NAME : SHINYA AICHI
COUNTRY : Japan
REGISTRATION NUMBER : 7275

GROUP REF. : B3
PREF. SUBJECT :3
QUESTION N° : 1

PS3.1: What are the benefits of digital solutions like IoT-sensors, machine learning, artificial intelligence, drones, robots etc. for substation life cycle from planning to maintenance? Which measures are necessary to increase the acceptance of intelligent IoT-based power equipment in substations?

Easy and affordable installation of IoT technology in existing substation assets

Introduction

In recent years, continuous monitoring of substation asset conditions have become easier due to advances in IoT technology and reductions in the price of sensors. Conventional time-based maintenance required a great deal of time and labor, including power outage operations and on-site work. Therefore, we are using IoT to constantly monitor substation equipment and conduct condition-based maintenance in order to reduce maintenance labor and improve supply reliability.

In addition, to expand the IoT installation, it is important to approach existing substation assets. Therefore, as an easy and affordable method for ioT installation in existing equipment, we have developed and operated monitoring system using control/operation DC current of switchgear.

Installation of DC current monitoring system

We use commercially available clamp-type DC current sensors after confirming its performance in advance. Since an enormous number of sensors are required to install in our substations, the use of commercially available products offers significant cost advantages. In addition, the clamp type sensor enables easy, vendor-lock-free, and power outage-free installation. These advantages can be a major driver to accelerate IoT installation.

Fig. 1 shows the overview of the monitoring system we have installed. The sensors are connected to the data concentrator via connector cable at the site. Triggered by the rising DC current due to equipment operation, the input to the sensor is automatically converted to data. The collected data is always transmitted via IoT gateway, allowing the user to remotely check the data in real-time. To date, more than 600 units of this system have been installed in almost all of our transmission substations.

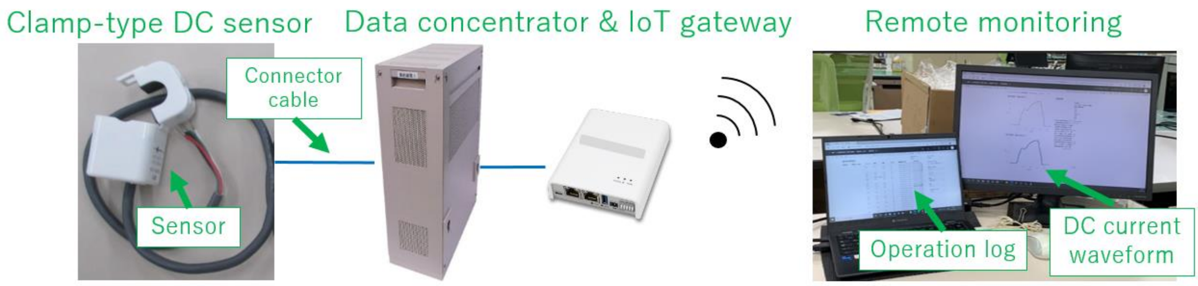

Fig.1 Overview of monitoring system

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Results and benefits from DC current monitoring system

More than one year has already passed since monitoring system was first installed in our transmission substations. During that period, some results were obtained, such as the confirmation of signs of abnormality from DC current waveforms. As an example, Fig. 2 shows a gradual increase in the peak value of the operating current waveform as the mechanism becomes more and more reluctant to operate. By detecting these signs and conducting inspection as necessary, it is possible to prevent serious failures before they occur. At present, about 100,000 data have been collected, and at least dozens of temporary inspections have been planned.

