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Original Research Article

ELECTRIC ENERGY NEEDS OF BELT CONVEYORS IN ONE OF THE POLISH LIGNITE MINES – METHOD OF ANALYSIS

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A b s t r a c t

The article develops and tests a method for comparing electric energy consumption by belt conveyors operating in a lignite mine. The source of information for creating the comparison method was data about the energy used by conveyors in one of the Polish lignite mines, the amount of transported mass, and the operating times of the conveyors. This data was collected for about 4 years in the mine for two twin conveyors transporting coal from the mine to the power plant. Parameters related to atmospheric conditions were also recorded: temperature and humidity. The measurements were taken at the same time on twin conveyors with standard belts. It can be assumed that any differences in energy consumption did not result from differences in operating conditions. The energy indicator used to transport 1 Mg of coal over a 1-kilometer distance in the analyzed period was calculated. The differences found in energy consumption between the conveyors analyzed were statistically significant. Since the conveyors selected for comparison were twins, it was expected that the result would be a lack of grounds for finding significant differences. It turned out to be otherwise, and this was thoroughly investigated.

Keywords: belt conveyor, steel cord conveyor belt, energy consumption, energy consumption index, statistical data analysis

1. INTRODUCTION

Belt conveyors and belt conveyor transport systems are characterized by continuous movement and are commonly used in brown coal mines. The main trends in developing mining belt conveyors include energy-saving transport of mined material while increasing the durability of the basic conveyor units, especially conveyor belts, idlers, and drives [1, 2, 3, 6, 7, 8].

Climate protection and rising energy costs are the main factors encouraging investments to improve energy consumption efficiency. Here, we can distinguish energy-saving belt conveyors, i.e., those on which energy-saving belts generating lower movement resistance are installed. Because

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conveyors transport bulk materials over long distances, it can be expected that using an energy-saving conveyor belt will significantly reduce the value of these resistances.

The rolling resistance of the belt on the idlers is a particularly important and largest component of conveyor motion resistance, to which the most attention is paid [3, 9]. Consequently, using an energy-saving belt will reduce the power needed by the conveyor drives and thus reduce the consumption of electric energy.

Belt conveyor energy efficiency measurements were carried out in one of the Polish brown coal mines. The total resistance to motion per single set of idlers was measured on a specially prepared measuring set [10, 15].

Electric energy consumption to transport 1 m^3 of mined material (earth or coal) depends on the degree of belt loading. Glinka [11] presented an analysis of electric energy consumption by drives of a 363 m long overburden conveyor with a nominal capacity of 1100 m^3/h in one of the Polish brown coal mines. This analysis was based on the results of experimental tests of efficiency and electric energy consumption collected over the three months from January to March. In the analyzed case, it was possible to reduce energy consumption by 62% when regulating the continuous belt speed as a function of efficiency and complete belt filling.

The economic and environmental aspects of optimizing technical solutions of belt conveyors to reduce their electricity consumption can be presented in the example of one of the lignite mines in Poland. Annually, 40 million tons of coal and over 100 million m^3 of overburden are extracted there. Ore transport is carried out on belt conveyors with a total length of more than 160 km. Ore transport consumes more than 50% of the electricity the mine uses. Therefore, the potential for savings seems huge [4, 5]. The mine will consume less electricity and pay lower bills for it. As a result, less CO_2 will enter the atmosphere, improving air quality and residents' health conditions.

2. DESCRIPTION OF DATA REGISTERED IN THE MINE

From January 2014 to December 2017, the following parameters were recorded in the PGE GiEK SA Bechatów Branch mine for two selected conveyors transporting coal to the power plant: working time during the month, mass transport, and energy consumption. The analyzed conveyors were of almost identical length. The conveyor marked with letter A for this article was 1012.6 m, and the conveyor marked with letter B was 1,018.5 m. Both conveyors had the same theoretical volumetric capacity Qv = 8000 m^3/h and mass capacity Qm = 6 400 Mg/h. The bulk density of brown coal was assumed to be 0.8 Mg/m^3. A belt of the same type, St 3150, with a width of 1800 mm, was installed on both conveyors A and B, while the belt on conveyor A was replaced with a new one after 6 months. Conveyor A did not record the transferred mass from January to July 2014 and June to October 2015 due to a scale failure. Therefore, both conveyors did not have the same number of measurements (conveyor A - 36 measurements and conveyor B - 48). The measurements were taken at the same time (apart from the period mentioned above without data recording); therefore, it can be assumed that any differences in energy consumption did not result from differences in operating conditions.

The research conveyors were placed on parallel coal lines. This makes comparison difficult because differences in the mass transported of coal and the operating time of the conveyors both in individual months and globally were significant. In effect, the actual average capacity of their work (the ratio of the mass transported in a given month to their operating time) was different in individual months. Furthermore, the measurements on conveyor A were shorter by 12 months. Therefore, it was necessary to develop a methodology to compare energy consumption data so that its results were reliable despite these differences.

2.1. Comparison of energy consumption data of two conveyors

In the analysis period from January 2014 to December 2017 in the Belchatów mine, conveyor A worked 18,025 hours in 36 months (in reality, it worked longer, but all its operating parameters were recorded only in this period). During this time, it moved 42 857,113 Mg of coal, consuming 12 270.4 MWh. Conveyor B worked for 48 months, moving 46,964,732 Mg of coal, consuming 14 134.70 MWh.

