RAILWAY TRACK WIDTH GAUGE PERFORMANCE REVIEW: EVALUATION OF TEST RESULTS AND THEIR IMPLICATIONS FOR SAFETY IMPROVEMENT

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Abstract—The deteriorated state of the railway line poses operational risks for railway transportation due to potential safety concerns. The train derailment occurred because of an abnormal track width that was not immediately repaired. This improvement was omitted because of the absence of an accurate and real-time track width measurement tool. Several gauge have been widely developed. The measuring instrument developed uses an LMP (Linear Motion Position) sensor to measure the width of the path. The measuring mechanism connects the LMP shaft to a roller bearing arm that can move linearly and dynamically according to the groove width of the path. The linear movement of the roller bearing with the arm connected to the LMP shaft is converted as a change in the path width. To determine the function and measurement results of the measuring instrument, measurement experiments were conducted at Sidotopo stations (lines 5 and 6). Line 5 was chosen because of the straight area of the money order needle, the parallel crossing groove, and the curve. Line 6 was chosen because there is a *gongsol* path. Measurements on each path are made twice with the starting point and opposite direction. The measurement data are shown in the form of a width graph to the distance with one red line as the tolerance limit for widening the width of the line (1074 mm) and one blue line as the tolerance limit for narrowing the width of the line (1065 mm). The measurement results show the consistency of the measurement results. The largest measured width condition is 1092 mm, and the smallest measured width condition is 1058 mm.

Keywords— railway, width, gauge, LMP, measurement.

1. INTRODUCTION

The number of train drops caused by railway conditions is one of the main challenges in the operation of the railway transportation system. The drop can cause disruption in travel, damage to trains, railway infrastructure, and the risk of accidents, shows in Fig.1, that can endanger the safety of passengers and crew. However, the limitations of facilities or infrastructure for measuring the width of railway lines are often an obstacle in performing this task efficiently and effectively. Manual measurement methods and inadequate tools can result in uncertainty in track width measurements, increasing the risk of drops and other disturbances, including the safety of rail inspectors.

Figure 1. Train Wheels Plummet From The Tracks

In addition, measurement time that is long is also a serious problem. Slow measurement processes can disrupt train operational schedules and result in costly delays for operators and passengers. In addition, railway tracks that are passed continuously can also make it difficult to make accurate measurements. Continuous train operational activities can interfere with the measurement process because they are conducted at night (when there are few trains in operation).

In facing these challenges, the development of compact and efficient railway line width gauges is the main concern. Gauges equipped with advanced sensor technology can help detect and monitor rail conditions more accurately and quickly. With the right technology, the measurement process can be carried out in real time without disrupting the train's operational schedule. In addition, the use of a gauge that is lightweight and easy to carry and operate is an important factor in making it easier to measure the width of the track in various hard-to-reach locations. Thus, the measurement process can be performed efficiently and flexibly without requiring a significant time and effort.

Thus, research on the development and trial of railway line width measuring devices can improve the efficiency and safety of railway operations. Therefore, this research is essential to support the development of a better rail transportation system.

According to the Regulation of the Minister of Transportation of the Republic of Indonesia Number PM. 60 of 2012, the main goal is to regulate standards and specifications related to railway infrastructure and operations in Indonesia[1]. One of the aspects regulated in this regulation is the width of the rail road, which is an important parameter in maintaining the safety and efficiency of railway operations. According to the Regulation of the Minister of Transportation, the standard width of rail roads in Indonesia is 1067 mm. The width of this rail walk is measured as the minimum distance between the two sides of the rail head, which is measured at 0-14 mm below the top surface of the rail. This emphasizes the importance of maintaining consistency in the width of the rail road to ensure compatibility with railway vehicles operating on the rail network.

