Asset Management of Power Transformers based on Data Analytics and Statistical Studies

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Abstract: - Currently asset management can be considered one of the main sources of disbursements of electric power companies. Essentially defined as an optimization problem, it aims to guide the use of the physical assets of a company, in the sense of optimizing its life cycle. From this process will be defined the policies of operation and maintenance of equipment, from its acquisition, until the most appropriate time for its replacement. Thus, it becomes strategic to use the decision-making process to reduce the costs of maintaining an asset in service and to extend the period of satisfactory operation of the asset. Based on these assumptions, a new methodology, translated in the form of computational software, is presented in this work to assist decision making in the management of assets in electric power companies.
Keywords:- Power Transformers, Power Systems, Applied Statistics in Electric Power

1 Introduction

The changes that the power systems have been experiencing in recent years had brought a significant impact on industry and utilities under organizational, economic, environmental and technological aspects.

Economic and environmental restrictions have become difficult to implement new generation plants, transmission and distribution lines construction, and transformation substations.

This fact implies facilities with equipment that will have to be used for a longer time, close to its limits of operation and near to the end of its lifetime. Consequently, it is necessary to use sophisticated control and management systems for the equipment and elements of the electrical system.

Nowadays, the continuous technological evolution in the field of computing and information technology has been making available systems with greater capacities of processing, storage, communication and data transmission, especially those dedicated to Smart Grid technologies [1].

This allows to rationalize the operating costs by the implantation of systems of monitoring, supervision and control. As a direct result, we have the optimization of equipment maintenance and control by the use of reliable and low cost tools, a better knowledge of the operational condition of the existing assets and, consequently, a better use of the equipment.

On the other hand, it can be verified that exists a few works that are able to relate asset management, business model and regulation scenarios to the reliability indices in the power systems [2].

For the company's side, some of them conduct audits to ensure that inspections are taking place in the planned manner and at defined intervals. The risk assessment is done annually and the results directly influence the investment planning decisions of the company [3].

The evaluation of the useful life, however, should consider that not all the equipment presents characteristics of failure rates similar to the curve of the bathtub [4].

Several studies, as in [5-9], among others, show that the reliability of electrical systems can be analyzed statistically. Thus, a database with information on the age of the equipment/system, the history of defects and failures and also of the preventive and corrective interventions carried out, allows the elaboration of optimized maintenance policies.

This fact underscores the operational challenges posed by the aging of the electric systems, especially the transmission systems [10].

Traditionally, major evolutionary efforts in power system analysis have focused on the development of algorithms and the refinement of computational models. However, one aspect usually relegated to the secondary plane is in the treatment of data and results from analyses performed.

According to [7], an infinity of information is currently available on the assets of the electric system, being therefore the main challenge to extract the characteristics of greater interest.

Based on such assumptions, this paper presents a model for the failure estimation in transmission systems based on historical data and recorded events for assets in a power transmission system.

2 Aging statistical analysis

Failure rates in electrical systems are obtained assuming that there are equipment connected to the system. Thus, eventually, one of these devices will fail at any given time and, therefore, we will have a failure rate associated to it.

Among the amount of equipment allocated to the system, some of them have a high level of failure rate and, consequently, are considered relevant from the point of view of system reliability [11].

It can be said that the variable failure rate is usually composed or represented by the indices that measure the quality of the service provided by the electric utility. This is due to the difficulty in obtaining historical data that represent the individual faults of the equipment that compose the analyzed system.

However, as a theoretical basis, it should be emphasized that if there is the possibility of using the historical data of the individual faults of the equipment, they would add greater precision to the method of calculation/estimation of the reliability of the electric system [12].

The database analyzed in this study is composed by information from power transformers. The information was extracted from the power transformer bases and, then, the variables are conditioned and the data are processed. Statistical analyzes are then feasible.

In order for such information to result in useful data, repositories containing fault histories must receive preprocessing, which consists of database packaging, inconsistent data correction, and analysis by relational graphs and probability distributions that take into account the age of the asset.

