Analysis of Asset Management Models for a Transformer Fleet in the National Laboratory of Smart Grids (LAB+i)

Authors:
Kevin Morgado, Eng.
Javier Rosero, PhD.

Institution:
Electrical Machines & Drives – Research Group
Universidad Nacional de Colombia
Contents

I. Introduction

II. Classification Method

III. LAB+i

IV. AM Implementation

V. Results

VI. Bibliography

VII. Questions
I. Introduction

- Life cycle monitoring
- Asset Management – ISO 55000
- Neural Networks – Artificial Intelligence
- Industry demands
- Research opportunities

Fig 1. Distribution Transformer [1].
Fig 2. Asset lifecycle [2].
II. Classification method

- Power transformer modeling
  - Thermal, DGA, Frequency, Partial discharges
- Life cycle
  - Consequence factor, failure probability, economic lifetime
- Output indicator calculation
  - Machine Learning, fuzzy Logic, mathematical models
- Measurement and output data frequency
  - Calculation time and output data format

Fig 3. Risk assessment matrix for a fleet of n transformers [4].

Fig 4. Failure probability versus age [5].
II. Classification method

Fig 5. Classification of 12 reference Asset Management models.
III. LAB+i

- Smart Meters
- Communication through Internet
- Osisoft PI System
- Model construction
  - 33 substations
  - 53 nodes
  - Radial Topology of 3 km
- Smart Grid analysis
  - Viability
  - Demand management
  - Renewable resources
  - Big Data - governance

Fig 6. Contributions R+D+I from pilots in LAB+I Laboratory [6].
IV. AM implementation

- Thermal Model
  - IEEE Standard C57.91
  - GTC 50
  - Hot spot value
- Three Substations
  - School of Medicine
  - Mathematics Faculty
  - Central Library
- High value of remaining years
- Correlation with overall temperature

Fig 7. Initial temperature measurements of oil insulation of three substations.

Fig 8. Thermal model results.
IV. AM implementation

- **Fuzzy Logic Model**
  - Transformer age
  - Insulating oil temperature
  - Hot spot temperature
- **Weighting model**
  - Transformer age
  - Transformer load
- **Three Substations**
  - School of Medicine
  - Mathematics Faculty
  - Central Library

Fig 9. Normalized fuzzy logic and weighting model results.
V. Results - Classification

• Challenge of establishing a general modeling.
• Data with Asset Management systems.
• Use of new computational tools.
• Applicability within the LAB+I.
• Socialization – Stakeholders.
• Understanding of rules and new models.

Fig 10. Membership output function for temperature.
V. Results - Implementation

- **Thermal Model**
  - Fluctuation in final indicator value.
  - High quantity of years of remaining life.
  - Influence of low insulation temperature.
- **Fuzzy Logic Model**
  - Stability and confidence.
  - Membership functions and rules
  - Use of limited data.
- **Weighting model**
  - Use of limited data.
  - Comparison challenges.
  - Low demand related to nominal value of transformers.

### Table 1. Transformer categorization.

<table>
<thead>
<tr>
<th>Substation</th>
<th>Thermal Model</th>
<th>Weighting Model</th>
<th>Fuzzy Logic Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine F.</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Good</td>
</tr>
<tr>
<td>Mathematics F.</td>
<td>Very Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Central Library</td>
<td>Very Good</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

### Table 2. Indicator standard deviation.

<table>
<thead>
<tr>
<th>Substation</th>
<th>Thermal Model</th>
<th>Weighting Model</th>
<th>Fuzzy Logic Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine F.</td>
<td>1.06380452</td>
<td>1.78568E-15</td>
<td>0.002605641</td>
</tr>
<tr>
<td>Mathematics F.</td>
<td>4.22224748</td>
<td>1.96425E-14</td>
<td>0.01056496</td>
</tr>
<tr>
<td>Central Library</td>
<td>5.5627336</td>
<td>1.96425E-14</td>
<td>0.015725283</td>
</tr>
</tbody>
</table>
VI. Bibliography


VI. Bibliography


VII. Questions