Comparing global differences in energy consumption does not make sense because the data recording times were different (36 and 48 months), and each conveyor worked effectively for a different time each month and transported a distinct mass of coal. However, comparing the unit energy consumption necessary to transport 1 Mg of coal seems sensible. Given that the length of both conveyors is about 1 km, it is possible to calculate the unit energy consumption indicator for transporting 1 Mg of lignite over a 1 km distance. Conveyor A used an average of 282.76 Wh, and conveyor B used 295.49 Wh. The differences are insignificant and amount to 12.73 Wh/Mg/km. During the analysis period, conveyor B used an average of 4.5% more energy than conveyor A to transport 1 Mg of coal over a distance of 1 km. Differences occurred over 3–4 years, so they may be significant. It is difficult to say the reason for these differences. The conveyors were selected for comparison because they did not differ in length or construction. They were considered twins. The significance of the differences in energy consumption can be verified statistically because the measurements were taken separately for each month, and it is possible to check whether the differences calculated for the global data from the entire period are also preserved in the individual months.

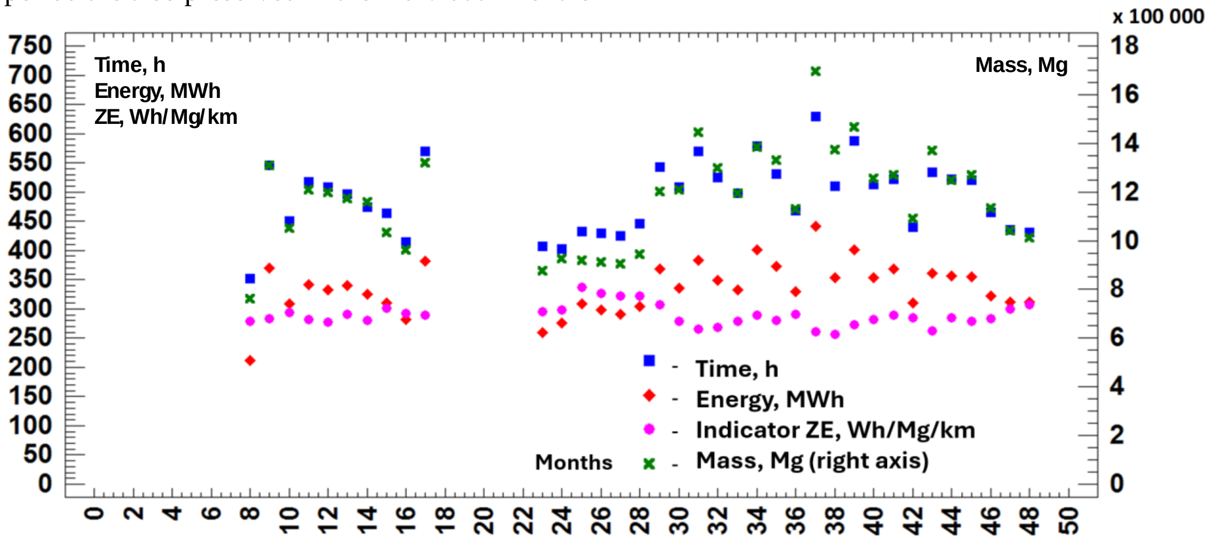

Fig. 1. Differences in conveyor operating time, coal mass transported, energy consumed, and unit energy consumption indicator ZE for transporting 1Mg of mined material for a distance of 1 km in subsequent months on the belt conveyor A

The source data (Table 1) and Figure 1 show that all the parameters analyzed changed significantly in individual months. This makes comparison difficult. Therefore, the capacity (in Mg/h) and the energy consumption index (ZE) per unit of mass and km of route (Wh/Mg/km) were determined. The coefficient of variation for both calculated indices was much lower than for the other variables. It amounted to 6.19% for capacity Q and 6.3% for the ZE index, while for working time in a month, it was 12.42%, for the transferred mass 16.97%, and for the energy consumed 13.1%. The figure shows that some variables are interrelated and change similarly, affecting the stabilization of the determined indices and reducing their fluctuation (Figs. 1-3).

Table 1. Basic statistics for the parameters analyzed on conveyor belt A

Statistic	Working time, h	Mass, Mg	Energy, MWh	Capacity Q Mg/h	ZE index, Wh/Mg/km
No. of measurements, pcs.	36	36	36	36	36
Mean	490.91	1.1694E6	334.96	2 370.6	288.6
Standard deviation	60.98	198752	43.88	146.6	18.19
Coefficient of variation	12.42%	16.997%	13.101%	6.185%	6.301%
Minimum	352.10	760503	212.00	2119.2	256.9
Maximum	629.40	1.6952E6	441.60	2693.3	336.4
Scope of changes	277.30	934653	229.60	574.12	79.5
Standard skewness	-0.004636	0.44078	-0.60453	0.043678	1.88
Standard kurtosis	-0.3699	0.133126	1.3228	-0.02087	0.84

