Designing Track Holder Device For Maintaining Spoor Width In Railway Geometry Maintenance

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Abstract: Track Holder refers to the efforts of redesigning spoor holder device that has been sold in foreign market. Looking at the use of hammer that causes movement and damage on both the holder and the track, the manufacture of the track holder is intended to attain precise spoor width (1,067 mm) without causing any damage to the rail components under affordable budget. The manufacture of the track holder should go through three stages namely preparation, assembly/production and finishing. The track holder device that has been designed consists of two motor systems namely the manual system and the electric system. The dynamo that has been installed is Wiper Colt 130 W and 12 V 3 A Battery. Then, the weight per unit of the device is 4 kg while the length of the device is 1.30 m. The track holder device is able to sustain weight up to 3,282 kg. The prototype of the device was tested on the rail track with three devices and 2-bearing gap. The results of the test show that the track holder device is able to shift the rail track when the fastenings from all of the six bearings are uninstalled. The cost of manual track holder manufacture is IDR 1,229,000.00 while the cost of electric track holder manufacture is IDR 405,350.00. In other words, the track holder device is prominent in terms of technology and price but the use of electric track holder device should be evaluated further on the use of ratio gear and dynamo.

1. Introduction
The mounting of rail track that has been performed in Indonesia is still manual. The practice of rail track mounting in the field still relies on the human resources and this includes the mounting of rail track on the bearing, the mounting of fastening and the compaction of ballast [1]. In relation to the mounting, derail is one of the accidents that have been caused by several factors namely time-worn rail track, incompatible spoor width and rail track gap difference. From the data that have gathered in the field, it seems that almost all rail-track mountings have relied on the use of both pen-puller and hammer; as a result, the rail track suffers from motion that might expand the spoor width which has been previously adjusted [2] [3].

The tolerance of rail track expansion has been regulated by the Minister Regulation Number 60 Year 2012 Regarding Rail Track Technical Requirements. In the regulation it is mentioned that the tolerance of rail track expansion is 1,067 mm for the width with +2 -0 for the new track and also +4

[1] [2] [3]
and -2 for the already operating track. Therefore, the expansion should not exceed the tolerance requirements [4] [5].

Nowadays, there are numerous mountings of double-track systems such as PLS (Peningkatan Kelas Jalan Lintas Selatan, the Improvement of Southern Highway Road Type) and JGJM (Jalur Ganda Jombang-Madiun, Jombang-Madiun Double Track System). As a result, it is necessary to devise spoor width holder that meets the requirements of both rail track mounting and rail track maintenance in Indonesia. The initial setting of rail track mounting highly defines the future of the Indonesian rail track system. Therefore, the 1,067 mm-width requirements should not be given any tolerance due to the fact that the rail track mounting is not an existing one [2] [6]. Based on the problems that have been previously elaborated, the researchers would like to propose a method for devising spoor width holder device in order that the 1,067 mm-width requirements might be properly maintained during both the rail track mounting and the rail track maintenance. The device is expected to decrease the occurrence of rail track width geometry, which has caused the expansion on the rail width [4]. Then, in the practice the device will rely on the mechanical screw metal system with horizontal direction and will hold the rail track width in 1,067 mm by means of cast [7] [8]. Through such effort, the study is expected to provide new innovation on reliable and more affordable track holder device. In addition, the study is expected to meet other objectives as follows:

- To identify the budget cost for the device manufacture;
- To identify the strength and the weakness of both the manual and the electric track holder device;
- To identify the optimum performance of both the manual and the electric track holder device;
- To compare the track holder device and the existing device

2. Method
The method that had been performed in the study was the field material observation. The data were gathered by directly observing the device materials in the field and the rail track existing condition for the application of the recently manufactured device. Following the device manufacture process, the data were also gathered by attending to each manufacturing step and process starting from the design entry until the manufacture details. In addition, the researchers also performed library study by reading the existing literatures that were relevant to the conduct of the study.

