COMPARISON OF MAIN CONTACT STRIP WEAR RATES BETWEEN LOCAL AND IMPORTED PRODUCTS ON THE PANTOGRAPH OF THE JAKARTA MRT TRAIN WHILE OPERATING ON THE MAINLINE

Akbar Zulkarnain[1]*, Rizky Rehandany[1], Dia Cahaya Putri[2]
[1]Railway Mechanical Technology, Indonesian Railway Polytechnic, Tirta Raya Street, Madiun City, East Java 63129, Indonesia
[2]Railway Systems Engineering and Integration, University of Birmingham, Edgbaston, Birmingham, B15 2TT, England
*akbar@ppi.ac.id

ABSTRACT
The Jakarta MRT (mass rapid transit) is an electric railway train with a track length of 16 km that runs from the Lebak Bulus station to the Hotel Indonesia roundabout station. The main component of the electric railway train is the pantograph, with a voltage source of 1500 Vdc leading to the train motor traction, part of the pantograph that is directly related to the upper flow of electricity is the main contact strip. Increase the use of domestic components by replacing imported product main contact strip components with local product main contact strips. Therefore, this study aims to compare main contact strip wear rates between local and imported products. The data in this study were obtained from Daily Maintenance in the form of kilometer data and wear rate data. Data analysis uses a simple linear regression method which aims to find a comparison between the wear rate and kilometres of main contact strips of local products and imported products. Based on the results of the analysis, it is found that the wear rate of the main contact strip of local products is better than that of imported products. While the service life of the main contact strip since the first kilometer of operation on local products is more durable than imported products.

Keywords: Jakarta MRT; kilometers; main contact strip; mileage; wear rate

INTRODUCTION
MRT (Mass Rapid Transit) Jakarta is one of the rail vehicle transportation service providers in Jakarta. MRT Jakarta operates at the end of March 2019 with a track length of 16 km consisting of 6 underground stations and 7 elevated stations, which are located between Lebak Bulus station and Bundaran Hotel Indonesia station. Supported by MRT Jakarta facilities with a total of 16 trainsets, each trainset consisting of 6 cars (Firmansyah, 2022). MRT Jakarta is one of the electric rail trains, which has a main component, namely a pantograph. The pantograph is a component that functions as a connector between the copper cable and the source of the upper flow of electricity, which operates at a voltage of 1500 Vdc. One of the main components of the pantograph is the main contact strip, which functions to channel electricity from the upper flow of electricity through friction when the train is moving. (Rifa'i and Prayogi, 2021).

Friction on the main contact strip against the overhead power cable can cause various problems on the main contact strip itself. Friction on the surface can cause heat which will result in wear, because the study of materials states that the hardness of a material decreases in the material if the temperature on the surface increases.(Surawan et al., 2021) Some of the damage that can occur due to this friction includes wear, cracks, leaks, and corrosion. (Besihi Technique and Style, 2013) Wear occurs due to repeated friction on the main contact strip against the overhead power cable which causes changes in shape and reduction of material on the main contact strip.

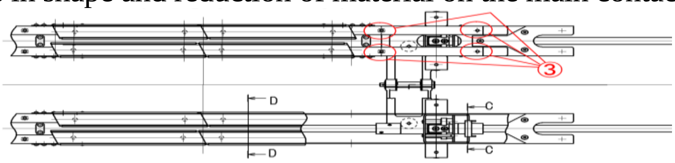

Figure 1. Cross Section of Main Contact Strip

These damages need to be monitored regularly and repaired if necessary so that the performance of the pantograph and main contact strip remains optimal and safe during train operations. (Sinaga et al., 2020). Next, it is necessary to measure the thickness of the main contact strip and measure the spring compression force so that the actual condition of the component is maintained. If a component is found that needs repair or replacement, then immediate action is taken. (Rifa'i and Prayogi, 2021). According to Law Number 29 of 2018 concerning Industrial Empowerment, Article 61 paragraph 1 states that the level of domestic components is at least 40%. Therefore, MRT Jakarta is trying to increase the use of domestic main contact strip components in the form of replacing imported main contact strip components with local main contact strip products. In addition, according to maintenance data, imported main contact strips experience high wear. So it is necessary to compare the wear rate of imported main contact strips with local main contact strips. In this study, testing was conducted on local and imported main contact strips using 2 trainsets, namely trainsets 1 and 6. The installation of local main contact strip was installed on the Pantograph Car 3 (M1') and the imported main contact strip was on the Pantograph Car 5 (M1). Both main contact strips use new products. This testing lasted for 5 months, namely (November - March) then during this testing, trainsets 1 and 6 will always use odd pantographs, namely car 3 and car 5.

