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ANALYSIS OF THE EFFECT OF CURRENT AND COOLING MEDIA IN TUNGSTEN INERT GAS (TIG) WELDING ON MECHANICAL STRENGTH AND MICRO STRUCTURE OF AISI 1045 STEEL FOR TRUSS FRAME MOTORCYCLE FRAME CONNECTIONS

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Abstract
Currently, metal joining techniques in the field of welding have developed rapidly. In constructions that use metal raw materials, most of the joints are made by welding. Apart from joining, the welding process can also be used for repairs, for example to fill holes in castings, make coatings on tools, thicken worn parts and other repairs. Welding is also widely used for building construction, bridges, piping and automotive. As we know, there are many types of welding used today. One of them is Gas Tungsten Arc Welding (GTAW) or commonly called Tungsten Inert Gas (TIG).
AISI 1045 steel is referred to as carbon steel because it complies with international coding, namely the 10xx series based on the nomenclature issued by AISI and SAE (Society of Automotive Engineers). The first number 10 is the code that indicates plain carbon, then the code xxx after the number 10 indicates the carbon composition. So AISI 1045 steel means carbon steel or plain carbon steel which has a carbon composition of 0.45%. Steel of this specification is widely used as a component of gears, shafts and bearings. According to its function, it must be able to withstand wear and tear due to friction with the chain. Wear resistance is defined as resistance to abrasion or resistance to dimension reduction due to friction
Keywords: GTAW, AISI 1045, 0.45% carbon

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Introduction

Welding (welding) is a metal joining technique by melting some of the base metal and filler metal with or without pressure and with or without additional metal and produces a continuous connection. This study uses aisi 1045 steel as the material tested, the welding used is Tungsten inert gas (TIG) welding, using cooling media, and various methods of using different currents.
The users of welding techniques in construction are very broad, including: shipping, bridges, steel frames, pressure vessels, penstocks, pipelines, rail vehicles and so on. Apart from manufacturing, the welding process can also be used for repairs, for example to fill holes in castings, hard coatings on tools, thickening of worn parts and other kinds of repairs.
Welding using electric arc welding is divided into 2 categories based on the use of the type of electrode, namely consumable electrode and non-consumable electrode. where the electrode does not burn, the filler uses another material that is melted together with the melting process of the parent metal. Types of welding in the consumable electrode category include Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW/MIG), Submerged Arc Welding (SAW) and Flux Core Arc Welding (FCAW). Meanwhile, one example of Non Consumable Electrode welding is Gas Tungsten Arc Welding (GTAW/TIG).

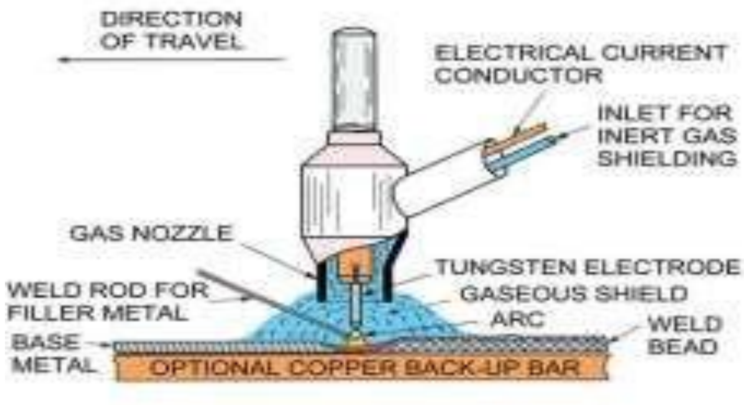
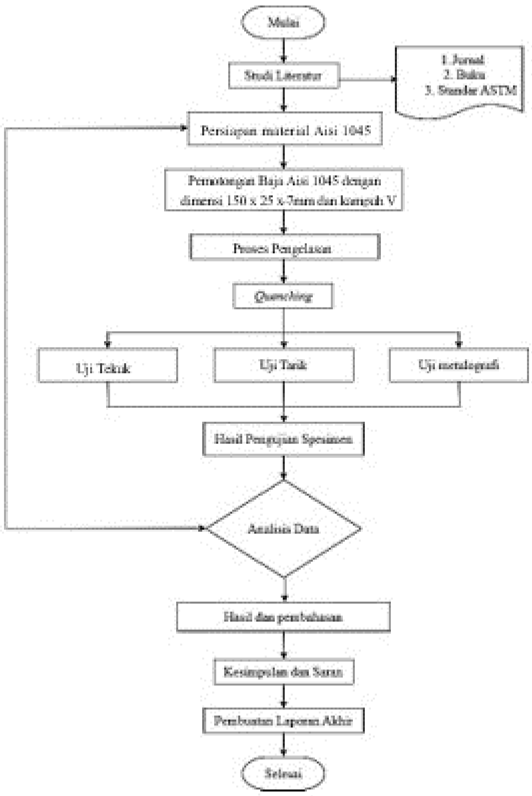


