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A study on the effectiveness of railway turnout by using roller cradle assembly along Kelana Jaya trackwork

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Abstract. Malaysia's railway transportation industry has faced significant demand for increased train reliability. Railway turnouts are a specific track system used to divert train direction, which is a vital component for enabling rail operating flexibility. Passengers are directly affected by service disruptions, forcing them to wait or pick alternative public transportation options to get to their destination. This will lower service dependability and consumer satisfaction. This study was conducted to assess the primary failure connected to the permanent way subsystem, which is turnout operation. The aim of this study was to do statistical analysis on the turnout dry slide chair. The failure's major statistics were examined, as well as the right solution, the primary cause improvement, and the efficiency, which was proven by on-site testing. Normal practices were assessed to ensure their effectiveness and to identify any areas for permanent improvement. The proposed solution was evaluated to validate, compare, and determine the parameters that influence the solution's effectiveness. This rigorous testing result demonstrates that the underlying issue has been resolved, resulting in an instant friction reduction of 64% to 83% for depot turnouts, as well as better operational performance.

1 Introduction

Turnout performance is influenced by the presence of movable parts, discontinuities in the rail geometry, and variability in the track support stiffness. The combination of these contributes to a high failure rate compared with a plain line track. References to studies showed that the failure of turnouts led to higher costs [1]. Lubricating the turnout is a very important task. A failure due to insufficient lubrication may cause traffic disruptions, possibly affecting the whole rail network. During operation, insufficient lubrication can cause dry slide chairs to fail [2]. The high friction between the switch rail and the slide chair makes it difficult to change the position of switch, which may result in serious switch failure, including forcing the point machine.

This research aims to identify the ideal friction reduction produced by the turnout system design itself. Three objectives will be met by the completion of this study: identify the

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primary reasons and potential contributors to the excessive friction between the turnout switch blade and slide chair. Second, determine the amount of friction between the turnout switch blade and slide chair, and third, evaluate the effectiveness by measuring friction reduction after installing the roller cradle assembly.

The project's limitation are as follows: This study used the Thyssen Kruup Turnout set number 5 type ballast track with Kelana Jaya LRT geometry alignment and clearance as samples for monitoring data and testing. Research was conducted on the original slide chair, and a proposal to attach a roller mechanism yielded positive research results. The research methodology and maintenance procedures adhere to AREMA standard recommendations. The THALES L910H switch machine model was used to operating this Turnout. The roller cradle system installed and tested in this study is from SCHWIHAG AG and uses metal roller barrel cassette types. Hardware equipment that used for measuring resistance on slide chair and points machine throw force gauge that is Force Measurement Device HZM, Hanning & Kahl.

As a significant study's finding, this improvement identifies potential mechanical factors that cause high friction between the slide chair and blade movement. It also determines the actual amount of friction required to optimise performance and the limitations that may cause the failure to occur. Validates the actual friction reduction that occurs after implementing the roller cradle system in a turnout.

2 Turnout

The role of the turnout (refer to Figure 1) is to provide flexibility to railway traffic operations by allowing trains to switch between tracks [3]. The variations and discontinuities in rail profiles employed in the turnout to fulfil the function of the switch and crossing provide additional dynamic loading during wheel passage, resulting in increased wear and tear on these components when compared to common track.

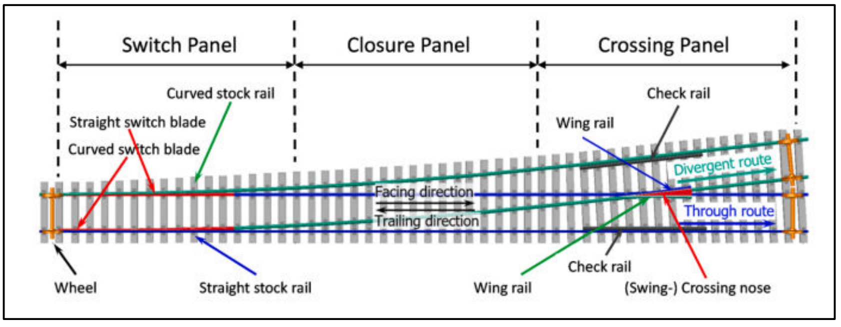

Fig. 1. Basic turnout layout [3].

The switch panel are the part of a turnout or layout ensuring the continuity of any one of two or three diverging tracks at the beginning of the divergence, consisting of two half sets of switches assembled, usually with bearers [3].

2.1 Point machine

A point machine, located adjacent to the switch blade, principally aligns the track position trackways and secures the turnout blade in that required position. In a turnout with an interlocking signal system, the turnout machine primarily executes the following main purpose: operating the switch blades, setting the switch blades at the required trackways, and detecting each trackway position of the turnout blades. Researchers have developed and improved various types and models of point machines, categorizing them into three categories: electro-mechanical, electro-hydraulic, and electro-pneumatic [4].

