LRT Coupler Dynamic Motion Analysis on R87, R95, and R1100 Towards AAR M 1001 Standards

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Abstract. In this study, a simulation will be carried out that analyzes the dynamic motion of the Tight lock coupler on the LRT train. This analysis aims to get the angle value at different curvature radius. The bend radius of the selected railroad tracks is R87, R95, and R1100. The Autodesk Inventor simulation's angle values will be compared with the AAR M 1001 (Association Of American Railroads) Standard. Based on these standards, it has been determined that the resulting angle limit should not exceed 13° because this will make the coupler detached. Based on the results of the dynamic coupler motion simulation, the largest angle produced is 9.36° at R95.

Keywords: LRT Coupler · dynamic motion · AAR M 1001

1 Introduction

The train is one of the most efficient means of mass transportation for transporting passengers (Syaifudin et al., 2019). Given its very important function related to safety, before being used on rail tracks during operation, the railroad track must be tested so that when the train is operating, it does not experience obstacles and incidents. So the design test is needed to ensure that the train design meets the requirements and is safe to operate on the track. Because the train has a function as a mode of transportation that has a fairly good travel time, of course, the safety and comfort obtained by users is a major requirement in increasing public interest in trains. To get comfort and security in the coupler system, researchers have conducted several studies related to the coupler (Ge et al., 2021; Handbook on LHB Coaches, n.d.; Mousavi Zadeh Noughabi et al., 2007; Xu et al., 2014; Zhu et al., 2018).

There were several incidents where the coupler was separated from the circuit while on the track, one of which was the Tawang Jaya train heading Semarang-Jakarta on a Sunday night at around 20.00 WIB, which pulled seven trains suddenly separated from the circuit after the train passed a crossing in the Ahmad Yani airport area. Semarang. This incident made the train passengers panic after the train they were traveling in stopped and made them immediately scatter when they found out that the train they were riding

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Table 1. Tight lock Coupler Specification

No	Parameter	Information
1	*Coupler Body*	AAR M201 GRADE C
2	*Knuckle*	AAR M201 GRADE E
3	*Lock*	AAR M201 GRADE B
4	*Knuckle Thrower*	AAR M201 GRADE B
5	*Knuckle Pin*	S45C
6	*Split Pin* ø 6x50	DIN 94
7	*Support Pin*	S45C
8	*Split Pin* ø 10x70	DIN 94
9	*Lock Lift*	AAR M201 GRADE B
10	*Bushing Coupler Body*	S45C
11	*Shank Shoe*	SCMn HII
12	*Axle Handle*	S45C
13	*Rod Handle*	AAR M201 GRADE B
14	*Spring Pin* ø 5×50	JIS B2808
15	*Rivet*	SS41
16	*Rotor Lever*	AAR M201 GRADE B

had been separated from the railway series in front of it. In this incident, there were no fatalities.

To prevent this incident from happening again, a design test is carried out on the track and calculating the angle of the coupler while on the track using the AAR M 1001 standard. AAR M 1001 is a standard manual for the design, fabrication, and construction of freight trains or passenger trains to standard limits. Of tracks on rail operations based on the Association Of American Railroads. Compilation of modeling for simulation on track and series of facilities using Autodesk Inventor and AutoCAD software.

2 Method

The results of data collection obtained in the simulation process are the results of the Tigthlock coupler specification table, variations in distance and track radius, LRT train modeling, passenger train modeling and tightlock coupler design. The coupler angle that will be simulated is the curve of R87, R95, and R1100 (Table 1).

Coupler Tight Lock specification data are as follows:

The type of coupler used is a tight lock coupler type 1600, which is commonly used in LRT circuits. The software used in the preparation of this 3D model is Autodesk Inventor Software (Fig. 1).