Next, the thickness measurement of the main contact strip will be carried out every daily maintenance. The measurement produces results that will be used as comparative material for this study. From the measurement results, data will be processed using Microsoft Excel and SPSS (Statistical Package for the Social Sciences) software with a simple linear regression method. Based on the description above, the author will compile a study entitled "Comparison of Main Contact Strip Wear Rate Between Local and Imported Products on MRT Jakarta Pantograph Trains When Operating on the Mainline". The results of this comparative analysis will later be recommended to the MRT Jakarta Rollingstock department as a consideration or reference for the main contact strip comparison results to provide the best results from the comparison.

METHOD

Data collection methods are divided into primary data and secondary data. Primary data in this study were obtained by conducting direct measurements in the field or MRT Jakarta depot. This measurement uses a vernier caliper to measure the thickness of the MRT Jakarta pantograph main contact strip. This observation activity was carried out from January 2024 to March 2024. Secondary data that will be used comes from reading sources, both journals, articles, or MRT Jakarta manuals. Secondary data in this study are in the form of data on the wear rate of the main contact strip during initial installation in November to December 2023, data on trainset 6 and trainset 1 kilometers from November to March, and specifications of local and imported main contact strip products.

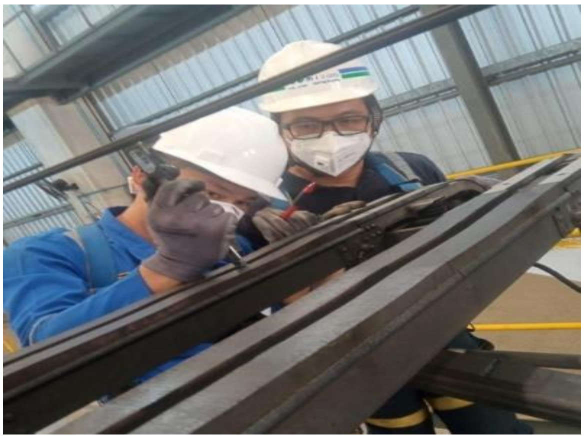

Figure 2. Main Contact Strip Thickness Measurement

After collecting the data, the next step is data processing. Primary and secondary data are grouped into tables using Microsoft Excel to be categorized into dependent variables and independent variables. In this study, the independent data includes kilometers of use, while the dependent data is the wear rate. Furthermore, the data will be tested for normality and linearity using SPSS. If the data passes the normality and linearity tests, it will be continued with a simple linear regression test on SPSS. The final stage after processing the data, will be analyzed the data to find out the results of the research that has been done by determining the conclusion of the analysis process that has been done. There are several pieces of data to be analyzed, namely data on kilometers of use against the rate of wear. At this analysis stage using simple linear regression analysis from SPSS. Before analyzing the data using the simple linear regression method, the data must be ensured to have passed the eligibility requirements of the simple linear regression model, namely by conducting a normality test and a linearity test. After the data can be said to have passed the normality and linearity tests, the next stage can be carried out a simple linear regression test. The results of the simple linear regression analysis in SPSS are interpreted to answer the formulation of the problem in this study. The use of SPSS in this study is the first normality test using Kolmogorov Smirnov which is used before the simple linear regression test analysis is carried out. The data tested for normality is kilometers of use with the rate of wear. Second, the linearity test is used before the simple linear regression test analysis is carried out. The data tested for linearity is kilometers of use with the rate of wear of the main contact strip. The third is a simple linear regression test used to find the effect of kilometers of use on wear on the main contact strip of local and imported products.

