

RESEARCH ON THE DEPENDENCE OF AIR HUMIDITY ON TRANSFORMERS' BREAKDOWN INDICATORS

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ABSTRACT

This article collects data on the breakdown indicators of traction transformers in operation in the railway system, as well as air humidity. The correlations between the number of faults in the traction transformers and the humidity in the air were determined. A regression model was used to determine these correlations.

Key words: *breakdown indicators, traction transformers, correlations.*

АННОТАЦИЯ

В данной статье собраны данные об аварийных показателях тяговых трансформаторов, находящихся в эксплуатации в системе железных дорог, а также о влажности воздуха. Определены корреляции между количеством неисправностей тяговых трансформаторов и влажностью воздуха. Для определения этих корреляций использовалась регрессионная модель.

Ключевые слова: *аварийные индикаторы, тяговые трансформаторы, корреляции.*

INTRODUCTION

Failure of the traction transformer can cause failures of other electrical equipments of electric locomotives [1-5]. This leads to the failure of electric locomotives, which in turn leads to many other problems. During operation, traction transformers are affected by many external factors that cause them to break down and fail [6-9]. One of the main factors influencing the performance of transformers is humidity. The presence of moisture (water) in the transformer leads to failure of the insulation, changes in the properties of the transformer oil [5-11].

RESEARCH METHOD

Data on the number of failures of traction transformers of ODTsE 5000/25 B and OTsR 5600/25 types in operation in the railway system for 2017-2019, as well as humidity in the air were collected.

THE RESULTS OBTAINED AND THEIR ANALYSIS:

Regression analysis shows how the variables x_1, x_2, \dots, x_n depend on the output variable Y .

The linear regression equation [2-7], which establishes a linear relationship between the two indicators, is:

$$y_i = a_i + b_i x_i \quad (1)$$

Where,

y_i –the number of traction transformers repaired;

x_i –humidity index;

a_i – - regression constant;

b_i –is the regression coefficient [2-5].

For: **ODTsE -5000/25 B**

2017

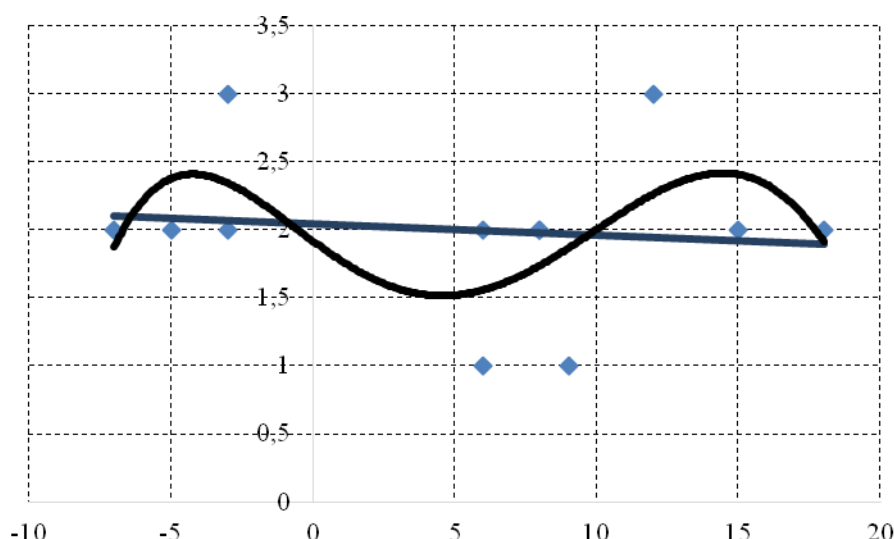


Figure 1. Dependence of the number of faults of the traction transformer type ODTsE-5000 / 25B for 2017 on the humidity in the air

The linear equation in 2017:

$$y = -0,0083x + 2,0442 \quad (2)$$

Determination coefficient: $R^2 = 0.0124$

The degree-dependent equation in 2017:

$$y = -0,0001x^5 + 0,0627x^4 - 10,522x^3 + 871,85x^2 - 35522x + 566527 \quad (3)$$