Figure 1. Gas Tungsten Arc Welding

Welding current and stress also affect the hardness value and microstructure of the test specimen. High welding speeds can result in a lack of penetration. The gap distance can also affect the strength of the connection, and result in a smaller heat input received per unit length. This can have the effect of rapid cooling, thus hardening hot areas. This study aims to examine the effect of current and stress on tensile strength, impact strength, hardness and microstructure in welding results with the hope that the use of low carbon steel will become more widespread with consideration that the price is still relatively cheap compared to other types of carbon steel.

Tungsten Dia. (mm)	DCEN AMPER	DCEP AMPER	AC UBW AMPER	AC BW AMPER
1.0	15-80	-	10-60	20-30
1.6	70-150	10-20	50-100	30-80
2,4	150-250	15-30	100-160	60-130
3,2	250-400	25-40	150-210	100-180
4,0	400-500	40-55	200-275	160-240
4,8	500-750	55-80	250-350	190-300
6,0	750-1000	80-125	325-450	325-450

Research Method



Specimen preparation in this research process the basic material used is AISI 1045 plate with a thickness of 7 mm, the shape of the material is shown below

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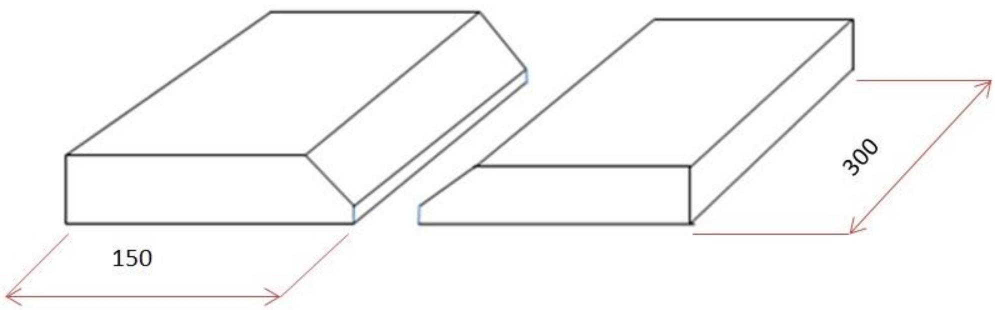


Figure 2. Pictures of pieces of welding connection types

Procedure for joining the specimen After the material is cut, the process of making the weld seam is then followed by joining the SMAW method. The sequence of how the SMAW equipment works is as follows:

- Placement of workpieces that have gone through a surface cleaning process.
- Use safety equipment in the form of gloves, leather jackets and eye protection helmets.
- Inserting the electrode tip into the electrode holder.
- Welding machine current adjustment as needed, then the machine is turned on.
- Hold the electrode holder with one hand and ignite the arc by scraping the tip of the electrode against the workpiece.
- During the welding process, you must always pay attention to the welding metal liquid.

Experimental research was carried out on AISI 1045 STEEL with dimensions of 150 mm x 25 mm x 7 mm with the following WPS (Welding Procedure Standard) welding parameters:
Welder : Nacep (already has WPQ GTAW)
Method : Tungsten Inert Gas (TIG)
Design : Butt join, single v butt join
Material : STEEL AISI 1045
Electrode : ER 70S-6
Gas : Argon Strong current : 140 A
Position : 1G/Falt
Dimensions: 150mm x 25mm x 7mm

Figure 3. Welding Machine Image

Results and Discussion

Tensile Test

Destructive testing to determine the strength of the material using a tensile testing machine

Figure 4. Specimen to be tested for tensile

In the tensile test, the test object is given a continuous one-axis tensile force which increases continuously, while at the same time observing the increase in length experienced by the test object, until the material breaks.

