Automated Wind-Icing Monitoring System

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***Abstract* — The principles of automated wind-icing monitoring system development for long-time monitoring of wind-icing events based on continuous measurements without personnel attendance are proposed in this contribution. The monitoring system was elaborated for National electric company "Ukrenergo", the greatest Ukrainian power utility. A description of monitoring system inside architecture and principles of its operation are offered.**

I. Introduction

In Ukraine the main problem of overhead transmission line (OHTL) reliability during winter period is icing in combination with high winds. There was a great number of icing and wind with icing storms with collapses of overhead transmission lines since the beginning of the twentieth century when the first lines in Ukraine were built. The greatest icing catastrophe for the last 50 years was in November 2000 when practically half of Ukrainian territory was under icing. So after these collapses the great attention has been paid to prediction, monitoring and studying of icing events.

In 1945 after World War II icing measurement device was built (see fig. 1). Principles of measurements were elaborated during next several years and were left without any changes from that time. The height of measurement device is 2 meters above ground level. The measurement procedure consists of manual measurements of icing cross-section on wire model, measurements of icing weight and wind velocity measurements during icing event.

The Ukrainian weather stations were built in outlying districts of settlements and during 50 years buildings, trees and infrastructure objects surrounded them. So, accepted methodology of icing measurements does not ensure representative results of loadings on overhead lines during weather events that influence the reliability aspects of energy supplying.

II. The Main Purposes for Building up an Automated Wind-Icing Monitoring System

The main aim of automated wind-icing monitoring system (AWIMS) development is increasing the operational reliability of existed overhead lines via prediction of icing events.

The main purposes for building up automated icing monitoring systems are:

- measurements must be without personnel presence;
- icing measurements must be continuous in time domain;
- information must represent the micro topographical peculiarities or influences on icing processes in any chosen point;

Fig. 1. Ice measurement device

- operator of power utility must immediately obtain information about icing processes;
- requirement to obtain statistically significant sets of data for determining and prediction of loading conditions;
- necessity of combined measurements of icing mass, wind speed and direction, temperature and humidity.

III. Development of Wind-Icing Monitoring System Technical Characteristics

Taking into consideration the above mentioned aims and purposes the main technical characteristics of wind-icing monitoring system were formulated in system approach for reliability increasing of existed OTL [1].

The mass of icing deposits on wires essentially depends from the angle between wind direction during icing processes and wire alignment. So the measured icing element of monitoring system must automatically take perpendicular direction to icing flow, because icing weight on measured device must be maximal in the equal conditions.

The height of measuring devices is 10 meters above the ground level. There were two reasons for changing the traditional height of icing measurement devises:

- the height of ice measuring devices must be comparable with the height of overhead transmission line conductors;
- the influence of the ground boundary layer on icing and wind measurements must be lowered.

Icing, temperature and wind measurement devices must work in a temperature range - 45 …+ 45 ^{0}C, under rain, hail, and hard icing.

A. Data Transmission and Management of Monitoring System

The structure of icing monitoring system assumes data transmission to the central Ukrainian informational office where the information is processed and storaged. The management of monitoring system is realized by means of inside program and in some extraordinary times management accomplished from electrical power substation office or from central Ukrainian informational office.

The principles of data transmission and monitoring system management are offered on fig. 2.

Using above-mentioned data the architecture of monitoring system was elaborated [2].

