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Research Article

Pipe Welding Jig for Greater Ease and Precision

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ABSTRACT

Pipe welding requires precision, stability, and safety to ensure results of acceptable quality. This study introduces a pipe welding jig designed to help welders maintain accurate 6G and 5G positions while reducing defects like misalignment and pipe distortion. The jig was designed to improve welding efficiency, safety, and precision, which makes the process easier and more consistent. A panel evaluation was conducted by five experts to assess four key aspects: design, ease of use, durability, and safety with an evaluation form with Likert-scale rating. The results were analyzed with Cronbach's Alpha which revealed a score of 0.720 that showed the items were reliable. Experts rated the jig highly particularly on its stability, usability, and effectiveness in improving welding accuracy. This tool can benefit vocational training and industrial applications by minimizing errors and increasing productivity while helping to ensure welders' well-being. Future improvements may include adjustable designs for various pipe sizes and automated features for enhanced efficiency.

Keywords: *Pipe welding, Jig design, Welding efficiency, Vocational training, Safety*

Introduction

Welding process requires significant energy and concentration and it demands mental focus and physical strength since precision is a top priority. Hence, the pipe welding jig was specifically designed to facilitate welders in performing pipe welding processes with greater ease and precision while providing better safety to welders or trainees of welding technology. This tool may reduce the risk of defects that may occur in pipes upon completion of the welding process while protecting them better from occupational hazards at their workspace during a welding process. Ultimately, this jig may improve workplace safety, welding efficiency and quality as well as welders' productivity.

Problem Statement

Welders tend to face several difficulties in welding metal pipes. First, welders often struggle to attain accurate 6G and 5G positioning due to the difficulty in maintaining the body posture and position needed to perform the

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operations while the tools which can enable such a process to be more efficient are limited. There are six numbers often used to refer to types of position used when welding and these are matched with the categories of these positions: flat, vertical, horizontal and overhead. It is imperative for welders to weld their workpieces according to the appropriate position since it directly affects the end result. Second, the weld beads produced are often imperfect due to pipe distortion during welding.

This project was expected to simplify tack welding and reduce the time required for welders to initiate the welding process. In the context of vocational training, this jig can help students perform pipe welding effectively and it supports better body posture which ensures a more comfortable welding experience that enables welders to focus more on the work. This prevents welders from suffering fatigue which can have consequential effects on their physical health in the long run.

Objectives

This purpose of this project was to assist welders especially trainees in achieving precise welding position with greater ease and precision. Hence, there were two objectives as follows:

i. To design a pipe welding jig that can be used at least by students of welding technology at Keningau Vocational College
ii. To evaluate the effectiveness of the pipe welding jig in producing well-formed weld beads that adhere to work plans and specifications.

The Importance of High-Quality Welded Pipes for Industrial Purpose

Huong (2021) asserts that to ensure high-quality welded pipes, several fundamental welding criteria must be met: the absence of convex defects, cracks on the surface, porosity, and welding processes that do not cause structural deformation in steel pipes. However, conventional iron pipe welding methods frequently result in inconsistent weld quality and uneven penetration. Moreover, welding quality is highly dependent on the welder's skill, making it difficult to maintain a uniform arc along the entire pipe diameter using traditional methods. If pipe weld quality fails to meet these essential criteria, the pipes may become unsuitable for their intended purposes, particularly in commercial and residential construction industries, as well as in the manufacturing and energy sectors. Therefore, this pipe holding jig has been developed to enhance welding efficiency and ensure precise and high-quality welds.

According to Demirel, Biskiner and Sahin (2023), welding defects indicate that there is a flaw in the welding process which can be attributed to various factors and such flaw can result in internal and external imperfections in the welded metal. A welding defect compromises the integrity of a workpiece and it is considered as failure in meeting acceptable universal standard. The most typical causes of such defect are poor welding techniques, limited welder's skill, the improper settings of welding equipment as well as selection of material. This implied the dire need in ensuring proper and smooth welding process that enables welders perform the process that creates welded metal pipes that meet the universal standard for it to be considered commercially viable, durable and visually appealing.

Welders' Fatigue Due to Welding Positions

Baek and Nam (2021) chastised welding process since it requires welders to be in awkward posture for an extended period of time where they have to bear forceful exertion, heavy work that is repetitive and excessive, static load and stress which causes them to sustain fatigue and tiredness and in the long run, suffer occupational illnesses. Okumus et al. (2023) conducted a survey on 12 welders in respect to the discomfort and pain they experienced as a result of two welding positions known as 2F position and 3F position. It was revealed welders experienced more knee, ankle, waist and upper arm fatigue when assuming 2F position while greater hand, shoulder, back, forearm and neck fatigue was felt more when they were in 3F position. Both positions could result in the eyes, knee, neck and waist discomfort. These findings indicate the need to address welders' healthy and safety when per-

forming welding procedure due to the pain-inflicting positions that they have to assume in completing the operation.