The evaluation was an effort of measuring the results or the impacts of an activity, a program or a project by comparing the objectives that had been defined and how these objectives had been achieved [9] [10]. Furthermore, based on the method that had been used for evaluating the condition improvement would be pursued until the expected results had been achieved. The parameter was the comparison on the design that had been drafted, the method that had been used for constructing the rail track and the performance of the existing device.

3. Results and Discussions
The old track holder will serve as the reference for the specification of the new track holder. Thus, the new track holder will be developed based on the analyses and the ideas as follows:

- The new track holder device should be operable on 1,067 mm – 1,087 mm width.
- The new track holder device should use the new motor system namely wiper dynamo colt 130 Watt.
- The clamp should not be located on the head of the rail track but instead the clamp should be located on the leg of the track.
- The new track holder device should be operable on UIC 54 rail track and below.
- The new track holder device should be operable on the straight and the arch rail track.
• The new track holder device should not be operable on the switch.
• The budget cost for the manufacture of the new track holder should be 1:6 cheaper than the imported track holder device.
• The new track holder device should be portable in order to ease the operation and the package of the rail track.
• The new track holder device should be easily applied on the rail track mounting and maintenance.
• The use of both the manual and the electric motor should be portable.
• The use of cast/measurement device is intended to identify the spoor width during the adjustment.
• The gap for the inter-track holder mounting is 2-bearing.
• The fastening mounting should be performed after the spoor width has been precisely in 1,067 mm with the support from the new track holder system.
• The new track holder device should be hit-resistant.

The design of the new track holder is drafted through Auto-CAD graphic design software and the new track holder is designed in mm. The complete design of the new track holder might be consulted in the following figures.

Figure 1. Track Holder Design (1)

Figure 2. Track Holder Design (2)
Figure 3. Track Holder Screw Design (3)

Figure 4. Track Square Design (4)

Figure 5. Track Holder Design (5)
Then, the results of the analysis on the track holder device are as follows:

- The main arm uses galvanic steel pipe material BJ 37.
- The welding relies on the use of RD-type electrode.
- The screw component is made of solid steel shaft with 1-mm width from one rotation to another.
- The motor relies on colt wiper dynamo for yielding the electric power.
- The motor axle uses 3-cm width pipe.
- 12 Volt ACCU is used as the power source.

The calculation for the budget cost of the track holder device might be consulted in Table 1. Then, the final results of track holder manufacture cost will be compared to the price of track holder device with old specification that has been sold in railway track equipment site such as www.aldon.co.com or www.geissmar.com. The price of manual track holder device with old specification is US$ 808.80, which might be around IDR 12,000,000.00 under (under the assumption that US$1.00 is equal to IDR 14,000.00). Indeed, from the comparison the track holder device with new specification is cheaper. The track holder device with new specification starts from the assembly of the arm, that includes lathing, welding, grinding and shaping shock axle into the pipe according to the design. As soon as the components of the device have been completely assembled, the device will be manufactured. The manufacture stages are as follows:

- In assembling the track holder, the ball joint is installed on the arm in order to strengthen the screw part.
- After the joining has been done, the two-way screw is adjusted and is installed into the gear that has been prepared.
- The clamps are assembled in accordance to the design.
- After the clamps have been completely assembled, the arm and the clamps are combined.
- For the finishing, the device will be grinded, welded and painted.
Table 1. Manual Track Holder Budget Cost