In order to obtain the equipment failure rate distributions, analyzes based on classical statistical theories were used.

Figure 1 shows the comparison of the manufacturing year of the transformers according to the quantity found in the registration databases.

In Fig. 2 it is possible to verify the relative percentage of the age of the power transformers, indicating that these are assets with relative age in operation.

Such relational graphs allow us to characterize the registered assets. The charts of the preventive and corrective maintenance rate in relation to the operating time were also compiled, as illustrated in Fig. 3 and Fig. 4.

It is noted that preventive maintenance in equipment, such as power transformers, is done in a more homogeneous way throughout its operating time. This result from the databases corroborates the importance of this type of equipment, which should be robust and should not fail.

3 Failure correlation

Based on the information on maintenance, the following hypothesis test was performed, i.e., how less preventive maintenance, more corrective maintenance?

To answer that question, several analyses where made using failure history for two transformers manufacturers, as registered in Fig. 5 and Fig. 6. Initial statistical studies on asset health were conducted within the domain of decades. In order to improve the accuracy of the rates, a polynomial interpolation was performed. This approximation technique consists of dividing the interval of interest into several subintervals and approaching, as gently as possible, these subintervals with (cubic) small degree polynomials. This type of interpolation reduces numerical instabilities that cause undesirable oscillations when several points are joined in a curve.

Graphs were also made that relate the failure rates to the voltage class of the equipment, as in Fig. 7 and 8.

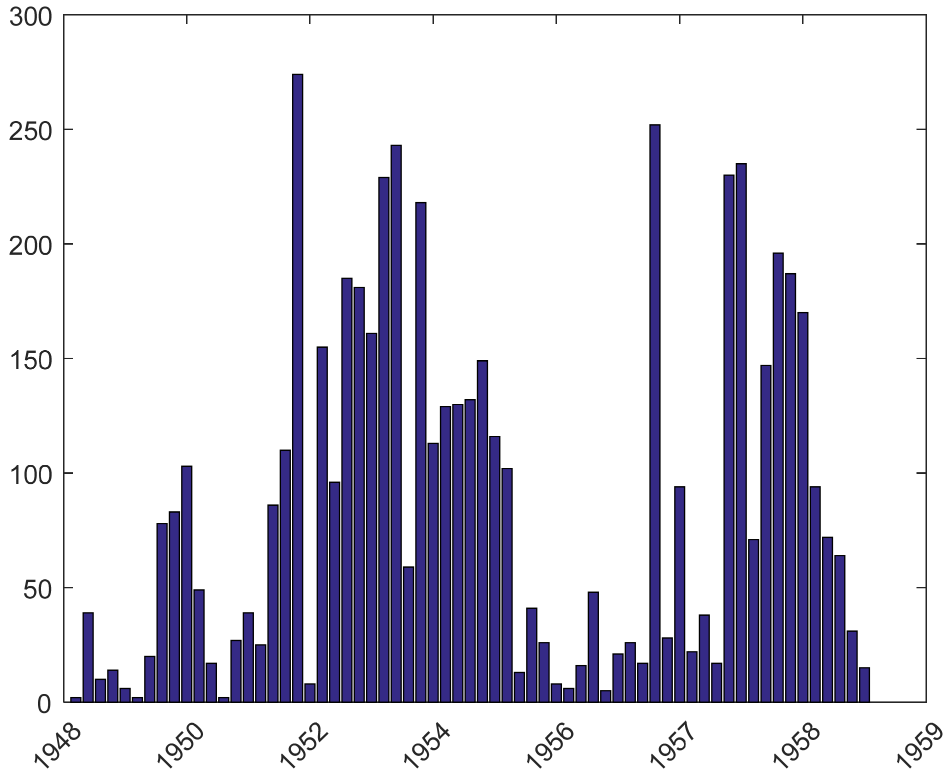

Fig. 1. Age of the transformers.