The hydraulic power unit inside the switch machine is equipped with an electric motor. Adjacent to the casing is the electrical motor with a reversible piston pump, while on the next side to it is a hydraulic block with a hydraulic tank underneath and valves. To transport oil, aluminium pipes with an exterior connect the pump and hydraulic block. To generate pressure, the pump is directly installed on the output shaft of the electric motor and is connected to it via flexible coupling via piping. The throwing block is moved by single-acting hydraulic cylinders positioned inside of the molded steel case. The hydraulic fluid is fed into these cylinders using pipes with the same outside diameters as the others.

2.2 Slide chair

The sliding chair is the primary component for two-tongue rail movement within a turnout point blade. The tongue blade will guide the flange into the locked position while the vertical stresses from the wheel are applied to the stock rail. The stock rail is connected to the slide chair through a rubber pad of the fastener system, so vertical displacement relative to the slide chair can occur under wheel loads [5]. The tongue blade can withstand the large vertical force based on its width [6]. The height of the turnout tongue blade is lower than the stock rail. This is mandatory in order to switch the tongue rail on the sliding chairs to the desired position. The ductile cast iron material was used according to standard DIN-EN-1563 as new ductile cast iron grades with a unique combination of tensile strength and high elongation achieved by the solution strengthening of the ferritic matrix by silicon with contents between 3% and 4.3% [7].

2.3 Roller system

A mechanical device that enables the reduction of friction between the switch blade and the slide chair. The main function of this device is to eliminate lubrication of the slide plates. However, the slide plates must be coated with a wax-sealed, corrosion-resistant, lubrication-free molybdenum coating or similar coating to prevent the formation of rust on the plates. The individual rollers will lift the switch above the slide chair surface when the switch blade moves between the open and closed positions; hence, there is no contact between the switch and slide chair plate. As there is no longer friction detected between plates and switch, the forces required to move the switch blade are lower, reducing the load on the switch operating mechanism.

2.4 Friction

For this case study, the friction for the switch blade and slide chair falls under static friction because the switch must be locked in one position. During movement, the process changes to sliding friction, which is defined as the resistance created between any two objects when they slide against each other. Because the sliding chair must be lubricated to reduce friction, this procedure is known as fluid friction, depending on the material. This is the typical frictional process that occurs with each turnout. The coefficient of friction (CoF) is the name given to the proportionality constant. It takes a constant value and has no unit, unlike other proportionality constants. Its value is determined by the two surfaces in contact.

3 Results and discussion

This chapter discusses the results of the work carried out based on the research methodology framework shown in Figure 2. All the data obtained via recorded maintenance database, site testing and observation were analysed to determine the results of the study. Further discussion of the results of the study is based on the interpretation of the data obtained; thus, a conclusion from the study is determined.

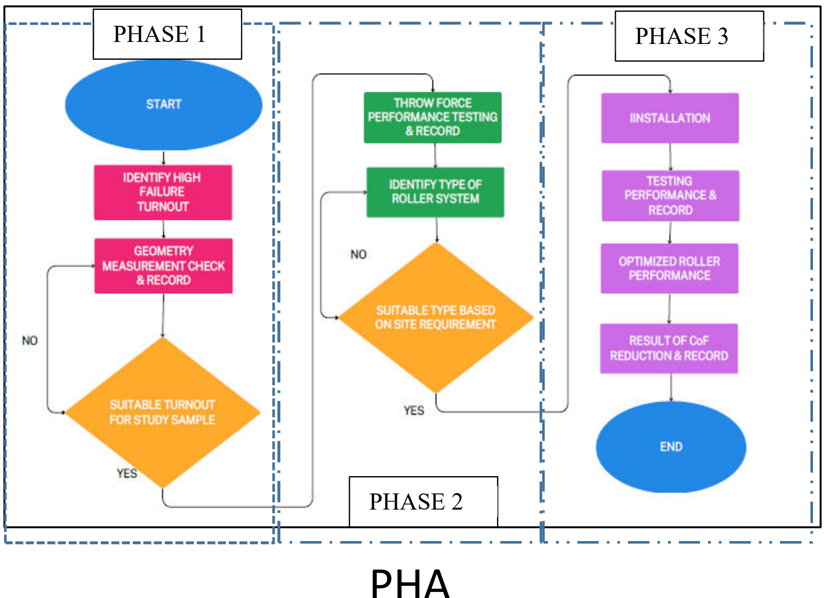

Fig. 2. Methodology framework.