Determination coefficient: $R^2 = 0,8645$

2018

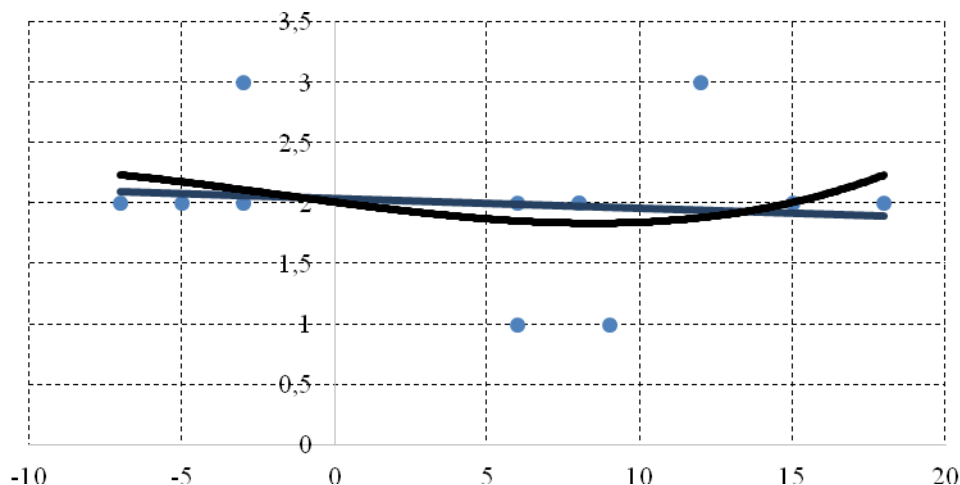


Figure 2. Dependence of the number of faults of the traction transformer type ODTsE-5000 / 25B for 2018 on the humidity in the air

The linear equation in 2018:

$$y = 0,0123x + 0,4852 \quad (4)$$

Determination coefficient: $R^2 = 0,3461$

The degree-dependent equation in 2018:

$$y = -8 \cdot 10^{-5} x^3 + 0,016x^2 - 0,9304x + 18,119 \quad (5)$$

Determination coefficient $R^2 = 0,998$

2019

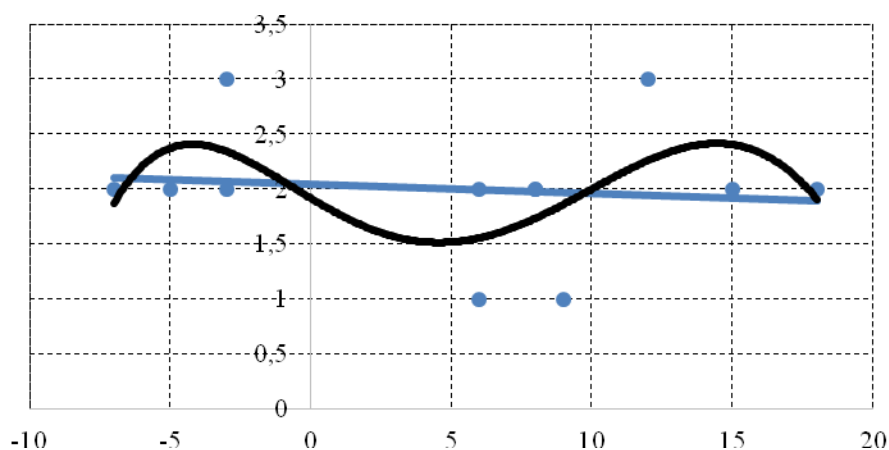


Figure 3. Dependence of the number of faults of the traction transformer type ODTsE-5000 / 25B for 2019 on the humidity in the air

The linear equation in 2019:

$$y = -0,0081x + 2,0093 \quad (6)$$

Determination coefficient: $R^2 = 0,1001$

The degree-dependent equation in 2019:

$$y = 4 \cdot 10^{-7} x^5 - 0,0001x^4 + 0,0202x^3 - 1,3565x^2 + 44,262x - 554,18 \quad (7)$$

