Inspection of Smaw Position 3G Material ST 37 Welding Results using the Penetrant Test (Pt) And Magnetic Test (Mt) Of Students At Subang State Polytechnic

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ABSTRACT

This study intended to get a clear picture of the readiness of students to take welding certification for the competency test scheme "Welding SMAW 3G". Five students in semester 4 of the POLSUB machine maintenance study program randomly selected to do the ST 37 material welding with the 3G position for butt weld and inspected using the Non-Destructive Test (NDT) Penetrant Test (PT) and Magnetic Test (PT) methods to get a prediction of student passing rates in the certification process. The results show that Specimens 1, 3, and 4 for PT testing are rejected and the MT test results are rejected where the length of the undercut defect is> 100 mm and the standard is only <50 mm. Specimens 2 and 5 are declared to have passed the PT and MT test because the defects in the specimens are still included in the standard where the undercut or indication of defects that occurs is still below <50 mm.

Keywords

SMAW Welding, Penetrant Test, Magnetic Test, NDT Test

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Introduction

Entering the Southeast Asian free market (MEA), the Indonesian people have demanded to prepare themselves as soon as possible not to be eroded in competition with other Southeast Asian countries. One of the important things to be prepared for is reliable Human Resources (HR), which means that they are ready with soft skills and hard skills. Specifically, for hard skills, the measure of the competence of the related human resources for a certain competency scheme is a competency certificate issued by BNSP through a Professional Certification Agency which is widespread throughout Indonesia. Acording to (E. Adhan, Nugraha, A and Baharta. R, 2018) Polytechnic is a place for students to get competencies in accordance with global standards. In order to prepare students to be certified so that their level of competence can be measured before facing the certification process, special provision is needed, so that if it turns out that the student is still not competent, the person concerned still has enough time to pursue competencies that have not been mastered. Several inspection methods to determine whether a welder is accepted or not include:1. Destructive Test (DT) 2. Non-Destructive Test (NDT) 3. Visual Inspection. All three are carried out on the welding results of students who will be certified, which for semester 4 SMAW welding, the test piece is a plate that is welded with a blunt connection (butt weld). NDT examinations can be in the form of a Magnetic test and a Penetrant Test.

Penelitian ini dimaksudkan untuk menginspeksi dengan metode NDT untuk menentukan seberapa jauh kesiapan mahasiswa prodi Pemeliharaan Mesin. This research is intended to inspect with the NDT method to determine the readiness of the Mechanical Maintenance study program students. The readiness indicator is the percentage of SMAW welding results for the 3G welding position that can be accepted based on the results of the NDT inspection with the Penetrant Test and Magnetic Particle Test methods. In this study, 5 students of the 4th semester of the Machine Maintenance study program were randomly selected for and asked to weld 1 test piece each for the 3G position butt weld. Furthermore, the NDT test was carried out with the Penetrant Test and Magnetic Test. Students who are declared competent if they can pass the NDT for the four test pieces prepared. Given the many types of non-destructive welding inspections (NDT inspection), in this study, the NDT inspection method is limited to NDT inspections with the Penetrant Test and Magnetic Test. The welding being tested is also limited to the SMAW welding process for welding the horizontal position plate (3G Position).

Literature Review

SMAW Welding

SMAW welding (Shielded Metal Arc Welding) welding electrode covered electric arc or better known as electric welding is the process of welding the main metal which experiences a melting effect of heating data from the electric busses that arise between the ends of the electrodes and the surface of the workpiece (Sonawan & Suratman, 2003). The electric arc is generated from a welding machine. The electrode used is a wire wrapped in flux as a protector which is sometimes called a welding wire. During welding, the electrode or welding wire will experience melting together with the main object which is part of the weld seam. As a result of this meeting, the weld seam will be filled with liquid metal coming from the electrode of the parent metal. The electric arc in addition to melting the welding wire which later freezes into metal also melts the flux. The flux is above the weld metal because the flux density is smaller than the weld metal when liquid. Then the liquid flux will become the slag that covers the weld metal after freezing. The liquid flux also protects the weld pool during melting and the weld metal is protected by the slag during freezing. Welding surfaces covered with slag must be removed using a hammer or grinder. To be able to weld with the SMAW process, equipment such as welding machines, electrode cables, and electrode holders, main metal cables, and parent metal holders are needed. Personal protective equipment during the SMAW welding process includes welding masks, gloves, and protective coats (Sonawan & Suratman, 2003).