RESULT AND DISCUSSION

The following is data on the effect of kilometers of use on the Wear Rate of the main contact strip on the Jakarta MRT train. The data will be analyzed by simple linear regression, but before the simple regression test is carried out, the data must be tested for classical assumptions, including normality tests and linearity tests. On trainsets 1 and 6 which have 4 pantographs per 1 trainset and 4 main contact strips per 1 pantograph. However, from the 4 pantographs, the Wear Rate data is taken from 2 pantographs. The wear rate to be analyzed is taken from Trainset 6 and Trainset 1 by finding the mean or average value.

Figure 3. Pantograph

According to the MRT Jakarta train manual on the propulsion system, the MRT Jakarta pantograph uses a single arm type, where each panhead consists of a combination of 2 main contact strips. The manual also provides information on the care and maintenance of pantograph components and their supporting components. Linearity testing is one of the requirements in simple linear regression analysis. The linearity test is used to determine whether the relationship between two quantitative variables is linear. The linearity test aims to determine whether the form of the relationship between the independent variable and the dependent variable is linear or not. This test is carried out using a scatter plot graph by adding a regression line.

The following are the criteria for linearity testing using scatter plots:

1. If the graph shows data plot points in the form of a straight-line pattern from top right down to bottom left or from top left down to bottom right, then the data is included in the linear category.
2. If the graph does not have a straight-line pattern from top right down to bottom left or from top left down to bottom right, then the data is not included in the linear (non-linear) category.

a. Trainset 6 imported products

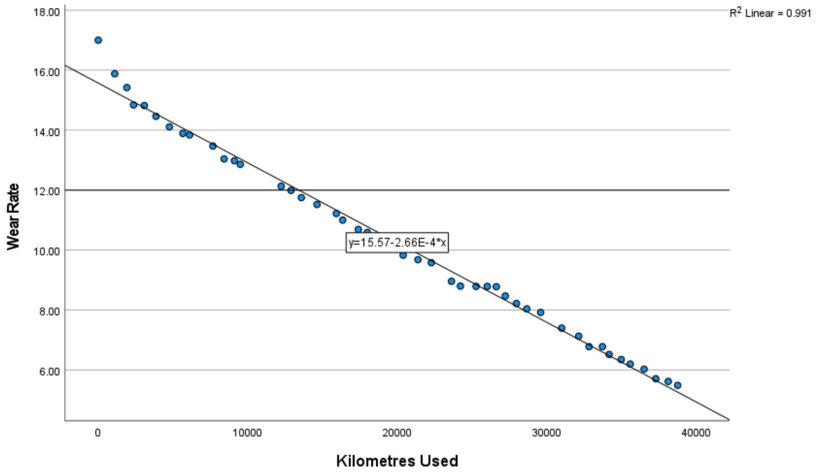

Figure 4. Scatter Plot Chart Trainset 6 imported products

In Figure 4, the data plot points can be seen in the form of a straight-line pattern from the top left down to the bottom right. It can be seen that there is a linear and negative relationship between the variable kilometers of use and the rate of wear. The negative relationship in question is that over time it will reduce the rate of wear on the main contact strip.

b. *Trainset 6* local Products

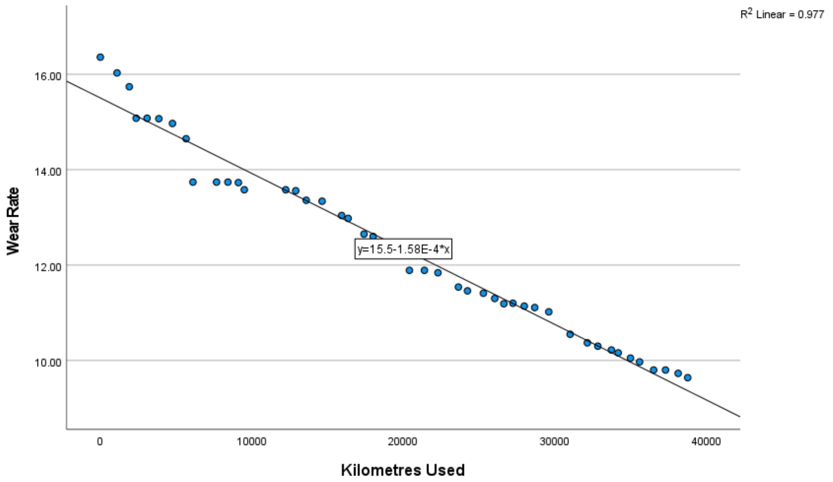

Figure 5. Scatter Plot Chart Trainset 6 local products

In Figure 5, the data plot points can be seen in the form of a straight-line pattern from the top left down to the bottom right. It can be seen that there is a linear and negative relationship between the variable kilometers of use and the rate of wear. The negative relationship in question is that over time it will reduce the rate of wear on the main contact strip.