Determination coefficient: $R^2 = 0,8762$

For: OTsR -5600/25

2017

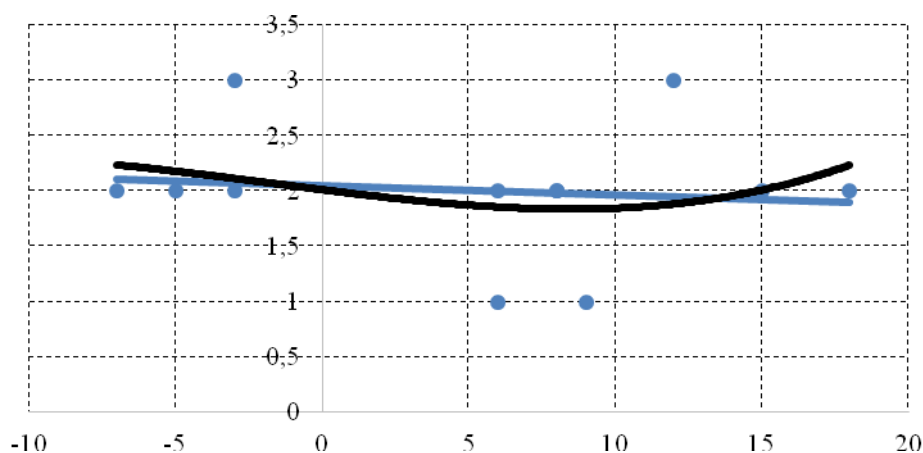


Figure 4. Dependence of the number of faults of the traction transformer type OTsR -5600/25 for 2017 on the humidity in the air

The linear equation in 2017:

$$y = 0,0066x + 1,2112 \quad (8)$$

Determination coefficient: $R^2 = 0,077$

The degree-dependent equation in 2017:

$$y = 0,0002x^3 - 0,0349x^2 + 2,1066x - 38,037 \quad (9)$$

Determination coefficient: $R^2 = 0,9669$

2018

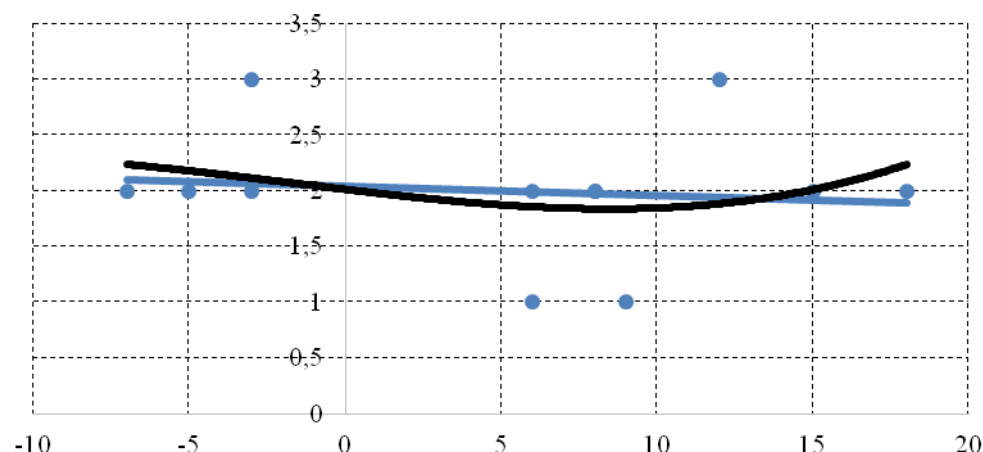


Figure 5. Dependence of the number of faults of the traction transformer type OTsR -5600/25 for 2018 on the humidity in the air