3.1 Data descriptions

3.1.1 Phase one

Failure records of turnout due to dry slide chair identified for testing sample and monitoring purposes. The records have been gathered manually via the maintenance database at each turnout category within the Kelana Jaya network. The researcher examined the maintenance record database from the various raw data sources for detail rectification and discovered that each failure was divided into two primary parts, which are switch machine component failure and turnout/dry slide chair. After compiling, recording, and analysing all of the raw data, the researcher determined that the main reasons for failure in 2019 were due to dry lubrication between the switch blade and the slide chair. This issue causes more than half of all failures and must be lubricated immediately on site as a rapid response step.

3.1.2 Phase two

The results of this experiment are shown in Table 1. We conclude that after applying 4 to 5 times of a thin layer via the spray technique, it validates that low friction between the blade and slide chair, compared to less lubricant, is the most effective.

Table 1. Throw force test result depot turnout.

Lubricant	Left Position		Friction (CoF)	Right Position		Friction (CoF)
	First Test	Second Test		First Test	Second Test	
No lubricant	1.09		0.30	1.75		0.49
1Thin layer	1.09	1.07	0.30	1.75	1.65	0.49
2 Thin layer	1.06	1.02	0.29	1.65	1.56	0.46
3 Thin layer	1.01	1.01	0.28	1.56	1.51	0.43
4 Thin layer	0.96	0.97	0.27	1.77	1.59	0.49
5 Thin Layer	0.98	0.91	0.27	1.49	1.72	0.41

In this phase, after a week and 7 days of monitoring for the depot turnout, it was found that the lubricant started to degrade and friction levels increased, although they did not reach their maximum values, which are not more than 3600 N. Table 2 displays the readings following seven days of exposure to outdoor weather. To preserve its performance with the previous reading, the thin layer method of the grease was reapplied five times, and throw force was measured again. Left and right are the locked positions for measuring reference purposes.

Table 2. Monitoring throw force for depot turnout.

Lubricant	Left Position		Friction (CoF)	Right Position		Friction (CoF)
	First Test	Second Test		First Test	Second Test	
No lubricant applied	1.4	1.4	0.39	1.64	1.63	0.46
5 Thin Layer	0.94	0.94	0.26	1.71	1.65	0.48

3.1.3 Phase three: depot turnout testing result validation

From the depot switch results, refer to Figure 3, which validates that after installing the roller cradle, the throw force and coefficient of friction decreased by approximately 64% to 83%. It is also indicating that by installing this roller system, the coefficient of friction can be maintained, and hence the turnout can be optimised for a long period of time.

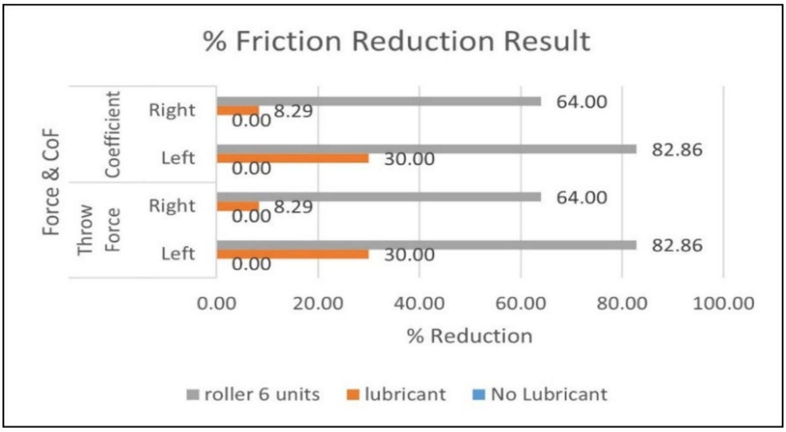

Fig. 3. Reduction % in force and cof before & after install roller on depot turnout.

4 Conclusion

Having discussed the key findings of this research, it is possible to conclude that after conducting numerous statistical analyses of the potential failure contributors to Kelana Jaya Line turnout, researchers were able to identify that the main causes of failure are from dry lubricant between the switch blade and slide chair.

Numerous measurement tests and statistical analysis of the amount of friction between the switch blade and the slide chair revealed that the use of lubricant resulted in an instant friction reduction of 8% to 30% for depot turnout.

The monitoring of the results and data above indicates that the friction reduction on the depot turnout was greatly reduced. The ingredients that cause this conclusion are the material and concept that entirely transfer friction from sliding to rolling, hence eliminating the high friction factor and completely generating lubricant.

With this result, all three objectives were satisfactorily met. It not only increases turnout performance but also lowers labour costs because no greasing is required. This reduces environmental risk by eliminating scheduled waste products. Return on investment (ROI) is expected to be reached when the roller cradle investment has been in place for four years and no longer requires the use of lubrication.

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