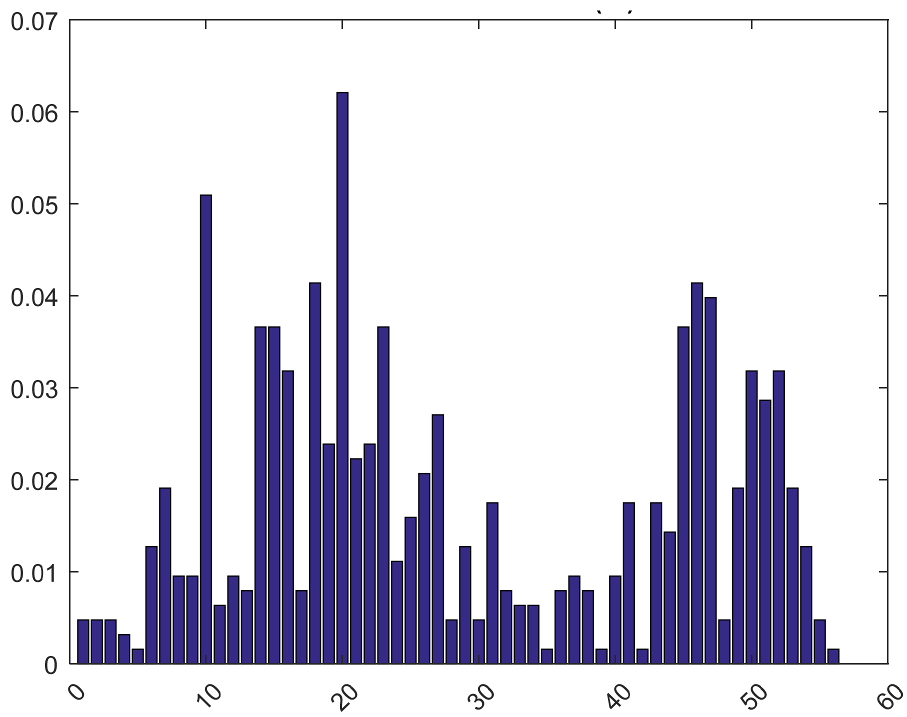

Fig. 2. Age of the transformers.

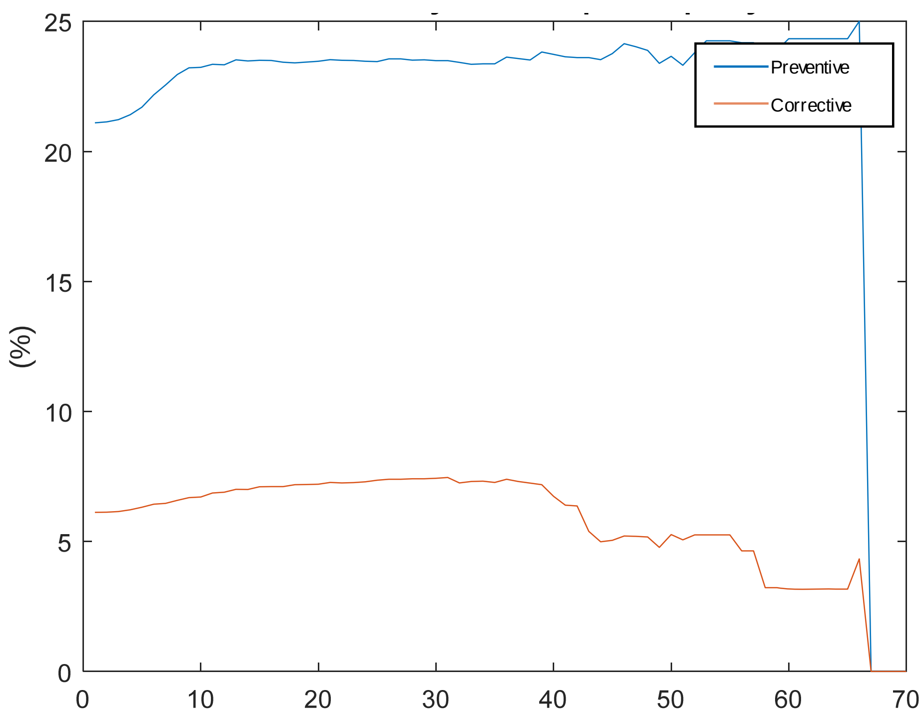

Fig. 3. Maintenance rate vs operation time.