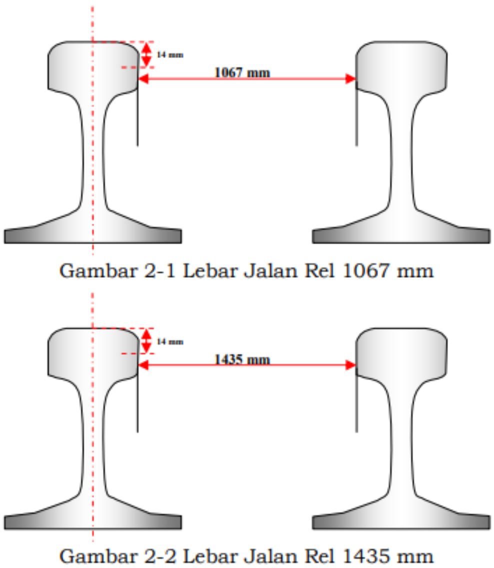


Figure 2. Railway Specifications[1]

The regulation also regulates the tolerance or limit of acceptable deviations in the width of the rail road. For new rail roads, the allowable tolerances are +2 mm and -0, which means that the width of the rail road can vary up to 2 mm wider than the set standard, but must not be narrower than the standard. As for the rails that have been operated, the allowable tolerances are +4 mm and -2 mm, which provides a little more flexibility but still considers safety and operational performance.

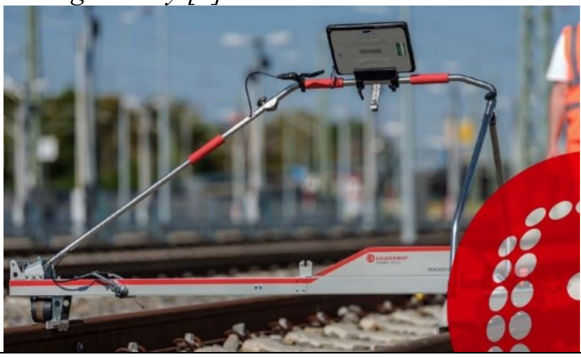
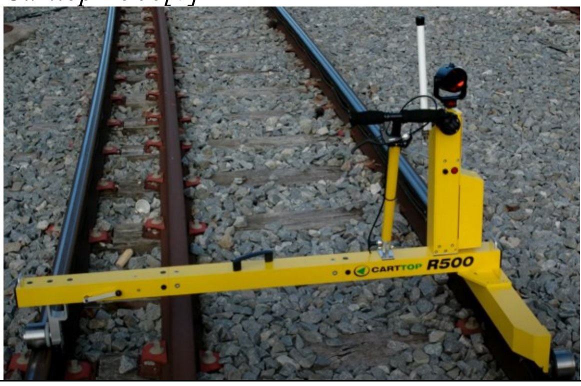
With this regulation, the width of the rail road can be maintained consistently in accordance with the set standards, thereby minimizing the risk of falls, accidents, and other operational disruptions. This reflects the Indonesian government's commitment to ensuring the safety and efficiency of the rail transportation system in the country.

2. Previous Researches

In accelerating so that this strip width measuring device can be realized, the observe-imitate-modify method is performed. Several tools produced have been benchmarked. Benchmarking is specialized in the technical part to determine the specifications and capabilities of the tool so that it can obtain the optimal bandwidth measuring tool. Benchmarking of several types of track width measuring instruments.

Table 1. Existing Railway Irregularity Measuring Instrument

No.	Product	Specifications
1	*American railway track measuring instruments railway gauges.[2]* 	*Brand :Liajie or we do OEM service* *Weight : 2,7 kg* *Material : Alluminum Alloy* *The analogue track gauge is used for measuring : Track gauge.* *Check rail gauge.* *Back-to-back distance*
2	*Aluminium Track Corrugation Measuring Trolley for Survey, Packaging Type: Box[3]* 	*Material : Aluminium* *Brand : KZV* *Measuring Speed : 1m/s* *Scanning Interval : 5 mm*
3	*High precision digital measurement track gauge railway specially track tools.[4]* 	*Dimension : 1610x35x40mm* *Brand : Lianjie* *Weight : 3.5 Kg* *Material : Aluminium Alloy* *Certificate : ISO* *Model Number : GJC-JG1*
4	*Amberg Clearance IMS 5000[5]*	*Gauge (mm) 1000,1067,1435,1520/24,1600.*