| Item                              | Unit  | Volume | Price (in IDR) | Budget (in IDR) |
|-----------------------------------|-------|--------|----------------|-----------------|
| 3 cm-diameter 6 mm-thick steel pipe | m³    | 1      | 200,000.00     | 200,000.00      |
| Gear                              | piece | 2      | 150,000.00     | 300,000.00      |
| Electrode welding grain          | pack  | 1      | 75,000.00      | 75,000.00       |
| Grinding eye                      | piece | 10     | 2,400.00       | 24,000.00       |
| Drilling eye                      | pack  | 1      | 50,000.00      | 50,000.00       |
| Sandpaper                         | roll  | 1      | 6,000.00       | 6,000.00        |
| Paint                             | can   | 2      | 27,000.00      | 54,000.00       |
| Nuts and bolts (2.5 cm-diameter)  | piece | 2      | 110,000.00     | 220,000.00      |
| Worker                            | people| 2      | 150,000.00     | 300,000.00      |
| Total Cost                         |       |        |                | 1,229,000.00    |
Table 2. Electric Track Holder Budget Cost

| Item                          | Unit | Volume | Price (in IDR) | Budget (in IDR) |
|-------------------------------|------|--------|----------------|-----------------|
| 3 cm-diameter 6 mm-thick steel pipe | m²   | 1      | 200,000.00     | 200,000.00      |
| Gear                          | piece | 2      | 150,000.00     | 300,000.00      |
| Reducer                       | unit  | 1      | 500,000.00     | 500,000.00      |
| Bearing                       | item  | 2      | 15,000.00      | 30,000.00       |
| Electrode welding grain       | pack  | 1      | 75,000.00      | 75,000.00       |
| Grinding eye                  | piece | 10     | 2,400.00       | 24,000.00       |
| Drilling eye                  | pack  | 1      | 50,000.00      | 50,000.00       |
| Sandpaper                     | roll  | 1      | 6,000.00       | 6,000.00        |
| Paint                         | can   | 2      | 27,000.00      | 54,000.00       |
| Nuts and bolts (2.5 cm-diameter) | piece | 2      | 110,000.00    | 220,000.00      |
| Dynamo                        | unit  | 1      | 235,000.00     | 235,000.00      |
| 12-volt batteries             | unit  | 1      | 300,000.00     | 300,000.00      |
| Worker                        | People | 2      | 300,000.00     | 600,000.00      |
| Total Cost                    |       |        | 1,229,000.00   |

In overall, the manufacture of track holder device takes about 10 days with attention to the workers’ resting time and paint-drying process period. The assembly of the track holder device itself actually takes around 30 minutes and track holder itself is portable so that the user might easily use and carry the device when the user is in the field. After the assembly process has been done, the track holder device might be sent to the direct field testing on the ballasted rail track.

The rail track holder assembly is conducted in the emplacement of Kroya Train Station. The assembly is intended for the railway mounting in the emplacement. Then, the track holder is installed in the Laying Track on the Platform Number 3 in Kroya Train Station. The instalment of the rail track holder at the end of the railway is temporary because the researchers would like to test how the performance of the rail track holder is when it is paired with the shaft; in the meantime, the performance test of the rail track holder device when it is paired with the dynamo is conducted in JPL 48 train stop. The conduct of the assembly is based on two aspects namely the operation and the method of the rail track holder assembly.

The operation of the rail track holder device is divided into two categories namely the manual operation and the electric operation. The manual operation relies on the use of shaft while the electric operation relies on the use of dynamo with the guidance of gearbox. The sequence of the manual operation is as follows:

- Prepare the device and loose both bolts on the rail clamp
- Install the clamp to hold both legs of the rail
- Tighten the screw bolt in order to hold the legs of the rail so that the railway might be properly held
- Put the lever on the main gear
- Prepare the cast or the Matisa for measuring the spoor width (the sample for the first testing is attained from the emplacement of Kroya Train Station and the spoor width in the sample is 1,077 mm)
- Move the shaft forward and backward in order to adjust the spoor width until the 1,067 mm requirement is met
- Perform the step a until f until the spoor width hits 1,067-mm requirement
Figure 9. Spoor width measurement with cast