Ismaila et al. (2011) researched on the ergonomic aspect of welding process and discovered that 70.8% of workers have to maintain similar posture all the time which contravenes ergonomic guidelines for working posture. This calls for new techniques, tools or technologies that can alleviate welders' physical burden by allowing them to perform the operation in a comfortable and safe position and posture.

Effects of Welders' Fatigue on Quality of Welded Metal

According to Lungu et al. (2020), welders' fatigue had a major impact on the technical performance as well as the accuracy of welded metal due to their inability to coordinate their hands, eye and feet when they were doing an exercise in certain positions that they felt uncomfortable and awkward. The study which was done on six subjects revealed numerous mistakes were made on the final workpieces that they operated on. These findings signified the importance in preventing welders from feeling fatigue which directly affects the quality of their work. The workers need to be provided with tools and condition which enable them to assume proper postures while executing welding tasks.

Welding Jig

According to Suhana et al. (2023), the current welding jig has several features including height adjustment, rotation adjustment, clamp adjustment and a workspace desk. However, there are few elements that need to be improved. A study was conducted on a standstill welding jig which can accommodate all 27 welding positions and it was shown to be more flexible, cost-saving and less space-consuming. It was believed that this could improve productivity, convenience and efficiency while enhancing teaching and learning process.

This project was intended to create a carriable welding jig that can be attached on walls, pillars and solid stands which enables the jig to be moved and adjusted better in order for it to be suitable for some complex welding procedure that may require constantly changing positions of the workpiece and the jig as well as the postures of the welder.

Pipe Welding Jig

This pipe welding jig was designed to enable welders to secure their accurate position while welding their workpiece. This was to prevent welders from slipping into the wrong position out of exhaustion or loss of focus which can result in errors.

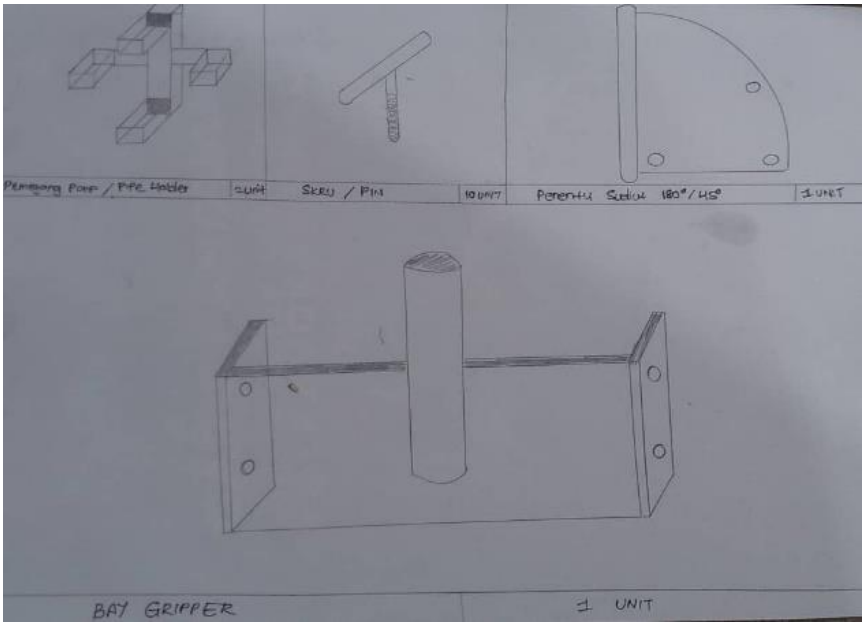

Figure 1. Sketch of the Pipe Welding Jig

The pipe welding jig can be adjusted to fit the desired position and angle for the welding process. It can be clamped against a protrusive or separation wall so it can be put at a level of height that suits the welders' height.

Figure 2. The Completed Pipe Welding Jig

Due to lack of availability of tools and equipment that can properly support the posture and position of welders to ensure safety, health and precision, this device was designed to address the several issues that may have consequential effects on workpieces as well as on welders' wellbeing.