Bending Test

This bending test aims to determine the magnitude of the flexural strength of the test object. The test is carried out by applying a bending load slowly until the specimen reaches its fatigue point. The manufacture of flexure test specimens refers to the ASTM E8 standard for flexure testing as shown below:

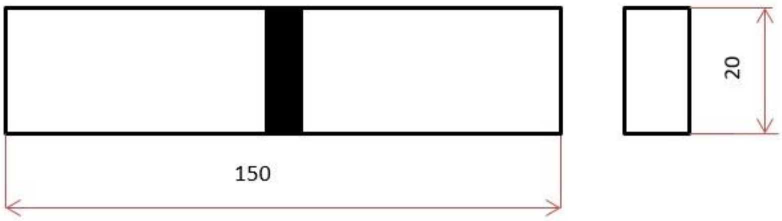


Figure 5. Bending Test Specimens (ASTM E8)

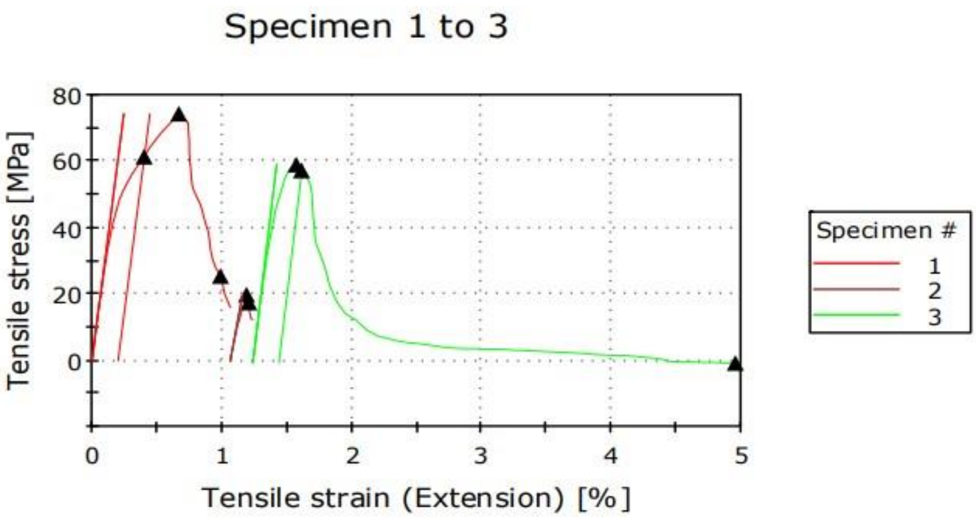
After carrying out tensile, bending and hardness tests, the following data is obtained: Data and Discussion of Tensile Test Results

1.Specimen with Neutral media
In the tensile test the Neutral specimens totaled 3 samples coded TN1, TN2 and TN3. Below is a comparison of the specimens before the tensile test and after the tensile test was carried out on the Neutral samples 1, 2 and 3 specimens

(a) Neutral variation specimen samples before the tensile test and (b) Neutral variation specimen samples after the tensile test.

From Figure 4.6 it can be seen visually that AISI 1045 steel TIG welding results with a Neutral variation in Figure (a) before the tensile test is carried out and Figure (b) after the tensile test is carried out, all the specimens crack or break in the weld metal area. All specimens were neking in the same area. This shows that there are still deficiencies in the manufacture of specimens and the TIG welding process of AISI 1045 steel.

Below is a graph of the test results of the neutral variation tensile test specimens where the red line indicates the first sample, the brown line indicates the second sample and the green line indicates the third sample



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No	Kode Sampe	Max Load (N)	Tensile Strenght (N/mm²)	Yield Strenght (N/mm²)	Elongation (%)	Modulus Young (N/mm²)
1	TN1	7.22	74.21	61.43	0,67	11.073
2	TN2	2.07	20.04	----	0.13	15.739
3	TN3	5.10	58.94	57.16	0.33	17.746
Mean		4,79	51,06	59,29	0,37	14,85

From the three samples of Aisi 1045 steel that were carried out TIG welding with a Neutral quenching variation, the maximum load average value was 4.79 N, the tensile strength was 51.06 N/mm², the strain that occurred was 0.37%, the yield strength of 59.29 N/mm², and Young's modulus of 14.85N/mm².