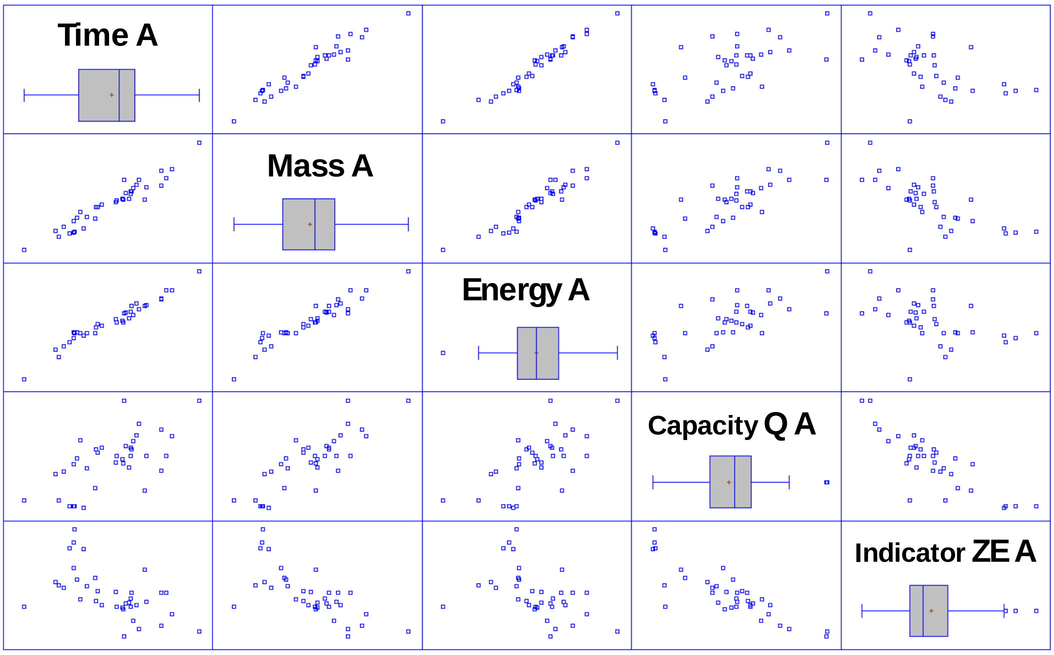

Fig. 2. Scatter and Box-and-Whiskers plots showing the relationships between the recorded parameters and the determined Q and ZE indicators for conveyor A

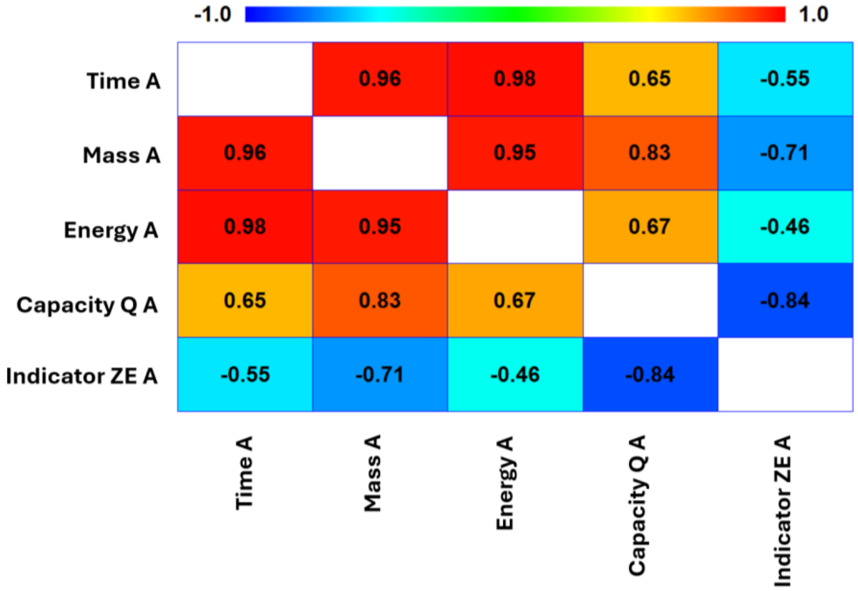

Fig. 3. Pearson Product-Moment correlations for measures and calculated parameters for conveyor A

Time, mass, and consumed energy are highly and positively correlated (Fig. 2-3). Capacity Q and the determined energy consumption index ZE are less correlated, with the correlation being positive for capacity and negative for ZE. The correlation between the amount of mass transported and the capacity is quite strong, which is unsurprising because ZE = energy/mass/distance and Q = mass/time. The correlations between capacity Q and time and energy are similar: 0.65 and 0.67, respectively. The correlation between capacity Q and the energy consumption index ZE is quite strong but negative (-0.84). This means that the higher the capacity (achieved in a given month), the lower the unit energy consumption index. This is consistent with the familiar feeling and research results [1-11]. The selected dependencies can show the scale of changes and are reliable because all correlations are statistically significant.

The parameters recorded for conveyor B covered 48 months (4 years). The variability of many parameters was higher than for conveyor A. The coefficient of variation for time, mass, and energy exceeded 20%. For mass, it was the highest (25.15%), and for working time and energy, it was at a similar level: 21.74% and 21.6%, respectively. Similarly to the twin conveyor A, the least changes were the capacity Q and the energy consumption index ZE, for which the coefficient of variation was 6.19 and 6.3%, respectively (Fig. 4, Tab. 2).

