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Study of Rail Defect in Klang Valley Double Track

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Abstract:
Significant challenges to the safety and efficiency of railway systems are posed by rail defects because there is a lack of specific analysis and comprehension of the root causes and trends of these rail defects. This study uses the data of rail flaw detection car (RFDC) in 2018,2019 and 2020 to analyze data of rail defects. Rail defect trend and root cause analyses are also performed to determine the underlying causes that have contributed to the occurrence of these defects. A research study conducted on seven types of rail defects in KVDT found that defective weld head was the most common defect, followed by engine burn fractures and transverse defects. The trend analysis of rail defects showed that defective weld head and engine burn fractures have increased in recent years, while transverse defects have decreased. This suggests that the most significant rail defects are changing over time, and that continuous monitoring and mitigation measures are needed to address the most pressing issues.

Keywords: Rail Defect, KVDT, Rail Flaw Detection Car (RFDC)

1. Introduction

The Klang Valley Double Track (KVDT) is a important part of regional transport, connecting crucial areas and facilitating the movement of passengers and products. However, rail defects pose significant challenges to the railway system's safety, efficiency, and dependability. Rail defects will cause problems to train operation in KVDT.

Numerous varieties of rail defects afflict the KVDT railway track, posing a significant threat to the safety and effectiveness of train operations. Broken rails stand out among these defects because of their

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**Corresponding author: joewono@uthm.edu.my* potential to cause derailments, service interruptions, and accidents, thereby endangering the safety of passengers and railway personnel. Broken rails are still pervasive throughout the entire rail network, despite ongoing maintenance efforts. However, there is a significant deficiency in the analysis and comprehension of the fundamental causes and tendencies of these rail defects. This restriction hinders the development of effective preventive and corrective measures necessary to resolve the issues and assure the long-term safety and integrity of the railway track.

The analysis of Rail Flaw Detection Car (RFDC) reports from 2018, 2019, and 2020 reveals the categories and number of rail defects, which can be used to prioritize maintenance and repair efforts. This study also acknowledges the importance of utilizing data analysis techniques, to identify trends and root courses of the rail defect.

Therefore, it is necessary to investigate and analyze the data collected from the rail flaw detection car (RFDC) to identify the trend, the root cause of rail defects and implement effective preventive maintenance strategies at KVDT in order to develop strategies and interventions for reducing and mitigating rail defects, thus improving the overall safety, efficiency, and sustainability of the railway system.

2. Materials and Methods

In order to conduct a comprehensive and successful research study, it is crucial to select a clear and well-defined methodology. The chosen methodology serves as a guiding framework that integrates various technical, commercial, and managerial aspects of the study. By following a structured research methodology, the researcher is equipped with the necessary knowledge and skills to effectively address the complexities and challenges of a rapidly evolving decision-making environment.

In this particular project, the focus is on studying rail defects in the KVDT railway system. The research methodology will outline the step-by-step process of identifying the trend of track defects, analyzing the root causes of rail defects, and implementing an effective preventive maintenance strategy.

The methodology will provide a systematic approach to gathering data, conducting analyses, and drawing meaningful conclusions. Figure 1 illustrates the research process, highlighting the key steps involved in achieving the research objectives.