		*Gauge measuring range(mm) -25 to+65 mm.* *Track alignment amu 2020/2030.* *Weight 57 kg* *Working temperature -10 ‘c until 45 'c*
5	*Goldschimidt continuous digital recording of track geometry [6]* 	*Dimension(lxwxh) 1050 x 870 x 1850 mm.* *Weight 25.7 kg* *Measure increament 0.25 m* *Gauge accuracy 0.5 mm measure range -15 - 50 mm* *Memory capacity 60.000 km* *Vertical regulation accuracy 0.2 mm measure range 2mm* *Temperature opreation -20 ‘c until 45 ' c 15/85 %*
6	*Carttop R500[7]* 	*Gauge range 914 - 1676 mm* *Range sensor -10 until +40* *Precision sensor 0.2* *Weight 36 kg* *Control using leica cs20/cs35*

3. METHOD

BENCHMARKING

In a design, requirements are accompanied by expectations. Therefore, the design requirements and objectives (DR&O) of the railway road width gauge are planned on the basis of the results of the analysis of the benchmarking products of several brands, as follows:

Must:

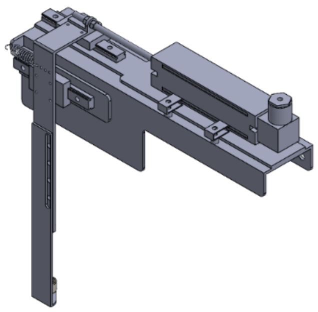
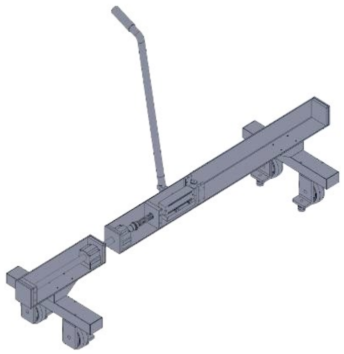
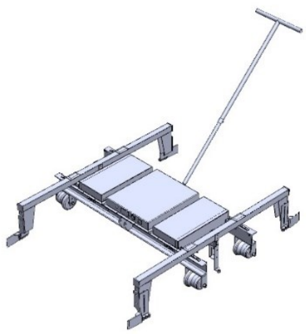
1. It can measure the width of the strip by 1067 mm.
2. Can be used easily.
3. Resistant to weather (waterproof and hot temperature resistant).
4. No skid when operated.

Hope:

1. Can be installed by plug and play.
2. It can be measured in critical areas such as money order hands, parallel crossing grooves, and curves where there are *gongsol* rails.
3. The installation process does not interfere with the loading and unloading of KPJ trucks.
4. The weight of the tool is not more than 50 kg so that it can be installed by two people

To obtain a design of a railway gauge that has good accuracy and efficiency, it is necessary to evaluate various alternatives in the design of the right gauge. The evaluation ensures that the tools selected comply with the design requirements and objectives (DR&O). The following are the three alternative designs and constructions of the track width measuring instrument, along with a description of the evaluation, as shown in Table 2.

Table 1. Design of Railway Irregularity Measuring Instrument

Type	The Design	Description
1		Design a type 1 strip width gauge: • It uses two LMP sensors, so it is quite difficult to install if it is done by two people. • When the KPJ truck maneuvers, the gauge roller can hit the rail head. • The LMP sensor is installed on the frame of the KPJ truck so that it can only be used on the KPJ truck (the KPJ truck at KAI varies greatly). • The track width gauge roller cannot measure the width of the track in the money order hand. • The track width gauge roller hit by sand or rocks (dirt) when passing through the safety rail groove at a level crossing. • The LMP sensor is not closed, so it is possible to be exposed to rainwater directly
2		Design and build a type 2 strip width gauge: • It does not consider the layout of the electrical circuit. • The LMP sensor is instantly integrated with the main frame and wheels to ensure that the LMP has a sufficient load. • LMP sensors can break when the tool is lifted or operated with the mechanism pushed. • The measuring device can only be operated with a push mechanism.
3		Design and build a type 3 path width gauge: • The measuring instrument stands alone and does not interfere with other mechanisms. • LMP sensor and enclosed electrical circuit so that it is waterproof and at a hot temperature. • The measuring instrument is plug and play (can be paired with a KPJ truck and pushed). • The weight does not exceed 50 kg, so it can be installed by two people.

Based on the three alternative types of railway gauge designs in Table 2, the type 3 design was chosen because it met all design requirements and objectives (DR&O). This section provides guidelines for the author on writing elements and illustration when preparing the manuscript..