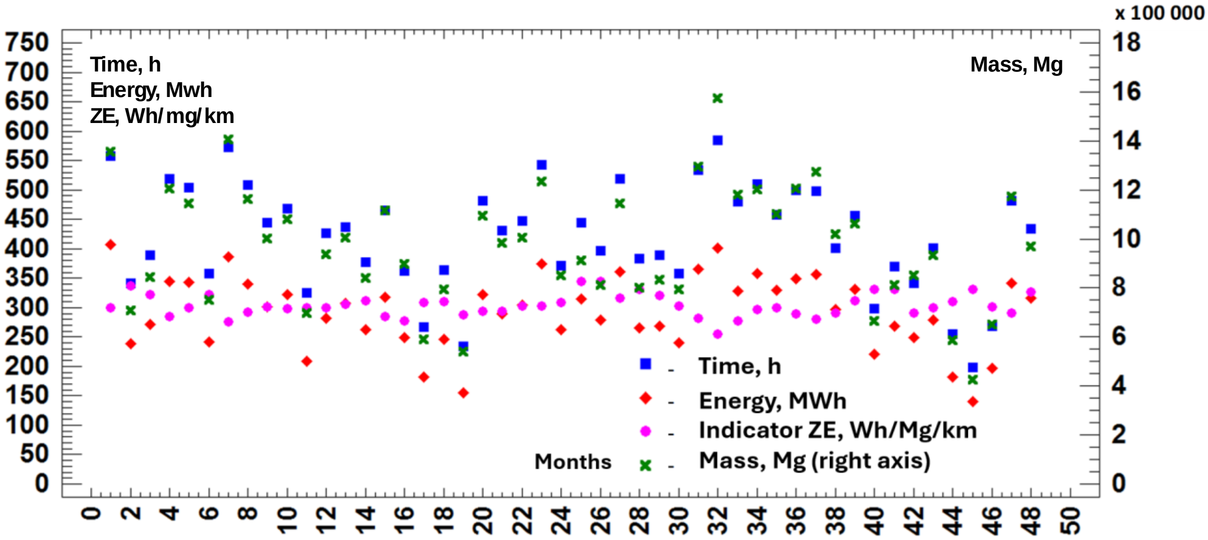

Fig. 4. Differences in the conveyor operating time, the transported mass of coal, consumed energy, and unit energy consumption indicator ZE for transporting 1Mg of mined material for a distance of 1 km in subsequent months on the belt conveyor B

Table 2. Basic statistics for the analyzed parameters on conveyor belt B

Statistics	Working time, h	Mass, Mg	Energy, MWh	Capacity Q, Mg/h	ZE index, Wh/Mg/km
No. of measurements, pcs.	48	48	48	48	48
Mean	419.83	969584	291.54	2296.9	303.58
Standard deviation	91.276	243846	62.97	142.2	19.12
Coefficient of variation	21.74%	25.15%	21.60%	6.191%	6.298%
Minimum	198.6	424723	140.7	2045.9	254.7
Maximum	584.7	1.574E6	406.5	2692.0	344.6
Scope of Changes	386.1	1.149E6	265.8	646.1	89.9
Standard skewness	-1.127	0.1462	-1.159	1.197	0.546
Standard kurtosis	-0.4053	-0.3152	-0.3449	0.079	0.0917

As before, the working time, transferred mass, and consumed energy are highly and positively correlated (Fig. 5, 6). The determined capacity Q and the energy consumption index ZE per 1 Mg of coal are not strongly correlated (the strongest +/-0.61 with the transferred mass). Capacity Q is positively correlated with all recorded parameters, and the energy consumption index ZE is negatively correlated. There is a strong negative correlation of capacity Q with the ZE index (- 0.85). All correlations must be statistically significant. Both determined indices include all recorded data: Q = mass/time and the energy consumption index ZE = energy/mass/distance. Their negative correlation confirms that the increase in capacity entails a decrease in the energy consumption index.

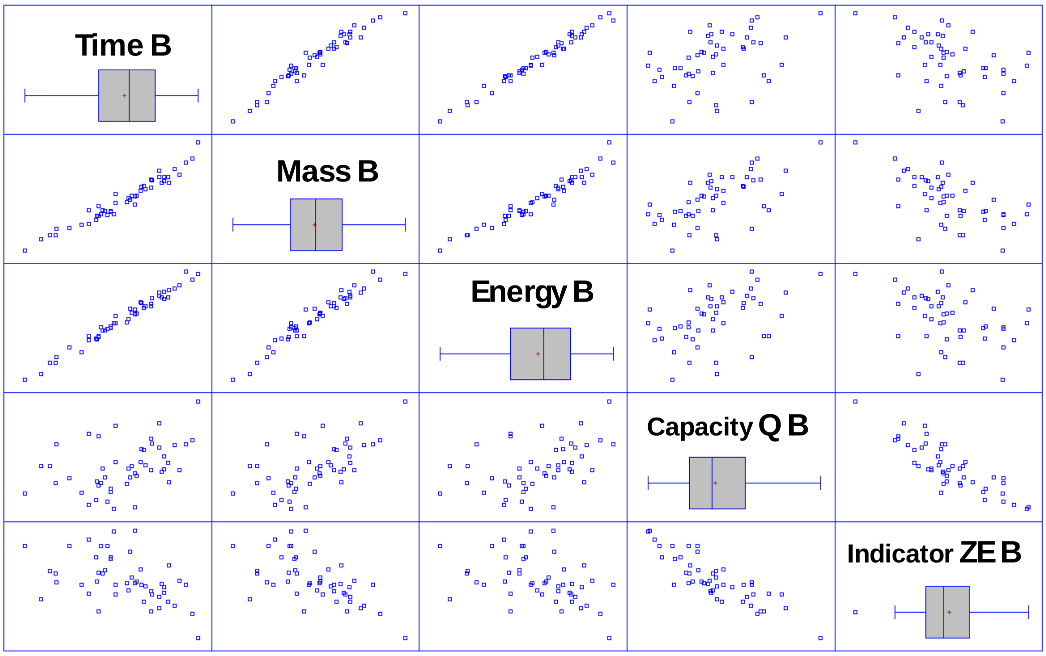

Fig. 5. Scatter and Box-and-Whiskers plots showing the relationships between the recorded parameters And the determined Q and ZE indicators for conveyor B