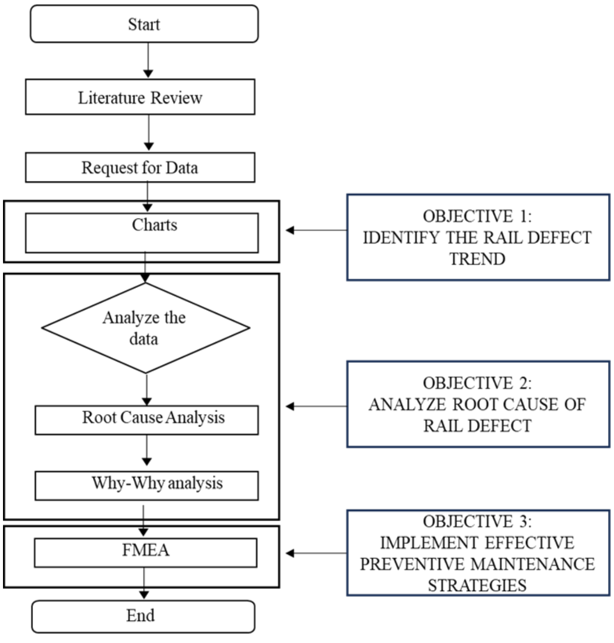


Figure 1: Methodology flowchart

2.1 Line Chart

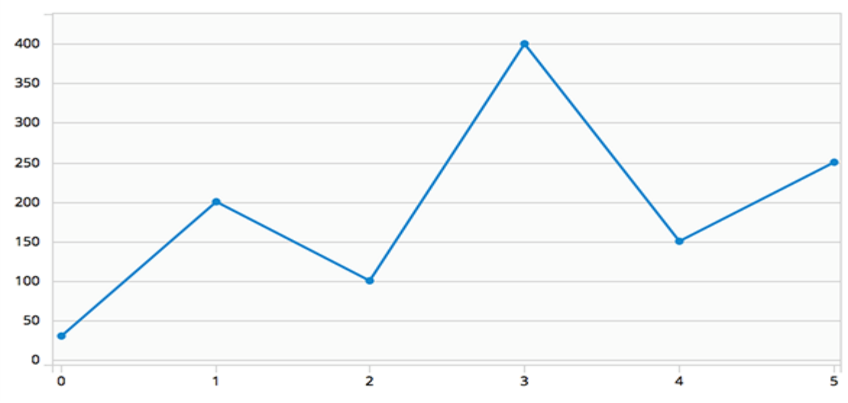


Figure 2: Line Chart

For this project, line chart is use to identify the rail defect trend in 2018,2019-, and 2020.A-line chart is the most effective visual representation of time-dependent variables [1]. In addition, it is the preferable method for representing trends or variables over time. People are acquainted with this straightforward chart, which consists of data values depicted as points along the X and Y axes and connected by line segments. Typically, time is depicted along the X-axis, and the Y-axis represents an important metric relative to the period being tracked.

2.2 Pareto Chart

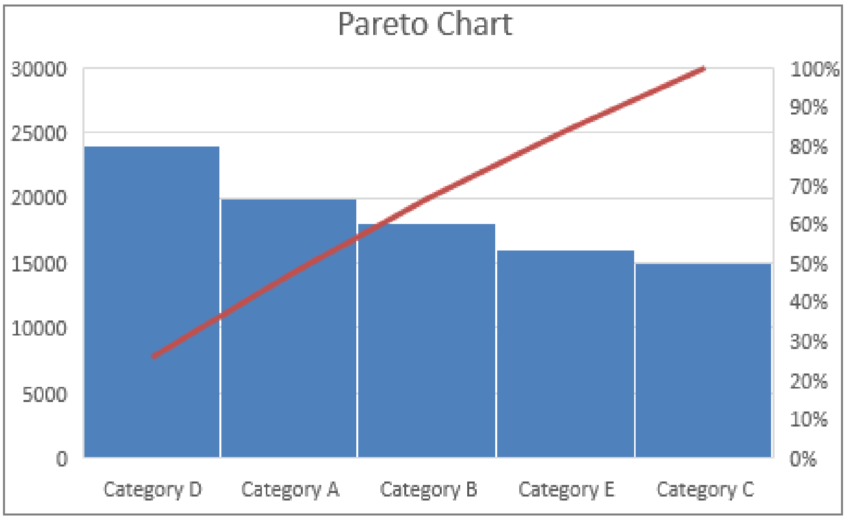


Figure 3: Pareto Chart

The Pareto principle describes a phenomenon in which 80 percent of variation observed in everyday processes can be explained by a mere 20 percent of the causes of that variation [2], [3.] A Pareto chart is used for this project to detect and monitor trends in the various types of defects in KVDT. The purpose of the Pareto Chart is to collect data on track defects and classify them according to the categories or causes of the defects.

On the graph, the cumulative percentage is shown on the horizontal axis, while the defects with the greatest frequencies are plotted on the vertical axis. To interpret the Pareto chart effectively, attention should be given to the point where the cumulative percentage curve starts to level off. This indicates a potential breakpoint, suggesting a critical defect or category that deserves special attention.