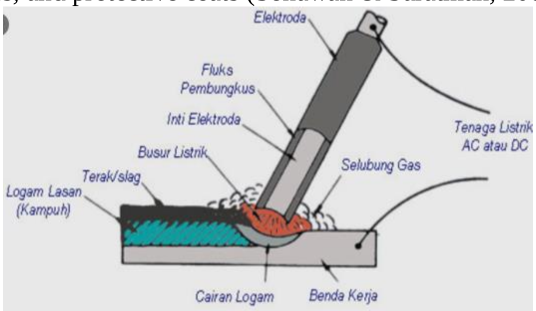

Figure 1. SMAW Welding Process
(Sonawan & Suratman, 2003).

Types of joints and welding positions

There are five basic types of joints in welding. The five types of joints include: butt joints, lap joints, T-joints, edge joints and corner joints. An illustration of the types of weld joints can be seen in Figure

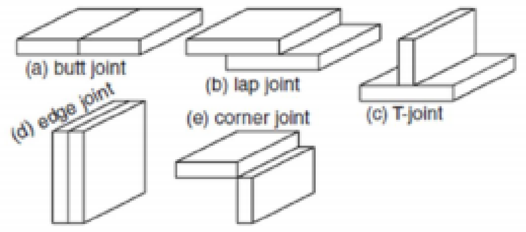

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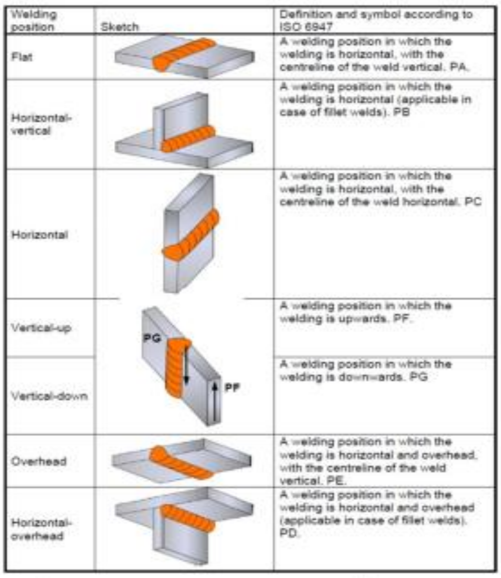
Figure 2. Basic Connection Types
(CSWIP 3.1, 2019)



Welding position	Sketch	Definition and symbol according to ISO 6947
Flat		A welding position in which the welding is horizontal, with the centreline of the weld vertical. PA.
Horizontal-vertical		A welding position in which the welding is horizontal (applicable in case of fillet welds). PB
Horizontal		A welding position in which the welding is horizontal, with the centreline of the weld horizontal. PC
Vertical-up	PG	A welding position in which the welding is upwards. PF.
Vertical-down	PF	A welding position in which the welding is downwards. PG
Overhead		A welding position in which the welding is horizontal and overhead, with the centreline of the weld vertical. PE.
Horizontal-overhead		A welding position in which the welding is horizontal and overhead (applicable in case of fillet welds). PD.

Figure 3. Welding Position
(CSWIP 3.1, 2019)

The butt joint is a connection where the two workpieces are in the same plane and connected at the ends of the two workpieces which are close to each other. A lap joint is a connection consisting of two workpieces that overlap each other. A T-joint is a connection where one workpiece is perpendicular to the other so that it forms the letter "T". The edge joint is a connection in which the two workpieces are parallel to each other provided that one end of the two workpieces is at the same level. A corner joint is a connection where the two workpieces form an angle so that they can be joined at the corner of the corner. The welding position according to the BS EN ISO 6947 standard consists of PA, PC, PF, PG, PE for butt-weld and PB, PD for fillet welding. The various welding positions can be seen in Figure 3.

