Science and Engineering: Ninth Edition" New York: John Wiley & Sons Inc.

Ding, D., Pan, Z., Cuiuri, D. dan Li, H. (2015), "Wire-feed additive manufacturing of metal components: technologies, developments and future interests", International Journal of Advanced Manufacturing Technology, Vol. 81 No. 1– 4, hal. 465–481.

Israr, R., Buhl, J., Elze, L. and Bambach, M., 2018. Simulation of different path strategies for wire-arc additive manufacturing with Lagrangian finite element methods. In LS-DYna Forum.

Ketaren, L.P., Budiarto, U. and Santosa, A.W.B., 2019. Analisa pengaruh variasi kampuh las dan arus listrik terhadap kekuatan tarik dan struktur mikro sambungan las GMAW (gas metal arc welding) pada aluminium 6061. Jurnal Teknik Perkapalan, 7(4).

Syahrani, A., Sam, A. And Chairulnas, C. (2013), "Variasi Arus Terhadap Kekuatan Tarik Dan Bending Pada Hasil Pengelasan Sm490". Jurnal Mekanikal, 4(2).

Wibawa, L. A. N., & Diharjo, K. (2019). Desain, Pemilihan Material, dan Faktor Keamanan Stasiun Pengisian Gawai Menggunakan Metode Elemen Hingga. *Jurnal Teknologi*, *11*(2), 97-102.

Winardi, Y., Fadelan, F., Munaji, M. and Krisdiantoro, W.N., 2020. Pengaruh elektroda pengelasan pada Baja AISI 1045 dan SS 202 terhadap struktur mikro dan kekuatan tarik. Jurnal Pendidikan Teknik Mesin Undiksha, 8(2), pp.86-93.