2.3 Root Cause Analysis

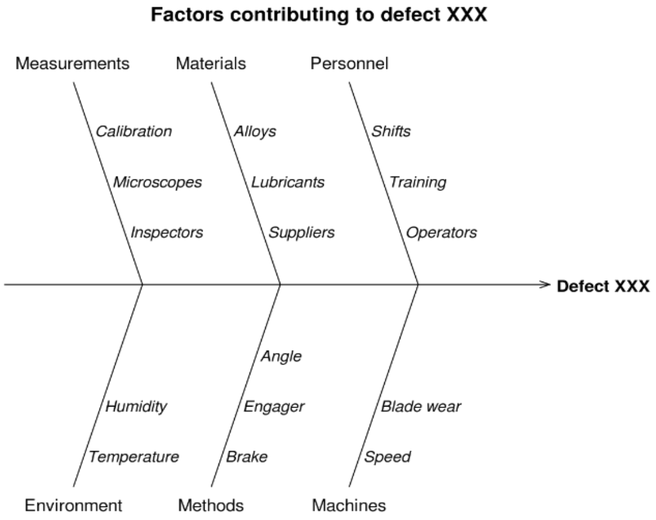
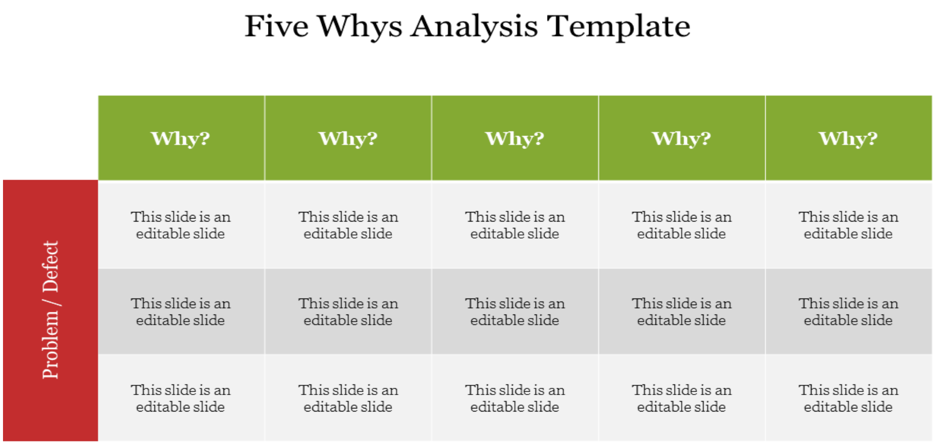


Figure 4: Root Cause Analysis

Root cause analysis is a structured and systematic approach that aims to delve deep into the factors and events that lead to the occurrence of a rail defect in KVDT. It involves thoroughly examining all the contributing elements, such as faulty welding practices, inadequate maintenance procedures, or external factors like environmental conditions. By identifying the root cause, which is the fundamental underlying issue or trigger, it becomes possible to develop targeted and effective solutions to address the specific problem at its core [4]. This comprehensive analysis allows for a deeper understanding of the entire chain of events and factors that culminate in a rail defect.

