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Maintenance Notes to Improve the Reliability of Wheel Flange Failure for Overhead Crane

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Abstract. Overhead traveling cranes in the industry have utility workload classifications and require high standards of safety and reliability by mobilizing lifting and transporting capacity variants of steel products, equipment, and other supports. The crane wheels are the main support in moving the end carriage so that the crane can work according to its function. Failures in the operation and maintenance cycle have occurred. Therefore, proper repair and maintenance methods are highly needed to restore the original design function to its working integrity. Logic tree analysis was used to breakdown all causes of failure; thus, mitigation was performed by carrying out continuous improvements rather than investigations. In this work, failure of the wheel flange in asset integrity management was found to be correlated with other related components which refer to the data of international standard for carrying out the needed repairs.

Keywords: Logic tree analysis; Maintenance reliability; Overhead crane; Repair method; Wheel flange

1. Introduction

Proper maintenance methods for overhead cranes are needed for the continuity of the production process and the high risk of danger (Cahyanti et al., 2018). Lifting and transport equipment has strict regulations, therefore a reliable repair system needed to align between work safety and asset integrity. Utility steel industry is quite busy for handling steel products such as slabs, billets, and coils with various capacities.

The overhead crane movement system is divided into three, namely traveling, traversing, and hoisting systems (Alzubaydy and Aziz, 2017). The traveling system moves the girder with a certain span and the end carriage uses wheels that are connected directly to the drive system. Traversing system is a movement across the girder by carrying equipment on a trolley using wheels in general. The hoisting system functions to raise or lower using a wire rope or chain of a certain model and type (Wijaya, 2021). All these movements have safety equipment, namely a brake system.

Maintenance programs in the form of preventive and predictive are carried out to maintain equipment performance. On a scheduled basis, two types of maintenance are carried out periodically according to government regulatory requirements. The repair system is carried out for damaged sub-equipment, where there are two decisions, namely repairable and replaceable.
Risk assessment is needed to reduce failure because it involves operators who are potentially dangerous and have undesirable consequences for the business (Mohammadi et al., 2021; Putra et al., 2022; Yuliati et al., 2023).

The movement of the crane which rests on the crane wheels and rails rub together, causing this damage to cause wear and tear (Kulka et al., 2020). The application of lubricant to the surface of the rails and wheels is intended to reduce reduction, limitations to the use of adhesion have been identified to avoid slippage during traction and braking (Mei and Hussain, 2010). The aim of this paper is to provide a reliable, safe, and effective maintenance strategy guidance through inspection program of wheel crane. Historical failure data and available references such as previous research standards are referred to as repair and selection methods.

2. Methods

The inspection guide for overhead cranes focuses on wheel linkage as critical point of equipment supporting the axis of movement. The principles of mechanical arrangement and parts refer to technical drawings and several available standards, both government regulations and international standards. Referring to international standards is very important for the implementation of asset integrity management concepts and principles. Wheels are equipment that is critical to safety, the integrity of location and function needs to be considered (Kiani and Fry, 2017). Therefore, this research uses the following flowchart to prevent failures that occur in wheel cranes according to the Figure 1.

![Flowchart failure prevention](https://doi.org/10.7454/jmef.v3i2.1056)
2.1 Failure reporting, analysis, and corrective action system (FRACAS)

A system for identifying, correcting system deficiencies, and preventing repeated failures (Lee et al., 2010) with the aim of improving crane reliability and availability. Information required regarding failures and defects during operation and maintenance includes time of the failure, cause of the failure, detailed description, corrective action, when and how the failure was detected and the effects of the failure.

Root cause analysis is one of the steps in FRACAS to determine the cause of failure. Fishbone diagrams, fault tree analysis, root cause logic tree analysis, pareto analysis and 5 why analysis are tools that are used to find the root of the problem. Strategy adjustment after getting to the root of the problem by making repairs to resolve equipment failures.

2.1.1 Wheel arrangements

Crane wheels are divided into driving and idle systems referring to the international standard DIN15090 (Karl Georg, 2022). The wheel rotates using a roller bearing and flange wheel to keep the wheel running on the track. The driving wheel uses a universal joint which is connected by a reducer gearbox and is driven by an electric motor, a braking system is applied to this arrangement. The wheels rest on the end carriage seen in Figure 2 which carries the moving overhead crane girder to transport the load. The wheel arrangement specifications are presented in Table 1.