2. Brine Quenching Specimens

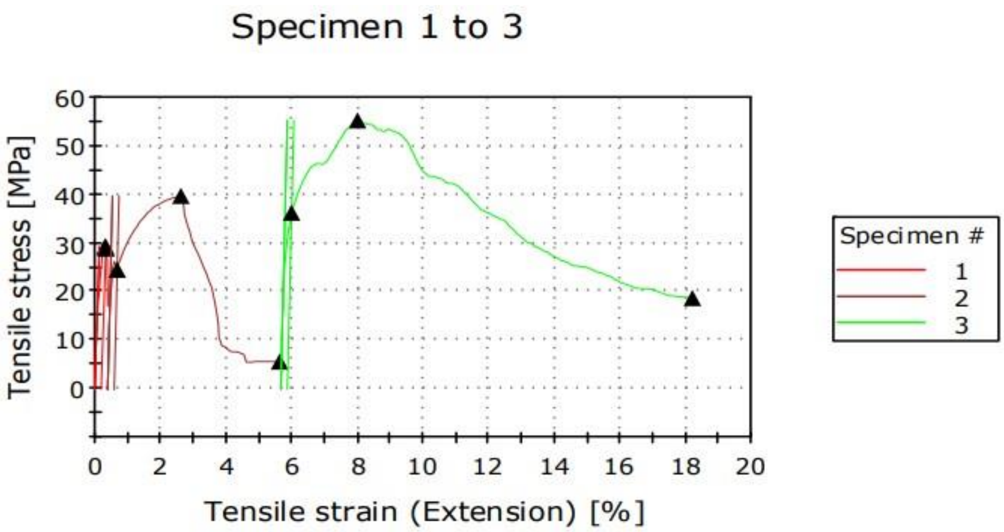
In the tensile test, the salt water quenching specimens totaled 3 samples coded TAG1. TAG2 and TAG3. Below is a comparison of the specimens before the tensile test and after the tensile test was carried out on the quenched salt water specimens samples 1, 2 and 3.

(a) Samples of variation of Brine before tensile test and (b) Samples of variation of Brine after tensile test.

From Figure 4.6 it can be seen visually that AISI 1045 steel TIG welding results with variations in salt water in Figure (a) before the tensile test is carried out and Figure (b) after the tensile test is carried out, all the specimens crack or break in the weld metal area. All specimens were neking in the same area. This shows that there are still deficiencies in the manufacture of specimens and the TIG welding process of AISI 1045 steel.

Below is a graph of the test results of the salt water variation tensile test specimens where the red line indicates the first sample, the brown line indicates the second sample and the green line indicates the third sample.

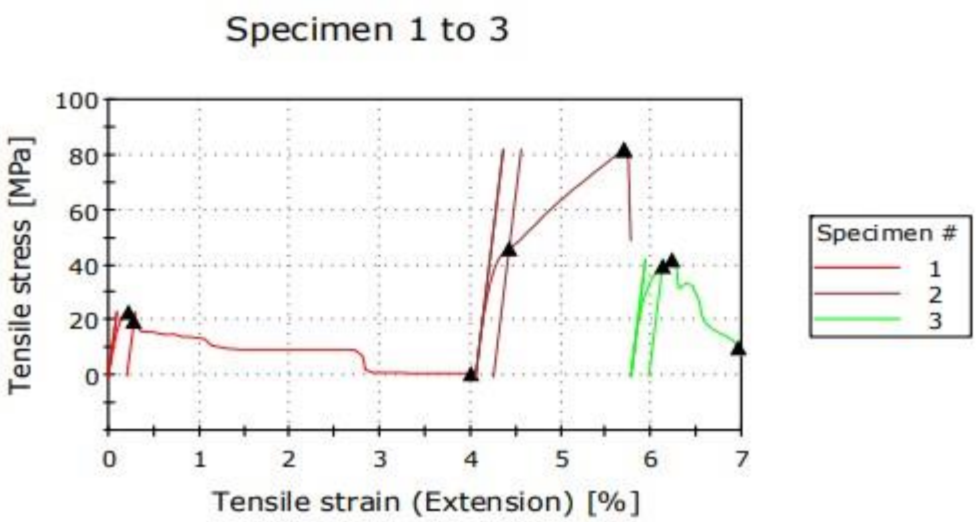
No	Kode Sampe	Max Load (N)	Tensile Strenght (N/mm²)	Yield Strenght (N/mm²)	Elongation (%)	Modulus Young (N/mm²)
1	TAG1	2.92	29.34	28.94	0,33	8.799
2	TAG2	3.80	39.72	24.56	2.30	1.724
3	TAG3	5.39	55.24	36.26	2.42	2.282
Mean		4,03	41,43	29,92	1,68	4,268



From the three samples of Aisi 1045 steel that were carried out TIG welding with salt water quenching variations, the maximum load average value is 4.03 N, the tensile strength is 41.43 N/mm², the strain that occurs is 1.68%, the tensile strength is yield of 29.92 N/mm², and Young's modulus of 4.268 N/mm².

