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RESEARCH ARTICLE

A Study of Welder Age on Welding Quality for Oil and Gas Offshore Structural Fabrication Project

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ABSTRACT

Welding is an important part of the building process since it incorporates the whole process, including the welder's ability. As a result, the goal of this study is to see how the age of the welder affects welding quality and faults in offshore struc-tural projects in Malaysia Marine and Heavy Engineering (MMHE). Human abili-ties give this activity more than the robotic process when compared to the oil and gas sectors. When the construction site has challenges with welder performance connected to daily fault contribution, the issues have been overwhelming. There was no additional research done to determine the impact of welder age on welding quality. Furthermore, there was no documentation examining the welder age groups for previous projects in MMHE and determining which location provided the lowest repair rate and zero-defect rate. In addition, the Human Resources de-partment lacks preliminary data analysis for the recruitment process as well as in-formation on the selection regime for future and impending projects. Qualitative and quantitative methodologies are used in research tactics. Using Minitab and SPSS software, a total of 591 welder data sets were collated and analyzed. The majority of the information collected from the Welding Depart-ment concerned seven (7) MMHE projects. Data screening, descriptive statistical analysis, and inferential statistical analysis were all part of the data analysis. The statistical analysis is based on three (3) variables: welder age (WA), welding defect (WD), and welding quality (WQ). The most important aspect of this research is the use of seven (7) statistical approaches to investigate the link between WA, WD, and WQ. The findings suggest that the best welder age is 34 when using descriptive analysis, and the best age group is 31 to 40 years old. According to inferential sta-tistical analysis, the ideal age for a welder is 34 to 36 years old.The age of the welder has a considerable impact on the overall outcome of the construction project. As a result, throughout the employment process, the recruit-ment firm must consider the health, welfare, and physical condition of each can-didate. This research has also provided project management with a broad struc-ture and guidelines to use in the recruiting process for a future project.

INTRODUCTION

Welders have become an important organization for those looking for work in the industrial sector. The popularity of heavy sector engineering, particularly in oil and gas, drilling, shipyards, buildings, aviation, and other areas, has grown year after year due to position demands and the highest-paid and strongest income. Welders in the industrial business, particularly in bulk and mass production, often employ a completely robotic welding process rather than relying entirely on human control. To achieve a greater production volume, this technique provides both a high output volume and a high material capacity. Human abilities give this activity more than the robotic process when compared to the oil and gas sectors. The rationale for this is to overcome set-up time delays as well as space and geometrical constraints.

According to the American Welding Society, by 2024, the welding shortfall will be 400,000 people. Welders who are approaching retirement age are not being replaced quickly enough by younger welders. The average age is 55, and only around 20% of the population is under the age of 35. It's never been more important to have access to a professional and established welding staff. Construction firms will need experienced welders to replace buildings, bridges, and highways as the country's infrastructure ages. Working on pipelines, wind turbines, and other energy delivery sources, a welder's competence will be useful in the alternative energy and oil and gas sectors.

Despite the rise in automated occupations, industries still need proven artisans' expertise and hands-on abilities to execute intricate building activities, maintenance, and repair work. This study looks at whether the age of the welder has an impact on the welding fault in a recent MMHE Sdn. Bhd. project.

1.1 Problem Statement

Welding quality is a critical term in sound-welding accuracy. Welding quality affects the service life and safety of the entire product, so inspection Guo focuses on welding quality (2019). Welding Performance result analyses are taken from the Welding Daily Report and calculated as defect length (mm) divided by total defect length from the Daily Report. The results were then taken from the Ultrasonic Test (UT) Report, which assesses and interprets the welding defect information to determine the defect length. The problem statement can be condensed from those mentioned above as follows:

(PS-1) There has been no further research into some aspects of the welder's performance in the Welding Daily Report, such as defining a welder's age group contributing to the highest or lowest defect during the construction project.

(PS-2) The analysis investigated which age groups contributed the least and most defects. However, the human resource department was unable to determine which welding age should be chosen and offered for future job openings. The Project Management Team has no idea which welder should be a part of their team.

1.2 Research Limitation

The limitations can have an impact on how the findings are interpreted at the end of the study. The following are the constraints encountered by the researcher during the research and development process:

i) The data, particularly the Welder List and Weekly Welder Performance, is from a previous and ongoing project.

ii) Some of the data received from the welding department was incomplete and was kept and stored by different people.

iii) Some information, particularly the age of foreign welders, was excluded from the population analysis due to a lack of data on the actual age of the welder, i.e., the foreign welder's passport number.

iv) Some of the information received from the welder's company is incomplete, and contacting the welder's company is extremely beneficial.

v) Some of the information obtained from Welder's Company is classified as confidential (contractor). For example, a welder-related document could include:

- Health history,
- background, such as previous experience, and
- salary

2 RESEARCH METHODOLOGY

This chapter discusses the research methodology used in this study. In general, the study employs the pragmatism research paradigm in conjunction with the abductive research approach. Based on the sequential inquiry strategy, only qualitative and quantitative research methods were used. The survey and archival research strategies were chosen to answer the research questions. Welding reports and direct contact with the person in charge of the contractor company were used as primary data collection tools. The data was analyzed using a variety of statistical techniques, including descriptive and inferential statistics via Minitab, such as the Independent Sample T-Test, ANOVA, Chi-Square, Correlation Analysis, and Regression Analysis.

2.1 Data Collection Method

Data collection is the systematic gathering and analysis of specific information in order to provide answers to relevant questions and evaluate the results. It is concerned with locating all of the data collected in the Welding Department, such as the Daily Welding Report and a specific subject matter. There are two (2) ways to identify the data collection for this study:

a) archival data from a current and past project; and

b) direct contact with Welder's company.