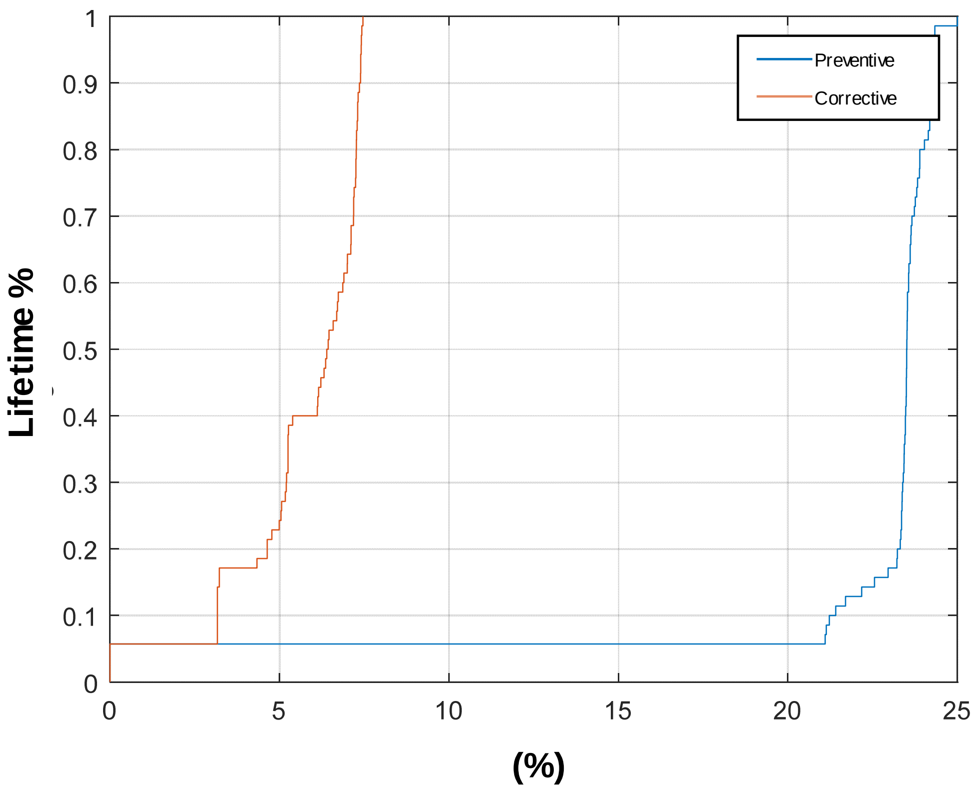

Fig. 4. Cumulative probability density function.