PRINCIPLE MECHANISM

The measuring instrument comprises two LMP sensors on the left and right sides. The LMP shaft is connected to a roller bearing arm attached to the rail road by a slider mechanism[8]. The roller bearing arm is also connected to a tensile spring, which ensures that this arm is always pushed outside the rail road. When taking measurements, the roller bearing arm is pulled toward the rail path until the roller bearing position holds the pull of the spring outward. When the track width is increased, the tensile spring pulls the roller bearing arm outward so that it remains attached to the inside side of the railway. When the track width is narrowed, the roller is pushed toward the inside of the rail road. Thus, the system will make the roller bearing rotate and roll on the inner side of the rail following the groove of the railway.

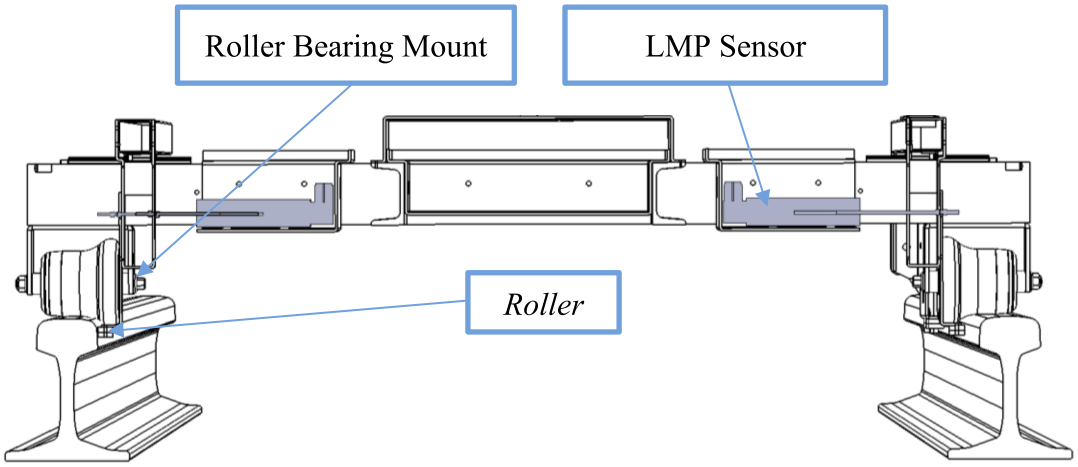


Figure 1. Design of Railway Irregularity Measuring Instrument Type 3

EXPERIMENT

To determine the performance of the measuring instrument, a measurement experiment was conducted on an actual railway line. Measurements were carried out on lines 5 and 6 of the Sidotopo station emplacement because the line is operated only for railway curtain activities with a maximum speed of 30 km/h and also has several criteria for the test area, namely:

a) Straight
b) There is level crossing
c) There is a gongsol arch
d) There is a money order hand

The railway line in the Sidotopo area, with the starting point of Sidotopo station on line 5, shows in Fig.4, as far as 850 m to the south, meets these four criteria. This fifth path is used as the first path of the measurement experiment. Testing was performed by walking and pushing the measuring instrument. In the first test, the measuring instrument was pushed in the south direction as far as 850 m. Then, the measuring instrument is pushed toward the North until it returns to the starting point of the measurement. Line 6 of the Sidotopo station is the second line of the measurement experiment. This line was chosen because there is a gongsol line.

Figure 2. Experimental Area (Sidotopo Station, Line 5)

Figure 3. Experimental Area (Sidotopo Station, Line 6)

4. RESULT AND DISCUSSION

Because of the measurement experiment, the measuring instrument could record widening data along the measured path on either path 5 or path 6. The design of the measuring instrument has been able to pass and record data in the area, plane crossing, arch, and groove gap of the gongsol rail. The measurement data on line 5 are shown in Figure 6. and 7. The measurement results on the same path but from different starting points and opposite directions show that the measurement results to the south reflect those to the north. This shows the consistency of the measuring tool when making measurements. Meanwhile, the measurement results data on line 6 show that the measurement results to the south reflect the measurement results to the north.

The image shows one green line as the upper limit or widening tolerance of the rail track on a straight line with a standard width of 1067 mm plus +4 mm (1071 mm) and one blue line as the lower limit of the width of the 1067 rail track minus -2 mm (1065 mm). In contrast to straights, the upper limit arch is 1067 mm plus +31 mm, so the upper limit is 1098 mm, as shown by the red line. The measurement results between the red and blue lines indicate that the width of the lane is at the normal limit. Meanwhile, the measurement results above the red line or below the blue line indicate that the lane width is abnormal or that it needs to be improved. Except for the arch area, the line width data above the red line can still be considered normal because it has a larger tolerance limit.