2.2 Sample and Data Population

The defect length from each welder has been gathered and analyzed using the archived data obtained from the Welding Performance and Welder List results from previous project completion. Data from seven (7) current and past projects was analyzed and investigated. If the data was found to be incomplete, it was obtained by phone. This study includes the following projects:

1) Project Tembikai Non-Associated Gas (TNAG)-2018

2) Bokor Phase 3 Redevelopment Project-2018

3) Topsides of Sepat-2A Facilities-2017

4) Bekok AA and BB Jackets and Topside-2020

5) Project Pluto Water Handling Unit-2019

6) Bergading CPP MRU Integration Project (2020)

7) Kasawari Gas Development Project (2020)

The defect length from each welder has been gathered and analyzed using the archived data obtained from the welding performance and welder list results from previous project completion. Data from seven (7) current and past projects was analyzed and investigated. Welder Age (WA), Welding Defect (WD), and Welding Quality (WQ) are the variables at play. The research data was analyzed using data screening, descriptive analysis, and inferential statistics analysis.

2.3 Research Design

The Research Design assists and guides the researcher in analyzing, investigating, and interpreting the Archival Data. It defines the data required for this study, the method for gathering and analyzing it, and how it answered the Research Questions. In order to achieve the Research Objectives, three (3) Research Questions were addressed.

Table 2.1: Linkages between RO and RQ

No	Research Objective (RO)	Research Questions (RQ)
1.	RO-1: To investigate the relationship between Welder Age (WA) and Welding Quality (WQ).	RQ-1: What is the relationship between Welder Age and Welding Quality?
2.	RO-2: To investigate the relationship between Welding Defects (WD) and Welding Quality (WQ)	RQ-2: What is the relationship between Welding Type of Defects and Welding Quality?
3.	RO-3: To develop the model of the relationship between Welding Quality (WQ), Welding Defects (WD), and Welder Age (WA).	RQ-3: How do the Welding Defects and Welder Age relate and affect the Welding Quality?

2.4 Data Analysis

The Construction Date ranges from the year 2017 to the year 2020. All of the Welders are working from local contractors. The total data expected will be more than five hundred (>500) data from the Daily Welder Report and compiled and gathered for analysis. The results are presented in Results and Analysis. There are three (3) methods for Data Analysis in this study. The best methods to analyze this data are:

a) Data Screening,

b) Descriptive Analysis, and

c) Inferential Statistical Analysis

2.4.1 Data Screening

All of the data was screened and sorted to ensure that it was entered and input correctly. The first step in the data analysis was to screen for missing data, outliers, and normality. During the Data Screening or Data Sorting process, two (2) categories of Archival Data were identified: Incomplete Data and Complete Data.

a) Incomplete Data

All Daily Welding Summary data, including Defect Length and Welding Process, are included. The incomplete data will be retained as K.I.V. (Keep In View) and not kept for analysis. The passport number of a foreign welder must be included in the Welding List.

b) Complete Data

Data includes all Daily Welding Summary information, including Defect Length and Welding Process information, as well as passport and Welding Identification (I.D) details. Data includes Defect Length and Welding Process Information, as well as passport and I.D. details. Minitab is the best Statistical Tool because it is specifically designed for Six Sigma Analysis needs. The data will provide a simple, effective method for entering statistical data. For further analysis, all data will be identified as coding, and text will be converted to numbering.

2.4.2 Descriptive Analysis

Descriptive analysis provides word descriptions of products as well as measures of the intensities of each attribute. Descriptive analysis is a necessary first step in performing statistical analyses. It provides an idea of the data's distribution and aids in the detection of outliers and typos.

2.4.3 Inferential Analysis

Data Screening is the welding database obtained from the Welding Department, which was used to begin the Inferential Statistical Analysis with Minitab. Inferential statistical analysis deduces population properties, for example, by testing hypotheses and generating estimates. The analysis described as using data analysis to infer underlying probability distribution properties is known as statistical inferential analysis. Seven (7) methods used for this analysis are as follows:

a) Independent Sample T-Test

The Independent Sample T-Test is the statistic application used to analyze the difference between Welder Age (WA) and Welding Quality (WQ).

b) ANOVA

It is used to examine significant mean differences between more than two groups of variables which is Welding Age (WA) – there are four (4) types of ages. Welding Defects (WD) - there are seven (7) kinds of defects.

c) Correlation analysis

The purpose of the Correlation Analysis is to analyze the correlation between the variables in Research Objective is intended to investigate the relationship between the Welder Age (WA) and Welding Quality (WQ).

d) Chi-Square

The Chi-Square is used mainly to diagnose and distinguish between the variables in the Research Objective.

e) Regression Analysis

The analysis is intended to investigate the overall relationship between Welder Defects (WD), Welding Age (WA), and Welding Quality (WQ).

f) Kruskal-Wallis Test- Nonparametric

For this study, this application aims to analyze the two (2) groups of WA, WD, and WQ with different sizes. The statistic application compares two or more independent models of equal or different sample sizes

- Between WA versus WQ
- Between WQ and WD

g) Mann-Whitney Test- Nonparametric

For this study, this application aims to analyze the two (2) groups of WA, WD, and WQ with different sizes. The Mann-Whitney U test is used when the data is ordinal or when the assumptions of the t-test are not met.

- Between WA versus WQ
- Between WQ and WD

2.5 Summary of Research Design

The table below contains a summary of the Research Design.

