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TEMPERATURE MONITORING OF METAL OXIDE SURGE ARRESTERS

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Varistor overtemperature above the ambient is an important state parameter of metal oxide surge arresters. The temperature monitoring using passive SAW sensors enables realisation of a surge counter function, an energy monitor, monitoring of electrical ageing and pollution stress. For temperature measurements during pollution tests of metal oxide arresters the not so advanced, TINY TALK sensors could be used. This method of temperature measurement was also applied in the field for temperature control of arresters tested at the pollution station near Głogów, Poland. The preliminary results during the first year of monitoring are presented and compared with results of similar measurements conducted in Germany close to the seacoast.

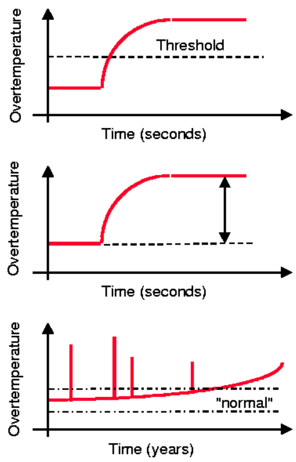
Key words: diagnostics, degradation, ageing, resistive current

1. THE ARRESTER TEMPERATURE - A UNIVERSAL MONITORING PARAMETER

All parameters worth to be monitored on surge arresters – energy absorption due to impulse or temporary overvoltages, power loss increase by electrical ageing or moisture ingress – will finally affect the temperature of the MO column and therefore can be checked on the basis of a temperature measurement. Different from other service parameters, e.g. the 3rd harmonics content of the leakage current, which is often used to detect possible electrical ageing, the temperature is not only an indirect measure of the actual service condition but the decisive operating parameter itself. The temperature of the MO column is the resulting effect of all influences together. At any time, independent from history and different origins the remaining energy absorption capability or the decision on thermal stability after operation of the arrester are given by the actual MO temperature and its change with time.

By evaluating the overtemperatures against ambient temperature, following basic functions can be realised, representing a complete overall monitoring concept: surge counter, energy monitor, monitoring of electrical ageing, monitoring of pollution performance (fig.1)[1].

Summarised, measurement of the arrester temperature facilitates an overall arrester monitoring, comprising function, which have not been realised yet. System requirements such as measuring range, bandwidth or time resolution are low, and electrical interference immunity is high. The main obstacle to its realisation has been the difficulty to measure temperatures on high potential. For the first time this was offered by wireless passive surface acoustic wave (SAW) temperature sensors, which do not impose restrictions like galvanic or optical connections or limited operating time of a battery supply [1]. The measurement system comprising SAW sensors is expensive. Therefore the TINYTALK sensors seems to be a very cheap alternative in the lab and also in the field.



a) Surge counter
Criterion: sudden temperature increase above a certain threshold, corresponding to e.g. 10% of rated energy absorption capability

b) Energy monitor
Criterion: amplitude of a sudden temperature increase

c) Monitoring of electrical ageing
Criterion: average continuous overtemperature exceeds the normal range

Fig. 1. Functions realised by temperature measurement

2. TINYTALK SENSORS

The sensors TINYTAG, TINYVIEW and TINYTALK can be widely used for measurement of different quantities like: humidity, temperature, voltage, current or vibrations. The measuring data (1800 or 3600 samples) can be stored in an EPROM memory and transmitted to the computer via a serial link. During the measurement no hardware connection to the environment is necessary while voltage is applied. Any influence of the test set up on the voltage distribution is thus avoided. The sampling rate can be changed from 0.5 second to 4.8 hours (the whole measuring time from 15 minutes to 1 year). The data are stored even in the case of discharged battery (typical lifetime of 4 years).

The sensor is mounted on printed board with the dimensions of 34×52 mm. Logging is started and the data retrieved (of-loaded) by means of the management software (OTML) which is run on a WINDOWS based host computer. The reading finishes after the memory is full or after sampling a chosen data number. The logger may be programmed to delay the start of the logging cycle by up to 45 days.

TINYTALK loggers are designed to operate over a temperature range of –40 °C to +75 °C (+125 °C) with the accuracy about 0,5 °C. For the application in surge arresters the sensor is integrated in aluminium tube of 60 mm diameter and 30 mm height which is usually used for length adjusting of the metal oxide resistor stack. The arrester current flows along the aluminium wall of the tube (fig. 2). The thermal time-constant is around 150 seconds (about 30 times shorter than thermal time-constant of the surge arrester).