c. *Trainset 1 imported products*

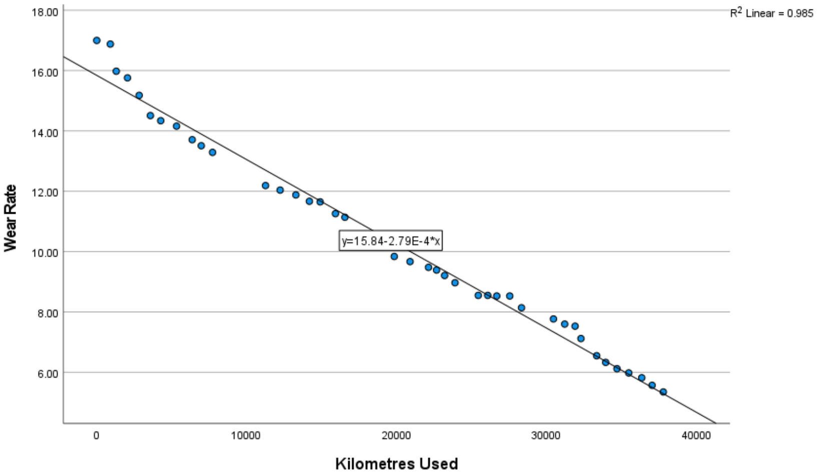

Figure 6. Scatter Plot Chart Trainset 1 imported products

In Figure 6, the data plot points can be seen in the form of a straight-line pattern from the top left down to the bottom right. It can be seen that there is a linear and negative relationship between the variable kilometers of use and the rate of wear. The negative relationship in question is that over time it will reduce the rate of wear on the main contact strip.

d. *Trainset 1* local products

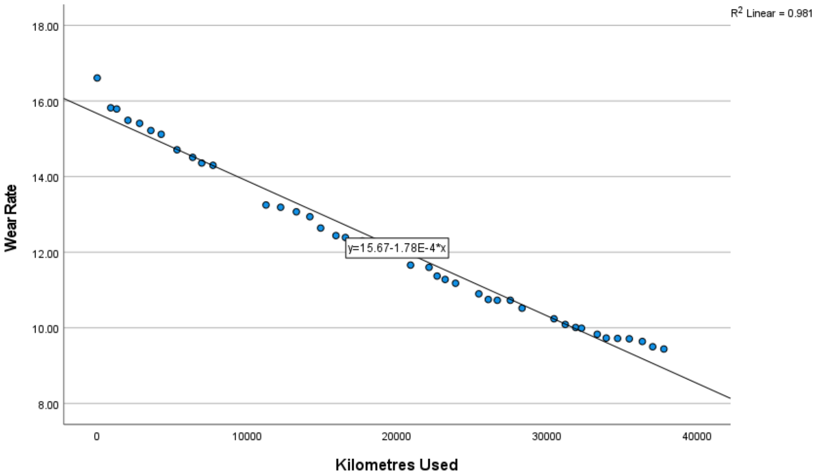

Figure 7. Scatter Plot Chart Trainset 1 local product

In Figure 7, the data plot points can be seen in the form of a straight-line pattern from the top left down to the bottom right. It can be seen that there is a linear and negative relationship between the variable kilometers of use and the rate of wear. The negative relationship in question is that over time it will reduce the rate of wear on the main contact strip. Linear regression test is used to analyze the effect of one independent variable on one dependent variable. To determine the influence between the independent variable and the dependent variable, a test is conducted by comparing the significance value with a probability value of 0.050. If the significance value is <0.050, then it is assumed that the independent variable has a significant effect on the dependent variable. However, if the significance value is >0.050, then it is assumed that the independent variable does not have a significant effect on the dependent variable. The following are the results of a simple linear regression test on kilometers used against wear rate:

a. ***Trainset* 6 imported products**

Table 1.
Output Model Summary Trainset 6 imported products

Model Summary				
Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	.996[a]	.991	.991	.29889