Table 2.2: Summary of Research Design

Research objective / research question	Research philosophy		Research approach	Research choice	Research strategy	Time Horizon		Data collection method	Data analysis
	Knowledge assumption	Research paradigm							
RO-1/RQ-1	Epistemological	Pragmatism (Paradigm)	Abductive research approach (Associated the Deductive)	Single method	Qualitative and Quantitative	Archival & survey	Cross-sectional	Welding report & Direct contact	Data screening/ Descriptive Statistical analysis/ Inferential Statistical Analysis i.e. T-Test/ ANOVA/ Correlation/ Chi-Square/ Regression
RO-2/RQ-2						Archival & survey			
RO-3/ RQ-3						Archival & survey			

3 RESULTS AND DISCUSSION

3.1 Data Compilation Analysis

Normality tests are used in statistics to determine whether a data set is well-modeled by a normal distribution and to compute how likely it is for a randomly distributed variable underlying the data set to be a normally distributed population.

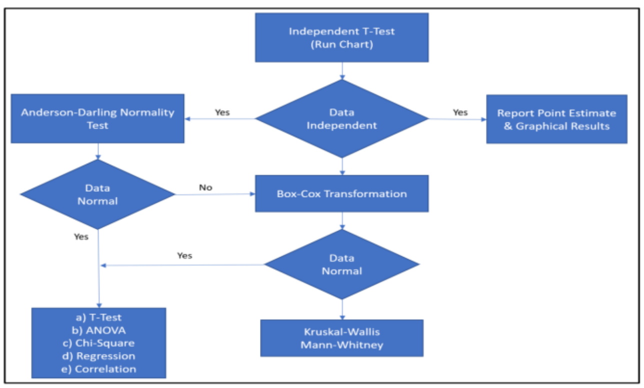


Figure 3.1: Process Flow for Data Analysis

3.2 1st Descriptive of WA- Graphical Summary

Minitab's Graphical Analysis is the best analysis for representing a graphical summary of the four (4) ranges of WA involved in the projects. The following are the summaries based on the Anderson-Darling Normality Test:

Table 3.1: Summary of Research Design

Project	N	P-value	Median	95% CI Mean	95% CI Median & Total
Bekok	72	<0.005	2	2~2.5	2 (35)
Bergading	31	<0.005	2	1.3~2	2 (15)
Bokor	227	<0.005	2	2~2.2	2 (104)
Kasawari	104	<0.005	2	1.7~2	2 (47)
Pluto	71	<0.005	2	1.5~2	2 (36)
Sepat	54	<0.005	2	1.4~2	2 (28)
Tembikai	2	<0.005	2	1.7~2.3	2 (15)
Total	591				

According to Table 3.1, all of the P-values for all Projects are less than 0.05. As a result, the Ho is rejected and the HA is accepted. The result shows that WA code 2 produces the best median for the abnormal data.

3.2.1 1st Descriptive of WA- Relationship between IV & DV

Schematic Diagram Relationship between IV and DV, the analysis was performed using the Anderson-Darling Normality Test, as shown in Table 3.1- WA Summary by Ages of Class. The results show that the median age ranges from 31 to 40 years old for the WA code-2. However, Graphical Analysis has also demonstrated that using Numerical Measure Analysis in the Tembikai Project at 34 to 40 years of age shows a normal data population with P-value>0.05.

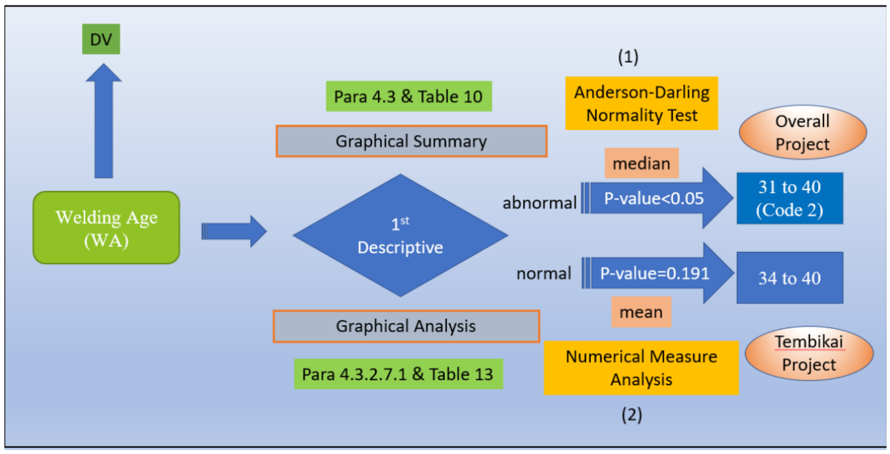


Figure 3.2: Schematic Diagram of WA

Table 3.1 shows that the group of welders aged 31 to 40 years (median) achieved the best group of welders that fit this Project using the Anderson-Darling Normality Test, despite the P-value of 0.05. In addition, Table 3.2 shows that the P-value is 0.191>0.05 using the Numerical Measure Analysis. As a result of using the mean as normal data, WA in the range of 34 to 40 is the best choice for the best Welder in the Tembikai Project.

