DESIGN IMPROVEMENT AND VIBRATION ANALYSIS OF A FABRICATED PIPE BEVELLING JIG FOR WELDING PREPARATION

This report is submitted in accordance with the University Teknikal Malaysia Melaka (UTeM) requirement for a Bachelor Degree of Manufacturing Engineering (Hons.)

by

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I hereby declare this report entitled "Design Improvement And Vibration Analysis Of A Fabricated Pipe Bevelling Jig For Welding Preparation." This is the results of my own research except as cited in the reference.

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Date : 30 June 2022

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka (UTeM) as partial fulfillment of the requirements for a Degree of Manufacturing Engineering (Hons.). The members of the supervisory committee are as follow:

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ABSTRAK

Serong paip ialah satu proses di mana sudut terhasil antara hujung paip dan permukaan yang perlu dikimpal. Dalam serong paip, beberapa piawaian perlu dipatuhi sudut mestilah dalam julat antara 30° hingga 45°. Jari putih akibat getaran (VWF) ialah kesan jangka panjang ke atas pekerja yang terhasil daripada penggunaan alatan tangan yang bergetar dalam masa yang berpanjangan. Ujian awal telah dijalankan untuk mengukur magnitud getaran bagi jig sedia ada dengan menggunakan vibrometer. Magnitud getaran tertinggi berlaku semasa menyerong paip 3.5 inci iaitu 116.59 m/s^2 dalam masa 5 minit dan 43 saat. Menurut Piawaian ISO Eropah, tahap pendedahan ini menghampiri had pendedahan penunjuk kuning iaitu antara 105 m/s^2 hingga 150 m/s^2. Kajian ini berhasrat untuk mencari kaedah terbaik untuk mengurangkan atau menghapuskan pendedahan getaran untuk pekerja apabila menggunakan jig yang direka. Masalah telah dikenal pasti dan kemungkinan penyelesaian telah dicadangkan untuk jig sedia ada untuk mencapai objektif. Pemutar paip automatik dan chuck tiga rahang telah dipasangkan. Selepas penambahbaikan reka bentuk ditetapkan dengan baik, semua data dan analisis telah diambil kira. Ia kemudiannya dibandingkan dengan analisis data ketepatan sudut serong antara mesin serong paip sedia ada dan selepas mesin serong paip menjalani proses penambahbaikan reka bentuk. Ketepatan ukuran sudut serong dapat dicapai hasil daripada penambahbaikan reka bentuk jig yang dibuat. Nilai purata ketidakpastian sebelum penambahbaikan reka bentuk menunjukkan 0°34'41.15", manakala nilai selepas penambahbaikan reka bentuk adalah lebih rendah pada 0°23'55.98". Ia menunjukkan bahawa ukuran sudut serong yang tepat boleh dicapai apabila motor dapat memutarkan paip pada kelajuan malar, yang menghasilkan tahap sudut serong yang berterusan. Mengurangkan pendedahan getaran adalah pendekatan terbaik untuk mengelakkan penyakit yang berkaitan dengan alat getaran seperti Sindrom Getaran Lengan Tangan. Kajian ini diharap dapat membantu industri logam dan fabrikasi dalam proses penyediaan kimpalan paip. Ini adalah untuk memastikan proses persekitaran yang selamat apabila menggunakan jig ini untuk menyediakan serong paip.