Fig. 2. TINYTALK temperature sensor integrated in a Aluminium tube

3. TEMPERATURE DISTRIBUTION ALONG THE ARRESTER

The temperature distribution gives more reliable information about the grading system than the measurement of voltage distribution. Here, however, the temperature distribution was experimentally verified within the complete 400 kV arrester. For this purpose seven temperature TINYTALK loggers were arranged within the MO resistor columns, three of them in the bottom unit and the other four in the top unit.

For the measurement the arrester was erected directly on the floor (not in a height of the 2.3 m as in the disconnector), which is the worst case condition with respect to operating temperature stress. In real service the uniformity will be slightly better and the temperature values somewhat lower. The applied voltage was the maximum line to earth voltage of the system. The arrester was energised for a time lasting long enough to reach steady state temperature distributions.

Fig. 3. Varistor column with inserted temperature logger

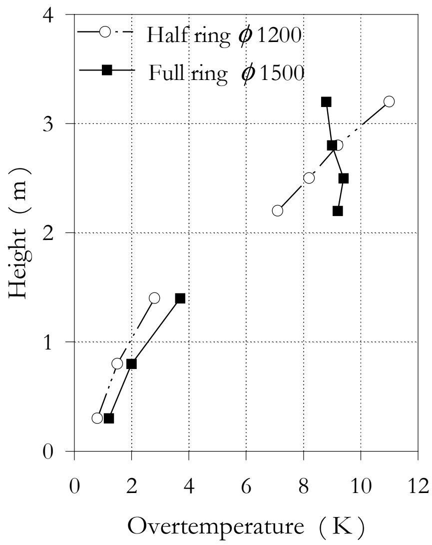


Fig. 4. Measured temperature distribution along the arrester (U_r = 336 kV) at applied maximum line-to-earth voltage of the system (U_m = 420 kV) [2]

Figure 4 shows in comparison the results for the arrester equipped with the standard grading ring of 1.2 m diameter and alternatively with the half ring of 1.5 m. diameter. The temperature distributions are basically in agreement with the calculated voltage distribution. It can be seen, however, that for the half ring the overtemperature continuously increases with arrester height. The uniformity of the voltage distribution is partly forced by self grading due to the resistive effect of the MO blocks, which starts for voltages above about 1.2 times their continuous operating voltage. Looking at the figures in more detail reveals, however, that the maximum overtemperature stress of 9.5 K in case of the full ring of 1.2 m diameter is exceeded by just 1,5 K when using the half ring of 1.5 m diameter. This difference is negligible, and as a final result the modifications of the grading ring are approved by this investigation. The arrester can be used without any restrictions.

4. TEMPERATURE MEASUREMENT OF MO VARISTORS IN THE FIELD

Before application in the field the sensors were tested to check their reliability under severe pollution conditions. For this purpose the arrester was non-uniformly polluted (as described in [3]) and the internal discharges were sustained for a period of 6 hours. Then the voltage was switched off and the sensor resistivity to aggressive products of partial discharges in a closed arrester was tested for next 24 hours. The varistor temperature in the test exceeded 117 °C (fig. 5). But the sensors were not damaged. The calibration procedure revealed their excellent accuracy of 0,5 °C. Additionally, the test has shown that the sensor and the battery can operate in the temperature over 100 °C. It is more than the temperature limit of 75 °C given in technical data.

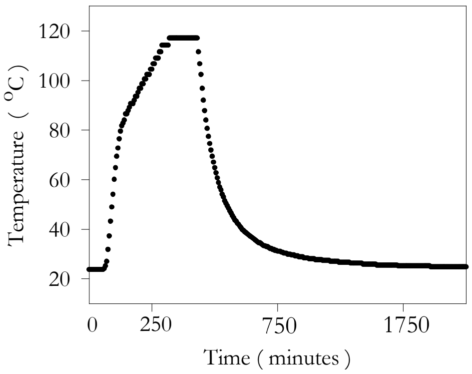


Fig. 5. Temperature increase during internal arcing test

The temperature measurement in the field was carried out at the pollution station in the copper plant Glogów in Poland. For this purpose two TINYTALK loggers were arranged within MO resistor column of two-unit arrester with a rated voltage 96 kV with porcelain housing (one in the top unit and one in the bottom unit). One logger was mounted into a one-unit porcelain arrester with rated voltage of 96 kV. The maximum continuous operating voltage of 77 kV was applied to the both arresters. The fourth logger was installed into one-unit 96 kV rated arrester that was not connected to the high potential. This sensor measures the reference temperature. The mean value of the reference temperature equals the mean ambient temperature.