Table 3.2: Summary of P-Value, Mean, and Median for WA versus Projects in Numerical Measure Analysis- Anderson-Darling

Project	N	%	P-Value	95% CI for Mean	95% CI for Median
Bekok	70	13	<0.005	36~40	34~39
Bergading	24	5	<0.005	34~41	34~39
Bokor	202	38	<0.005	38~41	36~38
Kasawari	94	18	<0.005	38~41	33~36
Pluto	62	12	<0.005	34~38	34~35
Sepat	43	8	<0.005	35~39	33~38
Tembikai	31	6	0.191	34~40	33~39
Total	526				

3.3 2nd Descriptive of WD

The WD summary using Microsoft Excel is the best analysis to represent the graphical summary of the WD. The summaries of WD are shown in Table 3.3 below:

Table 3.3 Summary of WD in the Projects

No	Welding Defect (WD)	Code Name	Code	N	%	Remark
1	No defect	No Defect (0)	0	245	47	None defect
2	Lack of Fusion	LOF (1)	1	92	17	Single
3	Lack of Penetration	LOP (2)	2	-	-	Single
4	Porosity	POR (3)	3	-	-	Single
5	Slag	SLAG (4)	4	37	7	Single
6	LOF/LOP	LOF LOP (12)	5	2	0.4	Combination
7	LOP/POR	LOP POR(13)	6	10	2	Combination
8	LOF/Slag	LOF SLAG (14)	7	70	13	Combination
9	LOP/ Slag	LOP SLAG (24)	8	1	0.2	Combination
10	POR/ Slag	POR SLAG (34)	9	5	1.0	Combination
11	LOF/LOP/Slag	LOF LOP SLAG (124)	10	12	2.0	Combination
12	LOF/POR/Slag	LOF POR SLAG (134)	11	24	5.0	Combination
13	LOP/POR/Slag	LOP POR SLAG (234)	12	2	0.4	Combination
14	LOF/LOP/POR/Slag	LOF LOP POR SLAG (1234)	13	7	1.0	Combination
15	Non-Active	NA(1)	111	19	4.0	Non-Active
Total			526			65 Welders without Age

The table above summarizes the WD discovered for this project. A single WD has a defect code of 0 to 4, and combination defects have a defect code of 5 to 13. A single defect is one that has been found only once, whereas combination defects are multiple defects discovered in the weldment during testing. In summary, there were a total of 245 welders who performed flawlessly throughout the construction process. There are 92 welders with LOF (1) or Lack of Fusion capacity for a single WD. Furthermore, there are 70 welders who use a combination of LOF and Slag (LOF/Slag). Overall, 526 welders worked with all of the subcontractors on this project, according to the project. It was also reported that 65 welders had incomplete data, such as ages.

3.3.1 2nd Descriptive of WD- Relationship between IV & DV

The Anderson-Darling Normality Test was used in the analysis Schematic Diagram Relationship between IV and DV, which is shown in Figure 3.3 Schematic Diagram of WD. Despite the fact that the P-value is <0.05, the results show that "No Defect" and "Lack of Fusion (LOF)" are the best criteria for Welding Defect (WD) relationship.

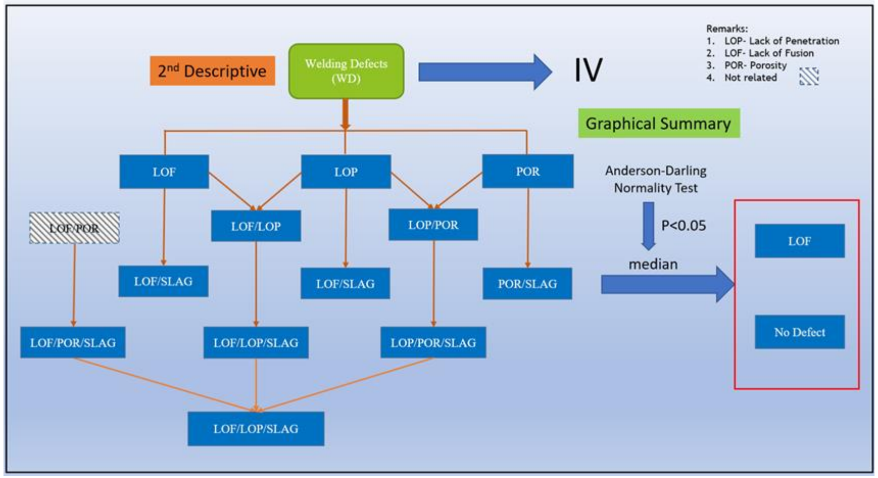


Figure 3.3: Schematic Diagram of WD

The analysis also reveals that Lack Fusion (LOF) and No Defect have the most defects in this project. As a result, management and the project team must identify the best solution and practice for reducing LOF. As a result, the schematic diagram has been updated to differentiate from the previous schematic diagram regarding the relationship between the WD and WQ.

3.4 3rd Descriptive of WQ

In Table 3.4, the Anderson-Darling Normality Test is used to determine whether the WQ data has a normal distribution or not. Because the data are abnormal, the majority of the P-values are less than 0.01. As a result, for the conclusion, the majority of the data are located at Code No.1~2 or 0.0 percent 1.0 percent.

Table 3.4: Summary of WQ in the Projects

Project	N	P-value	Median	95% CI for Mean	95% CI for Median
Bekok	72 (12%)	<0.005	1	1~2	1
Bergading	31 (5%)	<0.005	1	1~2	1~2
Bokor	227 (38%)	<0.005	2	1.5~1.7	1~2
Kasawari	104 (18%)	<0.005	2	1.5~1.7	1~2
Pluto	71 (12%)	<0.005	2	1.5~1.8	1~2
Sepat	54 (9%)	<0.005	2	1.5~1.8	2
Tembikai	32 (5%)	<0.005	2	1.3~1.7	1~2
Total	591				

3.4.1 3rd Descriptive of WQ-Relationship between IV & DV

Schematic Diagram Relationship between IV and DV, which is shown below in Figure 3.4 Schematic Diagram of WQ. Furthermore, the overall data shows that the majority of the data has a P-value of less than 0.05. In addition, the results show that WD at 0.0 percent and 0.01 percent to 1.0 percent have the best WQ relationship criteria.