Non Destructive Test (NDT)

Non Destructive Testing is testing carried out on non-destructive metals. To check the results of welds, some typical NDT inspections are:
- Penetrant testing (PT)
- Magnetic Testing (MT)
- Ultrasonic Testing (UT)
- Radiographic Testing (RT)

Generally, the top two tests are combined with the last two tests for optimal results. Liquid penetrant inspection has many advantages for checking weld results. NDT checks should be conducted to ensure initial and continuing performance. The penetrant test is a method of checking welds that is quite versatile in terms of the type and process of welding to check various applications, types, and welding positions without the need for complicated expertise and inexpensive prices (Siegel, 2004). The disadvantage is that it cannot detect defects trapped in the welding result. The ultrasonic test method is used to detect defects below the surface of the weld. This inspection requires special expertise from the operator to get optimal results and the price is quite expensive.

Penetran Test (PT)

The Liquid Penetrant Test method is the simplest NDT method. This method is used to find defects in exposed surfaces of solid components, both metal and non-metallic, such as ceramics and fiber plastics. Through this method, defects in the material will be seen more clearly.

The principle of penetrant test

This method is carried out with several testing stages, namely:

- Clean the surface of the object to be tested. This cleaning process is useful for removing dirt, dust and grease that stick to the surface of the object so that defects on the surface are not covered by dirt. This cleaning is done by spraying a penetrant cleaner on the surface of the object and then cleaning it with a cloth until the surface of the object is completely clean.
- After the surface of the object is clean, then the surface is sprayed with a liquid penetrant until it is flat on the surface, then it is left for 10 minutes (dwell time). The purpose of this dwell time is to give the penetrant the opportunity to enter the defective surface. The penetrant

used must have a good capillary force so that the penetrant can enter the defective surface. This penetrant must have a bright color so that it can be seen clearly when there is a defect on the surface when sprayed with the developer. Generally penetrant uses is red.

Figure 4. Penetrant Fluid
(Personal Documentation)

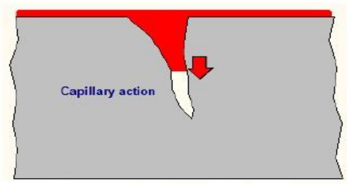


Figure 5. Penetrant capillary process
(http://Simula.com/ndtpt)

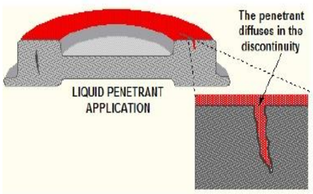


Figure 6. Liquid penetrant on defects
(http://Simula.com/ndtpt)

a. After 10 minutes, the surface of the object is cleaned using a cloth dampened with a cleaner penetrant and cleaned in the same direction.

b. Spray the developer penetrant that has previously been shaken on the surface of the object evenly, wait a few minutes, if the surface of the object has a defect, penetrant liquid spots will appear on the surface of the object. The nature of this developer is to pull back the penetrant left in the defect hole which is used as a sign of defects in the object.

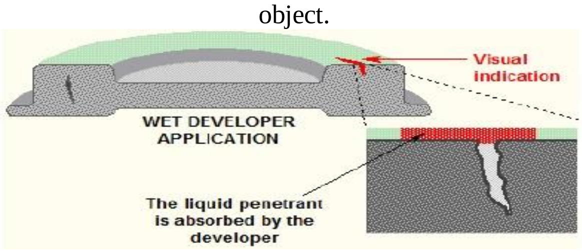


Figure 7. Surface defect detection
(http://Simula.com/ndtpt)

c. Mark the part of the object that has defects then clean the surface by spraying a cleaner penetrant and wiping it with a cloth until it is clean.