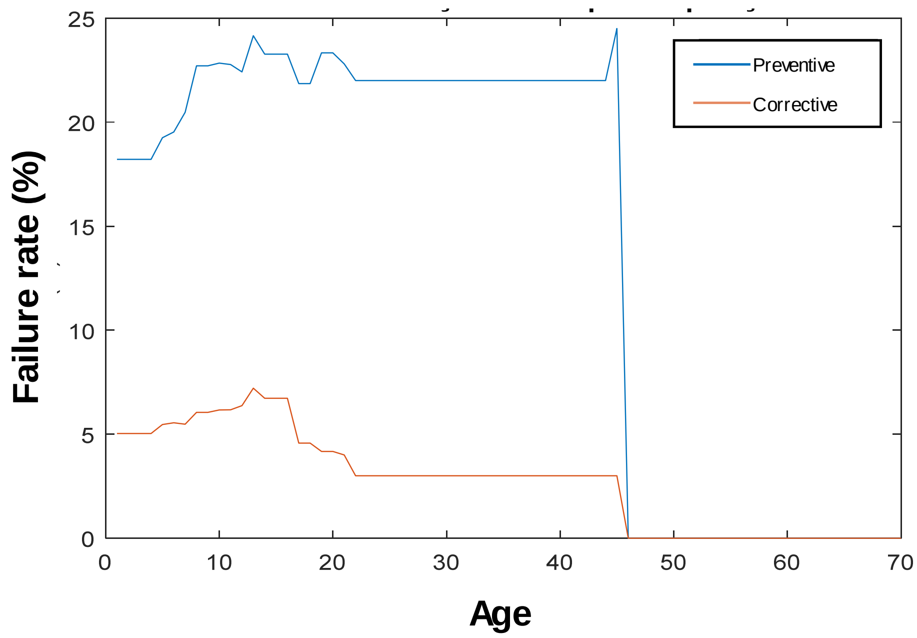

Fig. 5. Maintenance rate vs operation time for Manufacturer 1.

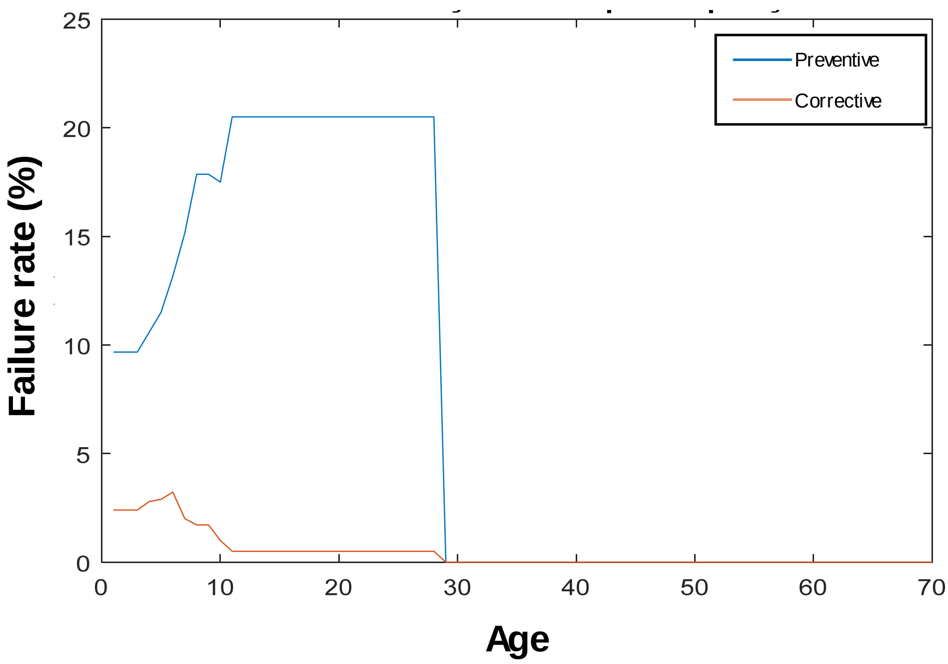

Fig. 6. Maintenance rate vs operation time for Manufacturer 2.