Figure 10. Spoor width adjustment with manual shaft

The instalment of dynamo-powered device is similar to that of shaft-powered device. The difference is that the instalment of dynamo-powered device demands electric power source. In the test, the power source is 12-volt battery. Then, the step of installing the dynamo-powered device is as follows:
• Prepare the dynamo and the battery (the battery might be taken from the motorcycle battery or specifically the 12-volt battery)
• Assemble and install the dynamo on the axle gear of the device and strengthen the bearing with Ring-12 pass key
• Install the clamp of the device on the legs of the rail track and strengthen the clamp with nuts and bolts
• Connect the dynamo to the battery with the socket and the cable that have been prepared
• Move the analogue of the device for rotating the dynamo and adjust the analogue until the 1,067-mm spoor width requirement has been attained

![Figure 11. The instalment of electric dynamo to the as gear](image1.png)

![Figure 12. The adjustment of spoor width by means of electric dynamo](image2.png)
The selection of the instalment method for the Laying Track is based on the feedback that the academic advisor provides in the field. Then, the manual operation is conducted in the first point because the manual operation provides more power to the rail track shift. Afterward, the electric operation is conducted in the second and the third point. The complete step in the instalment of the Laying Track is as follows:

- Install the three devices prior to the fastening (the installation is similar to the previous one)
- Install the three devices in the following sequence: manual – electric – electric; the gap from one device to another is 2-bearing at maximum
- Prepare the cast/Matisa on the head of the real in horizontal direction
- Use the Matisa to adjust the spoor width until the 1,067 mm-requirement has been met and then use the shaft-powered device to adjust the spoor width until the 1,067 mm-requirement has been met
- Adjust the spoor width on both dynamo-powered devices until the 1,067 mm-requirement has been met
- Install the fastening on each device and strengthen the ballast with HTT
- Uninstall the shaft and the dynamo and install the shaft and the dynamo again to the spoor part subsequently to all devices

![Diagram](figure13.png)

**Figure 13.** Instalment method of track holder

Note:
- : The mounting of the first device
- : The mounting of the subsequent device after the prior job has been done

The gap from one device to another is set to 2-bearing due to the maximum use of the device so that the workers should not need to put their extra power. Then, the experiment on the use of the manually operated device and the electrically operated device that has been conducted in Kroya Train Station and Upper Electric Line (LAA, ListrikAliranAtas) of API Madiun is analysed. The first experiment is conducted in the third emplacement of kroya Train Station with shaft-powered device by shifting the
spoor without any fastening from 1075 mm-width to 1,067 mm-width. The conduct of the first experiment will be explained in the following paragraph.

The obstacle that has been found from the experiment in the third emplacement of Kroya Train Station is that the shape of the clamp in the device does not efficiently pinch the legs of the rail track. It takes relatively two times for the workers to strengthen the bolts. As a result, the clamp in the device should be redesigned. Then, in terms of practicality there is not any obstacle that has been found because the rail track holder device might be carried by one worker only under any terrain. In addition, the rail track holder device is 100% functioning. The results of the revision that has been based on the experiment in the third emplacement of Kroya Train Station are as follows:

- The design on the end of the clamp should be claw-shaped in order to ease the instalment of the device in the legs of the rail track.
- The lock in the clamp should use one nut and one bolt.
- The metal elbow should be provided in order to gain more precision on the adjustment of the spoor width.
- An opening has been found during the clamp instalment; as a result, the device is not totally installed on the legs of the rail track.
- The RPM of the dynamo that has been too small, along with the gear that has been too big, has caused the rotation in the as become slow; as a result, the dynamo motor becomes inefficient for the urgent job.
- The size of the pipe is too long; as a result, when the device adjusts the track to meet the 1,067 mm-width requirement the pipe already hits the as and thus 4 cm of the pipe should be cut.