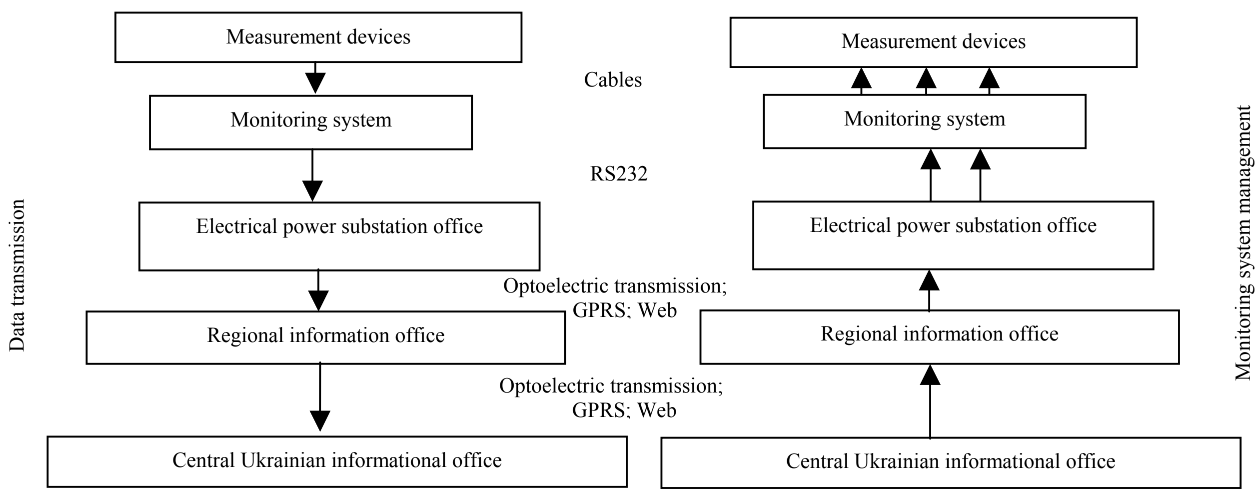

Fig. 2. Data transmission and management of monitoring system

B. Measurement Devices and Architecture of Monitoring System

The monitoring system consists of:

1 – ice mass measuring device (fig. 3):

where:

1a – strain gauge sensor BCA-6L (CAS Corporation (South Korea);

1b - photoelectric pickup of turning and driving gear to the perpendicular mean wind direction during icing (with averaging time – 10 min);

1c – wire simulator is 0,5 m length, 32 mm in diameter.

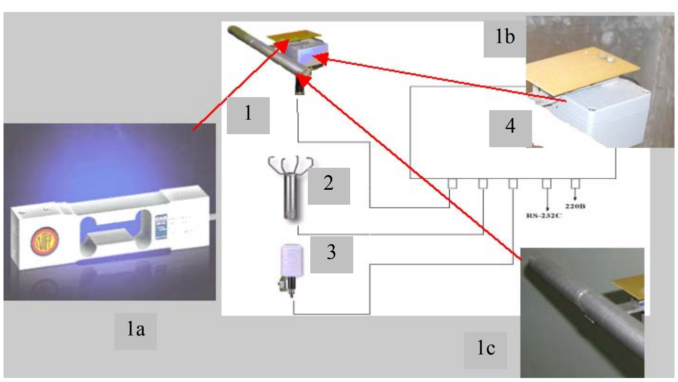

Fig. 3. Ice mass measuring device

2 – ultrasonic anemometer with wind direction measuring device 2D, which is produced in Germany by the firm Thies Clima (fig. 4);

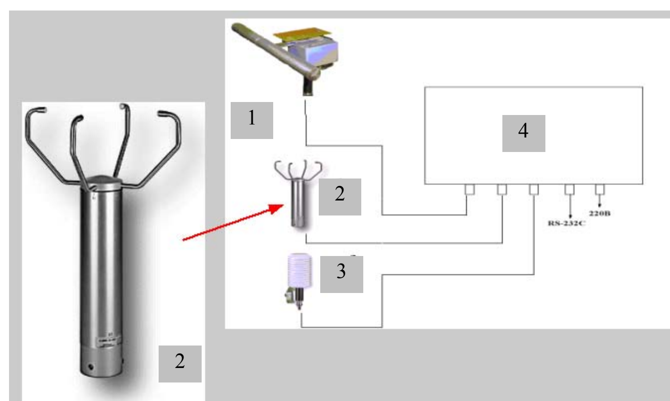

Fig. 4. Ultrasonic anemometer

The main advantages of proposed ultrasonic anemometer are compact sizes, absence of rotation details, and the possibility of heating.

3a – humidity and temperature measurement device (fig. 5), which is produced by the firm Thies Clima;

3b – sunscreen (fig. 4);

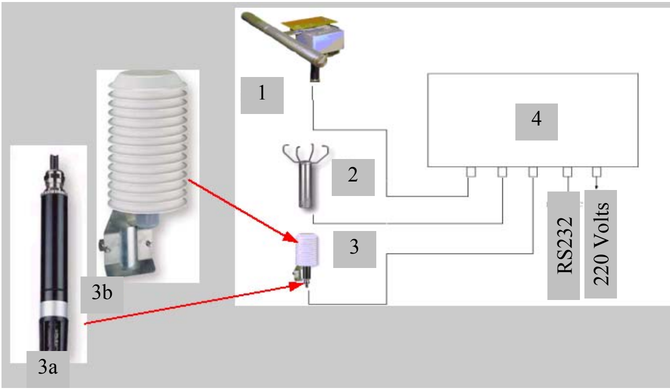

Fig. 5. Humidity and temperature measurement device

4 – system of data stoking and transmission (fig. 6).

