

Study Committee A3 Transmission and Distribution Equipment Paper 10645_2022

Development of switchgear condition monitoring using IoT technology for Condition Based Maintenance

Shinya AICHI
Chubu Electric Power Grid Co., Inc. (Japan)

Background of our study

- In recent years, advances in IoT technology and the low cost of sensors have made it easier to monitor the condition of substation assets.
- Until now, time-based maintenance (TBM) has been performed, but these have required a great deal of labor because they involve power outages operation and on-site work every few years.
- According to our experience, among the all substation assets, there are many failures of switchgear, and most of them are due to the failure of the operating mechanism.

Our policy change with IoT

- For improvement, we have changed our switchgear maintenance policy from TBM to CBM by using IoT.

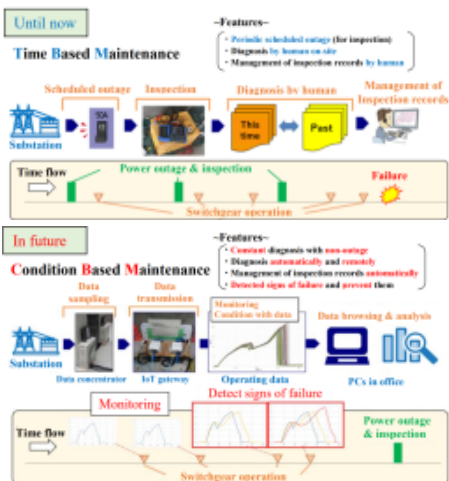


Fig.1 Conceptual image of transition from TBM to CBM

Our requirement for IoT installation

- As a means to practically install and expand the IoT, we seek "Affordable", "Easy", "Vender lock-in free", and "Power outage-free" installation is possible.

Selection of monitoring methods

- As monitoring methods satisfying our requirements for IoT installation, two monitoring items "DC (operating/control) current" & "Operating sound" were considered and their usefulness was evaluated.

DC current monitoring

Development of monitoring system

- Already installed in more than 300 substations.
- Use commercially available, clamp-type DC current sensor
- Real-time, remote browsing of data is possible.



Fig.2 Overview of our monitoring system

Results of DC current analysis

- DC current waveform data can be used to detect signs of abnormality

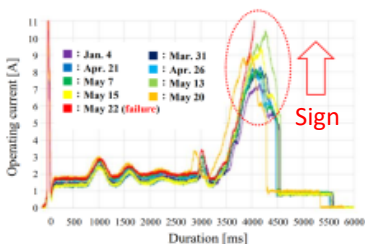


Fig.3 Operating current waveforms of 84kV-disconnector

- Compare waveform distributions to identify models with high/low risk of failure.

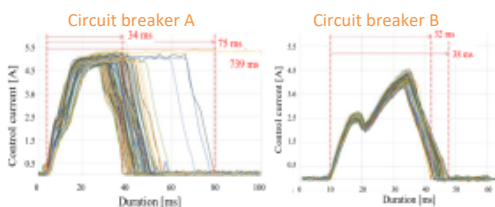


Fig.4 Control current waveforms of 84kV-CB

- These results can be used to prevent serious failures and to identify priority replacement models.

Study Committee A3 Transmission and Distribution Equipment Paper 10645_2022

Development of switchgear condition monitoring using IoT technology for Condition Based Maintenance continued

Operating sound monitoring

Development of two analysis methods

- Use "FFT (Fast Fourier Transform) color map" and "POA (partial overall) time trend" as effective analysis methods.

Results of operating sound analysis

- Measurements using a 84kV-CB to simulate various abnormalities.
- Detects characteristic patterns according to the abnormal parts and kinds.

Table1 Operation sound analysis of small-force mechanism parts (coils, plungers)

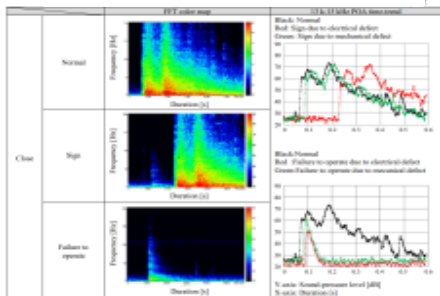
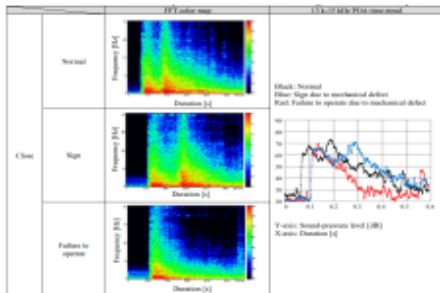


Table2 Operation sound analysis of large-force mechanism parts (link mechanism)



- Analyze data time trends against actual mechanism movements
- The abnormality patterns for each part are sorted out.