From Table 1, the output is obtained in the form of a correlation value (R) of 0.996 which indicates a perfect (very strong) relationship between kilometers of use and wear rate. This is supported by the coefficient of determination (R Square) of 0.991 which indicates that the independent variable (kilometers of use) has an influence of 99.1% on the dependent variable (wear rate), while the remaining 0.9% is influenced by other factors.

Table 2.
Output Coefficients Trainset 6 imported products

Coefficients						
Model		*Unstandardized Coefficients*		*Standardized Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
1	*(Constant)*	15,569	.087		179,484	.000
	Kilometers Used	-0.000266	.000	-.996	-70,502	.000

Table 2 shows the constant value (a) of 15.569 and the regression coefficient value (b) for the variable kilometers of use of -0.000266. Thus, the regression equation can be written as follows:

Y = a + bX

Y = 15.569 – 0.000266X

This equation can be interpreted as:

1. The constant value is 15.569, which means that the consistent value of the wear rate variable is 15.57.
2. The value of the regression coefficient X is -0.000266, which shows that for every 1% increase in the distance traveled (3,876 km), the main contact strip rate value decreases by 0.000266 mm.

Based on the significance value in Table 3, a significance value of 0.000 < 0.050 was obtained, so it can be stated that the variable of kilometers used (X) affects the wear rate (Y).

Table 3.
Output Model Summary Trainset 6 local products

Model Summary				
Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	.998a	.977	.976	.29057

From Table 3, the output is obtained in the form of a correlation value (R) of 0.988 which indicates a perfect (very strong) relationship between kilometers of use and wear rate. This is supported by the coefficient of determination (R Square) of 0.988 which indicates that the independent variable (kilometers of use) has an influence of 98.8% on the dependent variable (wear rate), while the remaining 1.2% is influenced by other factors.

Table 4.
Output Coefficients Trainset 3

Coefficients						
Model		*Unstandardized Coefficients*		*Standardized Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
1	*(Constant)*	15,505	.084		183,867	.000
	Kilometers Used	-0.00158	.000	-.988	-43,189	.000

Table 4 shows the constant value (a) of 15.505 and the regression coefficient value (b) for the distance variable of -0.000158. Thus, the regression equation can be written as follows:

Y = a + bX

Y = 15.505 – 0.000158X

This equation can be interpreted as:

1. The constant value is 15.505, which means that the consistent value of the main contact strip variable is 15.50.
2. The value of the regression coefficient X is -0.000158, thus indicating that for every 1% increase in the distance traveled (3,876 km), the wear rate of the main contact strip decreases by 0.000158 mm.

Based on the significance value in Table 4.13, a significance value of 0.000 < 0.050 was obtained, so it can be stated that the variable of kilometers of use (X) affects the variable of wear rate (Y).

b. ***Trainset 1 imported product***

Table 5.
Output Model Summary Trainset 1 imported products

Model Summary				
Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	.993a	.985	.985	.40392

From Table 5, the output is obtained in the form of a correlation value (R) of 0.993 which indicates a perfect (very strong) relationship between kilometers and wear rate. This is supported by the coefficient of determination (R Square) of 0.985 which indicates that the independent variable (used kilometers) has an influence of 98.5% on the dependent variable (wear rate), while the remaining 1.5% is influenced by other factors.

Table 6.
Output Coefficients Trainset 1 imported products

Coefficients						
Model		*Unstandardized Coefficients*		*Standardized Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
1	*(Constant)*	15,842	.121		131,419	.000
	Kilometers Used	-0.00279	.000	-.993	-52,380	.000

Table 6 shows the constant value (a) of 15,842 and the regression coefficient value (b) for the distance variable of -0.000279. Thus, the regression equation can be written as follows:

Y = a + bX

Y = 15.842 – 0.000279X

This equation can be interpreted as:

1. The constant value is 15.842, which means that the consistent value of the main contact strip variable is 15.84.
2. The value of the regression coefficient X is -0.000279, thus indicating that for every 1% increase in the distance traveled (3,778 km), the wear rate of the main contact strip decreases by 0.000279 mm.