ABSTRACT

Pipe bevelling is a process in which an angle is produced between the end of the pipe and the surface that needs to be welded. In pipe bevelling, some standards need to be followed. The angle must be in a range between 30° to 45°. Vibration-induced white finger (VWF) is a long-term effect on the worker that results from prolonged use of vibrating hand tools. Preliminary testing was conducted to measure the vibration magnitude for the existing jig using a vibrometer. The highest vibration magnitude occurs during the bevelling of a 3.5-inch pipe which is 116.59 m/s^2 within 5 minutes and 43 seconds. According to ISO European Standards, these exposure levels are nearing the exposure limits yellow indicator, which is between 105 m/s^2 and 150 m/s^2. This study intends to find the best methods to decrease or eliminate the vibration exposure for the worker when using the fabricated jig. Problems have been identified and possible solutions have been proposed for the existing jig to achieve the objectives. An automated pipe rotator and three-jaw chuck were developed. After the design improvement was well established, all the data and analysis were considered. It was then compared to the data analysis of bevel angle accuracy between the existing pipe bevelling machine and after the pipe bevelling machine undergoes the design improvement process. The precision of the bevel angle measurement was achieved as a result of the improved design of the fabricated jig. The average uncertainty value before the design improvement shows 0°34'41.15", whereas the value after the design improvement was lower 0°23'55.98". It indicates that precise measurements of bevel angles are possible when the motor can rotate the pipes at a constant speed, which results in a constant degree of bevel angle being produced. Reducing vibration exposure is an excellent approach to avoiding diseases related to vibration tools, such as Hand Arm Vibration Syndrome. This study is hoped to assist the metal and fabrication industry in the process of pipe welding preparation. This ensured a safe environment when using this jig to prepare a pipe bevel.

DEDICATION

I wholeheartedly dedicate this study
to my beloved mother, Radziah Binti Ali;
to my father, Mohamad Harani Bin Anu;
to my family;
to my very helpful classmates and friends;
to my honourable and resourceful supervisor, PM Dr. Nur Izan Syahriah Binti Hussein
for helps and guidance by means of giving me moral support, knowledge, time, cooperation, encouragement and understanding.
Thank You So Much

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Alhamdulillah, all praise to Allah S.W.T for His blessings and for giving me the strength to complete this research successfully. Without His righteousness, it would be impossible for me to go through all the obstacles and allegations in completing the research as the challenges are real.

First and foremost, I would like to express my sincere gratitude to my loved supervisor, Professor Madya Dr. Nur Izan Syahriah Binti Hussein. I am extremely thankful for her encouragement, assistance, and constructive criticism to become a better person and develop outstanding research.

I would also like to extend my gratitude to my dearest family members for their constant support, particularly to my parents, who have no doubts about my choices, studies, learning, and encouraging words that make me a better person every day.

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LIST OF ABBREVIATIONS

FKP	-	Fakulti Kejuruteraan Pembuatan
VWF	-	Vibration White Finger
ISO	-	International Organization for Standardization
HAVS	-	Hand Arm Vibration Syndrome
EAVS	-	Exposure Action Values
ELVS	-	Exposure Limits Value
HSE	-	Health and Safety Executive
SDN. BHD.	-	Sendirian Berhad

LIST OF SYMBOLS

°	-	Angle of degree
mm	-	Millimetre
m/s^2	-	Millimetre per second square
Inch	-	Inches
m/s	-	Meter per second
%	-	Percentage
Nm	-	Newton meter

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Pipe bevelling is a process in which an angle is produced between the end of the pipe and the surface that needs to be welded. There are a few methods to bevel a pipe, such as a portable or stationary bevelling machine or manually using a hand grinder, plasma, or torch cutter. The cheapest way to bevel a pipe is by using a hand grinder. Nevertheless, using a hand grinder for a long time will affect the worker's health when preparing the pipe welding.

In pipe bevelling, some standards need to be followed. The angle must be in a range between 30° to 37.5°, and it will form a 60° to 75° angle for both ends of the pipe by using a hand grinder, the inconsistent bevel quality or angle. A skilled worker must perform this process as the inconsistent bevel quality might affect the weldment quality and defects such as porosity. Using a manual hand-grinder, the probability of achieving an accurate dimension would be low due to the inconsistent grinding method and the grinder's vibration.