2.4 Why-Why Analysis



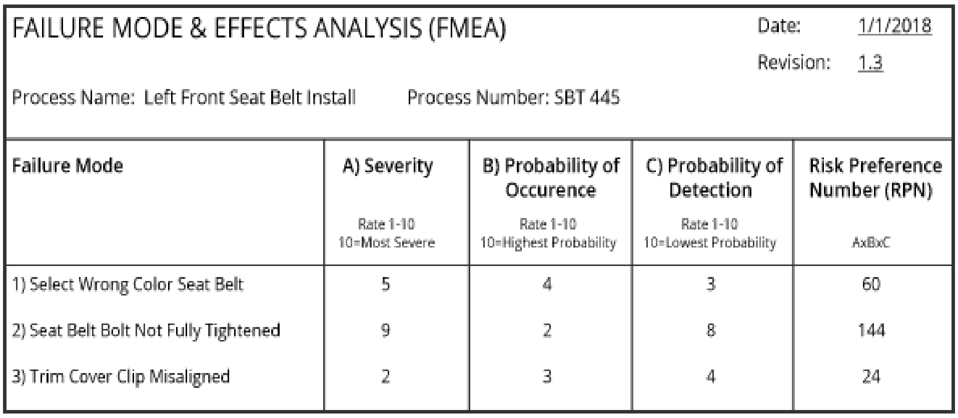
Five Whys Analysis Template

	Why?	Why?	Why?	Why?	Why?
Problem / Defect	This slide is an editable slide	This slide is an editable slide	This slide is an editable slide	This slide is an editable slide	This slide is an editable slide
	This slide is an editable slide	This slide is an editable slide	This slide is an editable slide	This slide is an editable slide	This slide is an editable slide
	This slide is an editable slide	This slide is an editable slide	This slide is an editable slide	This slide is an editable slide	This slide is an editable slide

Figure 5: Why-Why Analysis

The "5 Whys" technique is then applied to explore the cause-and-effect relationships related to the rail defect in KVDT. Starting with the observable problem, investigators ask "why" it occurred. Each answer leads to the subsequent "why" question, investigating deeper into the underlying causes until the root cause is uncovered [5]. This iterative process helps uncover multiple contributing factors and reveals the interconnected nature of the issues.

2.5 Failure Mode & Effects Analysis (FMEA)



FAILURE MODE & EFFECTS ANALYSIS (FMEA)

Date: 1/1/2018
Revision: 1.3

Process Name: Left Front Seat Belt Install   Process Number: SBT 445

Failure Mode	A) Severity Rate 1-10 10=Most Severe	B) Probability of Occurence Rate 1-10 10=Highest Probability	C) Probability of Detection Rate 1-10 10=Lowest Probability	Risk Preference Number (RPN) AxBxC
1) Select Wrong Color Seat Belt	5	4	3	60
2) Seat Belt Bolt Not Fully Tightened	9	2	8	144
3) Trim Cover Clip Misaligned	2	3	4	24

Figure 6: Failure Mode & Effects Analysis

Failure Modes and Effects Analysis (FMEA) is a tool for conducting a systematic, proactive analysis of a process in which harm may occur [2], [6]. Failure Modes and Effects Analysis (FMEA) is a systematic approach that enables the identification and evaluation of potential failure modes and causes for rail defects in KVDT. Additionally, FMEA enables the prioritization of failure modes based on their severity, occurrence probability, and detectability. This allows resources to be allocated efficiently, focusing on high-priority failure modes that pose significant risks.

3. Results and Discussion

The data has been collected to plot the defects trend for each defect in KVDT. This chapter also discuss on the defect's root cause using a few methods. The implementation of corrective maintenance for build-up process also has been reviewed and the problems, obstacles and challenges while the implementation also has been discovering and will be discuss briefly in this chapter. There are also failure modes and effects analysis study at the end of the research.