3. Aquadest Water Quenching Specimens
In the tensile test of the Aquadest Water quenching specimens, there were 3 samples coded TAA1. TAA2 and TAA3. Below is a comparison of the specimens before the tensile test was carried out and after the tensile test was carried out on the Aquadest Water quenching specimens samples 1, 2 and 3.

(a) Aquadest Water variation specimen samples before the tensile test and (b) Neutral variation specimen samples after the tensile test.
From Figure 4.6 it can be seen visually that the AISI 1045 steel TIG welding results with the variation of Aquadest Water in Figure (a) before the tensile test is carried out and Figure (b) after the tensile test is carried out, all the specimens crack or break in the weld metal area. All specimens were neking in the same area. This shows that there are still deficiencies in the manufacture of specimens and the TIG welding process of AISI 1045 steel.
Below is a graph of the test results of the tensile test specimens for the Aquadest Water variation where the red line indicates the first sample, the brown line indicates the second sample and the green line indicates the third sample.

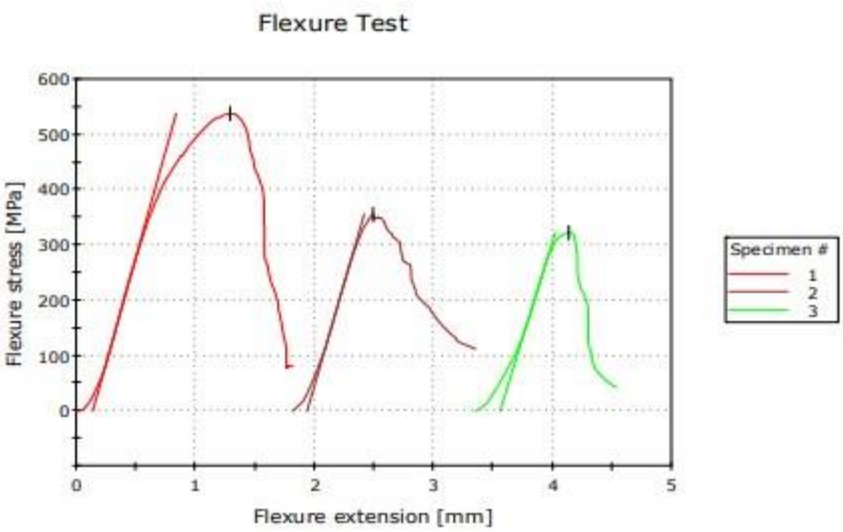


No	Kode Sampe	Max Load (N)	Tensile Strenght (N/mm²)	Yield Strenght (N/mm²)	Elongation (%)	Modulus Young (N/mm²)
1	TAA1	2.43	23.15	19.85	0,22	10.508
2	TAA2	7.61	81.79	46.15	1.66	4.918
3	TAA3	4.23	42.20	39.84	0.45	9.327
Mean		4,75	49,04	35,28	0,77	8,251

From the three samples of Aisi 1045 steel that were carried out TIG welding with the Air Aquqdest quenching variation, the maximum load average value is 4.75 N, the tensile strength is 49.04N/mm², the strain that occurs is 0.77%, the yield strength is of 35.28N/mm², and Young's modulus of 8.251N/mm².

2. Bending test results
Bending tests are performed with the lab's Bend Testing machine. Tensile testing PT. GUNA SUCCESS CORE, based on standard dimensions, bending tests were carried out to see the material's ability to bend 180°.

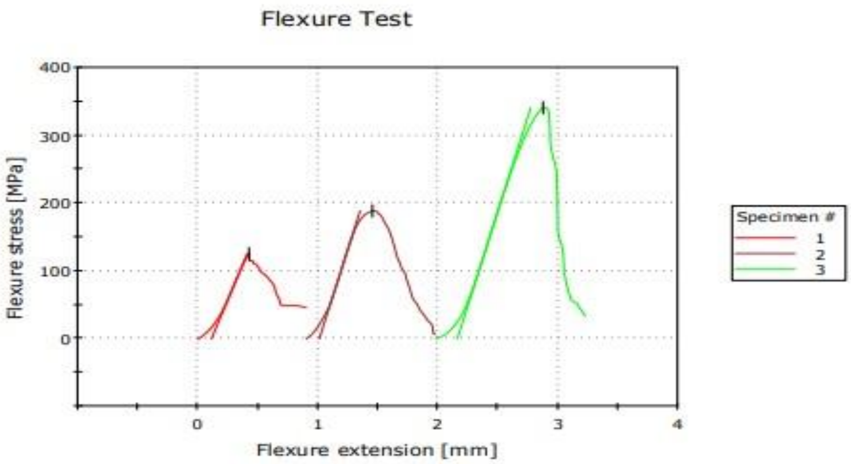
1. Bend test specimen with neutral cooling medium