The vibration happens when the swinging movements result from the tools, equipment, and machine-generated while working. For an extended period, grinding also will cause the worker to have a vibration white finger (VWF) condition due to prolonged use of vibrating hand tools. Hand-arm vibration syndrome is a common occupational issue that impacts employees in many sectors that utilize vibrating instruments (Shen and House, 2017).

1.2 Problem statement

Pipe bevelling or edge preparation produces an angle at the edge or flat angled surface on the end of the pipe (Prasad & Lingaraju, 2017)**.** A joint usually used in the weldment of pipe is the Butt joint (Khanna, 2014). A machining process usually produces a butt joint. (Singh *et al.*, 2019). Many problems occur when creating a groove at the end of the pipe. The most common problem in pipe bevelling is the consistent duration of preparing the pipe angle each time, as it needs to be done in the fastest cycle time possible.

Moreover, the vibration factor is an essential issue in bevelling a pipe. Most of the worker's hands are not in good condition when handling tools due to the vibration of the grinding machine for an extended period. This is because the workers need to ensure the angle accuracy is consistent. Accuracy is the most important in producing the bevelling angle. V-grooves angles are usually between 60° to 75° for pairing the pipe end. Each pipe must be around 30° to 37.5° depending on the standard to be applied. The welding operations will be simple, and the workpiece's penetration with a high depth will be achieved when producing a good angle (Pathak et al., 2021). At the same time, the root opening for both pipes is between 0.5 mm and 1 mm. The pipe bevelling requirement's tolerance must be followed to get a perfect weld(Prasad & Lingaraju, 2017).

Furthermore, exposure to vibration might affect the worker's health condition long-term. Vibration-induced white finger (VWF) is a long-term effect on the worker that results from prolonged use of vibrating hand tools such as a high-pressure water hose, rotary saw, hand grinding machine, and lawnmower, and more (Kurtul & Türk, 2018). There is no cure for healing this condition, but it is preventable.

Lastly, only skilled workers can bevel a pipe manually using a hand grinder (Pathak et al., 2021). This operation makes a flat angled surface at the end of a pipe. The pipefitter created the angled opening, which gives the welder access to the pipe wall's total thickness, enabling the welder to produce a consistent weld that will guarantee the assembly's mechanical continuity (Sanap *et al.*, 2016).

1.3 Objective of Study

The objectives of this study are:

i. To analyze the vibration and angle accuracy of the fabricated bevelling jig for welding preparation
ii. To perform design improvement of the fabricated bevelling jig for welding preparation.
iii. To validate the improved design of the bevelling jig for welding preparation.

1.4 Scope of Study

The scope of this study will be conducted at the Fakulti Kejuruteraan Pembuatan UTeM laboratory. This study will improve the existing design of a grinding machine's jig for pipe bevelling preparation to reduce the vibration. The current grinder bevelling machine will undergo a design improvement and the jig and fixture have been designed and fabricated from a previous study and research. The vibration analysis will be measured using a Vibro-Meter (hand-arm vibration meter) at FKP's laboratory to measure the vibration absorption on the worker's hand while bevelling a pipe using this bevelling jig. The bevelling will also be measured using measuring equipment such as a bevel protractor and bridge cam.

1.5 Significance of Study

This study intends to find the best methods to decrease or eliminate the worker's vibration exposure when using the fabricated jig. Design improvement will be proposed to achieve the objectives. After the design improvement is well established, all the data and analysis must be considered. This will compare the data analysis of vibration between the existing pipe bevelling machine and after the pipe bevelling machine undergoes the design improvement process. This study will help the metal and fabrication industry in pipe welding preparation. It will ensure a safe environment when using this jig to prepare a pipe bevel.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will review a passed study, internet sources, and journals related to pipe bevel preparation, bevelling standards, existing pipe bevelling machine, and how the vibration affects the workers while handling grinding machines. This review aims to go through prior research on the topic, such as the most effective approach for decreasing vibration and jig design to reduce worker handling of a machine or tools. Some studies will be reviewed on this topic to minimize the exposure of vibration while conducting a grinding process to prepare an angle at the end of the pipe joint. The literature review identifies, evaluates, and synthesizes the relevant literature within a particular field of research. Some studies may be reviewed on this topic to reduce vibration absorption when operating a grinding machine with a hand while constructing a bevel for an end pipe joint before preparing a pipe welding process.