Based on the significance value in Table 4.16, a significance value of 0.000 < 0.050 was obtained, so it can be stated that the variable of kilometers used (X) affects the variable of wear rate (Y).

a. *Trainset* 1 local product

Table 7.
Output Model Summary Trainset 1 local product

Model Summary				
Model	R	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	.991a	.981	.981	.29026

From Table 7, the output is obtained in the form of a correlation value (R) of 0.991 which indicates a perfect (very strong) relationship between kilometers of use and wear rate. This is supported by the coefficient of determination (R Square) of 0.981 which indicates that the independent variable (kilometers of use) has an influence of 98.1% on the dependent variable (wear rate), while the remaining 1.9% is influenced by other factors.

Table 8.
Output Coefficients Trainset 1 local product

Model		*Unstandardized Coefficients*		*Standardized Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
1	*(Constant)*	15,670	.087		180,894	.000
	Kilometers Used	-0.00178	.000	-.991	-46,586	.000

Table 8 shows the constant value (a) of 15.56 and the regression coefficient value (b) for the distance variable of -0.123. Thus, the regression equation can be written as follows:

Y = a + bX

Y = 15.670 – 0.000178X

This equation can be interpreted as:

1. The constant value is 15.569, which means that the consistent value of the main contact strip variable is 15.57.
2. The regression coefficient value of X is -0.000266, thus indicating that for every 1% increase in the distance traveled (3,778 km), the wear rate of the main contact strip decreases by 0.000266 mm.Based on the significance value in Table 4.19, a significance value of 0.000 < 0.050 was obtained, so it can be stated that the variable of kilometers used (X) affects the variable of wear rate (Y).

Regression analysis can be used to predict or forecast the distance traveled (km) of the main contact strip on the Jakarta MRT pantograph. by using the regression equation that has been obtained. The minimum limit for using the main contact strip on the Jakarta MRT pantograph is 5 mm. The following is the regression equation for each trainset:

Table 9.
Regression Equation

Variables	Regression Equation
Trainset 6 imported products	Y = 15.569 – 0.000266X
Trainset 6 local products	Y = 15.505 – 0.000158 X
Trainset 1 imported product	Y = 15.842 – 0.000279 X
Trainset 1 local product	Y = 15.670 – 0.000178X

A. Trainset 6 imported products

$$Y = 15.569 - 0.000266X$$

$$5 = 15.569 - 0.000266X$$

$$0.000266X = 15.569 - 5$$

$$X = \frac{15.569 - 5}{0.000266} = 58{,}511$$

It can be concluded that the main contact strip on the 6 imported trainset products will be replaced with a new condition when the distance traveled reaches 58,511 km.

B. Trainset 6 local products

$$Y = 15.505 - 0.000158X$$
$$5 = 15.505 - 0.000158X$$
$$0.000158X = 15.505 - 5$$
$$X = \frac{15.505 - 5}{0.000158} = 66{,}487$$

It can be concluded that the main contact strip on the 6 local product trainsets will be replaced with new ones when the distance traveled reaches 66,487 km.

C. Trainset 1 imported product

$$\mathrm{Y} = 15.842 - 0.000279\mathrm{X}$$
$$5 = 15.842 - 0.000279X$$
$$0.000279X = 15.842 - 5$$
$$X = \frac{15.842 - 5}{0.000279} = 56{,}763$$

It can be concluded that the main contact strip on imported trainset 1 will be replaced with a new condition when the distance traveled reaches 56,763 km.