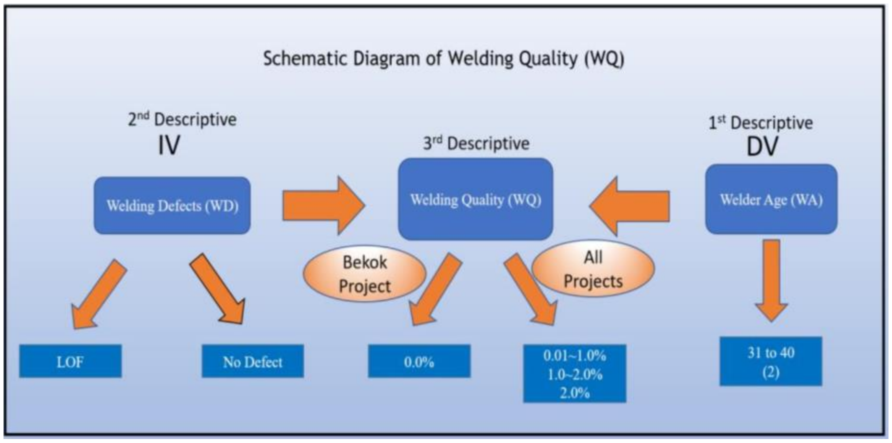


Figure 3.4: Schematic Diagram of WQ

Table 3.4 also demonstrates that the majority of Welders performed with the greatest skill and credibility to achieve zero or fewer defects, or a 0.0 percent to 1.0 percent Repair Rate during construction. When the welders performed "No Defect," the WQ or repair rate percentage achieved the highest quality or zero percent repair rate. Bekok Project indicates that the median for WQ is one (1) or 0.0 percent, and the overall Project, primarily the welding repair rate, is two (2) or 0.011.0 percent. At 31 to 40 years old, the WA or Dependent Variable (DV) has had a significant impact on this schematic diagram.

3.5 Numerical Measure Analysis

The collected data is analyzed using graphical and numerical statistical methods. The statistical method can also help in identifying the major causes of the process's total variation. The mean, median, mode, percentiles, range, variance, and standard deviation are the most commonly used numerical measures for quantitative data. The information analysis using the Numerical Measure Analysis for WA, WD, and WQ is shown below.

Table 3.5 10 Summary of P-Value, Mean, and Median for WA versus WQ (code)

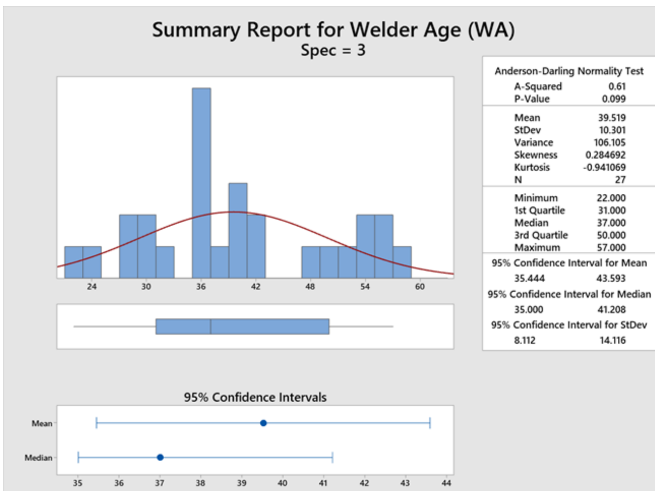
Repair Rate (%)	Code (WQ)	Defect Title	N	P-value	95% CI for Mean	95% CI for Median
0.0%	Spec=1	Zero Defect (WQ)	245 (47%)	<0.005	36~38	34~36
0.01% to 1.0%	Spec=2	Welding Quality (WQ)	235 (45%)	<0.005	38~40	35~38

> 1.0%	Spec=3	Welding Quality (WQ)	27 (5%)	0.099	35~44	35~41
NA	Spec=4	Non-Active	19 (4%)	<0.005	34~40	34~39
Total Welder		526	Total Welder with missing/ without Age		65	Grand/Total=591

Based on the data presented above, it is clear that:

The highest WD is Spec=1 (0.0 percent), with approximately 245 Welders posing non-defected during the projects. While Spec=3 (>1.0 percent) is the lowest number with only 27 Welders. Because the data has a normal distribution and the P-value is 0.099, Spec=3 most commonly occurred in WA between the ages of 35 and 44. Non-Active Welders range in age from 34 to 39 years old, with a total of 19 Welders. Total of 65 Welders with missing/unknown ages are mostly/mostly foreigners. Two (2) of the welders are from the local.

Chart 3.1 Anderson-Darling Analysis for WA versus Spec=3 in Minitab



Because of the difference in data median and mean, the result is not accessible to the relationship between WQ and WA, as shown in Table 3.6. When compared to Spec=3, the data distribution for Spec=1 and Spec=2 is abnormal.

Table 3.6: Relationship between WA versus WQ

Welding Quality (WQ)	Code	WA	
		95% CI for Mean	95% CI for Median
0.0%	Spec=1	36~38	34~36
0.01% to 1.0%	Spec=2	38~40	35~38
> 1.0%	Spec=3	35~44	35~41

WA at 34 years old is the best age to propose to Human Resource for upcoming project involvement because it demonstrates that this age group performed admirably during construction with no defects. 35 to 38, on the other hand, clashed and overlapped with Spec=3 (>1.0 percent). As a result, the age range of 35 to 38 is not ideal for management. However, analyzing the relationship between WA and WQ is critical because top management wants to know the best range of WA for their best team for the project.