2.2 Pipe bevel

A pipe bevel is the essential part of pipe welding. Pipe bevelling is a welding preparation method that creates an angle between the pipe's end and the surface to be welded. A bevelled end is when the pipe end is formed with a certain degree of angle. The quality of the bevelled pipe directly impacts the welding quality. Thus, proper preparation must be required to ensure the best weldment quality (Copier, 2020). Besides bevelling, pipe bevelling can also be used as deburring pipe ends for safety and aesthetic purposes.

2.2.1 Pipe Bevelling Preparation

The quality of the pipe joint is directly affected by the pipe joint preparation. In many cases, the failure of the pipe joint may be affected by poor joint preparation. The pipe welder must be familiar with and practice the skills necessary to successfully prepare the joint for welding. Proper selection and preparation of groove angles are critical in fabricating a welded joint. A proper joint design should be chosen to provide the least amount of deformation and residual stresses in the weldment while also being cost-effective (Srinath Reddy et al., 2019).

When pipe ends are bevelled, a weld is better likely to be accepted, lowering repair or cut-out expenses and keeping a project on track. Bevelling pipe ends is a critical aspect of getting a good weld. It improves the weldment surface area, resulting in stronger welds that can withstand higher stress essential for pipe weldment (Dai et al., 2020).
Below is the step in weld joint preparation (Hughes, 2009):

1. The weld joint has been appropriately prepared in accordance with the specified procedure.
2. The joint is correctly sized, especially the groove angles, groove radius, root face, etc.
3. Ensure temperatures are in accordance with Welding Procedure Standards.
4. Tack weld the pipes together after any pre-heated requirement.

To weld a pipe, or a single-v but joints are commonly used. Each of the elements of the weldment has its standard name. Those names are usually used in pipe welding, and the welder must be familiar with the terms, as shown in Figure 2.1 (Hoobasar Rampaul, 2003).

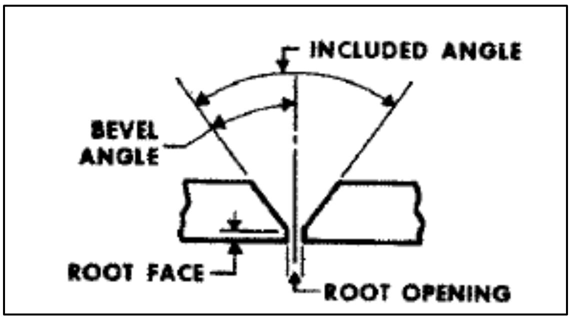


Figure 2.1: Welding Process Definition

2.2.2 Pipe bevelling standards

Some guidelines must be followed while bevelling pipes, such as the angle must be between 30° and 37.5°, and it must create a 60° to 75° angle on both ends of the pipe when using a manual grinder to avoid uneven bevel quality or angle. By referring to Figure 2.2, all the dimensions should be followed. Because the bevel quality may affect the weldment quality and failure such as porosity, etc., this technique must be performed by a qualified worker (Lucas, 1991).

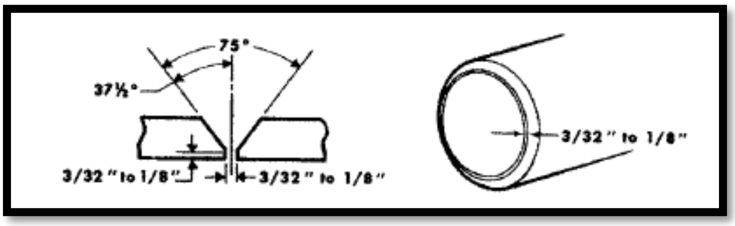
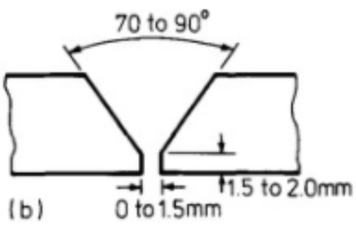


