

# Investigation of factors influencing the operational characteristics of traction transformers

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**Abstract.** This article presents the results of visual inspections and a brief statistical analysis of the data obtained in order to identify the observed defects in traction transformers of ODTsE 5000 / 25 B and OTsR 5600/25 types in operation in the railway system. The analysis revealed that the main parameters that determine the operational characteristics of traction transformers are windings and insulation. Recommendations for the prevention of faults in traction transformers and increase their service life have been developed.

**Keywords:** traction transformer, fault, winding, insulation, magnetic conductor, ODTsE 5000 / 25 B, OTsR 5600/25.

## 1 Introduction

Any device loses its performance over time, traction transformers too. Traction transformers are the main source of electricity for electric trains [1, 2-4].

Its malfunction or downtime leads to a lack of power supply to the rolling stock, which, in turn, leads to a downtime of the rolling stock and, as a result, to many other problems (late arrival of passengers and cargo at the destination, violation of traffic schedules, etc.). The uninterrupted and trouble-free operation of electric trains depends on the condition of the traction transformers [1, 5, 6].

Analysis of literature sources shows that [7-16] during the operation of transformers, malfunctions can be observed in the form of failure of the magnetic circuit, insulation failure, faults at the output of the transformer, oil leakage, cracks inside the transformer, excess of the permissible oil temperature, violations of oil circulation, loss of dielectric properties of oil, cracks in the rods, transformer operation with noise.

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**Table 1.** Classification of transformer faults by elements [2, 3, 17-21].

<b>Magnetic conductor</b> <ul style="list-style-type: none"><li>• Failure of steel sheet insulation</li><li>• The magnetic conductor overheats</li><li>• Sticking steel sheets together</li></ul>
<b>Winding</b> <ul style="list-style-type: none"><li>• Insulation failure of turns<ul style="list-style-type: none"><li>• winding deformation</li></ul></li><li>• cracks in the winding rod</li></ul>
<b>Input</b> <ul style="list-style-type: none"><li>• Cracks in the insulator</li></ul>
<b>Cooling system</b> <ul style="list-style-type: none"><li>• Oil pump failure</li><li>• Clogged oil pipes</li></ul>
<b>Oil</b> <ul style="list-style-type: none"><li>• Loss of dielectric properties of oil</li><li>• Excess of oil temperature</li></ul>
<b>Tank</b> <ul style="list-style-type: none"><li>• Cracks, fissures</li><li>• Oil leak</li></ul>
<b>Others</b> <ul style="list-style-type: none"><li>• Noise operation of the transformer<ul style="list-style-type: none"><li>• Wetting of insulation</li><li>• Combustion of insulators</li></ul></li></ul>

Therefore, the study of factors affecting the operational characteristics of traction transformers is one of the most pressing issues in the power supply of the railway system.

The aim of the work is to study the factors influencing the operational characteristics of traction transformers and to identify the main factors.

## 2 Materials and methods

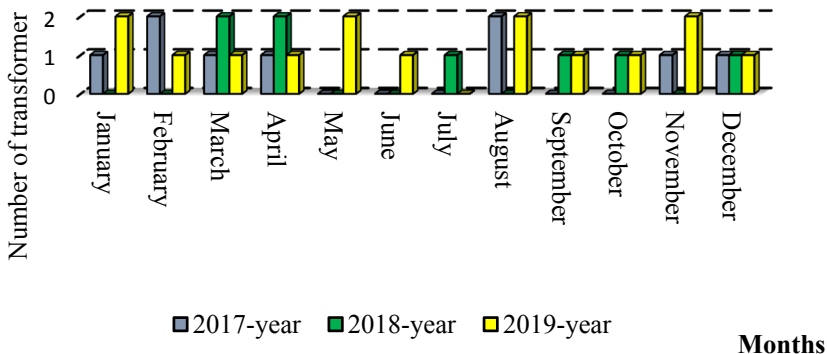
The data was collected on the identification of existing defects in them and the repair of traction transformers of types ODTsE 5000/25 B and OTsR 5600/25, operated in the railway network.

Defective traction transformers were examined. A brief statistical analysis of all the data obtained was carried out.

## 3 Results and discussion

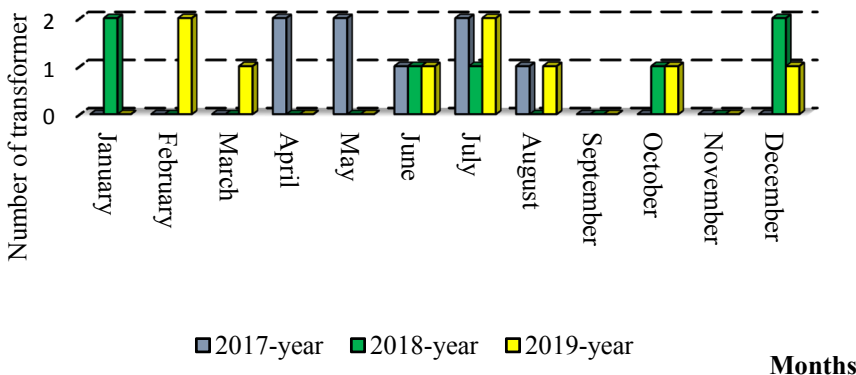
Traction transformers of types ODTsE 5000/25 B and OTsR 5600/25 that are in operation on the railways in 2017, 2018, 2019 for various reasons (due to the fact that it is time to repair the rolling stock for malfunctions during operation ...) have been repaired.