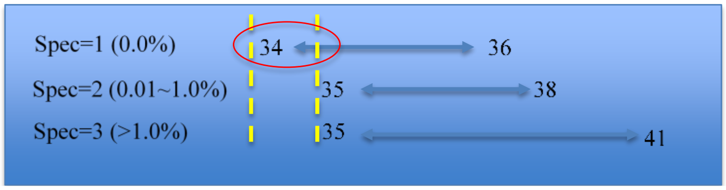


Figure 3.5: The Graphic Data between WA and WQ

3.5.1 Numerical Measure Analysis-Relationship between WA versus WD

The WD code in Minitab has been created to analyze the relationship with WA. According to WD, codes 0 to 4 are single defects, while codes 5 to 13 are combination defects. As a result, because the majority of the P-values are less than 0.05, we will conclude that the WD and WA have no relationship in this study. However, we would like to advise human resources and management that the best age to recruit at is 34 to 36 years old because the repair rate is zero percent even if the data distribution is abnormal. Table 3.7 shows that, even though the P-value is less than 0.05, age 34 to 36 is the main contributor to No Defect (0) at 95 percent CI for a median.

The detailed description of WD is provided below:

i) Welding Flaws (Codes 1–4): Typically, this defect occurs when the NDT prop (UT machine) detects a single WD only at the weldment. During the inspection, no other defects were discovered.

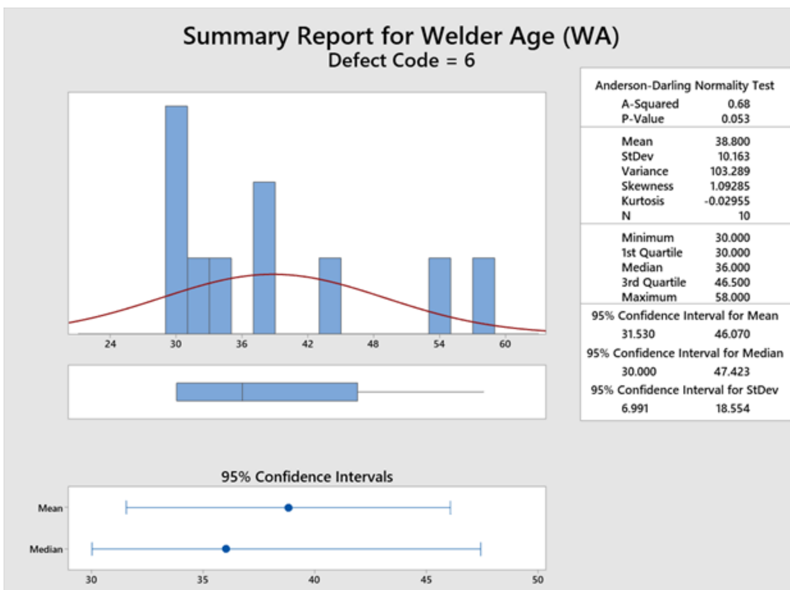
ii) WD (Codes 5–13): This defect is referred to as a combination defect because it contradicts the WD Codes 1 through 4. When the welder does not properly treat the weldment in sound-weld, multiple flaws can occur. Typically, the flaws or imperfections are located very close to or overlapped with one another.

Table 3.7: Relationship between WA versus WD

Code Name (WD)	Code	N	%	P-Value	95% CI for Mean	95% CI for Median
No Defect (0)	0	245	47	<0.005	36~38	34~36
LOF (1)	1	92	17	<0.005	36~39	34~38
LOP (2)	2	-		-	-	-
POR (3)	3	-		-	-	-
SLAG (4)	4	37	7	0.012	37~42	35~43
LOF LOP (12)	5	2	0.4	35~47		
LOP POR(13)	6	10	2	0.053	32~46	30~47
LOF SLAG (14)	7	70	13	<0.005	37~42	35~40

LOP SLAG (24)	8	1	0.2	31		
POR SLAG (34)	9	5	1	0.218	31~51	34~54
LOF LOP SLAG (124)	10	12	2	0.381	40~52	37~55
LOF POR SLAG (134)	11	24	5	0.094	34~39	33~39
LOP POR SLAG (234)	12	2	0.4	28~31		
LOF LOP POR SLAG (1234)	13	7	1	0.861	32~47	31~48
NA(1)	111	19	4	<0.005	34~40	34~39
Total	-	526	-	-	-	-

Chart 3.2 Anderson-Darling Analysis for WA versus WD=6 in Minitab



3.5.2 Numerical Measure Analysis- WQ versus WD

The below table depicts the relationship between WD and WQ, where WD is represented by a single defect or a combination of defects. The table in 2nd Descriptive of WD, provides more information on the list of WD, whether single or combination imperfections. The No Defect (0) WD code has the highest total number, N of WD, followed by LOF (1) and LOF/ slag (7). During the construction, only eight (8) numbers of the WD code LOF/LOP/POR/Slag (13) were detected. The table below details the relationship between WD and WQ. The relationships depict the categorization of the number of passed and failed defects.