Magnetic Test (UT)

Magnetic Test is the process of attracting particles to magnetic materials due to discontinuities so that they will form outlines. In places where the magnetic field leaks leave the object area, iron particles will be attracted to the area and this is an indication of discontinuity in the area as shown in Figure 2.1. Magnetic field leaks are actually lines of magnetic force that leave the magnetic part and flow through the air from one pole to the other opposite. The basic idea of particle magnetic testing is to identify discontinuities in

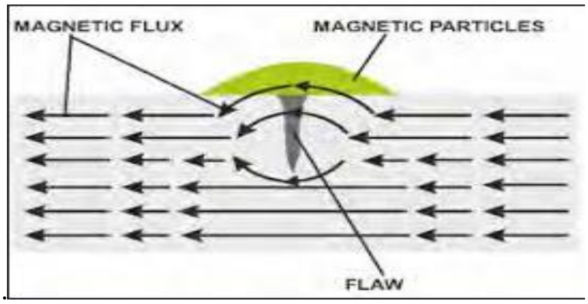


Figure 8. The concept of a simple Magnetic Test

Testing ofMagnetic Particle Inspection (MPI)

Testing of *Magnetic Particle Inspection* (MPI) is non-destructive testing (NDT) to detect discontinuities that are usually linear and located at / near with the component surface and ferromagnetic structure, MPI based on magnetic laws is therefore limited to only materials that can support the flux lines. Metals can be classified as ferromagnetic, paramagnetic and diamagnetic, where:

a. Ferromagnetic is a metal that is strongly attracted to a magnet and is easily magnetized. For example iron, nickel and cobalt.

b. Paramagnetics such as austenic stainless steel are weakly attracted by magnetic fields and cannot be magnetized.

c. Diamagnetic is a metal that is slightly repelled by a magnet and cannot be magnetized. For example bismuth, gold and antimony. (Smilie, R.W. (2000).

Implementation method

The research method was carried out experimentally in which the 4th-semester students of the Machine Maintenance study program as the object of their research were asked to do direct welding and the results were inspected using the Penetrant Test (PT) and Magnetic Test (PT) methods. In this study, using ST 37 material was then carried out the SMAW welding process in the 3G butt joint position on the plate material with a size of 30 cm x 15 cm x 1.2 cm which was leveled 300 for each specimen. The welding process uses a Lorch machine with a rooting electrode of LB 52U with a diameter of 2.6 mm using a current of 70 - 90 Amper and a voltage of 380 volts, while the filler uses a 3.2 mm diameter LB 5218 electrodes with a current of 80-100 Amper and a voltage of 380 volts.

RESULTS AND DISCUSSION

The Penetrant Test (PT) test results are seen in the image.

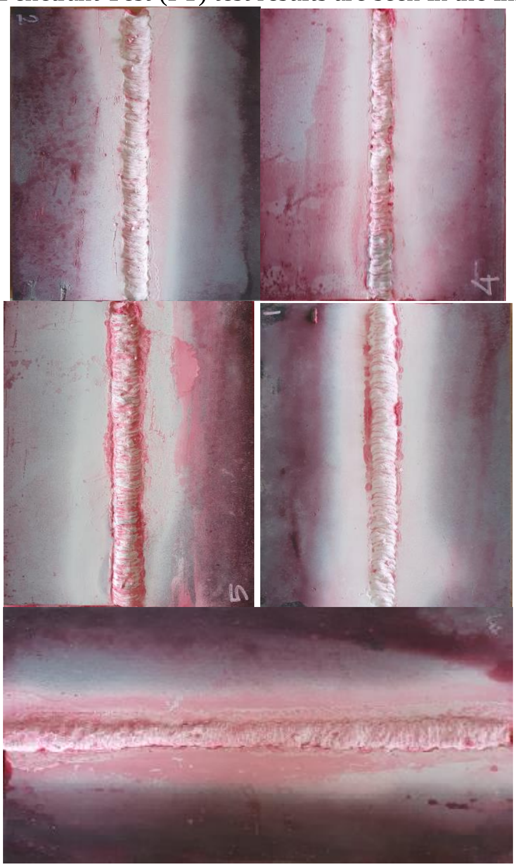
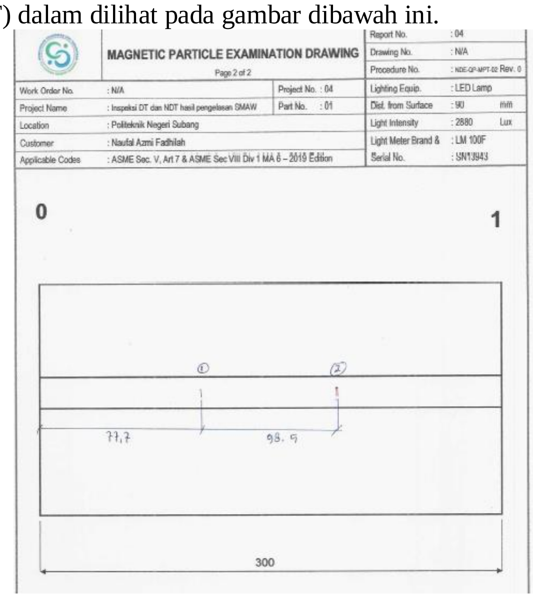