System of data stoking and transmission includes controller module and switching modules of measurement devices heating. The power supplying for heating processes and the work of AWIMS is received from electric power net of 220 Volts.

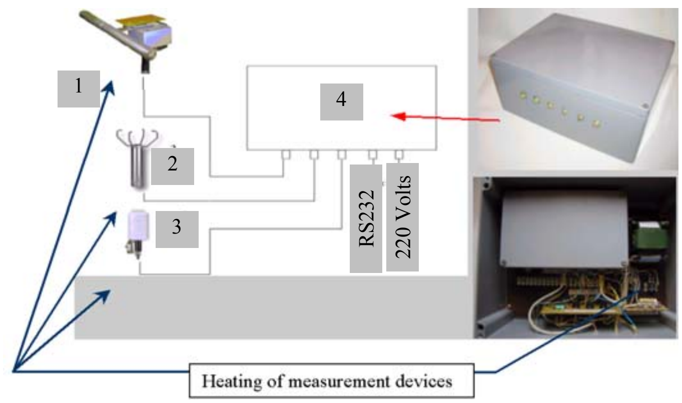

Fig. 6. System of data stoking and transmission

The main purposes of AWIMS software are the management of monitoring system and communication with the electric power substation office. The software consists of two parts, the first part is AWIMS controller software and the second part is electric power substation office software (fig. 7). AWIMS controller automatically measures 6 climatic parameters: wind speed and direction, air temperature and humidity, icing mass and wind pressure on ice-covered wire. The data transmission from AWIMS controller to electrical power substation control unit is realized every 30 minutes by means of cable connection via interface unit RS232.

Fig. 7. Window of monitoring system software

Range of measured climatic parameters:

temperature (t^o), ºC	- 40 …+ 40
humidity (χ), %	to 100
weight of icing deposits (G), N/m	to 50
wind velocity (V), m/s	to 60
wind direction (β), ˚	0 … 360
wind pressure on ice-covered wire (Q), N/m	to 50

The experimental investigations of monitoring system in climatic cell (fig. 8) and over 1-year exploitation showed the availability of accepted technical solutions.


Fig. 8. Experimental investigations of monitoring system in climatic cell

Now the weather station is being explored on Donbas National Academy of Civil Engineering and Architecture testing ground.


Fig. 9. General view of monitoring system

IV. Principles of AWIMS Net Building

There are 21 647 kilometers of OHTL by voltage 220 – 750 kV under operation in NEC “Ukrenergo” on the territory over 600 000 square kilometers. So the optimal allocation of AWIMS on this territory demands studying the spatial icing distribution.

For this analysis four parameters were taken into account. Firstly, the results of existing weather stations data analysis were compared with climatic loads that were standardized by former Soviet Union Rules [3]. The annual maximums of ice loading from 1945 to 2000 for 203 Ukrainian weather stations were used for analysis.

Secondly, the analysis of OHTL failure statistical data was carried out. A comparison of the first and second steps of analysis shows practically the same result with the exception of some mountainous areas and the northern part of Ukraine.

Thirdly, the analysis of spatial icing distribution was fulfilled. On this stage every case of hard icing was analyzed. For Ukraine the maximal icing was realized on the territory from 10 000 to 226 000 square kilometers with the exception of mountainous and hilly areas where this parameter was from 100 to 5 000 square kilometers in dependence of local topography. So, for flat country terrain the representative area of AWIMS is accepted approximately equals to 8 000 square kilometers. Using the results of this analysis the threshold sensitivity of AWIMS before alarm signal was calculated.

The fourth stage consists of the estimation of OHTL density per square kilometer. So, the first, second and fourth stages of analysis showed where the AWIMS must be set and third step gave approximate representative area.

Using the above mentioned analysis the places of AWIMS set were defined (see fig. 10), where the first phase consists of eight indispensable monitoring systems. For safety and maintenance properties the AWIMS are located on electrical substations territory.