Methodology

According to Bryman (2016), panel testing is an evaluation method involving a group of experts or stakeholders who assess a project, product, or service before proceeding to the next stage. The primary objective of panel testing is to obtain comprehensive feedback on critical aspects of a product. Five experts with minimum 10 years of experience in teaching welding technology and vocational subjects as well as with bachelor's degree and skill certificate in areas relevant to this discipline were chosen as the assessors. The panel of assessors was selected based on their expertise and qualifications as well as their availability in conducting the assessment within a specified period of time in a designated location. The instrument for the panel evaluation contained four major aspects and these were design and structure, ease of use, reliability and durability and safety. Likert-scale rating represented by a range from number 1 (strongly disagree) to number 5 (strongly agree) was used to indicate the assessors' opinions.

Table 1. Panel Evaluation Instrument

Items	Evaluation Criteria
Design and Structure	
1A	The jig has a suitable design for holding pipes.
1B	The jig's structure is strong and stable during welding.
Ease of Use	
2A	The jig is easy to assemble and disassemble without difficulty.
2B	The jig's adjustment system functions well for various pipe sizes.
Reliability and Durability	
3A	The jig demonstrates good durability for prolonged use.
3B	The jig is easy to maintain and requires minimal effort for upkeep.
Safety	
4A	The jig is equipped with adequate safety features to reduce the risk of injury.

The data collected from the five assessors were analyzed through the use of statistical software in order to identify the means and standard deviation of each item from the five assessors as well as in examining the reliability of the instrument.

A reliability test was conducted using Cronbach's Alpha coefficient to assess the internal consistency of the survey instrument. The table below presents the results of the reliability analysis.

Table 2. Reliability Statistics of the Panel Evaluation Form

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of items
.720	.718	7

The Cronbach's Alpha value obtained is 0.720 which indicated an acceptable level of reliability. According to Tavakol and Dennick (2011), a Cronbach's Alpha value that surpasses 0.7 is considered acceptable and it reflects a decent level of internal consistency among the instrument items. This result demonstrated that the rating form used possesses stability and reliability which meant that the items measured are interrelated and they effectively captured the intended concept.

Findings and Discussion

Table 3.0 indicates that the mean values for each item ranged from 4.20 to 4.40 which evinced that the assessors provided relatively high scores for all evaluated items. The standard deviation values range between 0.447 and 0.548 and such range suggested that slight variation in the assessors' answers although it is still within a small range. This reflects a good level of consistency in the responses provided by all five assessors. Overall, the assessors had similar perspectives on the items assessed in the rating form.

Table 3. The Mean and Standard Deviation for Each Instrument Item

Item	Mean	Std. Deviation	N
1A	**4.40**	**.548**	**5**
1B	**4.20**	**.447**	**5**
2A	**4.20**	**.447**	**5**
2B	**4.20**	**.447**	**5**
3A	**4.40**	**.548**	**5**
3B	**4.40**	**.548**	**5**
4A	**4.40**	**.548**	**5**

The findings from the panel evaluation indicate that the pipe welding jig effectively enhances stability, precision, and safety in the welding process. Experts rated it highly in several key areas particularly in maintaining accurate 6G and 5G positions which are crucial for high-quality welds. The jig's adjustability allows welders to achieve better posture and reduces fatigue which ultimately improves their productivity. Additionally, the reduced risk of pipe distortion and welding defects supports more consistent and reliable welds. This jig is a valuable tool for both trainees namely vocational students in the field as well as experienced welders.

Implication and Recommendation

The design of this jig may have significant implications for vocational training and industrial welding applications. In educational settings, the jig provides students with better support for learning precise welding techniques which can help them acquire industry-relevant skills and it also aligns with the need for safety and ergonomics at workplace which are in the vocational college curriculum. In the manufac-

turing and construction sectors, the jig contributes to higher-quality welded pipes which subsequently reduces material waste and the need for rework. Furthermore, since this tool improves workplace safety and ergonomics the risk of occupational injuries caused by poor posture and excessive strain can be minimized. In addition, the cost of retrofitting existing welding jigs or creating new jigs are economically feasible. To further enhance the jig's functionality, some of the suggested improvements are as follows:

- Adjustable clamps and multi-angle settings to accommodate various pipe sizes
- Automated positioning features for increased accuracy and ease of use
- Lightweight but durable materials to improve portability without compromising stability
- Integration with welding simulators to enhance training experiences for vocational students

Further studies should expand the sample size of panel evaluations and conduct real-world testing in industrial settings to validate long-term effectiveness.

Conclusion

This study demonstrates that the pipe welding jig effectively improves welding precision, efficiency, and safety. By addressing common challenges in 6G and 5G positioning, it enhances the overall quality of welds and reduces defects. The positive panel evaluation results suggest that this innovation is beneficial for vocational training and industrial applications. Future enhancements could optimize its design, automation, and adaptability, further increasing its impact in the welding industry. Future studies could explore long-term impacts on productivity and operator safety in industrial settings.

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