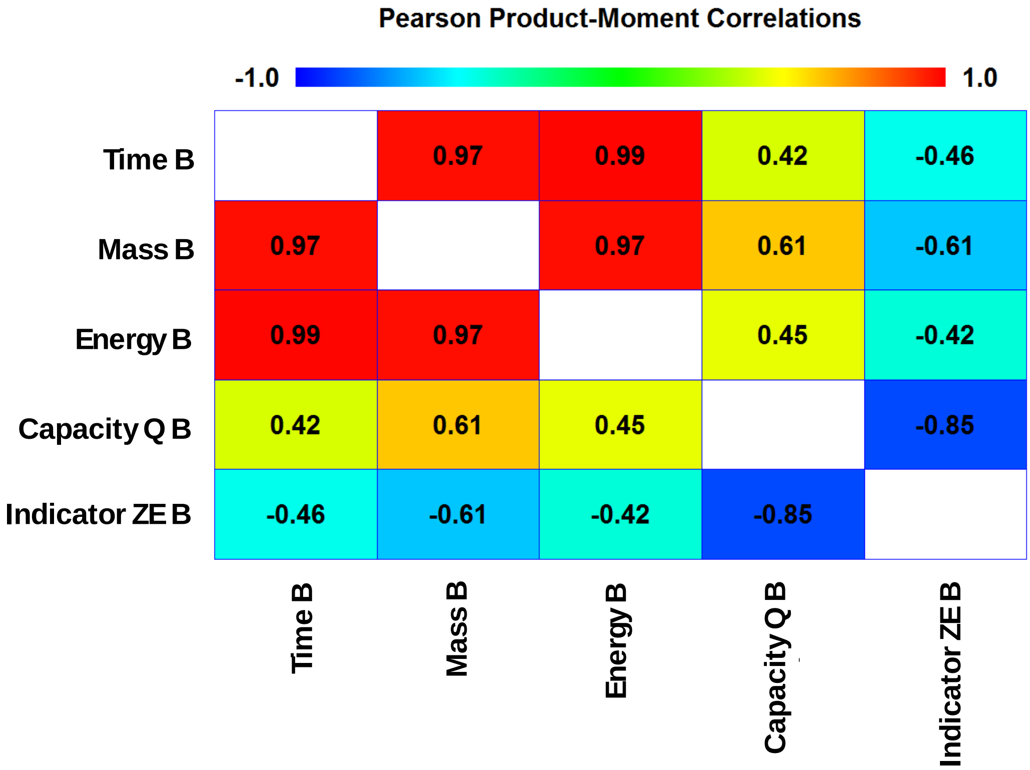

Fig. 6. Pearson Product-Moment correlations for measures and calculated parameters for conveyor B

2.2. Quantitative description of the unit energy consumption index ZE on A and B conveyors

To investigate whether the differences in unit energy consumption identified for the global data from the entire study period are also noticeable in individual months, comparative tests of 2 samples were carried out in the Statgraphics Centurion v.18 program.

The comparison procedure aims to compare two independent random-variable samples. Tests are carried out to determine whether there are significant differences between the means, medians, and variances of the analyzed populations. The recorded measurements are treated as independent samples because the conveyors worked in separate runs, and data on their operation were not recorded on conveyor A in all months. Therefore, we assume no relationship exists between the selected observation in one sample and any observation in the other. If the conveyors worked in one run and the samples were equal, the operating times and the transferred mass would be identical, and it would be possible to carry out a test of samples for energy consumption in pairs. The calculated differences in energy consumption in individual months were then examined. Unfortunately, the data were independent and characterized by high variability in particular months, and comparison is much more difficult. It must also be concerned with unit energy consumption aggregating the energy used and the mass transfer of coal.

Figure 7 compares two ZE energy consumption indicators histograms for both conveyors. The modal value for conveyor A is slightly above 280 Wh/Mg/km, and for conveyor B, it is 300 Wh/Mg/km.

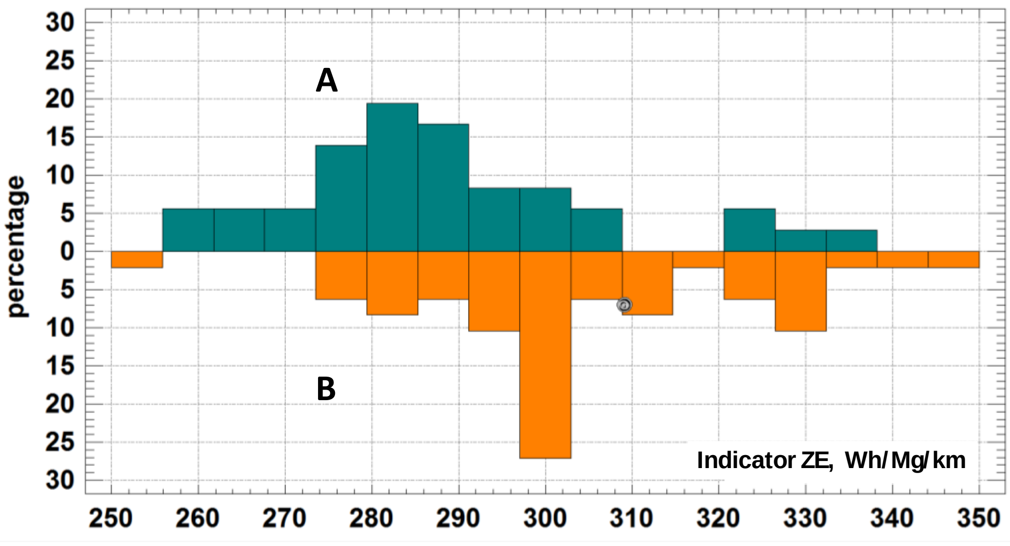

Fig. 7. Comparison of two histograms of unit energy consumption indicators ZE for conveyors A and B

Therefore, the density distributions for both conveyors are shifted relative to each other, which confirms that the ZE indices are slightly lower for conveyor A. This can be seen in the drawing of the density traces of both distributions (Fig. 8). The density trace provides a nonparametric estimate of the probability density function of the analyzed populations. It is created by calculating the number of observations that fit into a constant-width window that is moved over the entire range of the data. Using the cosine function smooths the graph because it reduces the weight of observations located further from the center of the window.