Fig. 1 shows the number of traction transformers of ODTsE-5000 / 25B type repaired between 2017-2019 by months.



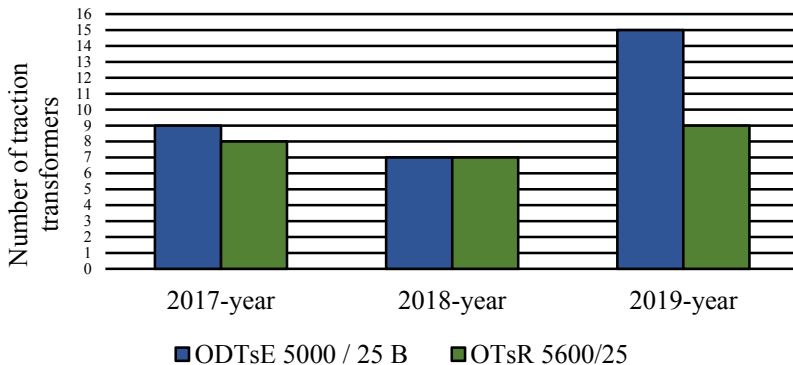
**Fig. 1.** Yearly index of repaired traction transformers of ODTsE-5000 / 25B type.

Fig. 2. shows the number of traction transformers of OTsR 5600/25 type repaired in 2017, 2018 and 2019 by months.



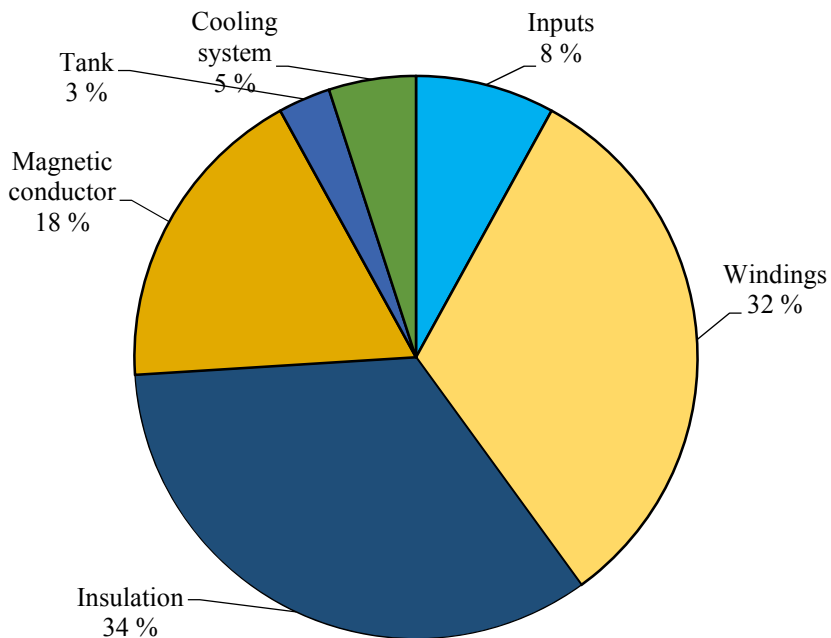
**Fig. 2.** Yearly performance of repaired OTsR 5600/25 transformers.

A total of 17 traction transformers of OTsR 5600/25 and ODTsE-5000 / 25B types were repaired in 2017, 14 in 2018 and 24 in 2019 (Fig. 3).



**Fig. 3.** By total number of types of traction transformers repaired in 2017, 2018 and 2019.

Traction transformers were brought in for repair for various reasons (winding faults, insulation faults, magnetic circuit faults, etc.). The results of statistical analysis in 2019 show that 34 % of all faults are related to insulation, 32 % – to windings, 18 % - to damage to the magnetic circuit, 8 % – to inputs, 5 % – to cooling system, 3 % – in the tank (Fig. 4).



**Fig. 4.** Fault indicators of transformers on elements.

Visual inspection revealed insulation defects (Fig. 5). As can be seen from Fig. 5, the main faults are associated with the insulating part of the traction transformers.



**Fig. 5.** Fault detected in traction transformers.

## 4 Conclusions

Research has shown that the most common failures in traction transformers are winding and insulation. To increase the integrity and service life of traction transformers, it is advisable to pay attention to the following recommendations.

When repairing traction transformers, it is necessary to pay more attention to insulation and winding parts:

a) Due to the fact that the main insulating function in traction transformers is oil, special attention should be paid to laboratory testing and oil purification when reusing used oil.

b) Review insulation technologies.

c) It is recommended to pay attention to the potential of personnel repairing insulation and windings.

Following the above recommendations will prevent major failures of the traction transformers in the rail system and will increase the service life of the traction transformers, which in turn will provide energy and economic benefits for the railway system.

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