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Evaluate the Influencing Factors of Transformer Equipment Life Based on Correlation Analysis

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Abstract: *The scale of the power system has been expanding year by year, and the society's demand for power system equipment has also increased sharply. Therefore, the assessment of the life of power system equipment is of great significance to improving the safe, reliable, economical and efficient operation of the power grid. This article will use the Pearson product moment correlation coefficient to evaluate the factors that affect the life of transformer equipment, and explore the correlation between transformer life and installation location, voltage level, cooling mode and other influencing factors to explore the impact of these attributes on transformer life. To provide data support for improving the precision investment level of equipment, and to provide guidance and suggestions for the procurement of power grid enterprises.*

Keywords: *Correlation analysis, Pearson product moment correlation coefficient, Equipment life, Transformer*

1. Introduction

The power transformer is a key device for power transmission and transformation systems, but also an important link between power plants and power companies and customers[1, 2]. Its role is not only a significant impact on the safety, efficiency, and continuous operation of the entire power system. At this stage, the size of the power system is still on the rising period, and the equipment demand in the power system is gradually increased[3-6]. Therefore, reasonable application statistical analysis techniques for scientific life assessment of grid equipment can not only reduce the operation and maintenance cost of power equipment, but also contribute to the stable operation of grid equipment, prevent major safety incidents.

In summary, it is critical to the life evaluation of the power equipment. This article will analyze the factors affecting the life of transformer equipment based on correlation analysis[7]. Reduce corporate operating costs by providing guidance and advice to future enterprise equipment procurement.

2. Correlation Analysis Theory

The correlation analysis is a research topic that has developed with the founding of statistical disciplines in the 20th century, which is widely used in the field of science and technology. In the statistics of probability and mathematics, Pearson Product-Moment Correlation Coefficient is used to measure the interaction between the two variables X and Y, the value range is in the range of [- 1, 1].

The number of Pearson test correlation between the two samples is expressed as the lowercase English letter *r*:

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} \# \quad (1)$$

In order to understand the influencing factors of transformer life, the correlation analysis of transformer lifetime is first analyzed, and these attributes have the degree of impact on transformer life.

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3. Source of Samples and Data

Before performing correlation analysis, we collected data about the scrapped transformers in 2018 and 2020. In 2018 - 2020, a total of 49 reported waste transformers, and the life time statistical results are shown in Figure 1.

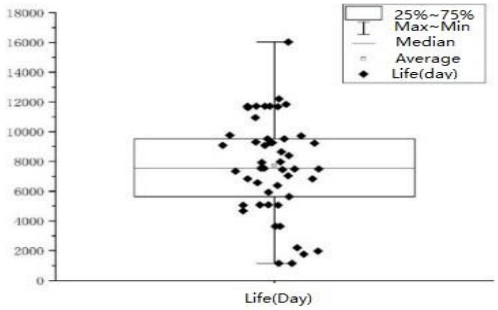

Figure 1: Life time descriptive statistics.

4. Empirical Analysis

In order to understand the factors of the life of the transformer, we correlate the life of the transformer with the indicators of the installation position, the voltage level, the cooling method, and test the extent of these attributes on the life of transformer. The verification value is positively correlated with the property and life time, and the inspection value indicates that the attribute is related to the life time of life, and the larger the absolute value, the stronger the correlation, and the weak is weak.

The correlation between the indicators and defects of the installation position, the voltage level, and the cooling method are studied below.

Table 1: Life and mounting position correlation coefficient table.

Use environment	Correlation coefficient
Outdoor	0.092
Indoor	-0.092

As shown in Table 1, outdoor and indoor installation methods and transformers have no significant correlation, the correlation coefficient is low; however, the outdoor installation method is positively correlated with the length of life, indicating that the transformer can extend the life of the transformer outdoors. The construction of the household and life is negatively impact on the length of life.

Table 2: Life and Voltage Level Related Coefficient Table.

Voltage level	Correlation coefficient
Alternating Current 35kV	-0.392
Alternating Current 110kV	0.128
Alternating Current 220kV	0.067
Alternating Current 500kV	0.284

As shown in Table 2, the voltage level is 110kV, 220kV and 500kV is positively correlated with the length of life. The correlation coefficient is 0.128, 0.067, 0.284, which is the strongest in the 500 kV transformer and the defect rate, and has a positive effect on the extended life; The voltage level is 35kV is related to the length of life, and the corresponding correlation coefficient is -0.392, which has a negative impact on the life.

Table 3: Life and cooling mode related coefficient table.

Cooling-down method	Correlation coefficient
Natural cooling / Oil-immersed self-cooled (ONAN)	-0.338
Forced oil and air cooling (ONAF)	0.066
forced-directed-oil and forced-air cooled type (ODAF)	0.299
Forced-oil and water cooling (OFAF)	0.087

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As shown in Table 3, the cooling mode is that Forced-directed-oil and forced-air cooled type (ODAF), Forced-oil and water cooling (OFAF), Forced oil and air cooling (ONAF) are positively correlated with life, in which forced-directed-oil and forced-air cooled type (ODAF) cooling method. The strongest relocation is the strongest, indicating that this cooling mode is longer; while the cooling method is Natural cooling / Oil-immersed self-cooled (ONAN) and life is negative, the corresponding correlation coefficient is -0.338, this cooling method Transformer life is short.

Table 4: Life and Winding mode related coefficient table.

Around the group type	Correlation coefficient
Duplex winding	-0.392
Three-winding	0.160
Self-coupling	0.336

As shown in Table 4, the three-winding and self-coupled winding modes were positively correlated with the lifetime, with the correlation coefficients of 0.160 and 0.336, respectively. The correlation coefficient is larger in the self-coupling mode, and the transformer in this way lives longer. However, the Duplex winding mode is negatively correlated with the defect rate, and the corresponding correlation coefficient is-0.392, which shows that the transformer life of the double winding form is short.

Table 5: Life and regulation mode related coefficient table.

Voltage regulation mode	Correlation coefficient
On-load voltage regulating	-0.372
Off-Circuit Voltage Regulation	0.372

As shown in Table 5, the On-load voltage regulating is negatively related to life, and the transformer with this voltage regulation is short; while Off-Circuit Voltage Regulation is positively related to life, and the transformer with this voltage regulation is longer.

Table 6: Life and manufacturer related coefficient table.

Manufacturer	Correlation coefficient
Inner Mongolia Transformer Factory	0.133
Shenyang Transformer Factory	0.177
Tianjin Transformer Factory	0.153
Harbin Transformers Responsible company	-0.268

As shown in Table 6, manufacturers positively related to life are Inner Mongolia Transformer Factory, Shenyang Transformer Factory and Tianjin Transformer Factory. These transformers have long life, and manufacturers negatively related to life are Harbin Transformers Responsible company, which have short transformer life.

5. Conclusion

In this paper, the transformer is the research object, collecting related information such as transformer characteristics and status, and has correlated analysis. Finally, there is no excitation pressure, Inner Mongolia Transformer Factory Production, Shenyang Transformer Factory Production, Tianjin Transformer Factory Production, Three-winding, Self-coupling, forced-directed-oil and forced-air cooled type (ODAF), AC 110kV, AC 500kV transformer Enterprises can focus on the transformers having the above features in future equipment procurement, debugging and overhaul.

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