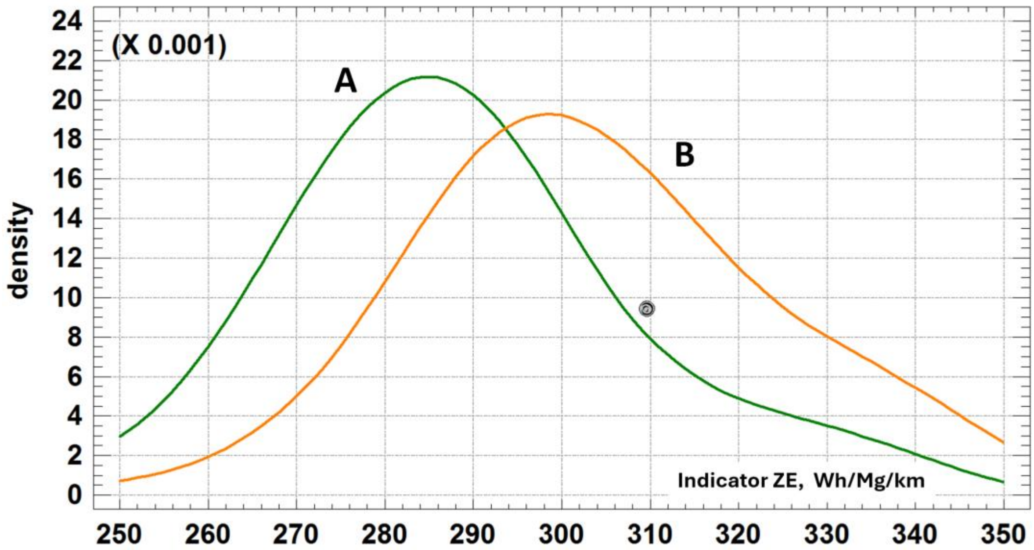

Fig. 8. Comparison of 2 density traces of the unit energy consumption indices ZE for conveyors A and B

Table 3 presents a series of descriptive statistics for the two data sets analyzed. As can be seen, various measures of central tendency (means, median, etc.) for conveyor A are lower than those for conveyor B by about 5%. The harmonic mean differs the least (by 4.93%) and the median the most (by 5.19%). Dispersion measures vary slightly more. The ZE energy consumption indicators from conveyor A are less dispersed than those from conveyor B, which may result from the more significant number of measurements collected from the latter. The variance differs the most. For conveyor A, it is 9.56% lower. The standard error behaves oppositely, lower for conveyor B (by -9.81%). Interestingly, the coefficient of variation is identical for the indicators from both conveyors and amounts to approximately 6.3%. The minima are also similar. It is 254.7 Wh/Mg/km for conveyor B, which differs by -0.85% from the indicators for conveyor A. The maximum of the ZE indicators is also the highest for conveyor B and amounts to 344.6 Wh/Mg/km (2.4 % higher than for A). As a result, the difference between the energy consumption indicators for conveyor B is approximately 90 Wh/Mg/km and is more significant by 11.6 % than for conveyor A. This is probably due to the more substantial number of measurements. Interestingly, for conveyor B, which is characterized by higher energy intensity (on average by approximately 5%), the lowest ZE energy consumption index was recorded, which undermines this general trend and is confirmed by calculations. This low consumption was recorded in August 2016. At that time, the energy consumption on conveyor A was 268.75 Wh/Mg/km. Therefore, it was 5.5% higher. It is worth noting this fact because it is necessary to consider the reasons for this difference. This is essential information because it shows that the unit energy consumption on the same conveyor can be lower than the maximum by 26.08% (by 90 Wh/Mg/km) or higher than the minimum by 35.28%. It is worth investigating the reasons for such significant differences because they significantly exceed the savings that can be achieved using energy-saving belts, the savings potential of which is estimated at 15-20% based on laboratory tests [1, 6]. It is worth mentioning that standard belts of the same type and from the same manufacturer were used on conveyors A and B during the analysis period.

Other positional statistics (quartiles and sextiles) generally maintain the differences noted for the central values, which indicates a shift of the entire distribution for the ZE index for carrier A by about 4-6% to the left towards lower values. However, the interquartile and interactive ranges are much smaller for carrier A by 22.61% and 25.83%, indicating that the distribution of the ZE index for carrier A is more slender than for carrier B.

This is confirmed by statistics that describe the shape of the distribution. Kurtosis is positive and higher for conveyor A than for B, for which it is close to 0, which is characteristic of a normal distribution. However, the kurtosis for conveyor A does not exceed 0.9, so it does not undermine the validity of using statistical comparative tests of both random samples from the rest of the article. Deviations of up to +/- 2 are permissible. Higher skewness for conveyor A indicates a more significant asymmetry on the right side of this distribution, which can be seen in Figures 7 and 8. Deviations are also within the permissible limits of +/- 2. For statistics describing the shape of the distribution, relative differences were not calculated because they do not contain significant information. The absolute value of these statistics determines the shape, and this does not differ significantly from the normal distribution, especially for data from conveyor B.