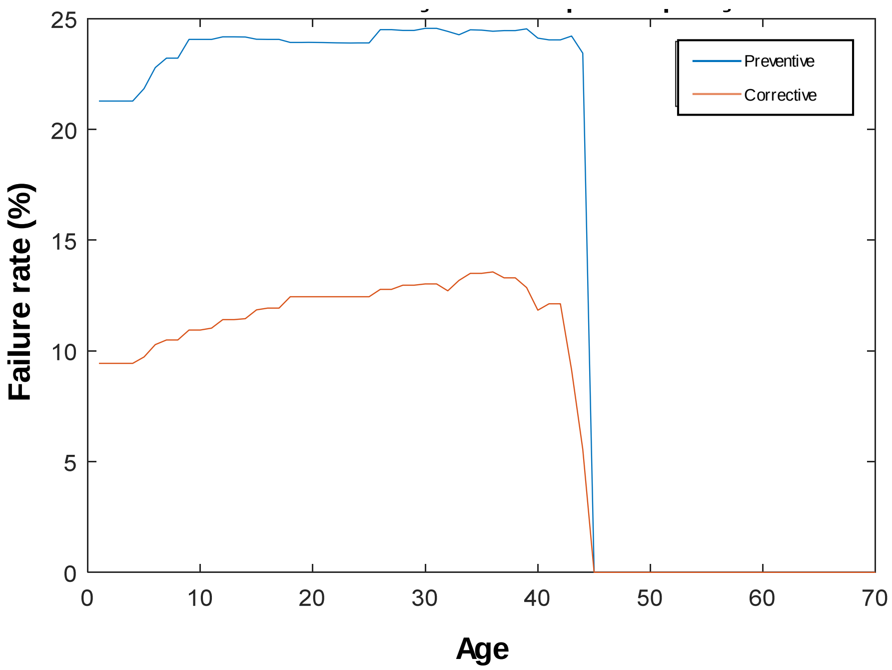

Fig. 7. Maintenance rate vs operation time for 345 kV.

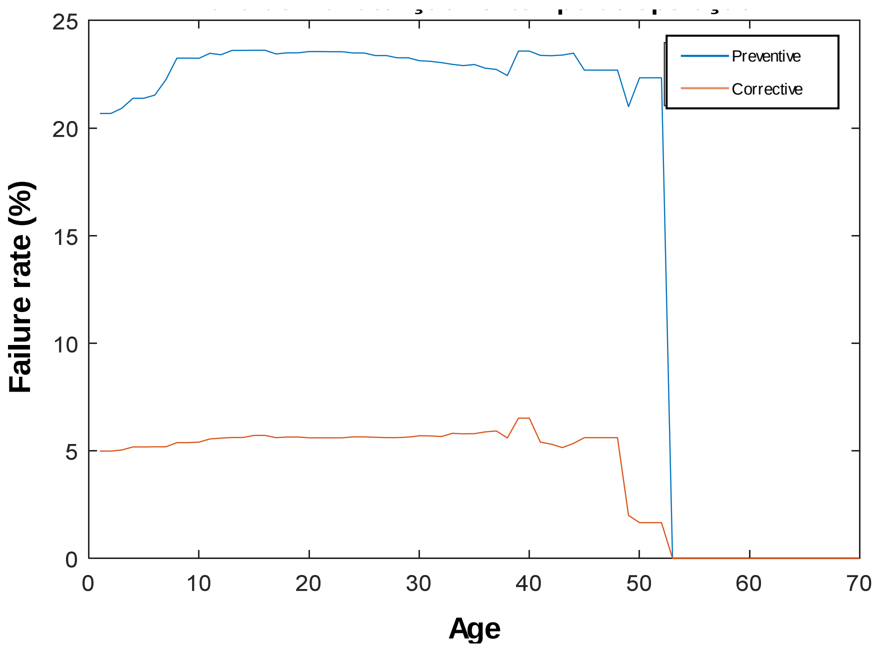

Fig. 8. Maintenance rate vs operation time for 440 kV.

4 Conclusions

The management of assets in electric power systems has played an important role in the strategic scenario of electric power companies, mainly in the aging of the equipment present in the transmitters and distributors' parks.

As these devices become longer in operation, it is justifiable to develop methodologies that prematurely identify their health condition, taking into account not only historical series, but also all available tools of analysis that currently companies own for equipment.

In this work we have presented the partial developments of a methodology based on database processing and statistical studies that can aid in the decision making of preventive maintenance in equipment aimed at asset management of electric sector companies. We highlight the results from case studies of real databases for the purpose of validating the modules.

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