Analysis of quality student practice results in shielded metal arc welding

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Abstract. This study aims to describe and determine the breakdown level of the V Groove welding results of students in Shielded Metal Arc Welding practice in the 3G (Vertical Up) position based on the American Welding Society standards. This study uses a quantitative descriptive research approach to describe the quality of the welding results. The collecting data in this study uses a visual assessment checklist based on AWS standards. The research conduct in a fabrication workshop at, Department of Mechanical Engineering Education, Faculty of Engineering, Yogyakarta State University. The data analysis technique was done by visually assessing students’ welding results and averaging them then describing them. The number of samples from this study were all training participants totaling 18 students. The results of this study indicate that: overall, the pass rate of students in welding the V groove connection in the 3G position SMAW practice is still meager, from a total of 18 students, none of them passed. Most students did not pass welding in the irregular bead, free from arc stray and spatter, undercut material, weld profile, and crater cross-section. The cause of student failures is due to a lack of understanding of how to avoid welding defects.

1. Introduction

Education is the spearhead of a country, in the sense that if a country wants to develop, education must be the top priority. Through education, it can meet human needs in developing their abilities, which will impact the nation’s economy. Jonathan & Micah explained that education provides opportunities for each individual to empower themselves through intellectual development, skill acquisition, vocational development, and awareness of the environment [1]. Education is to develop and explore the cognitive, psychomotor, and affective potential in a person.

Education in Indonesia consists of formal, non-formal, and informal education. The three education pathways complement and enrich each other based on the competence of their respective expertise. One of the formal education in higher education is vocational education. Clarke & Winch, which defines Vocational education, is confined to preparing young people and adults for working life, a process often regarded as a rather technical and practical nature [2]. Furthermore, the BRICS Business Council states that vocational education has an essential role in creating a ready-made workforce in the industry [3]. Vocational education aims to prepare graduates to be independent, fill job vacancies, and develop competencies based on their expertise.

Department of Mechanical Engineering education, Faculty of Engineering, Yogyakarta State University has several areas of expertise, including those focusing on fabrication. Based on the level of the National Work Qualification Framework (NWQF), graduates in Diploma III are at level V. Referring
to the Presidential Decree No. 8 of 2012 article 2, that the qualification levels of KKNI level V are into technician or analyst positions. Furthermore, qualifications at level V must have the following competencies: (1) Able to apply and utilize science, technology, and/or arts in their fields; (2) Able to carry out specific tasks; (3) Have basic operational knowledge and factual knowledge of specific work fields; and (4) Responsible for work and can be given responsibility for guiding others [4].

Welding is the process of joining two metals or alloys by increasing the surface temperature to be joined so that they become liquid and fuse [5]. Welding is the process of joining the base metal into one unified whole. In the industry's manufacturing and production processes, welding plays an essential role because it is considered the most efficient process. To obtain quality welded joints that meet standard requirements, welding personnel qualified and have a welding competency certificate recognized by national certification bodies such as the National Professional Certification Agency (NPCA) is required. The welding personnel's qualifications are divided into welder or welding operator, welding engineer, welding supervisor, and welding inspector.

Welding is an important thing that must be considered in detail because it dramatically affects the strength of the construction of a tool and is not only the strength of the welding but also the visuals of the welding results that must also meet standards such as the American Welding Society (AWS) or the Welding Procedure Specification (WPS). Students need to be equipped with exceptional skills to be recognized in the world of work, so a competency certificate is needed to equip them to get a job. In fabrication, the standard welding certification is SMAW welding with vertical up (3G) vertical groove seam joints. Welding certification to prepare for quality learning is needed because it leads to the industry's required work fields and the required certification.

There is a research on visual inspection on shielded metal arc welding products of Asian welding contestants in Yogyakarta province. The results showed that the aspects that become the weakness of contestants were a lack of understanding and knowledge in determining the welding requirements especially in identifying the welding code, selecting the current welding, recognizing the type of metal material, recognizing the type of shielded metal arc welding electrodes, and knowing the function of occupational safety and health [6]. The other study showed that the conventional job sheets have not been able to solve some of the problems that exist in the learning activities of SMAW subject. Students need the other media in order to improve their understanding on the subject [7].