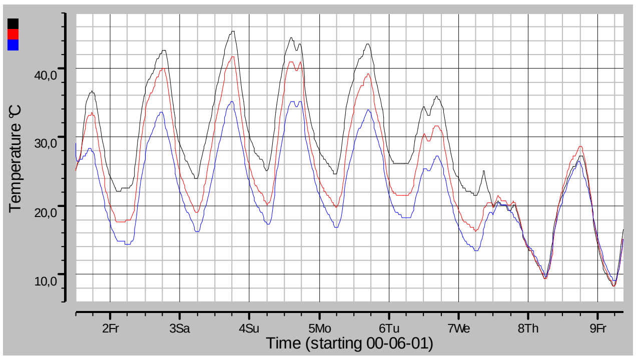


Fig. 6. Temperature inside the two unit 96 kV rated surge arrester at the pollution test station Glogów in June 2000. Lower line - the ambient temperature, middle line - the temperature inside the bottom unit, upper line - the temperature inside the upper unit

The top and middle trace on fig. 6 shows the temperature in the top and bottom unit of 96 kV rated arrester. The maximum temperature is reached at noon, the minimum in the night. The lower trace represents the reference temperature in the arrester without voltage. The temperature in the top unit is about 4 K higher than in the bottom unit and about 8 K higher than the reference temperature. On June 7. 2000 the voltage was switched off. In the night three temperatures are equal. But at noon the reference temperature is about 2 K lower than the temperature in the both arrester units. This discrepancy is caused by the different insolation of two-unit arrester and the reference arrester (the reference arrester is situated in a less insolated position).

Usually the temperature of arresters is only the function of the ambient temperature. But on 30 March 2001 the apparent non-regularity was noticed. The overtemperatures in two-unit arrester and in one unit arrester measured in March 2001 are shown in fig. 7.

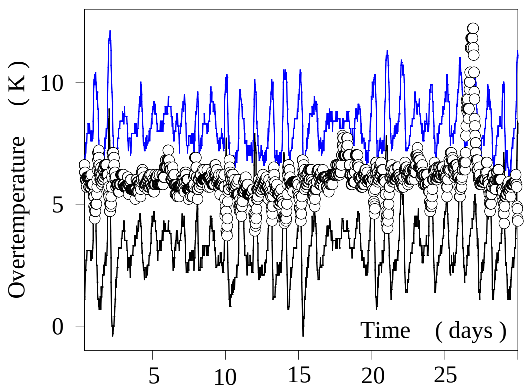


Fig. 7. The overtemperatures inside the two unit arrester and inside the one unit arrester during March 2001 Bottom line - bottom unit, upper line - upper unit, circles at the middle - one unit arrester

The temperature inside one unit arrester is mostly between the temperatures of both small units. Only on 30 March the temperature of one-unit arrester was higher than in the upper unit of two-unit arrester. This situation is showed also in the fig. 8.

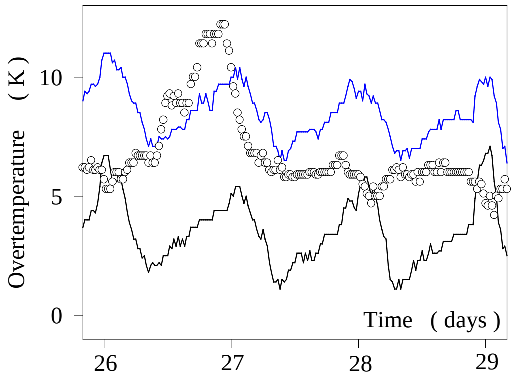


Fig. 8. The overtemperatures inside the two unit arrester and inside the one unit arrester at the end of March 2001. Bottom line - bottom unit, upper line - upper unit, circles at the middle - one unit arrester

The reason of such different behaviour can be the formation of stable dry band on the housing of single unit arrester. In this case the temperature of varistor column opposite to the dry band is higher than at the lower part of varistor column [4]. The phenomena of dry bands formation is a matter of statistics. Additionally, only one stable dry band on the housing can be formed under specific weather conditions (the long time of high humidity, fog, drizzles). Therefore this phenomena was observed only one time during 8 months lasting registrations.

CONCLUSIONS

1. The TINYTALK sensors are resistant to internal discharges and can therefore be used to measure the temperature inside MO arresters in the field.
2. The simple and cheap system has shown very good performance so far and can be used for other applications.
3. The temperature inside the arrester at the pollution test station (pollution level III - heavy) changed mainly due to the changes of ambient temperature. The recorded maximum temperature was 46 °C high. The influence of pollution is rather small. Only one times it was recorded the unusual temperature increase probably due to formation of stable dry band on the housing.

LITERATURE

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