The linear equation of in 2018:

$$y = 0,0155x + 0,1906 \quad (10)$$

Determination coefficient: $R^2 = 0,4639$

The degree-dependent equation in 2018:

$$y = 1 \cdot 10^{-4} x^3 - 0,0192x^2 + 1,2069x - 22,872 \quad (11)$$

Determination coefficient: $R^2 = 0,948$

2019

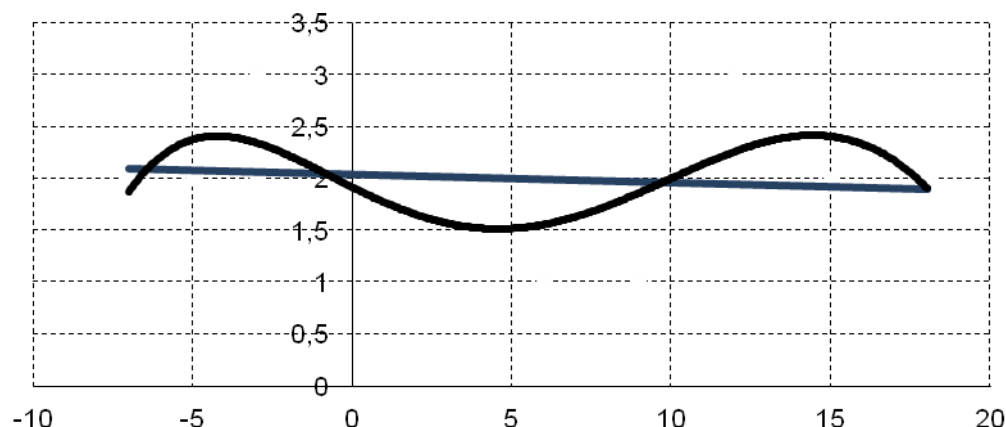


Figure 6. Dependence of the number of faults of the traction transformer type OTsR -5600/25 for 2019 on the humidity in the air

The linear equation in 2017:

$$y = -0,002x + 1,4291 \quad (12)$$

Determination coefficient: $R^2 = 0,0107$

The degree-dependent equation in 2019:

$$y = -7 \cdot 10^{-7} x^5 + 0,0002x^4 - 0,0281x^3 + 1,6652x^2 - 46,789x + 501,64 \quad (13)$$

Determination coefficient: $R^2 = 0,7067$

Total

2017

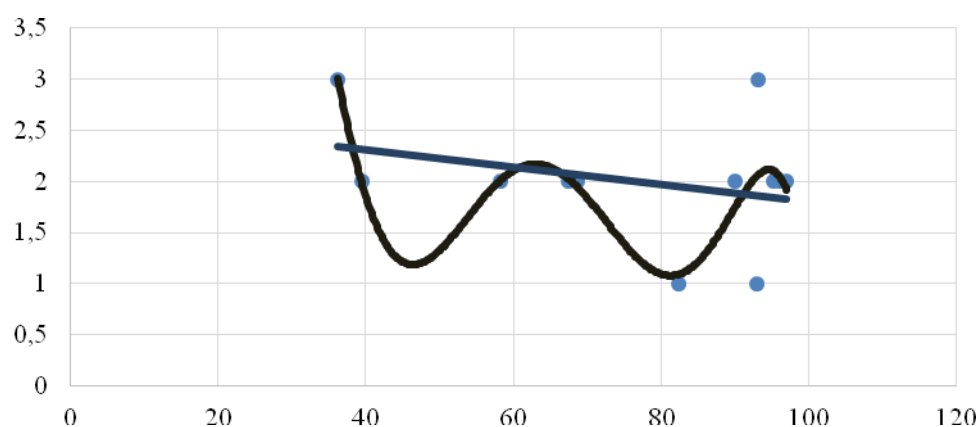


Figure 7. Dependency of 2017's overall traction transformer rate of failure on air humidity

The linear equation in 2017:

$$y = -0,0085x + 2,6519 \quad (14)$$

Determination coefficient: $R^2 = 0,0979$

The degree-dependent equation in 2017:

$$y = -6 \cdot 10^{-9} x^6 + 2 \cdot 10^{-6} x^5 - 0,0003x^4 + 0,0252x^3 - 0,9797x^2 + 18,418x - 121,66$$

(15)