The obstacles faced by some lecturers include the high cost of electrodes and steel plate specimens used in welding practices. Part of the reasonable cost is spent only on conducting welding experiments, which are wasted so that many welding actors do not provide standard facilities for student practical work. These problems can have an impact on the results and quality of student work. Adhering to welding practice standards, in general, is very important to improve student competence. This underlies the analysis of SMAW practices' welding quality at the 3G position in the Mechanical Engineering Diploma III Study Program. This research aims to determine the quality level of the visual test results on the welding of 3G positions in SMAW practice.

2. Methods

This study uses a descriptive research approach to describe a particular population or field's characteristics systematically. This study describes the quality of 3G welding results in SMAW practice in the Mechanical Engineering Diploma III study program, Faculty of Engineering, Yogyakarta State University. The sample used was 18 students who were randomly selected. The data collection technique uses an instrument checklist totaling 12 items based on AWS standards, as shown in table 1. The student welding results that have been completed and then performed a visual test with instruments from AWS. The visual test by taking measurements, and then it is described based on the data obtained.
### Table 1. Assessment instrument based on AWS standards [8].

| Indicator                        | Permissible limits                                                                 |
|----------------------------------|-------------------------------------------------------------------------------------|
| Crack                            | There should be no                                                                  |
| Weld/base-metal fusion           | Between the base metal and the added metal looks together                           |
| Crater cross-section             | All crater must be filled                                                           |
| Reinforcement (Weld profile)     | Thickness below 8 mm, max reinforcement 2 mm                                        |
| Undercut                         | If the construction is subjected to a tensile load, the UC ≤ 0.25 mm                |
| Porosity                         | Piping porosity diameter ≤ 1 mm, P ≤ 10 mm, or P ≤ 20 mm at 12 inches.              |
| Free from arc stray and spatter  | 99% clean                                                                            |
| Stop/run                         | The difference in height does not exceed 1.5 mm                                     |
| Irregular bead profile           | Should not exceed 2 mm                                                              |
| Lack of fusion                   | There should be no                                                                  |
| Hi-lo                            | 1 mm max                                                                            |
| Distortion                       | Must not exceed 3°                                                                   |

### 3. Results and Discussion

The results obtained in this study were data on the results of welding the 3G position with SMAW, which was attended by 18 students of Diploma III in Mechanical Engineering. The assessment of the welding results used to assess students’ 3G SMAW welding results is by using AWS standards. The welding result assessment instrument is a checklist form to assess students' welding results, and then it is analyzed and described—the results of the assessment in figure 1.

The assessment of the welding results based on AWS standards shows that none of the results from the 3G position welding have passed the visual test. The non-slip on the student's welding results still contained a welding defect that was not allowed. From the assessment of the diagram of the image above, it can be how well the students can weld 3G positions with SMAW. The assessment results of welding in the 3G position still have an assessment item with an error rate of below 50%. The error and

![Figure 1. The number of students who passed.](image-url)
welding defects still occur, such as an irregular bead, arc stray, and spatter, stop/run, undercut, crater cross-section, grove profile weld, and lack of fusion. Of the seven welding defects that often occur can be seen that experience, knowledge, and welding competence in welding techniques are very important as primary capital as a professional welder that conforms to industry standards.

The irregular bead is irregular welding, including a welding path that is too wide or too narrow and has a surface that is too convex or concave. These characteristics occur by low electrode quality, too slow welding speed, too high or low currents, and improper arc voltage. Arc stray is a discontinuity consisting of metal that melted back, a metal that is affected by heat, or changes in the profile of the finished weld surface or the surface of the base material resulting from an electric arc. These characteristics occur due to the lack of experience of the welders in welding. Spatter is usually by high current, too long arc, irregular arc, and unstable.

The stop/run occurs due to inexperience in the reconnection process when the electrodes run out. This error can occur when the welding process is; the joints are not cleaned first. The undercut is the burning of the base metal at the end of the welding. This type of damage can change by too high a current setting, an arc gap that is too long, and failure to fill the crater with weld metal. Lack of fusion is the welding process's failure to hold the base metal layer together, or the base metal rolls over the plate's surface. This type of damage by the following conditions: failure to raise to the melting point, improper flux, dirty plate surface, and incorrect current adjustment.

4. Conclusion
Based on the research results and discussion regarding the visual test of student welding practices on the SMAW welding of the V groove connection in the 3G position. The results concluded that the quality of the welding results is still low. If welding engineering students' competency is based on a visual test using AWS standards, the results are still below the criteria. Welding defects that need improvement include irregular bead, arc stray and spatter, stop/run, undercut, crater cross-section, and reinforcement.

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