D. Trainset 1 local product

$$\mathrm{Y} = 15.670 - 0.000178\mathrm{X}$$
$$5 = 15.670 - 0.000178X$$
$$0.000178X = 15.670 - 5$$
$$X = \frac{15.670 - 5}{0.000178} = 88{,}005$$

It can be concluded that the main contact strip on imported trainset 1 will be replaced with a new condition when the mileage reaches 88,005 km. From the results of the calculation of the predicted service life of the MRT Jakarta main contact strip based on kilometers of use, the following graph is obtained:

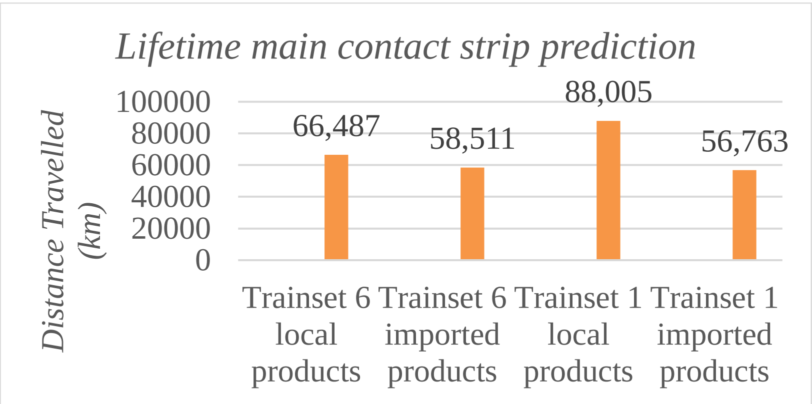

Figure 8. Lifetime main contact strip prediction results in diagram against distance traveled

From Figure 8, it can be predicted that trainset 6 local products will be replaced when the distance traveled reaches 66,487 km, trainset 6 imported products when the distance traveled reaches 58,511 km, trainset 1 local product when the distance traveled reaches 88,005 km, and trainset 1 imported product when the distance traveled reaches 56,763 km.

CONCLUSION

From the research conducted, the following conclusions can be drawn:

1. Based on the comparison of the results of the wear rate using SPSS software with the regression method, the results show that the main contact strip on trainset 6 local products gets the equation result Y = 15.505 - 0.000158X which means that for every 1% increase in the mileage value (3,876 km), the main contact strip decreases by 0.000158 mm. Meanwhile, on trainset 6 imported products, the results are equation Y = 15.565 - 0.000266X which means that for every 1% increase in the mileage value (3,876 km), the main contact strip decreases by 0.000266 mm. Furthermore, on trainset 1 local products, the results are equation Y = 15.670 - 0.000178X which means that for every 1% increase in the mileage value (3,778 km), the main contact strip decreases by 0.000178 mm. Meanwhile, on imported product trainset 1, the equation Y = 15,842 – 0.000279 is obtained, which means that for every 1% increase in the distance traveled (3,778 km) the main contact strip decreases by 0.000279 mm. From the description above, it can be concluded that the wear rate on each trainset of the local product main contact strip is smaller than the imported product main contact strip. This is because the hardness of the material on the local product's main contact strip is greater than that of the imported product.
2. Based on the comparison of the results of the wear rate against the service life using SPSS software and simple linear regression analysis, it was found that Trainset 6 local products will reach the minimum limit of main contact strip usage (5mm) when the distance traveled is 66.487 km, while Trainset 6 imported products will reach the minimum limit of main contact strip usage (5mm) when the distance traveled is 58.511 km. Furthermore, on Trainset 1 local products will reach the minimum limit of main contact strip usage (5mm) when the distance traveled is 88.005 km, while Trainset 1 imported products will reach the minimum limit of main contact strip usage (5mm) when the distance traveled is 56.763 km. From the description above, it can be concluded that the service life of each local product main contact strip trainset is longer than the imported product main contact strip. This is because the wear rate on the local product's main contact strip is lower than the wear rate on the imported product's main contact strip.

REFERENCES

Adi, W. T. (2019). Kajian umur jalan rel berdasarkan keausan dengan metode dari area dan perjana. *Jurnal Perkeretaapian Indonesia*, *3*.

Aditya Permana, B. (2016). Studi eksperimen dan analisa laju keausan material alternatif bearing pada poros propeller kapal. *Jurnal Mechanical Engineering Department Faculty Of Industrial Technology Sepuluh Nopember Institute Of Technology*.

Arrachman, R. firdaus muhammad. (2023). Kajian pengaruh jarak tempuh terhadap diameter roda untuk memprediksi umur pakai roda lrt palembang. *Jurnal Perkeretaapian Indonesia*.