Figure 9. Resulst of Penetran Test

Tabel 1. Testing Result of PT

No	Size(mm)	Standard	Indication	Info.
1.	d=3mm	d=2 mm	Spatter	Reject
	l=176 mm, D= 1,7 mm	l=<50 mm, max D = 1 mm	Undercut	
	2 mm	H=2mm	Excess weld metal	
2.	l=45 mm, D= 0,7 mm	l=<50 mm, max D = 1 mm	Undercut	Accept
	d=2mm	d=2 mm	Spatter	
3.	15 mm	15 mm	Miss Alignment	Reject
	l=45 mm, D= 1,7 mm	l=<50 mm, max D = 1 mm	Undercut	
4.	l=125 mm, D= 1,9 mm	l=<50 mm, max D = 1 mm	Undercut	Reject
	d=3	d=2 mm	Spatter	
5.	Individu=1,0 mm cluster 40 mm²	Individu=1,5 mm cluster 50 mm²	Porosity	Accept
	l=45 mm, D= 1,7 mm	l=<50 mm, max D = 1 mm	Undercut	
	d=1,5	d=2 mm	Spatter	

Based on table 1 above, according to the CWSIP 3.1 Acceptance Levels Plate and Pipe standard of the 5 specimens that were tested for the Penetran Test (PT), there were 3 specimens that were declared Rejected because the average undercut exceeds the total number of undercut lengths <50 mm and the diameter of the Spatter exceeds 2 mm. Specimens that were declared passed or Accepted were 2 specimens whose average defect was included in the approved standards, namely Undercut not exceeding 1 <50 mm, Spatter diameter d = 2 mm and Individual Porosity not exceeding 1.5 mm.Adapun hasil pengujian Magnetik Test (MT) dalam dilihat pada gambar dibawah ini.



Figurre 10. specimen test ofMT 1

From the figure above it can be an indication that the length of defects that occur in rice in Specimen 1 is less than 176.2 mm when added. If the defect indicates an undercut then specimen 1 is declared

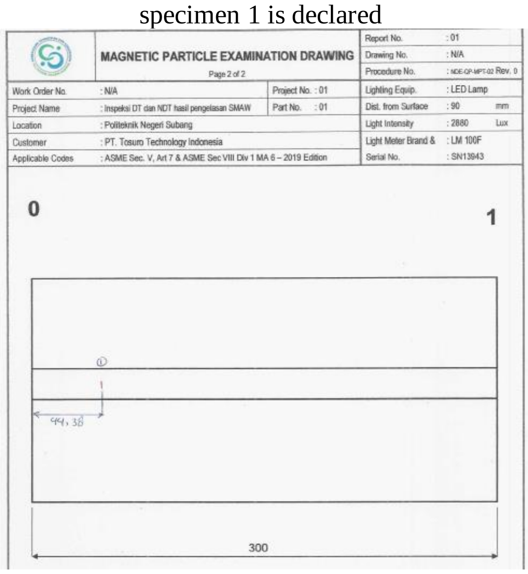


Figure 11. specimen test MT 2

From the figure above, the results of the magnetic particle test (PT) indicate a long defect measuring l = 48 mm and indicated as an undercut defect which is standard tolerated only l = 15 mm and