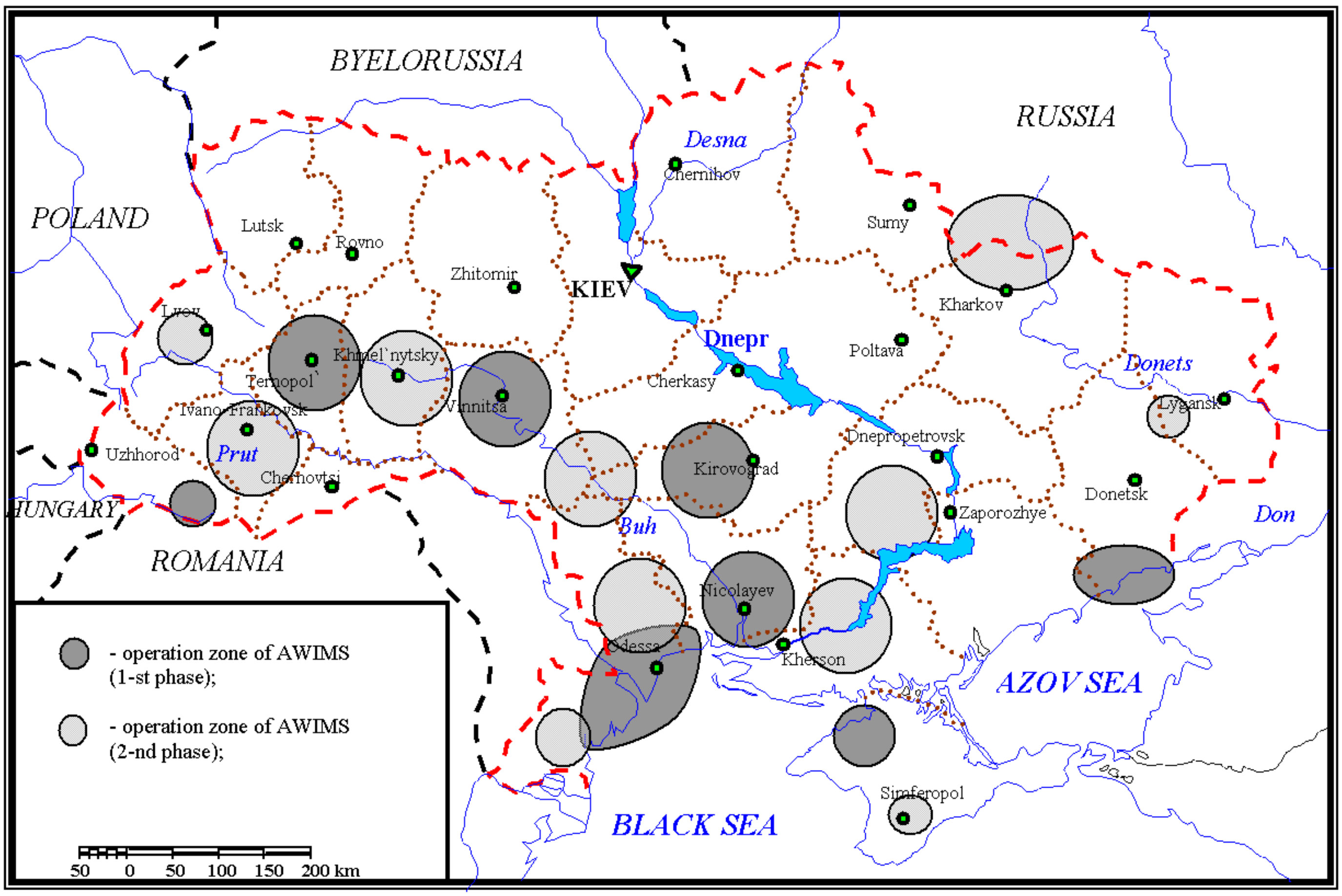

Fig. 10. The AWIMS location on territory of Ukraine

IV. Conclusion

The Automated Wind-Icing Monitoring System, which is described in this article, allows accepting a lot of technical information about icing processes in dangerous regions, stocking information during wind-icing impacts, giving warning signals under icing. The end of 2005 on electrical substations of NEC «Ucrenergo» will install the eight indispensable AWIMS.

V. References

Periodicals:

[1] Horokhov Ye., Grimud G., Nekrasov Yu., Turbin S. Principles of reliability and safety maintenance of overhead transmission line structures under icing. *Vestnik DSACEA. Makeyevka. 2003-3(39), vol. 1,* pp. 76-83. (in Russian).

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Standards:

[3] *Electric Installation Code.* Minenergo USSR. Moscow. 1987. 648 p.