Table 3.8: Relationship between WQ and WD-Code, Percentage, Passed, and Failure

WQ Code	%	WD	N	Remarks

1	0.0%	No Defect(0)	290		Passed
2	0.01~1.0%	LOF(1)	86	252	Passed
		Slag(4)	34		
		LOF/LOP(12)	2		
		LOP/POR(6)	11		
		LOF/Slag(7)	69		
		LOP/Slag(8)	1		
		POR/Slag(9)	5		
		LOF/LOP/Slag(10)	13		
		LOF/POR/Slag(11)	22		
		LOP/POR/Slag(12)	2		
		LOF/LOP/POR/Slag(13)	7		
3	>1.0%	LOF(1)	13	30	Failed
		Slag(4)	3		
		LOF/Slag(7)	9		
		LOF/POR/Slag(11)	4		
		LOF/LOP/POR/Slag(13)	1		
4	N/A	N/A	19		Not active
		Total	591		Passed:542 (92%) Failed: 30 (5.1%)

3.5.3 Numerical Measure Analysis-WA, WD, and WQ

Total 245 Welders were performed during the construction, making 0.0% of Repair Rate (WQ). While 235 welders possessed 0.01~1.0% in Spec=2 and 27 welders are failed due to more than 1.0% of repair rate.

a) Total 45 welders are WD Spec=1 which is 0.0%

b) Total 17 welders are WD Spec=2 which is 0.01%~1.0%

c) The total of three welders are WD Spec=3 which is >1.0

Table 3.9: Relationship between WA, WD, and WQ including welder without/ with the Age

WQ	WQ Code	WD Code	Total N Overall (Included WA without Age)			Total N (Excluded WA without Age)		Remark
			N		Age	N	Age	
0.0%	Spec=1	0	290 (49%)		-	245 (47%)	21~60	65 Welders are
0.01~1.0%	Spec=2	1	86	252 (43%)	-	235 (45%)	22~62	
		4	34					
		5	2					
		6	11					
		7	69					

		8	1					without the age. Two (2) amongst them are local
		9	5					
		10	13					
		11	22					
		12	2					
		13	7					
>1. 0%	Spec=3	1	13	30 (5%)	-	27 (5%)	22~57	
		4	3					
		7	9					
		11	4					
		13	1					
NA	Spec=4	111	19 (3%)		-	19 (4%)	30~53	
Total			**591**			**526**		

3.6 Inferential Statistical Analysis

Inferential Statistical Analysis is defined in Paragraph 2.4.3 as methods concerned with analyzing a subset of data (sample) in order to make predictions or inferences about the entire set of data (population). Seven (7) statistical methods are the best method for the Statistical Analysis based on the Inferential Statistical Analysis.

3.6.1 Regression Analysis in Minitab- WA, WD, and WQ

A Regression equation is generated to describe the statistical relationship between one or more predictor variables and the response variable. For example, according to Research Design in Paragraph 2.3 & Table 2.1, RO-3, Objective Regression Equation between WA, WD, and WQ is as follows.

Regression Equation

Spec (WQ) = 1.3292 + 0.02522 Defect Code (WD) + 0.0724 Welder Age (WA) Code

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.3292	0.0456	29.16	0.000	
Defect Code (WD)	0.02522	0.00112	22.57	0.000	1.00
Welder Age (WA) Code	0.0724	0.0203	3.57	0.000	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.527647	47.63%	47.45%	47.19%

Figure 3.6: Regression Analysis between WA, WD, and WQ with Minitab

P-value ≤ α: The relationship is statistically significant. In this case, the P-values are 0.00 (constant), 0.00 (WD), and 0.010, as shown in Figure 4.18. (WA). Assume, however, that the P-value is less than or equal to the significance level (α =0.05). In that case, the regression coefficient between WD, WQ, and WA with R-sq is approximately to reach 48%, indicating a statistically significant relationship between the response variable and the term.

3.6.2 Regression Equation and 3D Graphic View

Based on the Minitab software analysis of the above data gathered in Excel, the information concluded that the Regression Equation has approved the result is almost accurate. As a result, the Minitab Regression Equation can be used to create a Model of Analysis for this study. Using GeoGebra 3d Calculator, the 3D model of Regression Equation is used to generate the 3D view from the equation. Figures 3.7 and 3.8 depict the equation's top and side views, respectively.

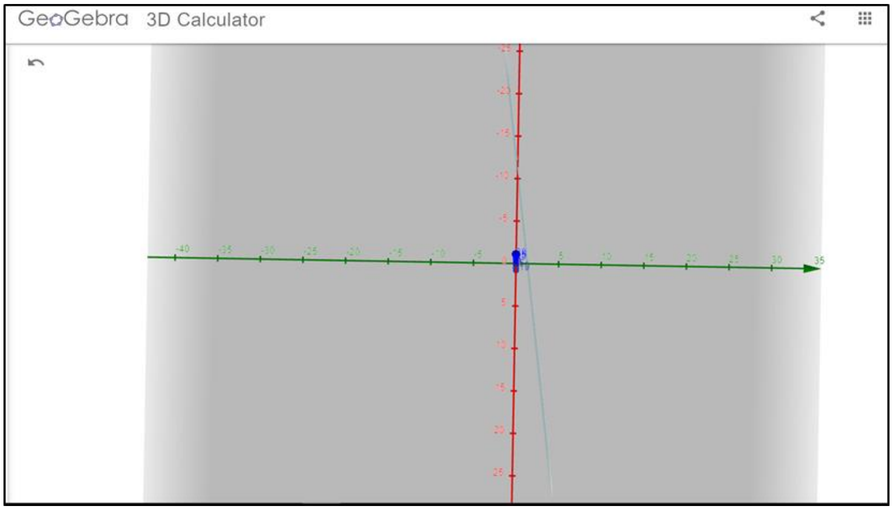


Figure 3.7: Top View of 3D model of Regression Equation using GeoGebra 3D Calculator