3.1 Summary the Types of Rail Defect

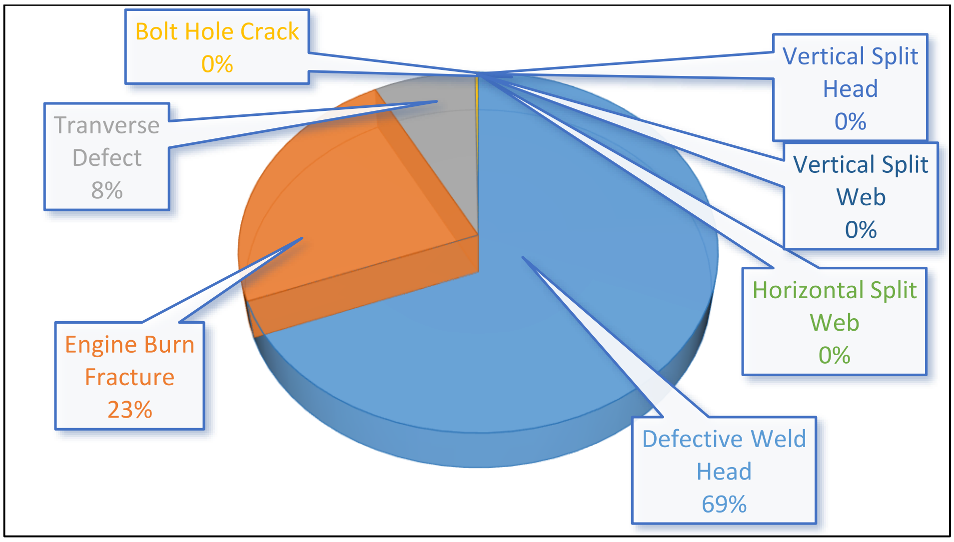


Figure 7: Pie Chart Types of Rail Defects for Overall Year

Figure 4.2.1 above shows the types of defects for the overall year. In this research, the researcher has found 7 types of rail defect, engine burn fracture, transverse defect, defective weld head, vertical split head, horizontal split web, vertical split web, and bolt hole crack. From the data recorded, the highest defect is a defective weld head. This defect tends to occur in KVDT track, followed by transverse defect, engine burn fracture and bolt hole crack.

3.2 Number of Rail Defect

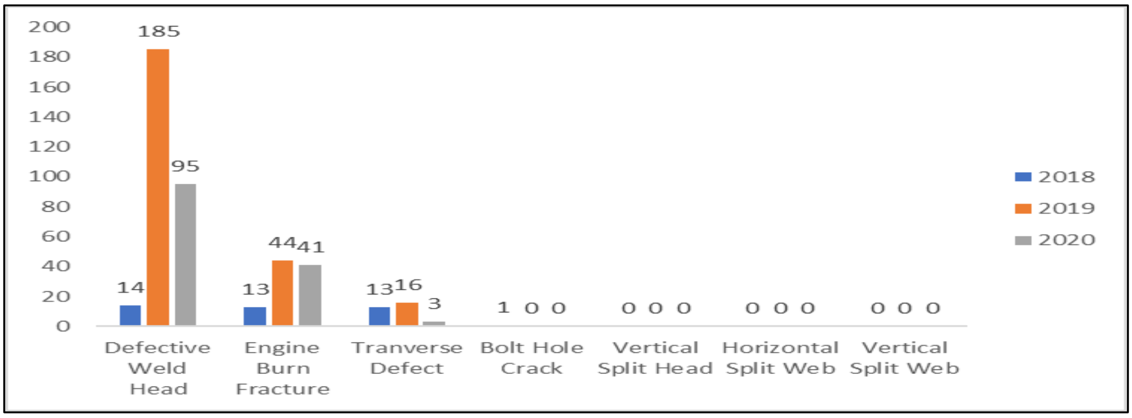


Figure 8: Bar Chart Number of Rail Defects in 2018,2019 and 2020

Based on the findings presented in Figure 8, an analysis of rail defects related to defective welded heads revealed a total of 14 defects in 2018, 185 defects in 2019, and 95 defects in 2020, resulting in a cumulative total of 294 defective weld heads. In the case of engine burn fractures, there were 13 reported defects in 2018, 44 defects in 2019, and 41 defects in 2020, making a combined total of 98 defects over the three-year period. Similarly, transverse defects accounted for 13 defects in 2018, 16 defects in 2019, and 3 defects in 2020, with a total of 32 defects observed throughout the study. On the other hand, bolt hole cracks were identified in only one instance in 2018, and no instances were recorded in 2019 or 2020. Furthermore, no existences of vertical split head, horizontal split web, or vertical split web defects were reported. Overall, the total number of rail defects amounted to 41 in 2018, 245 in 2019, and 139 in 2020, resulting in a cumulative total of 425 defects across all categories