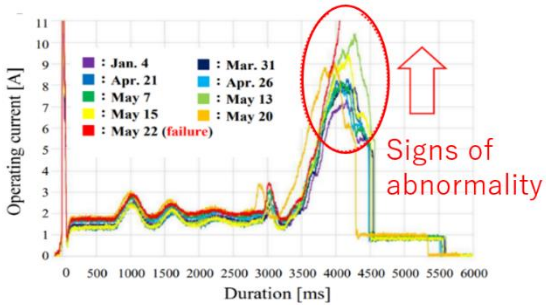

Fig.2 DC current waveforms on a disconnector

In addition, we revised the periodic inspection cycle with the benefits of the monitoring system installation. In the case of circuit breakers, the inspection cycle with power outages was revised from "once every six years" to " as necessary (depending on conditions),". As a result, the inspection frequency we actually conduct has been greatly reduced. However, our other verification showed that parts replacement (especially electrical components) is required once every 24 years, so the actual reduction in inspection frequency is about 75%.

Conclusion and Future Policies

We developed and installed DC current monitaring system. The use of commercially available clamp-type sensors enable "easy," "affordable," "vendor lock-in free," and "power outage-free" installation in existing substation assets. These advantages can be a major driver for the installation and expansion of IoT in substation. Also, from our first-hand experience, it showed that DC current waveform data can be used to detect signs of abnormality and prevent serious failure. This achievement has significantly reduced the frequency of inspections with power outages.

As future policies, we are considering (1) Development of automatic data analysis system using AI and (2) Expansion of monitoring items and CBM of the entire substation.

Regarding (1), at present, threshold values are set for "peak value" and "energization time" of DC current waveform data to alert the person in charge, after which the system relies on human judgment of abnormalities. This requires a lot of time and labor for data analysis. Therefore, we are developing a system that automatically performs precise analysis of abnormalities from data using AI. In addition, we will clarify the relationship between substation asset mechanisms and data, and make more advanced and practical use of data.

Regarding (2), we aim to expand the application of CBM by monitoring not only switchgear but also other substation assets such as transformers in the future. For this purpose, monitoring methods other than DC current are necessary. Therefore, we are developing monitoring methods as shown in Fig. 3. And eventually, we will apply CBM to the entire substation.

With the above approaches, we will optimize substation management strategy for sustainable energy supply.

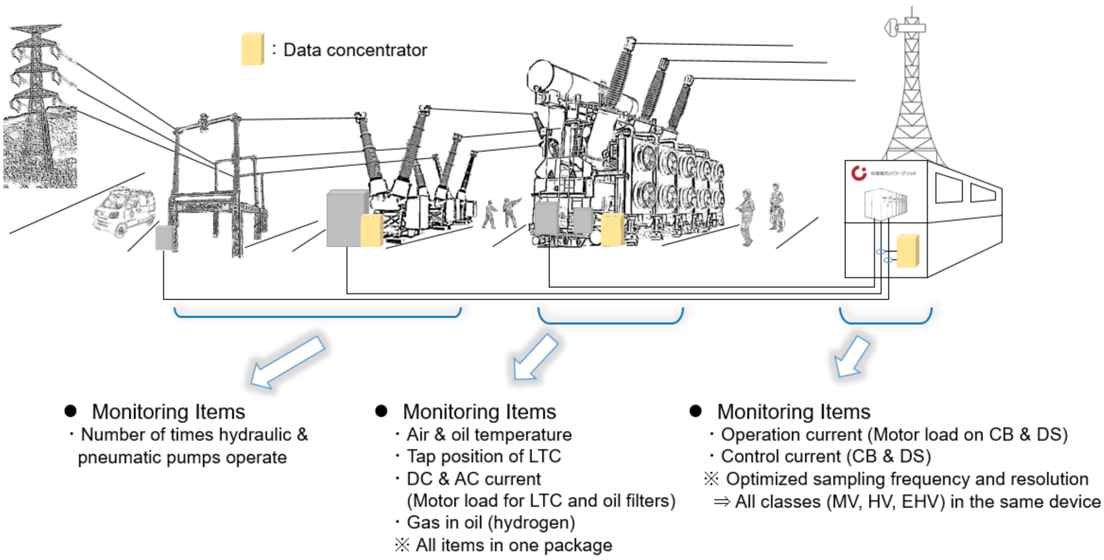

Fig.3 Overview of Substation Monitoring Items