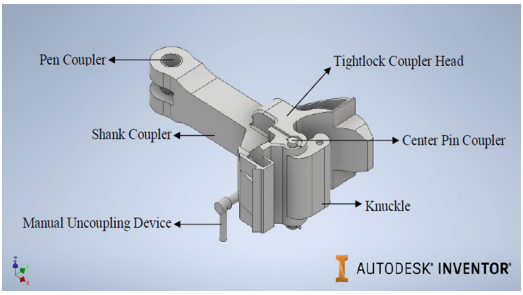

Fig. 1. Tight lock Coupler Modeling

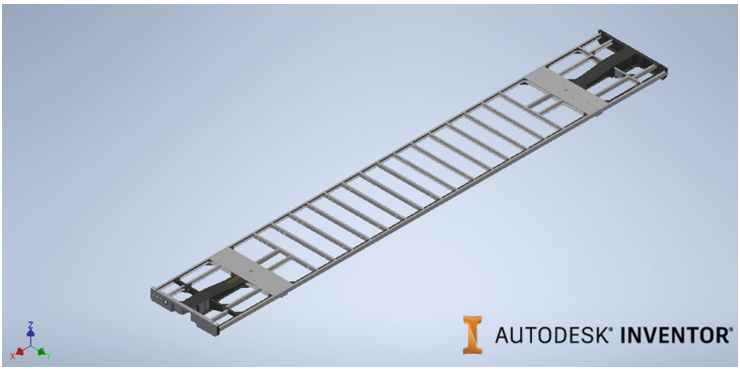

Fig. 2. Passenger Train Model

The concept of modeling passenger trains is arranged into a 3-dimensional (3D) model using Autodesk Inventor Software and learns the types of models of passenger trains that will be used as object designs in this simulation (Fig. 2).

3 Result

Figure 3 shows the coupler has an angle value of 0° on a straight line which indicates the angle is still in a safe condition because it is still below the AAR M 1001 standard limit of 13° (Fig. 4).

3.1 Coupler Angle on Track R95

Figure 5 shows the simulation results on the R95 coupler A trajectory which has an angle value of 8.54°, while the highest angle on the B coupler is 9.36° which indicates the curve is still in a safe condition because it is still far from the standard limit of 13°.

Figure 5 shows that the transition from a straight line to the R95 coupler has a change in the angle value, whose value can vary at each position, where the maximum value is at the angle of the coupler A with a maximum weight of 8.54° and a minimum value of 1.42°. And for the angle of coupler B has a maximum value of 9.36° and a minimum