3.3 Defect Trend

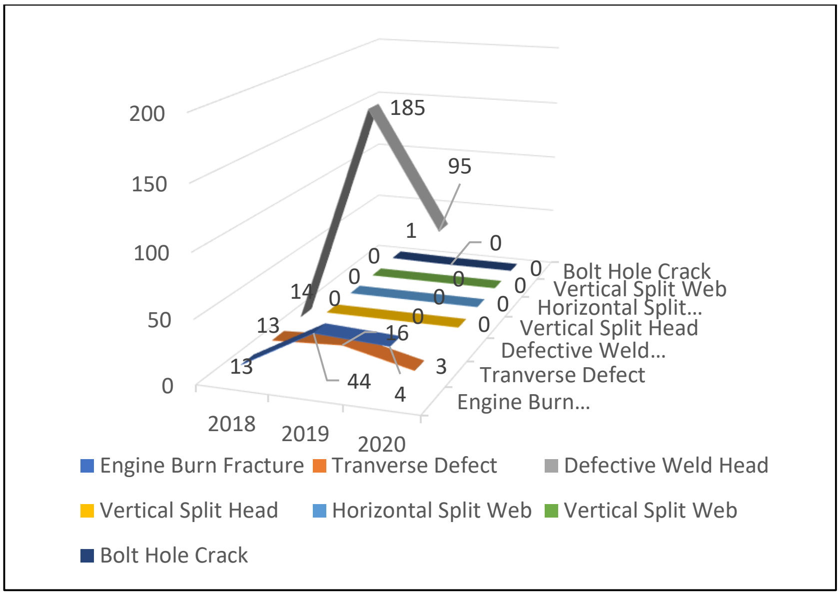


Figure 9: Line Chart Defect Trend

In the year 2018, there were 14 reported defects of Defective Weld Head, followed by 185 defects in 2019, and 95 defects in 2020. Engine Burn Fracture had 13 reported defects in 2018, which increased to 44 in 2019, and then slightly decreased to 41 in 2020. Transverse Defect had 13 defects in 2018, 16 defects in 2019, and only 3 defects in 2020. Bolt Hole Crack had 1 reported defect in 2018 and no reported defects in both 2019 and 2020. No cases of Vertical Split Head, Horizontal Split Web, and Vertical Split Web defects were reported in any of the years.

3.4 Pareto Chart of Defects

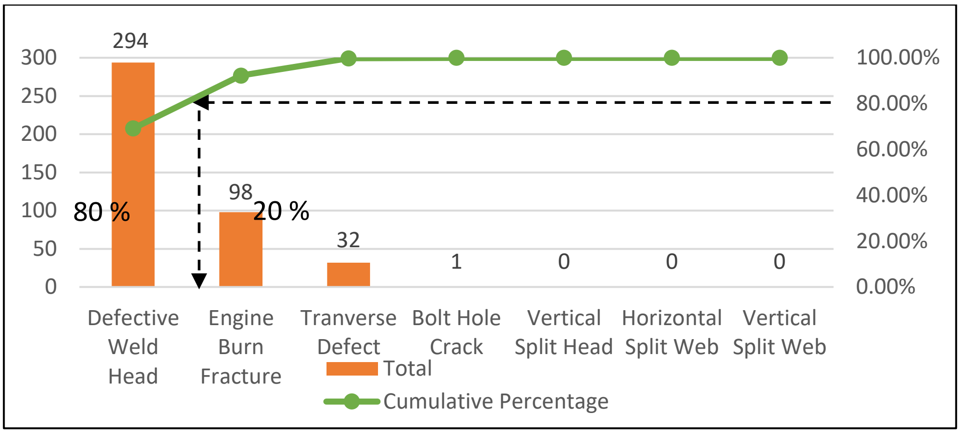


Figure 10: Pareto Chart Relationship Between Defects and Its Frequency

According to the 80% principle, it is important to focus on the categories that cover 80% of the defects, which in this case is Defective Weld Head. However, even though Engine Burn Fracture and Transverse Defects individually don't contribute to the 80% cumulative percentage, they still have significant importance in the context of rail defects. Ignoring these categories would overlook important safety and operational concerns. Therefore, a comprehensive analysis of all rail defect types, including Engine Burn Fracture and Transverse Defects, is crucial for effective maintenance and improvement of track conditions.