Determination coefficient: $R^2 = 0,4823$

2018

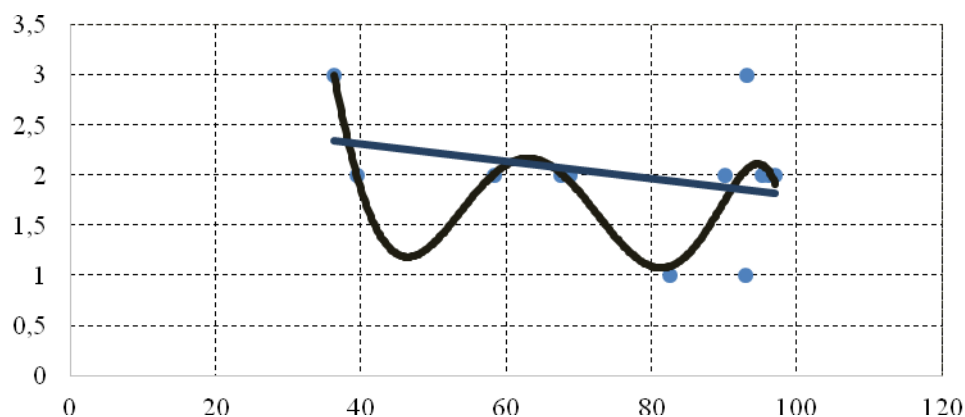


Figure 8. Dependency of 2018's overall traction transformer rate of failure on air humidity

The linear equation in 2018:

$$y = -0,0085x + 2,6519$$

(16)

Determination coefficient: $R^2 = 0,0979$

The degree-dependent equation in 2018:

$$y = -6 \cdot 10^{-6} x^6 + 2 \cdot 10^{-6} x^5 - 0,0003x^4 + 0,0252x^3 - 0,9797x^2 + 18,418x - 121,66$$

(17)

Determination coefficient: $R^2 = 0,4823$

2019

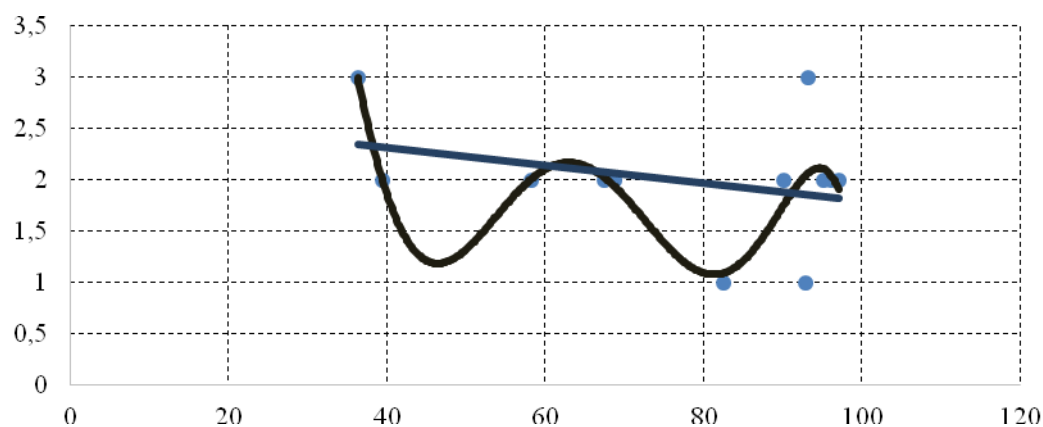


Figure 9. Dependency of 2019's overall traction transformer rate of failure on air humidity

The linear equation in 2019:

$$y = -0,0085x + 2,6519 \quad (18)$$

Determination coefficient: $R^2 = 0,0979$

The degree-dependent equation in 2019:

$$y = -6 \cdot 10^{-9} x^6 + 2 \cdot 10^{-6} x^5 - 0,0003x^4 + 0,0252x^3 - 0,9797x^2 + 18,418x - 121,66 \quad (19)$$

Determination coefficient: $R^2 = 0,4823$

CONCLUSION

The equations of dependence of traction transformers on humidity are obtained. The dependence of traction transformers on air humidity was found to be exponential.

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