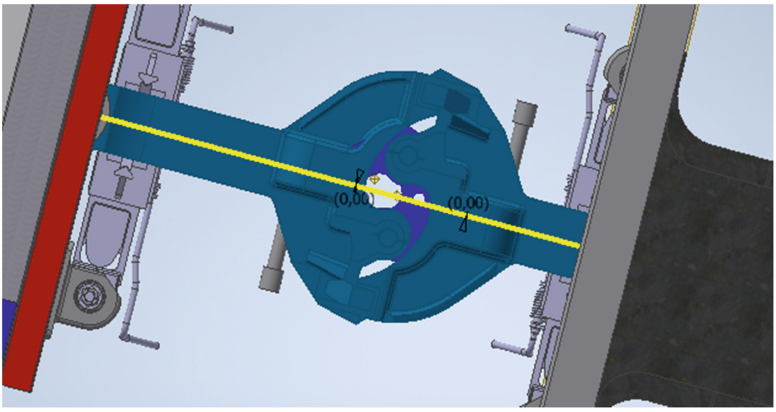

Fig. 3. Angle 0^{o} Coupler on a Straight Track

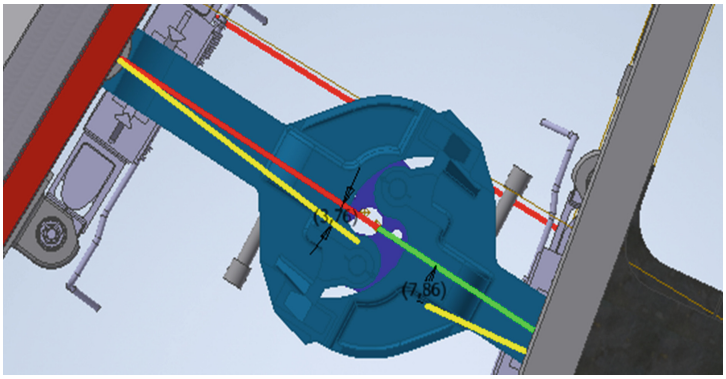

Fig. 4. Simulation of the Coupler Angle on the R95

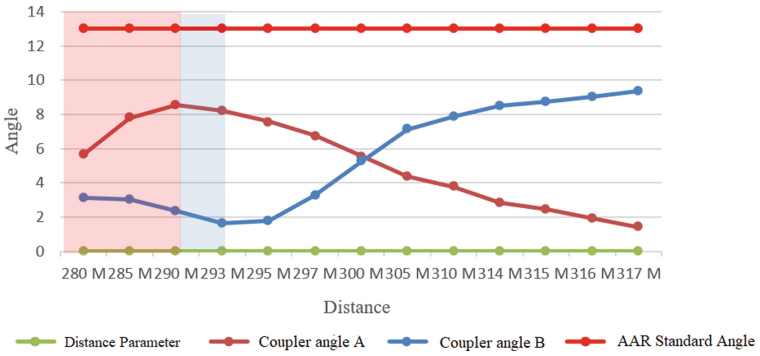

Fig. 5. The angle formed at each distance on R95

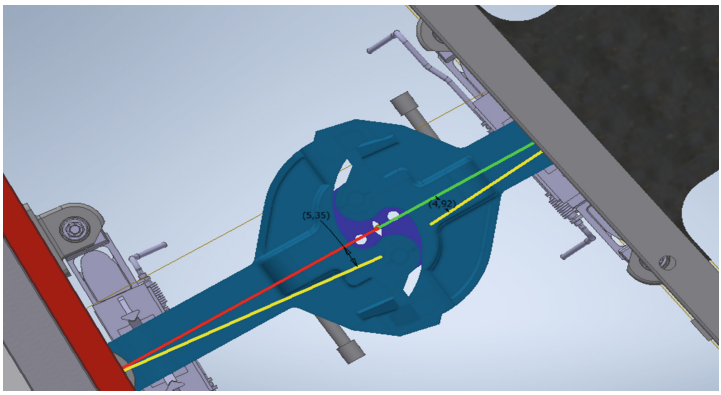

Fig. 6. Coupler angle formed 5.35° at R 87

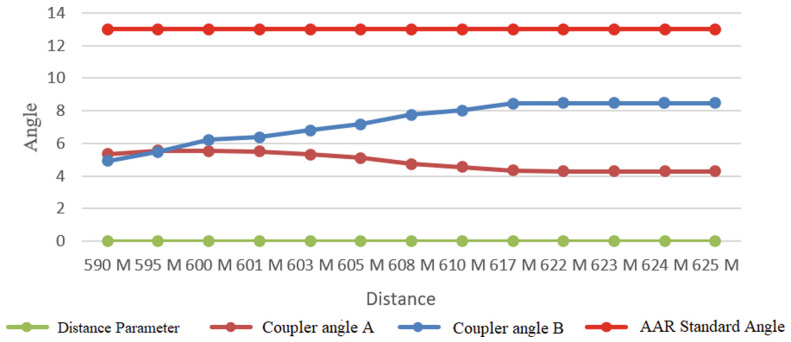

Fig. 7. The angle formed at each distance on R87

value of 1.65°. In the first condition, there is a change in the angle of the coupler, which tends to increase from the initial 5.66° to 7.79° and gradually increases until it reaches the maximum angle on the straight path into the R95 path with the angle value on the coupler A slowly becoming 8.54° and decreases to 8.2° by the time the first bogie entered the R95 track. At the same time, the position of the angle value on coupler B is relatively smaller than that of coupler A with an angle value of 3.11°. It continues to decrease until it reaches the lowest angle on coupler B with an angle value of 1.65° which is adjusted by the motion of the coupler.

3.2 Coupler Angle on Track R87

In the R87 path, coupler A has an angle value of 5.35°, while the highest angle in coupler B is 4.92° which indicates the curve is still in a safe condition because it is still far from the standard limit of 13° (Fig. 6).