![Figure 14. The clamp for the legs of the rail track prior to the re-design](image)
On the other hand, the testing in the LAA API Madiun is intended for the geometry maintenance job of the rail track by using the rail track holder. The sequence in the testing is as follows:

- Measure the spoor width of each point with matisa and also number record each point (note: the shifting of the spoor width is 2-bearing at each point)
- Scratch the ballast on the point that has been defined
- Release the fastening by using pen-puller or sledgehammer
• Install the manual-powered track holder first and then the two electric-powered track holders on the subsequent point
• Put the matisa on the first point in the rail and then shift the rail track by using the shaft until the 1,067 mm-requirement of the spoor width has been met
• Continue the previous step on the second point by using the electric-powered rail track holder
• Install the fastening and release the track holder from both legs of the rail track and then continue to the following track (the step a until e should be performed continuously)
• Close the ballast again and strengthen the ballast using HTT

![Image](image_url)

**Figure 17.** Geometry maintenance work on the rail track by using the rail track holder

**Table 3.** Example of Geometry Measurement Results from the LAA API Madiun Track

| Point | Required Spoor Width | Spoor Width | Shifting |
|-------|----------------------|-------------|----------|
| 1     | 1,067 mm             | 1,067.50 mm | - 0.50 mm |
| 2     | 1,067 mm             | 1,066.40 mm | + 1.40 mm |
| 3     | 1,067 mm             | 1,066.20 mm | + 1.20 mm |
| 4     | 1,067 mm             | 1,065.60 mm | + 2.60 mm |
| 5     | 1,067 mm             | 1,066.80 mm | + 0.20 mm |
| 6     | 1,067 mm             | 1,069.10 mm | - 2.30 mm |

The obstacle that has been found in the second test is that the type of the rail track in LAA API Madiun is R42 while the track holder that has been designed is compatible for R54 type. As a result, the clamp width for clamping the legs of the rail track is so big that the track holder is hanging on the rail track. Not to mention, the boost force of the dynamo is still so insufficient that the gear becomes out of the track.
The solution might be suitable for countering the obstacle is providing steel plate on the elbow clamp of the device as the mounting part so that the rail track holder device might pinch the legs of the rail well. Then, for the RPM, there should be more calculation on the motor design so that the power and the RPM of the dynamo will be compatible and sufficient. In addition, the weight, the shape and the cost of the rail track holder should be calculated again.

![Figure 18. Mounting part of type 42 rail track](image)

The advantages of the manual-powered rail track holder device are as follows:

- The manual-powered rail track holder device is more time-economic because the shaft is directly operated on the axis of the gear in the device.
- The manual-powered rail track holder device is faster in shifting the spoor width geometry and the in adjusting the device itself.
- The manual-powered rail track holder has lower manufacture cost.

On the other hand, the disadvantage of the manual-powered rail track holder device is that the device is still manual. Since it relies on human power, much power will be exerted.

In comparison the advantage of the electric- or the dynamo-powered rail track holder device is that the electric-powered rail track holder relies on the electricity as the power source. As a result, this type of track holder devices saves more energy. Unfortunately, the only disadvantage is that the dynamo power is still insufficient and thus the design of the dynamo should be improved. Furthermore, there are also several problems in relation to the dynamo that should be solved:

- The dynamo is difficult to be mounted on the gear axis since the dynamo installation takes quite a long time.
- The RPM of the dynamo is too low and consequently it takes longer time to shift the spoor width.
The manufacture cost of the dynamo-powered rail track holder device is expensive due to the use of the components such as the gear box, the dynamo itself and the battery. The dynamo-powered rail track holder device is still low and this situation has caused the gear to be out of the rail track.