Azizah, W. (2022). Preventive maintenance jaringan listrik aliran atas kereta rel listrik sebagai. *Repository.Upi.Edu Universitas Pendidikan Indonesia*.

Budiyanto. (2018). Spss adalah-pengertian, sejarah, fungsi, kepanjangan. The SAGE Encyclopedia of Educational Research, Measurement, and Evaluation. https://doi.org/10.4135/9781506326139.n655

Firmansyah, M. D. (2022). Analisis tegangan roda grooved wear pada rel mass rapid transit jakarta dengan metode elemen hingga. *Jurnal Perkeretaapian Indonesia.*

Hidayat, T., Novan, D., & Mahardiono, A. (2015). The maintenance evaluation of railway rolling stock in indonesian railways compan. UPT-Balai Pengembangan Instrumentasi Lembaga Ilmu Pengetahuan Indonesia Gedung 30 Jl. Sangkuriang Bandung-Indonesia.

Kresnawan, Y. (2021). Analisis laju keausan main contact strip pantograf kereta rel listrik. *Jurnal Fakultas Teknologi Industri Program Studi Teknik Mesin*.

Kubo, S., & Tsuchiya, H. (2004). Recent developments in the installation of carbon contact strips on pantographs. Https://Www.Jstage.Jst.Go.Jp/Article/Rtriqr/45/4/45_4_184/_pdf/-Char/En.

Ningsih, endah kurnia. (2016). Studi eksperimen dan analisa keausan journal bearing dry contact pada rotary valve mesin pembuat pasta. *Jurnal Jurusan Teknik Mesin Fakultas Teknlogi Industri Institut Teknologi Sepuluh Nopember*.

Rahman Hananto, C. (2021). Optimasi penempatan gardu traksi listrik aliran atas (laa) antara stasiun ceper – stasiun gawok berdasarkan penurunan tegangan untuk meningkatkan keandalan pasokan daya listrik krl. Jurnal Teknik Elektro Fakultas Teknik Universitas Muhammadiyah Surakarta.

Ridho Adi Negoro. (2019). Menentukan nilai koefisien gesek statis melalui alat peraga gaya sentripetal untuk menumbuhkan sikap ilmiah siswa. Jurnal Risalah Fisika, 3(2), 27–31.

Rifa'i Dan, A. S., & Prayogi, E. (2021). Analisis laju keausan main contact strip pantograf kereta pt mrt jakarta. In *Jurnal Syntax Admiration* (Vol. 2, Issue 3). https://doi.org/10.25105/jetri.v20i1.8952

Sahri, J., Susman, K., & Zulkarnain, M. (2019). Uji normalitas, uji linearitas dan uji independensi. *Jurnal Fakultas Ilmu Keolahragaan Universitas Negeri Padang*.

Shafira, R., Gagarin Irianto, C., & Kasim, I. (2022b). Analisa jatuh tegangan pada mass rapid transit (mrt) jakarta. *Jurnal Ilmiah Teknik Elektro*,14–27

Surawan, T., Kurniawati, N., Digdoyo, A., Sujatmika, H., & Agusta, H. (2021). Analisa pengaruh pola operasi terhadap laju keausan carbon strip pada pantograf. In Jurnal Teknologi (Vol. 9, Issue 1). Universitas Jayabaya. https://doi.org/10.31479/jtek.v9i1.132

Suryatman, M. M. L. A. (2011). Analisis manajemen perawatan untuk perhitungan availabilitas sistem ac toshiba rpu 4003x pada kereta api argogede di pt kai. Industrial Research Workshop and National Seminar.

Syafa'at, I. (2008). Tribologi, daerah pelumasan dan keausan. Jurnal Momentum UNWAHAS, 4.

Widiyarta, I. made, Pawarta, I. made, & Lokantara, I. P. (2015). Perilaku keausan lapisan Ni-Cr pada baja karbon sedang akibat kontak sliding (metode pelapisan flame powder spray coating). Universitas Udayana.

Yuliara, I. made. (2016). *Modul regresi linier sederhana* (Universitas Udayana). https://simdos.unud.ac.id/uploads/file_pendidikan_1_dir/3218126438990fa0771ddb555f70be42.pdf.