No	Kode Sampe	Max Load (N)	Max flexure stress (Mpa)	Flexure strain (Extension) (mm)	Modulus of elasticity E (Gpa²)
1	BN1	12852.76	537.51	35.75	0.5375
2	BN2	7615.33	355.43	37.51	0.3554
3	BN3	7067.73	323.00	37.24	0.3230
Mean		9178.61	405.31	36.83	0.4053

From the three samples of Aisi 1045 steel that were carried out TIG welding with a Neutral quenching variation, the maximum load average value was 9178.61 N, the maximum bending stress was 405.31 Mpa, the flexural strain in extension was 36.83 mm, and the elastic modulus was 0.4053 Gpa².

2. Bending test specimens of brine cooling medium



No	Kode Sampe	Max Load (N)	Max flexure stress (Mpa)	Flexure strain (Extension) (mm)	Modulus of elasticity E (Gpa²)
1	BAG1	3070.36	125.80	35.00	0.1258
2	BAG2	4238.69	188.67	36.99	0.1887
3	BAG3	8221.51	340.85	35.51	0.3409

Mean	5176.85	218.44	35.83	0.2184

From the three samples of Aisi 1045 steel that were carried out TIG welding with variations of Salt Water quenching, the average maximum load value was 5176.85 N, the maximum bending stress was 218.44 Mpa, the flexural strain was 35.83 mm, and the elastic modulus was 0.2184 Gpa².

3. Bending test specimens of aquadest water cooling media

No	Kode Sampe	Max Load (N)	Max flexure stress (Mpa)	Flexure strain (Extension) (mm)	Modulus of elasticity E (Gpa²)
1	TN1	15881.99	686.36	36.23	0.6864
2	TN2	13229.24	55915	35.70	0.5591
3	TN3	3295.03	154.33	37.45	0.1543
Mean		10802.09	466.61	36.46	0.4666

From the three samples of Aisi 1045 steel that were carried out TIG welding with the Air Aquadest quenching variation, the maximum load average value was 10802.09 N, the maximum bending stress was 466.61 Mpa, the bending strain in elongation was 36.46 mm, and the elastic modulus was 0.4666 Gpa².

Conclusion

After carrying out tensile testing and bending testing with 3 samples provided for each variation by looking for the average value, the test results state:
1. In determining the use of quenching media sufficient to produce a significant effect on the values of tensile strength, yield strength, modulus of elasticity and tensile strain. The test specimen with the highest tensile strength value was obtained by using the Neutral variation with a value of 51.06 N/mm², while the lowest tensile strength was obtained by the Salt Water quenching variation with a value of 41.43 N/mm². The highest yield strength was obtained by the Neutral variation with a value of 59.29 N/mm², while the lowest value was obtained by the Salt Water quenching variation with a value of 29.92 N/mm². The highest modulus value was obtained by the Neutral variation with a value of 14.85 N/mm², while the lowest value was obtained by the Salt Water quenching variation with a value of 4.268 N/mm². And the highest tensile strain was obtained by the Salt Water quenching variation with a value of 1.68%, while the lowest value was obtained by the Neutral variation with a value of 0.37%.
2. Determination in the use of quenching media produces a slightly different effect on the value produced in the TIG welding material buckling test AISI 1045 steel produces a significant effect on bending stress, bending strain and modulus of elasticity. While the highest average bending stress value was produced by using the Aquadest Water quenching variation with a value of 466.61 MPa, while the lowest average bending stress value was produced by using the salt water quenching variation with a value of 218.44 MPa. The highest bending strain value is produced by the use of a neutral variation with a value of 35.83 mm. Meanwhile, the lowest bending strain was produced by using the Salt Water variation with a value of 35.83 mm. on the results of the highest elastic modulus value produced by the use of variations of Aquadest Water with an average value of 0.4666 Gpa2 . While the lowest average value of the elastic modulus is produced by the use of salt water variations with a value of 0.2184 Gpa2.

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