Table 3. Basic statistics for the analyzed parameters on conveyor belts A and B

Descriptive statistics:	**A**	**B**	**Absolute difference**	**Relative difference, %**
No. of measurements	36	48	12	25.00%
Mean	288.60	303.60	15.0	4.94%
Median	284.84	300.44	15.615	5.19%
Geometric mean	288.03	302.99	14.96	4.94%
Harmonic mean	287.50	302.40	14.90	4.93%
Variance	330.63	365.58	34.95	9.56%
Standard deviation	18.18	19.120	0.94	4.90%
Coefficient of variation	6.30 %	6.30 %	-2.8 E-05	-0.04%
Gini coefficient	-0.651	0.036	0.687	
Standard error	3.031	2.760	-0.271	-9.81%
Geometric Standard Deviation	1.064	1.065	0.0011	0.10%
Mean absolute deviation	0.046466	0.0484	0.002	3.96%
Minimum	256.87	254.70	-2.17	-0.85%
Maximum	336.35	344.57	8.22	2.39%
Range	79.48	89.87	10.39	11.56%
Lower quartile	278.81	291.37	12.56	4.31%
Upper quartile	296.15	313.88	17.625	5.62%
Interquartile range	17.34	22.41	5.065	22.61%
Skewness	0.7694	0.1929	-0.577	
Standard Skewness	1.885	0.5455	-1.339	
Kurtosis	0.6891	0.0648	-0.624	
Standard Kurtosis	0.844	0.0917	-0.752	
Sum	10388.6	14571.8	4183.2	28.71%
Sum of squares	3.01 E+06	4.44 E+06	1431420	32.23%

2.3. Statistical significance of differences in unit energy consumption on both conveyors

The differences visible visually (Figs. 7, 8) and identified by various descriptive statistics (Table 3) may be accidental; therefore, it is necessary to examine their statistical significance. Randomness is indeed unlikely because the differences concern not only the central tendency measures but also the positional statistics and the distribution density trace (Fig. 8), which is duplicated, and both traces are parallel-shifted relative to each other on the axis of the energy consumption indicator ZE. Nevertheless, this requires formal verification.

For this purpose, the means were compared, and the 95% confidence interval was determined. 95.0% confidence interval for the mean of ZE indicators for conveyor A:

288.573 +/- 6.1523 [282.42; 294.725].

95.0% confidence interval for the mean of ZE indicators for conveyor B:

303.579 +/- 5.5519 [298.027; 309.13].

The 95.0% confidence interval for the differences in the unit energy consumption index was also determined, assuming equal variances:

-15.0058 +/- 8.21328 [-23.219; -6.79249].

Since this interval does not contain 0, there is a statistically significant difference between the two means at the 95% significance level.

A t-student test of the significance of two means was also performed to compare them. The null hypothesis that both means are equal was tested, with the alternative hypothesis that they differ. Assuming equal variances, the value of the t statistic was determined at t = - 3.63452. The calculated P-value was 0.00048454. Since the computed P-value is less than 0.05, we can reject the null hypothesis in favor of the alternative hypothesis at a significance level of alpha = 95%.

The test can be performed when the variances of the two samples are equal. This assumption is justified in the analyzed case, as indicated by the F-test results to compare the standard deviations below.

The standard deviations calculated for two conveyors, A and B data, were also examined, and the 95.0 % confidence interval was calculated.

The standard deviation for A: [14,748; 23.7188]

The standard deviation for B: [15.9169; 23,9495]

The ratio of variances: [0,489773; 1.71932]

Table 4. Comparison of two standard deviations for the ZE indicators for conveyors A and B

	Conveyor A	**Conveyor B**
Standard deviation	18.18	19.12
Variance	330.63	365.58
Df	35	47
The ratio of variances = 0.9044		

The F test was applied to test the null hypothesis that the standard deviation in 2 groups is the same (sigma1 = sigma2) with the alternative hypothesis that the deviations are different (sigma1 <> sigma2). The statistic value F = 0.90439 was calculated, with a P-value = 0.764154.

The confidence interval for the variance ratio extends from 0.489773 to 1.71932. It contains the value 1, indicating no statistically significant difference between the standard deviations of 2 samples at the 95.0% confidence level.

The F-test can also test a specific hypothesis about the population standard deviations from which the two samples are drawn. In this case, the test is constructed to determine whether the ratio of standard deviations is 1.0 against the alternative hypothesis that the ratio is not equal. We cannot reject the null hypothesis because the calculated P-value for the F test is not less than 0.05.

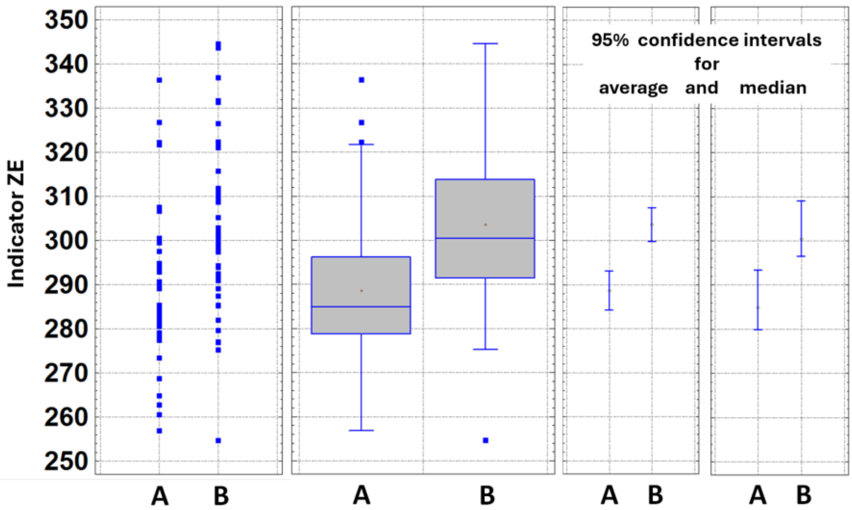

Fig. 9. Comparison of Box-and Whiskers, scatter plots, and confidence intervals for the mean and median for unit energy consumption indicators ZE for conveyors A and B

The F tests and calculated intervals assume the samples come from normal distributions. The values of standardized skewness (A: 1.885 and B: 0.545) and kurtosis (A: 0.844 and B: 0.0917) range from -2 to +2, indicating no significant deviations from normality. Therefore, there is no basis for invalidating the tests that compare standard deviations.