![Flange wheel arrangement](image)

**Figure 2** Flange wheel arrangement

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Driving</th>
<th>Idle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel diameter</td>
<td>500 mm</td>
<td>500 mm</td>
</tr>
<tr>
<td>Bearing size</td>
<td>22,230</td>
<td>22,230</td>
</tr>
<tr>
<td>Gearbox ratio</td>
<td>19.2</td>
<td>-</td>
</tr>
<tr>
<td>Motor</td>
<td>22 kW</td>
<td>-</td>
</tr>
<tr>
<td>Universal joint</td>
<td>Lz 2,500mm</td>
<td>Lz 110 mm</td>
</tr>
<tr>
<td>1,500 RPM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>42 CrMo4</td>
<td>42 CrMo4</td>
</tr>
<tr>
<td>450 HB</td>
<td>450 HB</td>
<td></td>
</tr>
<tr>
<td>Wheel pitch span</td>
<td>29,500 mm</td>
<td>29,500 mm</td>
</tr>
</tbody>
</table>

2.1.2 Runaway rail alignment

With various types, Runaway rail has several types referring to the VDI 3576 for crane tracks (Ghashoun et al., 2021), DIN 4132 and DIN 18800 standards for steel construction (Madhya Bhotekoshi Jalavidyut Company Limited, 2013). These references also including A rail profiles,
flat steel rail and square steel rail (Demag Cranes, 2018). The construction of the rail span in the traveling and traversing system has an important role in the lifespan of the crane wheels. ISO 12488-1 describes travel and traversing path tolerances for wheels (ISO, 2012) according to Figure 3 and Figure 4, respectively.

![Figure 3 Tolerance of travelling span](image)

![Figure 4 Tolerance of traversing span](image)

3. **Results and Discussion**

3.1. **Root cause analysis**

The focus of failure that will be discussed is on the crane wheels. Failure modes based on 2014-2016 history can be seen in Figure 5, which shows very significant flange wheel failure. The effect of such a failure could be the crane derailing and causing safety issues and significant business losses.

![Figure 5 Pareto chart failure](image)

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Pareto results show that flange wheel failure has experienced significant repetition of failure, therefore corrective action is needed as a top priority. The root of the problem of flange wheel failure is an error in material selection or a neglected welding procedure system in the repair method. Wrong design which has an impact on bolt tightening when assembling the wheel on the end carriage and shaft looseness related to wheel and shaft assembly. As well as rail span deviation due to failure of the clamp rail and wear on the rail pad as described in Figure 7.

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3.2. **Failure mode mitigation result and recommended action**

Actions taken to mitigate failure mode include wrong repair method, shaft looseness, improper tightening on site location and span deviation. Testing on the welding procedure system and material selection will be carried out over the next 3 years involving a qualified third party. The main material selection is carried out after carrying out a function analysis which is followed by a selection process with ranking based on material characteristics (Nafisah et al., 2024). The wrong repair method currently has been completed using a procedural document in the form of a standard operating procedure with continuous monitoring for the result, so that it does not require further action than on site checking.

Wrong design in the wheel assembly is concluded by the improvement of ISO for shaft assembly fitness of housing and bearing tolerances as indicated on balloon number 1; as well as obstacles related to the method of tightening bolts at the location by changing the cover and bolt type as seen on balloon number 2. Modifications are carried out by considering the failure modes that have been revealed in the logic tree analysis which can be seen in Figure 8 for wheel design.

![Figure 8 Wheel design improvements](before_after.png)

**Figure 8** Wheel design improvements

**Figure 7** Logic tree analysis

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Measuring the span of the traveling rail shows a deviation of up to 10 mm, which is already at the maximum point for class 1 ISO 12488-1 (Table 2). Corrective mitigation is needed by aligning the rail rather than the rail clamps which function to tie the rail alignment. Crane geometry measurements also need to be considered regarding the position of the end carriage fastening pin-bushing which affects the alignment of the wheel center.

<table>
<thead>
<tr>
<th>Column</th>
<th>Actual measurement mm (Ref. 29,500)</th>
<th>Span deviation (mm)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29,500</td>
<td>0</td>
<td>Normal</td>
</tr>
<tr>
<td>2</td>
<td>29,500</td>
<td>0</td>
<td>Normal</td>
</tr>
<tr>
<td>3</td>
<td>29,500</td>
<td>0</td>
<td>Normal</td>
</tr>
<tr>
<td>4</td>
<td>29,500</td>
<td>0</td>
<td>Normal</td>
</tr>
<tr>
<td>5</td>
<td>29,490</td>
<td>-10</td>
<td>Narrows</td>
</tr>
<tr>
<td>6</td>
<td>29,500</td>
<td>0</td>
<td>Normal</td>
</tr>
<tr>
<td>7</td>
<td>29,500</td>
<td>0</td>
<td>Normal</td>
</tr>
<tr>
<td>8</td>
<td>29,500</td>
<td>0</td>
<td>Normal</td>
</tr>
<tr>
<td>9</td>
<td>29,495</td>
<td>-5</td>
<td>Narrows</td>
</tr>
<tr>
<td>10</td>
<td>29,490</td>
<td>-10</td>
<td>Narrows</td>
</tr>
<tr>
<td>11</td>
<td>29,505</td>
<td>+5</td>
<td>Widens</td>
</tr>
</tbody>
</table>

4. Conclusions

This paper shows the role of international standards in asset integrity management in the form of data including failure history, technical drawings, arrangement, and construction tolerances. It was concluded that design errors need to be emphasized again regarding the role of quality control/quality assurance. Preventive maintenance actions are required in the form of inspections, adjustments, lubrication and storage of repair data as maintenance strategies. As a continuous improvement step, maintenance strategies reviews are required in the form of regular failure mode analysis after the operation and maintenance stages to maintain crane reliability and safety.

References


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