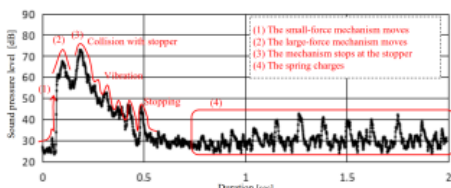


Fig.5 Key of pattern recognition (CB close operation)

- These results help to prevent serious failures and identify the parts of abnormality.
- Trial installation at an actual outdoor substation and successful measurement.

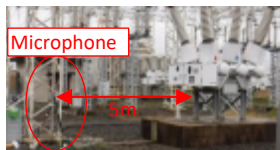


Fig.6 Trial situation at the actual substation

Conclusion

Usefulness of the two monitoring methods

- Both of the two monitoring methods (DC current and operating noise) are easy to install and show sufficient analytical performance.
- In particular, DC current monitoring system has been installed in many substations, and has achieved results such as analysis based on actual data and extended inspection cycles.

Inspection cycle of gas circuit breakers in our company

Previous: 1 time / 6 years → Present: As necessary (depending on condition)

Our future strategy

- Development of the automatic data analysis system using AI
- Expansion of monitoring items and CBM of the entire substation

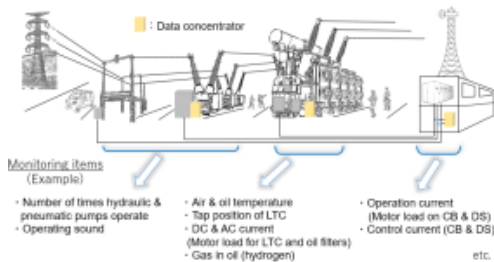


Fig.7 Future concept of substation monitoring items

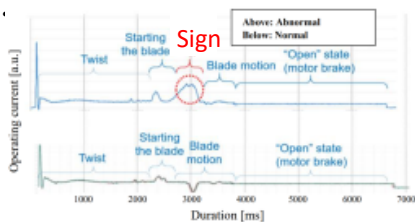
We will conduct more advanced and practical IoT utilization to optimize substation management strategy for sustainable energy supply.

Study Committee A3 Transmission and Distribution Equipment Paper 10645_2022

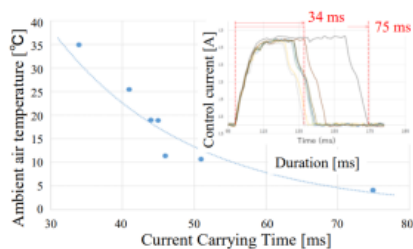
Development of switchgear condition monitoring using IoT technology for Condition Based Maintenance

continued

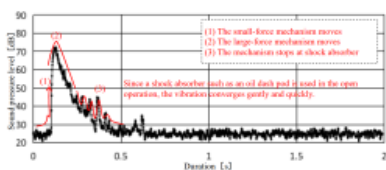
Examples of other DC current waveforms



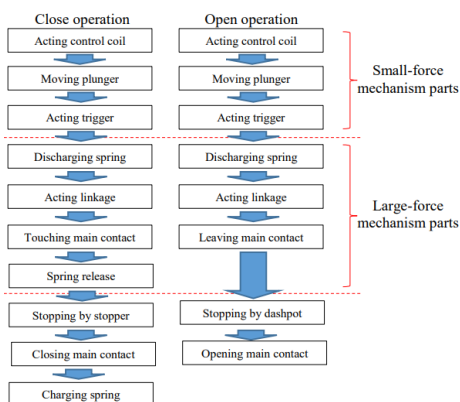
Correlation between current carrying time and ambient air temperature



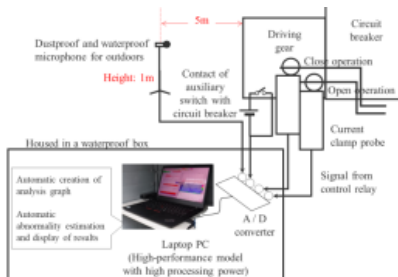
Key of pattern recognition (CB open operation)



Process in close/open operation in case of motor-spring driving gear



Configuration of operation sound monitoring device



Simulation of switchgear abnormalities