The median equality test was also performed. The median ZE index for conveyor A was 284.835 Wg/Mg/km, and for conveyor B, 300.44 Wg/Mg/km. The equality of medians was tested with the Mann-Whitney test (Wilcoxon). The null hypothesis that both medians are equal was tested, with the alternative hypothesis that they are not equal.

The mean ranks for sample 1 (A): 31.0556 and sample 2 (B): 51.0833, the W statistic value = 1276.0, and the P-value = 0.000199712 were determined. The hypothesis was rejected for alpha = 0.05.

In this test, both samples are combined, and all values are sorted from the smallest to the largest. The rank means of 2 samples in the combined data are compared. Since the P-value is less than 0.05, there is a statistically significant difference between the two medians at the 95.0% confidence level.

The graph (Fig. 9) compares carrier data and presents confidence intervals for means and medians. It can be seen that they are separate intervals and do not overlap.

The Kolmogorov-Smirnov test was applied to determine the compatibility of the distributions of 2 samples. Statistics DN = 0.458333 and K-S = 2.0788 were calculated, along with an approximate P-value of 0.00035276.

This test calculates the most significant distance between the cumulative distributions of 2 samples. In this case, the maximum distance is 0.4583, which can be seen visually (Fig.10). Since the P-value is less than 0.05, there is a statistically significant difference between the two distributions at the 95.0% confidence level.

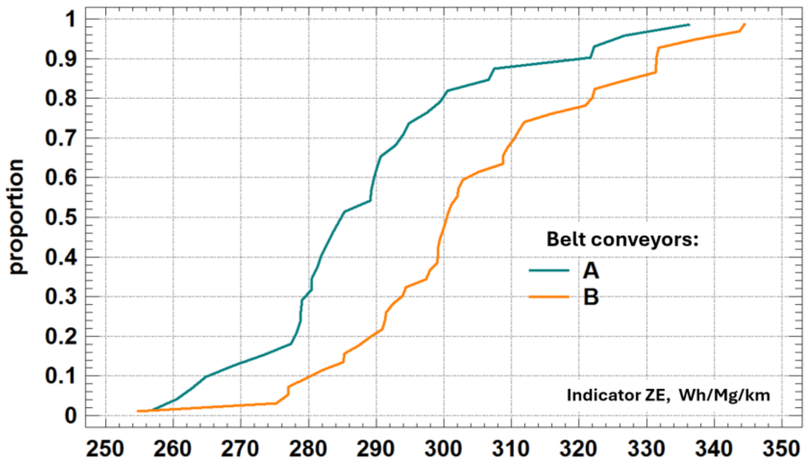

Fig. 10. Chart of two cumulative empirical distributions for the energy consumption indicators ZE calculated for both conveyors A and B

3. CONCLUSIONS

The presented analyses clearly show that the calculated energy consumption indicators ZE for the two analyzed conveyors, A and B, differ, and these differences are statistically significant.

The conveyor marked with the letter A has significantly lower energy consumption than conveyor B. Its average electricity consumption for transporting 1 Mg of brown coal was 288,573 Wh/Mg/km, lower than that of conveyor B, which consumed 303,579 Wh/Mg/km.

The differences in energy consumption between conveyors are not significant. The average values differ by about 15 Wh/Mg/km, about 5%. However, they are permanent and occur at all levels of energy consumption. The empirical distribution graphs are almost parallel shifted relative to each other (Fig. 10). 15 Wh is not much, but it should be remembered that annually, over 40 million Mg of lignite is transported to the power plant at PGE GiEK SA Branch KWB Belchatów over a considerable distance. The reasons for this state of affairs have not been identified at this analysis stage. However, statistically significant differences were found and described in detail.

The test conveyors were selected as twins. Therefore, the expected comparison result should not be grounds for stating significant differences. However, this turned out to be different, and this should be investigated in more detail.

Certain assumptions can already be made based on the data presented. First, on both conveyors, specific consumptions were recorded in different months in the 256.87-336.35 Wh/Mg/km range from the minimum to the maximum consumption for conveyor A. This range was greater for conveyor B, from 254.7 Wh/Mg/km to 344.6 Wh/Mg/km.

Therefore, the variation of results on the same conveyor is much greater than the differences between them. The data ranges for conveyors A and B are 79.5 Wh/Mg/km and 89.9 Wh/Mg/km, respectively. Therefore, they are more than five times higher than the differences between both conveyors (15 Wh/Mg/km).

A possible explanation may be the dependence of energy consumption on working conditions, e.g., seasons, temperature, and humidity. The resistance to the movement of the conveyors depends on this [1-3, 6, 9]. However, the differences in conditions cannot explain the differences between conveyors A and B because they worked under identical conditions.

Another vital premise that should be examined is the effect of conveyor capacity on specific energy consumption. In the case of both conveyors, a relatively strong negative correlation was found between the ZE index and the actual average capacity Q. For conveyor A, the Pearson correlation coefficient was -0.84 (Fig. 3), and for conveyor B, -0.85 (Fig. 6). This can be seen in the graphs (Figs. 2 and 5). It is essential that the average capacity on conveyor A (2,370.6 Mg/h) was 3.21% higher than on conveyor B (2,296.9 Mg/h). With a negative correlation, this may explain the observed differences. Studies on the influence of mineral flow variability on the energy consumption of conveyors have already been conducted in Poland [16-18], and it is worth publishing the results of comparisons, including energy-saving belts, in the next papers in English.

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