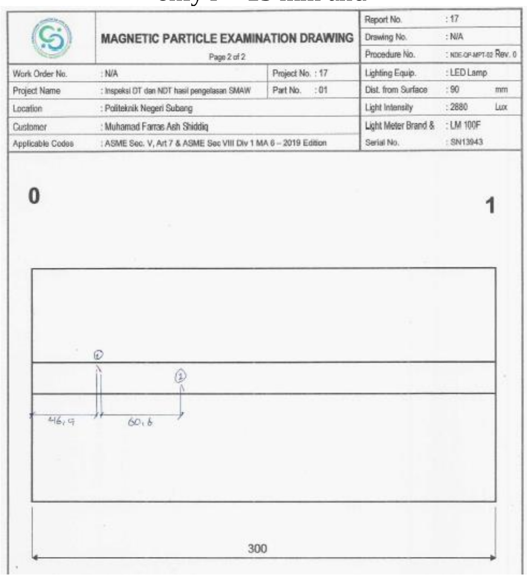


Figure12. specimen test MT 3

From the figure above there is an indication of defect that is 106.4 mm in length and an indication of the defect is an undercut. As per the accepted undercut standard is l = 15mm and specimens 3 did not meet the critea and was declared rejected.

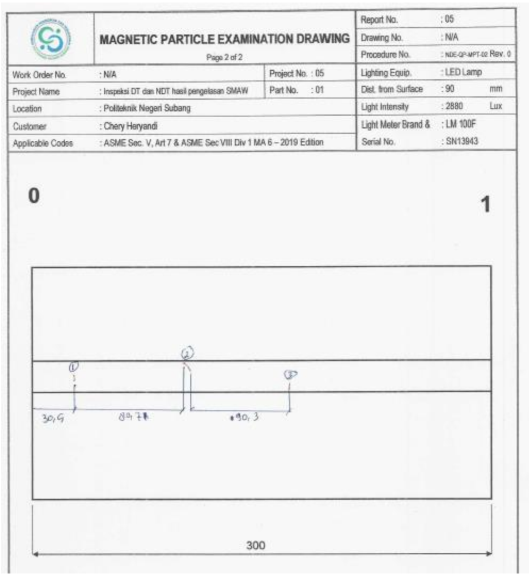


Figure 13. specimen testMT 4

From the figure of the Magnetic Test (MT) test results, there is an indication of defects whose length is l = 201.5 mm, according to the standard, the test results of the 4th specimen state Rejected.

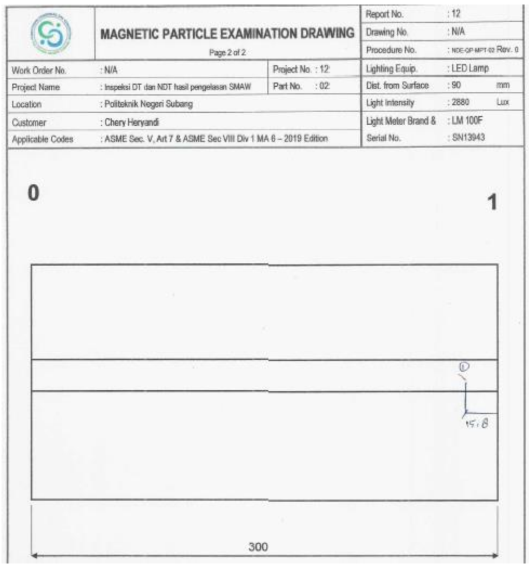


Figure15. specimen test MT 5

From the figure of the Magnetic Test (MT) test results there is an indication of a defect whose length is l = 14.8 mm, according to the standard, the test results of the 5th specimen declare acceptance.

Conclusion

The conclusions of this study are from several explanations of randomly selected students and the NDT test results still need to be improved and added hours of practice for 3G SMAW welding. Specimens 1, 3 and 4 for PT testing are Rejected and MT rejected test results where the length of the undercut defect is> 100 mm and the standard is only <50 mm. Specimens 2 and 5 are declared to have passed the PT and MT test because the defects in the specimens are still included in the standard where the undercut or indication of defects that occurs is still below <50 mm.

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