On the other hand, Bolt Hole Crack has minimal occurrence and negligible impact on the overall number of rail defects. It won't be considered a significant factor in this analysis. Instead, the focus should be on categories like Defective Weld Head, Engine Burn Fracture, and Transverse Defects, which have a more substantial influence on the number and severity of rail defects. By prioritizing these categories, resources and efforts can be efficiently allocated to address the key issues and enhance the overall condition and safety of the railway track.

3.5 Root Cause Analysis

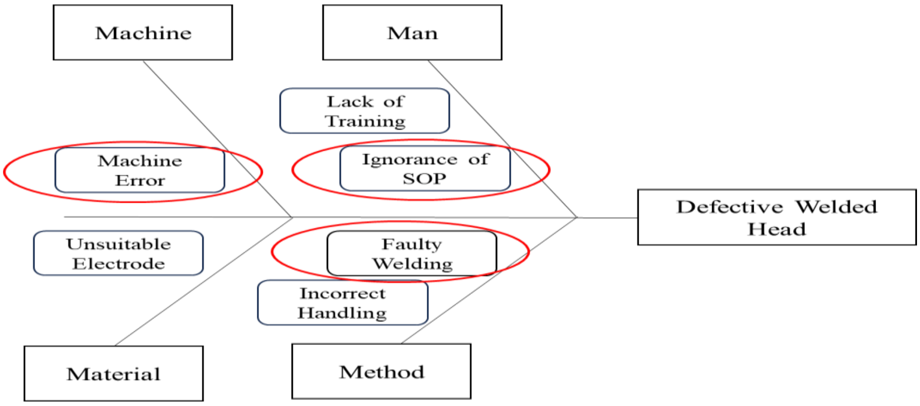


Figure 11: Root Cause Analysis for Defective Weld Head

Defective weld heads are rail faults that occur due to various reasons, such as lack of training, failure to follow standard procedures, machine errors, improper handling, and the use of inappropriate welding electrodes. These factors can lead to structural or integrity-related defects in the weld joints of rail sections.

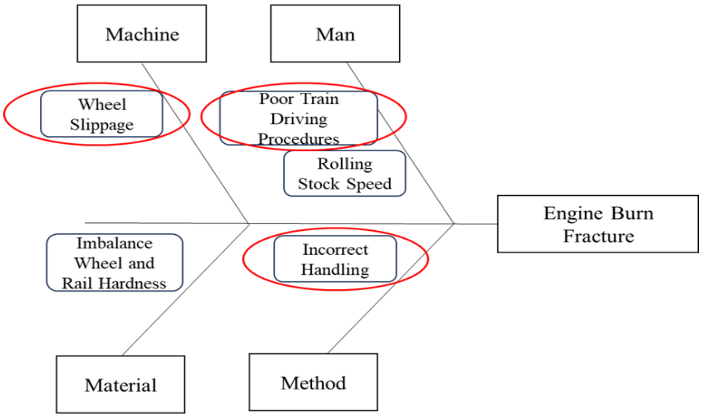


Figure 12: Root Cause Analysis for Engine Burn Fracture

Engine burn fractures, another type of rail defect, are caused by poor train driving procedures, high speeds, wheel slippage, incorrect handling, and an imbalance between wheel and rail hardness. These factors contribute to excessive stress, overheating, and tension concentrations on the rail, leading to progressive fractures.