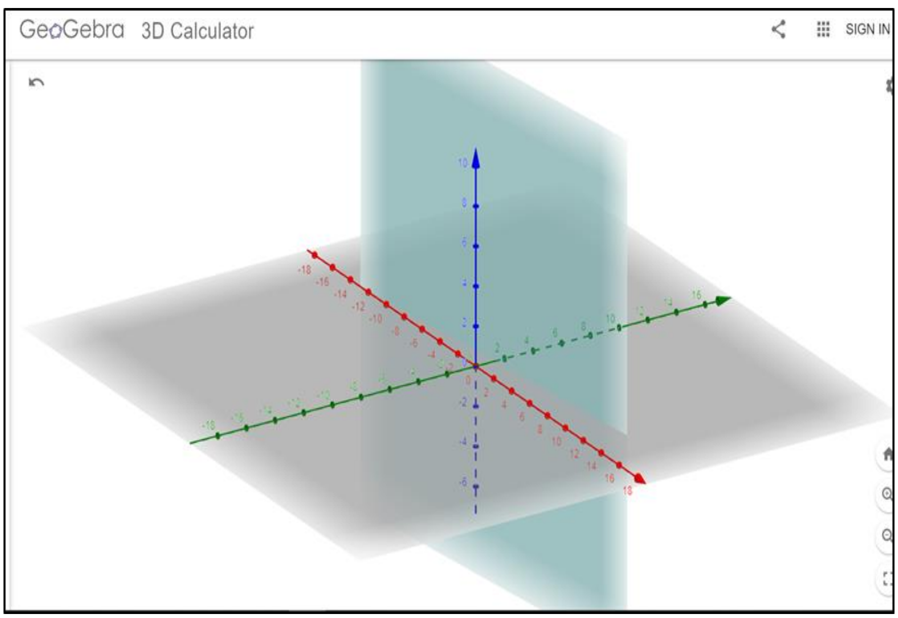


Figure 3.8: Side View of 3D model of Regression Equation using GeoGebra 3D Calculator

4 CONCLUSION

This chapter aims to conclude the research that began with the limitation to the study of the Welder Age on Welding Quality during the construction of the off-shore structure in MMHE. Following that, this chapter discussed the research's limitations and recommendations for future research. Finally, the final section brings the chapter to a close.

4.1 Implication of the Study

In terms of how they affected the overall outcome of the project analysis, the findings made a few contributions to the WA. Aside from the welder's background and hiring experience, the study provided management with additional recruiting procedures, guidelines, and a framework. Welder qualification tests should also be made more stringent by assigning more supervisors to oversee the welding qualification tests. The welder's background information, including identification number and age, must be included in the qualification test result. The Daily Welding Report is the same and shows the total number of joint numbers and defects completed by the welder on a daily basis. The report, however, does not imply that the welder's age be monitored for analysis. The study also shows that the WD of LOF and LOF/SLAG percentage is the highest defect; thus, this implication proves that cleanliness to remove welding slag is critical during the welding process. All data preservation is necessary to prevent data loss and demonstrate how archival data from current and previous projects is stored and preserved in a systematic manner.

Welders who work on construction sites must be in good physical and mental health. According to Qin, J. et al. (2014), welders are exposed to a variety of occupational hazards during welding, including dust, heavy metals, fluoride, ozone, nitrogen oxides, carbon monoxide, and noise, as well as ultraviolet rays [2]. As a result, when making hiring decisions, project management and human resources must consider healthcare. According to Ramzam M. et al. (2014), compensation such as salary, rewards, indirect compensation, and employee performance are critical for employee performance [3]. The main limitation of this study is that it only looks at the banking industry. As a result, specific research on welder performance should include both the welder and the heavy engineering construction worker, particularly in the oil and gas sector.

4.2 Research Limitation

This study has a few limitations that should be highlighted. First, insufficient data was gathered through vendor submission, particularly regarding the age data of the foreign welder. The incomplete information was kept as KIV in Figure 3.1 and was not included in the data analysis, particularly in WA. The welder who works with the subcontractor also lacks the necessary information to complete the entire study. The subcontractor struggled to provide complete cooperation because some of the data were difficult to locate due to technical issues with the archive information. Second, due to incomplete data, approximately eleven (11) percent, or 65 welders, from the data collection were excluded from the study. The missing numbers were excessively large and had a minor impact on the data analysis. Because the majority of the data was also discovered, the privacy and sub-contractor were hesitant to submit our salary, overtime, and bonus references.

4.3 Future Recommendation

Implementing Six Sigma Methodology as an improvement approach in welding activity is suggested for future improvement [4]. Furthermore, implementing the appropriate statistical technique by using the Minitab and SSPS software in the Welding Department to analyse the data provided from the inspection is highly recommended. The auditing team should play a critical role in ensuring that the company and the subcontractor have a secure location to protect and store data. It is recommended that the Quality Team and the Welding Department ensure that the Welder Age analysis is carried out. It is also critical that the welder's identification, particularly if he is a foreign welder, be included, along with his or her age. The age of the welder must also be stated in the Welding Daily Report (WDR) in order to easily track local and foreign welders. The NA (Non-Active) Welder study should be expanded and included in future research. Weekly and monthly data for welder health are also important to analyse in order to obtain more informative data from the Safety Department. It is also preferable to obtain more detailed information about WA, WD, and WQ; data collection necessitates additional data analysis from the Welding Department from a previous project completed at MMHE. This information is required to analyse all of the characteristics of the total number of welders, defects, and welding process types involved in the repair rate.

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