Simulation of Grooved Wear on Mass Rapid Transit Train Wheels by Finite Element Method

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Abstract. The purpose of this study is to obtain stress values and safety factors on wheels with grooved wear. Grooved wear was found on the MRT wheel during the monthly inspection. The method used in this research uses the finite element method, namely ANSYS software. The depth of grooved wear used is 2 mm, 3.5 mm and 4 mm. The simulation results show that Grooved Wear with a depth of 4 mm has the highest stress. In static loading it has a stress of 186.3 MPa with a safety factor of 3.6. Simulation results show that at grooved wear depths of 2 mm, 3.5 mm and 4 mm, the stress value is still below the allowable stress of 514.2 MPa or yield stress of 685.6 MPa so it can be concluded that it is still safe.

Keywords: Grooved wear, finite element, wheel.

1 Introduction

Bogie is an important component of the train that has the function of supporting the train body. The wheels on the train have a function to deliver passengers from the origin station to the destination station, and also have a function to help move the train at high speed or according to the specifications of the equipment [1], [2].

MRT Jakarta has recently had a problem during monthly maintenance, which is damage to the wheels called Grooved Wear or what can be referred to as grooved wear on the wheels. Grooved Wear is present on all wheels of the MRT facilities[3]. Grooved Wear occurs every day that the trains operate [1], [2], [4]. Each train of wheel material is eroded to a depth of 0.2-0.4 mm per month according to data obtained during monthly maintenance of the MRT Depot. With the existence of the current Grooved Wear condition on the MRT wheels, many things may happen when the train is operating, which can have an impact on passenger safety, such as derailment or train crashes. Therefore, it is necessary to analyse the Grooved Wear stress so that the reliability of the wheels while on the main line can be maintained[5]–[7].
To investigate the stress on the wheels of the Jakarta MRT, stress analyses were carried out on wheels that contained Grooved Wear and were in contact with the rail using ANSYS 2019 software. This simulation test consists of static load stress tests, vertical dynamic loads, and lateral dynamic loads. The loading on the wheels is based on the maximum axle load of the Jakarta MRT rail, which is 14 tons [8].

The purpose of this loading simulation is to obtain the maximum stress value and safety factor. From the results of the analysis, it can determine the safety conditions on the wheels that have Grooved Wear on the MRT. In addition, it also gets an overview of the stress distribution and shape changes that occur due to the application of loads on wheels that have Grooved Wear. The results of the analysis will determine the resulting safety level of the MRT wheels containing Grooved Wear.

2 Method

This research was conducted by testing using ANSYS 2019 software[9], [10]. The first thing to do is to make modelling by designing the part first, after the part is finished in the new design, combine the wheels with the rails with the assembly process. After the wheel is in contact with the rail from the assembly process, then import geometry from solidwork 2020 software to ANSYS software with the STEP (.stp) file type. The purpose of this modelling is to analyse the stresses resulting from static and dynamic loading simulations.

Figures 2 and 3 above are an outline of the Jakarta MRT wheels (Mono-bloc corrugated) and MRT rails (UIC 54) and Dimension Grooved Wear British Standard, (2010), which will be recreated into three dimensions with a depth of 0 mm, 2 mm, 3.5 mm, 4 mm (MRTJ Depot Laboratory, 2021).

After modelling, in this simulation, material input is given in the form of mechanical properties of wheel and rail materials, which are also used in the simulation. Can be seen in tables 1 and 2.

**Table 1** MRT Wheel Material Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
</table>
Table 2 MRT Rail Material Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Satuan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulus Young (E)</td>
<td>210000 MPa</td>
</tr>
<tr>
<td>Yield stress ($\sigma_y$)</td>
<td>1130 MPa</td>
</tr>
<tr>
<td>Density</td>
<td>7859,8 kg/m³</td>
</tr>
<tr>
<td>Poisson Ratio</td>
<td>0,3</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>1190 MPa</td>
</tr>
<tr>
<td>Gravitational acceleration</td>
<td>9,8 m/s²</td>
</tr>
</tbody>
</table>

After inputting the material, the next step is to determine the mesh size. Mesh itself is dividing several elements into several nodes or points. Mesh uses element size 15 mm and resolution 2 in ANSYS software.

The quality of meshing during analysis can be seen from the skewness table, where the smaller the skewness number the better and more acceptable. After the meshing process can be continued by giving restrictions and loading. Providing support is done at the axle place on the wheel. Based on the Jakarta MRT rail maximum axle load standard of 14 tonnes Ramadhani, (2020).

After inputting materials, loading, constraints and meshing, then perform the solve process. The more and more complex the number of geometries and elements produced, so the longer the solve process in static and dynamic analysis in ANSYS 2019 software, the output produced in the test is stress, safety factor.
3 **Result**

3.1 **Static Load on Normal Wheels**

The results of the maximum stress of the normal wheel with the wheel in Figure 3, it is found that the von mises point has a stress at a certain point shown in the figure, namely with a maximum stress of 46.383 MPa on the normal wheel and a safety factor of 14.7.

![Fig 3 Maximum Stress on Normal Wheel](image)

![Fig 4. Safety Factor on Normal Wheel](image)
3.2 2 mm Grooved Wear Stress Static Condition

The results of the maximum stress of the Grooved Wear wheel with a depth of 2 mm in Figure 5, it is found that the von mises point has a stress at a certain point shown in the figure, namely with a maximum stress of 117.75 MPa on the wheel with a Grooved Wear depth of 2 mm and a safety factor of 5.8.

![Fig. 5 2 mm Grooved Wear Stress Static Condition](image)

3.3 3 mm Grooved Wear Stress Static Condition

The results of the maximum stress of the Grooved Wear wheel with a depth of 3.5 mm in Figure 7, it is found that the von mises point has a stress at a certain point shown
in the figure, namely with a maximum stress of 116.55 MPa on the Grooved wear wheel and a safety factor of 5.8.

![Fig 7 3.5 mm Grooved Wear Stress Static Condition](image1)

![Fig 8 Safety Factor](image2)

3.4 **4 mm Grooved Wear Stress Static Condition**

The results of the maximum stress of the Grooved Wear wheel with a depth of 4 mm in Figure 9, it is found that the von mises point has a stress at a certain point shown in the figure, namely with a maximum stress of 184.14 MPa on the Grooved wear wheel and a safety factor of 3.7.
3.5 Analysis

Figure 11 shows that the presence of grooved wear on the wheel causes an increase in stress in the grooved wear area of the wheel. In addition to the increase in stress, with grooved wear that is too deep when running on the main line, many events may occur, such as endangering the train when passing through the wessel, and when the train runs through the curve.
4 Conclusion

Of the four variations in the depth of Grooved Wear using static and dynamic loading in Ansys Workbench software, it was found that the maximum stress distribution result value occurred at 186.3 MPa at static load against yield stress of 685.6 MPa and allowable stress of 514.2 MPa. These results show that it is still declared safe because the results of the stress value are still below the yield stress.

References