Figure 7 shows a straight line switching on the R87. The coupler has a change in the angle value, whose value can vary at each position, where the maximum value is at the angle of the coupler A with a value of 5.75° and a minimum value of 4.3°. And for the angle of the coupler B has relatively more significant importance than the value of the angle of coupler A with a maximum of 8.47° and a minimum value of 4.92°. In the first

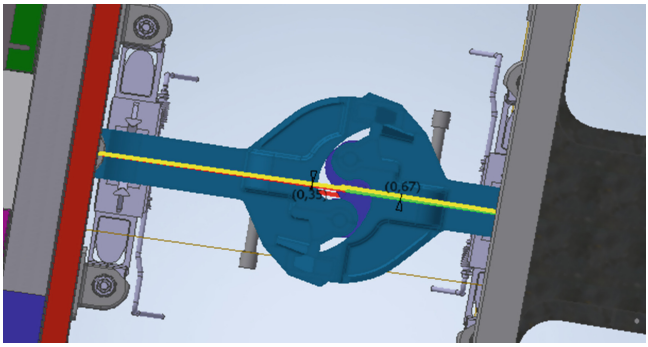

Fig. 8. Coupler Illustration on R1100.

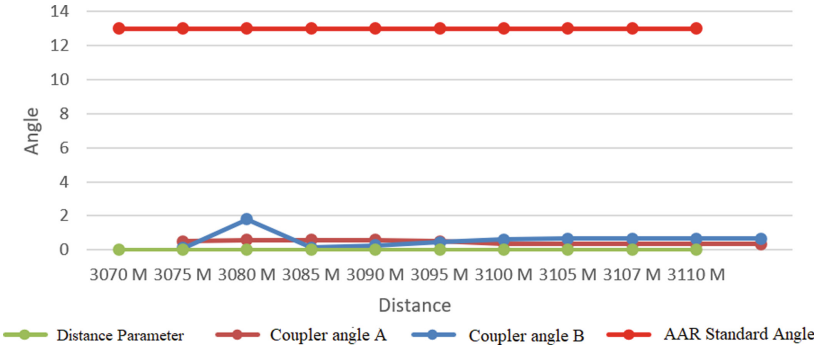

Fig. 9. The angle formed at each distance at R 1100

condition, there is a change in the angle of the coupler, which tends to increase from the initial 5.35° to 5.57° and slowly decreases to 5.54°, with a maximum of reaching the highest angle value on a straight line to R87 with the angle value of coupler A being 5 .5° when the first bogie enters the R87 track. While the position of the angle value on coupler B when compared to coupler A with an angle value of 4.92° to 5.49° and gradually increases until it reaches the highest angle on coupler B with an angle value of 6.38° adjusted by the motion of the coupler.

3.3 Coupler Angle on R Track 1100

In the R1100 track, coupler A has the highest angle value of 0.59°, while the most increased angle on coupler B is 1.79° which indicates the curve is still in a safe condition because it is still far from the standard limit of 13° (Fig. 8).

Figure 9 shows a straight line switching on R1100. The coupler has a change in the angle value, whose value can vary in each position, where the maximum value is at the angle of the coupler A with a maximum value of 0.59° and a minimum value of 0.35°. And the coupler angle B has a maximum value of 1.79° and a minimum total value of 0.11°. In the first condition, there is a change in the angle of the coupler which tends to increase from the initial 0.5° to 0.58° and gradually increases until the maximum reaches the highest pitch on R1100, with the angle value on coupler A being 0.59° when the first

bogie enters in the R1100 track. While the position of the angle value on coupler B is not much different from that of coupler A with an angle value of 0.11° and it increases in coupler B with an angle value of 1.79° and decreases again with an angle value of 0.12° which is adjusted by the motion of the couplers.

4 Conclusion

From the simulation variations on the R path from the Cawang station route to Cibubur station using Autodesk Inventor software, it was found that the highest simulation value was on the R95 route, with a value of 9.36°. These results indicate that the route between Cawang station and Cibubur station is still considered safe because the simulation results are still below the limits set by AAR M 1001 (Association Of American Railroads), which is 13°.

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