The manufacture cost for the sample is taken from the HSPK for the Regency of Banyumas; as having been reported by the website of UMK 2018, the amount that has been agreed by the Regent of Banyumas is IDR 1,583,000.00. Then, the fund disburse is based on the guideline of AHSP (AnalisaHargaSatuanPekerjaan, Price-Per-Job Unit Analysis) for the Laying Track Maintenance in the third emplacement of Kroya Train Station with reference to HPS (HargaPerkiraanSendiri, Manually Calculated Cost). HPS is attained from the team calculation on the cost of the workers’ need and equipment with reference to an institution or a company. The sample of RAB for the device testing is taken from HPS Satker 2 PLS 2 for the Laying Track Maintenance, which has been conducted by Hapsaka Mas Company – BahanaSupridoKreasi KSO, with addition on the calculation of RAB for the device design. The sufficient number of workers for the Laying Track Job is 38 people with 6-hour window time. The Salary-Per-Worker Unit Analysis (AHSP, AnalisaHargaSatuanPekerja) on the Laying Track Maintenance might be consulted in the following paragraph.

The per-meter budget for conducting the Laying Track Maintenance is attained from the calculation of coefficient volume for the worker in each meter of maintenance. The maintenance itself consists of track dismantle, rail track geometry adjustment and ballast compaction by using HTT (Hand Tie Temper). Then, the calculation in the RAB generates the cost of each job. The total cost for the maintenance will be as follows:

\[
\text{Total Cost} = \text{IDR 46,600.00 + IDR 60,000.00 + IDR 117,800.00 + IDR 43,600.00 + IDR 47,791.00 + IDR 315,791.00} \\
= \text{IDR 316,000.00}
\]

Therefore, the total cost that should be met for conducting the Laying Track Maintenance from the dismantle until the compaction is IDR 316,000.00 / meter.

The calculation for the device coefficient is based on the installation period of all devices with reliance on 2 workers. After the cost has been identify, the cost will be added with the total price of Laying Track. Then, in defining the coefficient the time period for each point of adjustment that should meet the 1,067 mm requirement width should be calculated first through the following method.

Identified:

Workers : 2 people
7 points with 8.40 m-distance with 30-minute job

\[
Q_T = \frac{8}{30} = 0.267 \frac{m}{minute}
\]

Working hours : 7 hours (window time)
Size of production quantity : QT
2 workers are able to complete 8.40 m within 30 minutes.

Productivity : \(0.267 \frac{m}{minute} = 16,02 \frac{m}{hours}\)
Working hours per day : \(6 \frac{hours}{day}\)

Workers \(= \frac{6 \times 2}{16,02} = 0.749 OH = 0.75 OH\)
After the coefficient of the worker has been attained, the coefficient might be inputted into the RAB Calculation Table with the addition of the total cost. The result then will be as follows.

Identified: Track Holder Maintenance Job

Budget = Coefficient × Unit Price
= 0.75 × IDR 70,000.00
= IDR 52,500.00

Total Cost = IDR 316,000.00 + IDR 52,500.00
= IDR 368,500.00

VAT 10% = IDR 36,850.00

Overall Cost = IDR 368,500 + IDR 36,850
= IDR 405,350.00

In sum, the total cost that should be met for the device use and the Laying Track Maintenance, including the value-added tax, is IDR 405,350.00 / meter.

4. Conclusions and Suggestions

Track Holder Device is a rail track maintenance device that serves to fix the rail track geometry that has not met the standards. In terms of the new specification for the straight line and the arch line with 1,067-mm spoor width, the new track holder device has several advantages namely the device is both manual- and electric-powered, the device is easy to use and the device is portable. In comparison to the straal owned by Indonesian Railways Company, the new track holder device is more prominent because the design of the device has already been adjusted to the workers’ capacity and it is wear-resistant. In addition, the new rail track holder device is able to push and pull the rail track while the straal is only able to pull the rail track.

The per-meter cost for operating the track holder device is IDR 405,350.00. The manual-powered track holder device is more efficient in comparison to the electric-powered track holder device because the manual-powered track holder device spends shorter time of installation and lower cost yet it is able to earn the quality similar to the electric-powered device. It is expected that the track holder device might be developed further in terms of both design and function so that it might gain better performance in the future.

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