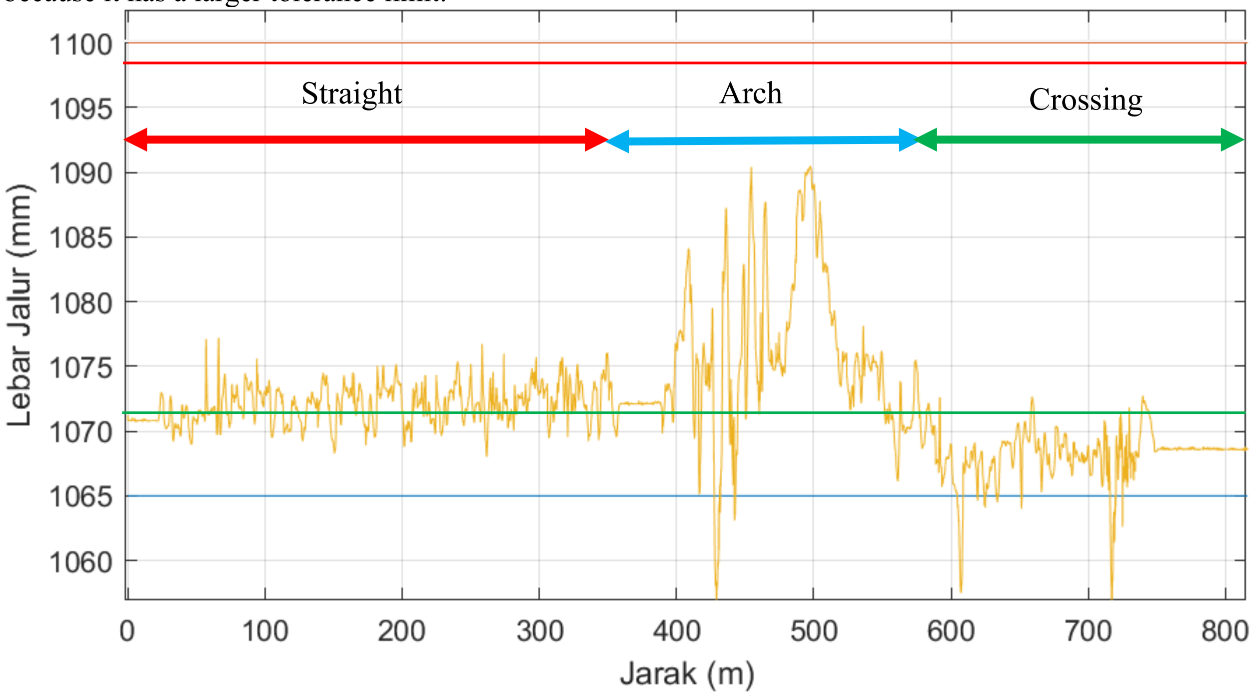


Figure 4. Track Width Data Measured on Line 5 of Sidotopo Station to the South

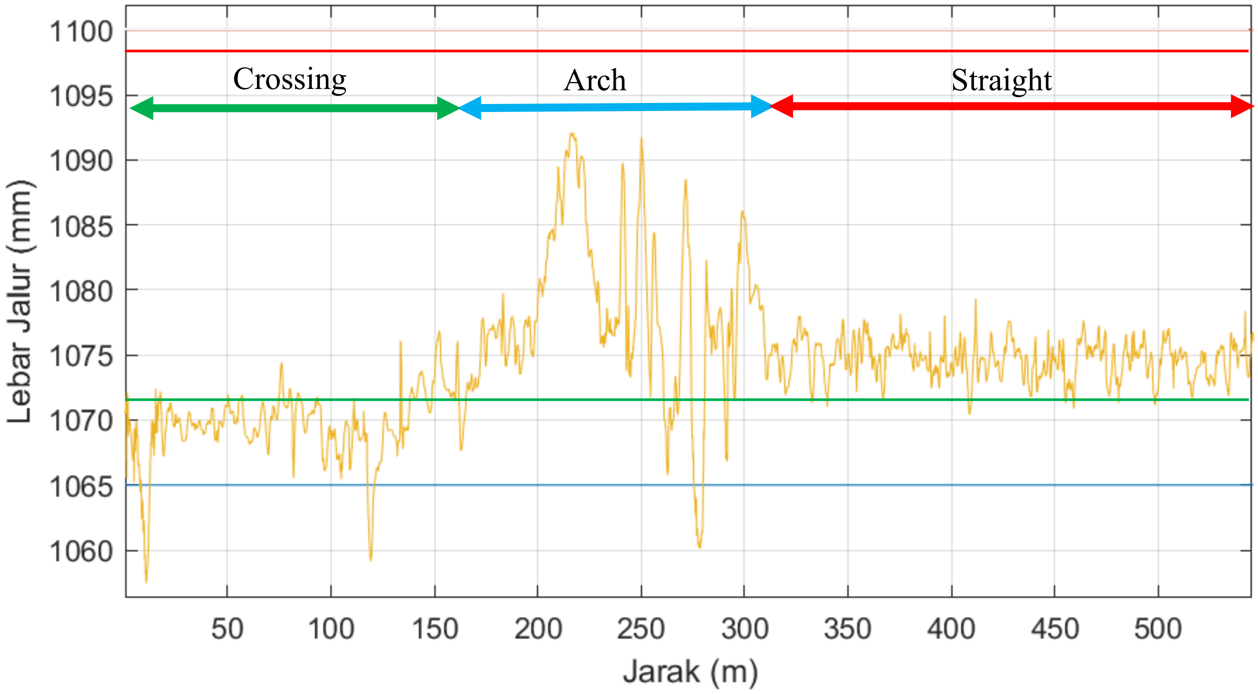


Figure 5. Track Width Data Measured on Line 5 of Sidotopo Station to the North

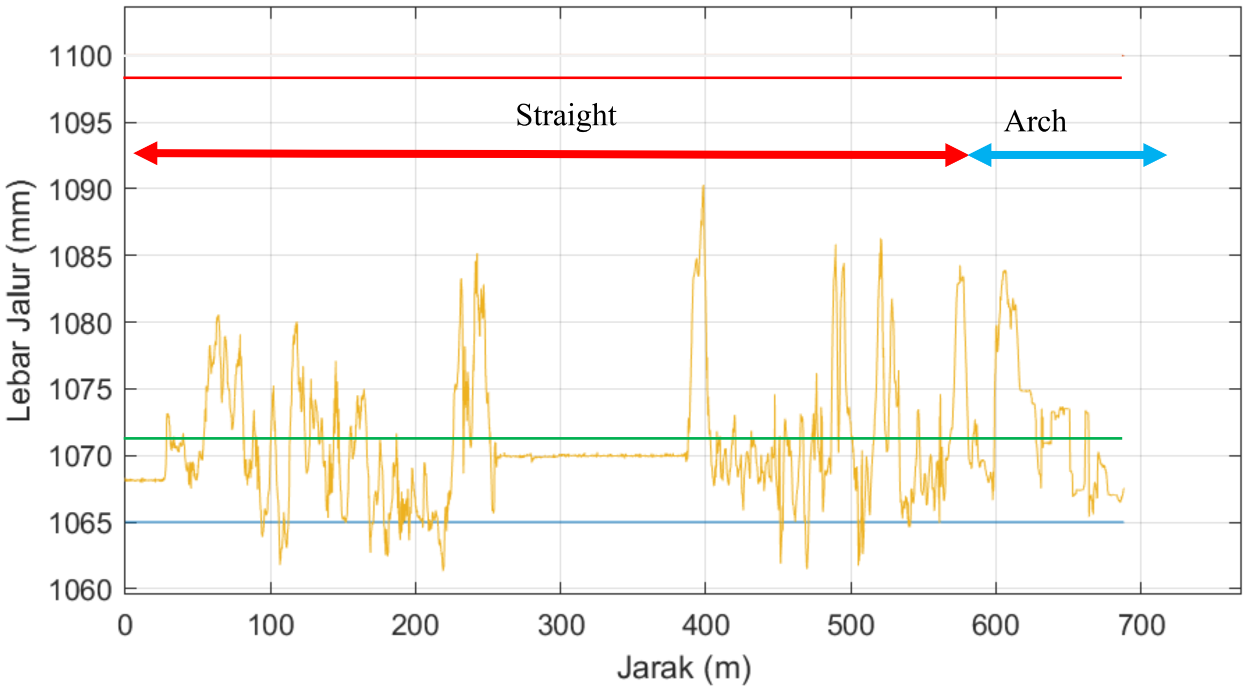


Figure 6. Track Width Data Measured on Line 6 of Sidotopo Station to the South

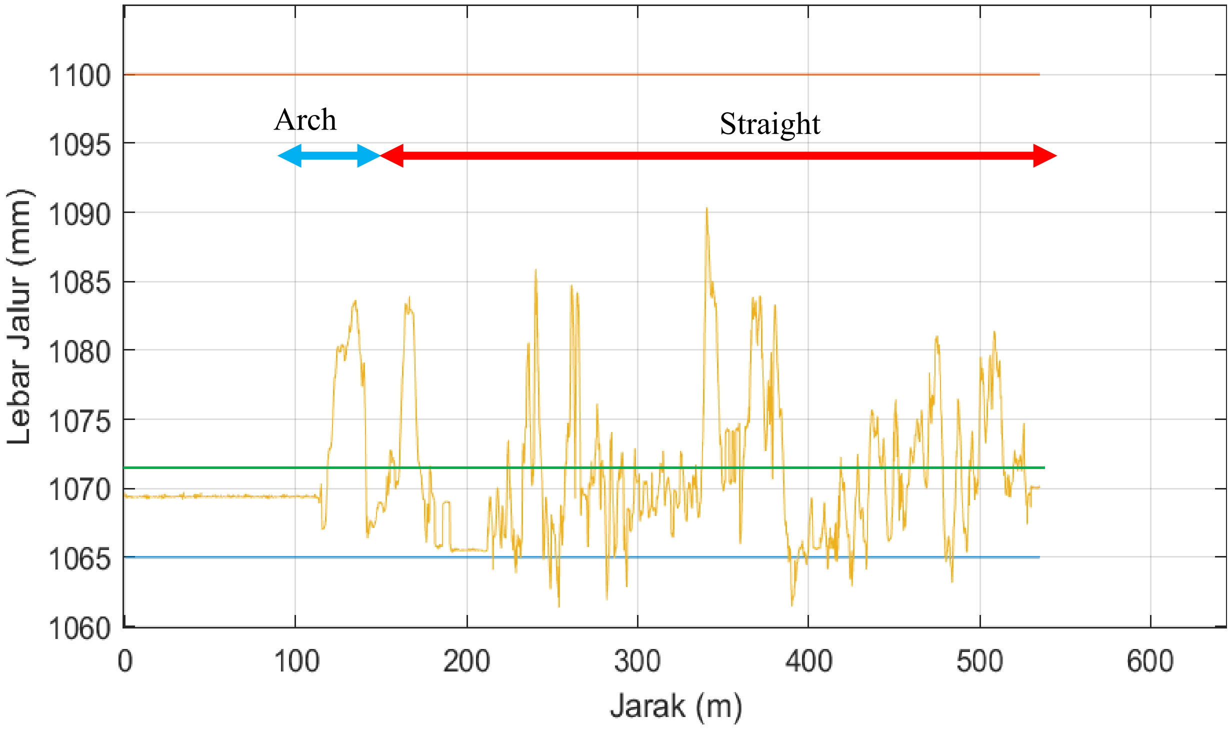


Figure 7. Track Width Data Measured on Line 6 of Sidotopo Station to the North

The measurement data also show that the narrowest span data that can be measured is 1058 mm, as shown by the measurement results of the measuring instrument on the 5th line. Meanwhile, the largest track width data that can be measured is 1092 mm, which is also shown by the results of measuring instrument measurements on line 5. This widest and narrowest range can be used as a reference for the range limit of the measurable line width change.

5. CONCLUSION

Track width gauges can be used to measure the widening of rail lines with straight, arch, money order needles, plane crossings, and gongsol tracks. The measurement data also show the consistency of the measurement results. Therefore, the measuring instrument can be used for continuous measurement of the width of the track without having to have a gap due to the condition of curves, money order hands, level crossings, and gongsol tracks.

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