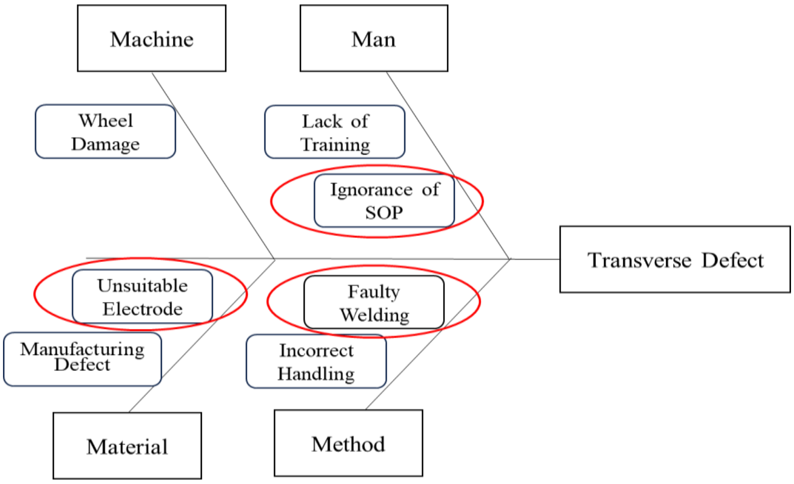


Figure 13: Root Cause Analysis for Transverse Defect

Transverse defects in rails occur perpendicular to the rail direction and can be attributed to insufficient training, failure to follow procedures, wheel damage, faulty welding techniques, improper handling of equipment and materials, the use of unsuitable electrodes, and manufacturing flaws in the rail material.

3.6 Failure Modes and Effects Analysis (FMEA)

Table 1: The Data Details and Information with Risk Priority Number

No	Risk	Risk Priority Number	Action
1	Incorrect handling	18	Neglect
2	Manufacturing Defect	18	
3	Machine Error	24	
4	Wheel Damage	24	

5	Ignorance of SOP	36	Monitoring
6	Lack of Training	36	
7	Incorrect Handling	36	
8	Unsuitable Electrode	36	
9	Rolling Stock Speed	36	
10	Incorrect Handling	36	
11	Lack of training	45	
12	Imbalance Wheel and Rail Hardness	48	
13	Ignorance of SOP	48	
14	Faulty welding	48	
15	Faulty Welding	60	Solve
16	Poor Train Driver Procedures	60	
17	Wheel Slippage	64	
18	Unsuitable Electrode	64	

Table 2: The FMEA Table for Selected "Solve" Risk with its Risk Response

No	Failure Mode	Category	Root Causes	Risk Response
1	Defective Weld head	Method	Faulty Welding	a) PIC need to monitor the welder
				b) Training for new welder
				c) Inspection personnel to focus more
2	Engine Burn Fracture	Man	Poor Train Driver Procedure	a) Enrol in training course
				b) Physical and mental fitness
		Rolling Stock	Wheel Slippage	a) Change new wheel
				b) reprofile the wheel
3	Transverse Defect	Method	Unsuitable Electrode	a) Recall and check current electrode
				b) PIC need to ensure suitable electrode

Based on the Failure Modes and Effects Analysis Table 1, the researcher will divide the risk into the 3 categories, Solve, Monitoring and Neglect according to the Risk Priority Number. Rail defects falling within the range of 0 to 30 should be neglected, those between 31 and 50 should be monitored, and any defects with a value of 51 and above should be addressed and solved. The 'solve' categories require for immediate action to ensure the risk not repeatedly occurs with red colour highlighted. Meanwhile, the rest highlighted with yellow and green each.

4. Conclusion

In conclusion, this project has successfully examined rail defects in KVDT, identified their trends and root causes, and proposed effective preventive maintenance strategies. The findings provide valuable insights for improving safety and efficiency in railway operations. The most common rail defects were defective weld heads, engine burn fractures, and transverse defects. While these defects may have lower ratios, they still have a significant impact and should not be neglected. By addressing issues related to welding methods, training, train driving procedures, wheel damage, and suitable electrodes, the occurrence of rail defects can be reduced. This project emphasizes the importance of monitoring, training, and implementing risk responses in the Method, Man, and Machine categories to mitigate the risks associated with rail defects. Implementing these measures will contribute to safer and more efficient railway operations.

Lastly, there are several recommendations for future studies in this project. Firstly, it is suggested to investigate rail defects in other railway systems and tracks to gain a comprehensive understanding of their occurrence and patterns across different regions. This comparative approach would help identify specific factors that contribute to rail defects and facilitate the development of targeted prevention strategies. Secondly, incorporating alternative non-destructive testing methods alongside ultrasonic testing can improve the accuracy of defect identification by detecting surface flaws and irregularities. Lastly, expanding the data analysis period to five years or more would provide a larger dataset and a deeper understanding of trends and root causes of rail defects. This longer-term analysis would uncover potential recurring issues and enhance the assessment of their impact on safety and operational performance.

Acknowledgment

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