Figure 2.2: Dimension of V-groove (Lucas, 1991)

According to the standards, a pipe with a minimum wall thickness of more than 3mm should undergo welding preparation. Table 2.1 shows the joint preparation used in pipe welding (Hoobasar Rampaul, 2003).

Table 2.1: Pipe Bevelling Standards (Hoobasar Rampaul, 2003)

Type of pipe joints standards	Description
	A fundamental square edge, close butt joint arrangement may be used to weld the tubes with a wall thickness that is less than 3mm
	A single V butt joint is utilized to weld tubes with more than 3mm wall thickness.

When the bevel is formed on a thick pipe, it will have a "U" shaped groove to decrease the quantity of welding filler metal utilised. Bevelling is a key aspect of the pipe welding engineering procedure. Due to being welded together, the forms of two pipe ends have been altered by removing some of the metal from each end. Bevelling can be done manually by hand-grinding or automatically by using a machine. Because the pipe ends are bevelled, it's more likely that welding will be permitted, lowering the cost of repair or cutting while keeping the project on track (Showaib & Elsheikh, 2020).

2.3 Jigs and Fixtures

Nowadays, people's demand for manufactured products has rapidly increased dramatically. As a result, manufacturers have created innovative methods to produce high-quality products at a higher production speed to fulfil the rising demand. As stated by Chennu in 2015 Jigs and fixtures are used for various purposes (Chennu, 2015). Decrease in production costs, improvement in production rate, high precision of products with no manufacturing errors, modifiability, simple machining of complicated shaped components, lesser quality control expenses, etc.

Jigs and fixtures are manufacturing tools used to fabricate identical and similar components. It is a tool that acts as a tool-guiding and workpiece holding system designed especially for machining and assembling huge batches of components. The purpose of jigs and fixtures is to remove the need for a specific set-up for each workpiece, allowing faster production while maintaining that each workpiece is produced with a particular tolerance, as stated by (Meduettaxila, 2012). He also identifies that if the jig or fixture has appropriately set up, the number of components can be manufactured quickly and easily without any extra set-up. Figure 2.3shows the example elements in jig and fixture.

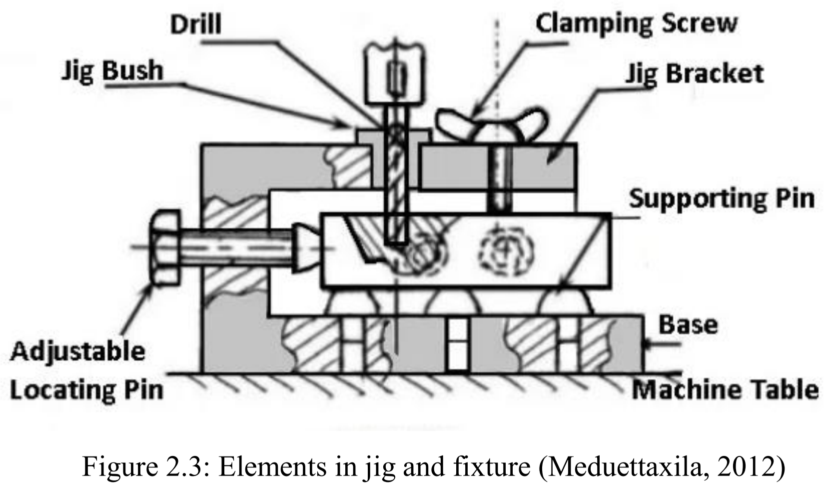


Figure 2.3: Elements in jig and fixture (Meduettaxila, 2012)