ACOUSTIC DETECTION OF NOISE EMISSION FROM DISCHARGE ACTIVITY IN POWER ENGINEERING

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ABSTRACT

This article deals with results from analysis of acoustic signal obtained from experiments realized in non-homogeneous electric field. These signals exist in the form unwanted noise which can be used also for diagnostic purpose. In power engineering this case occure in high voltage power station and transmission lines. We analyse acoustic signal from acoustic sensor in audible band from 1 kHz to 20 kHz. The acoustic signal transmitted from object is unique for specific conditions. Exploitation of audible band for discharge detection is difficult in outdoor bias level. Advantage of this method consist in simple results prepare.

KEYWORDS

acoustic noise, discharge, acoustic sensor

1. INTRODUCTION

Electric equipments are in the form of different electrode systems produced. Between these electrodes exists different shapes of electric field. In the area of the high voltage technique electric fields are classified according to electrical field homogenity into:

- homogeneous,
- slightly non-homogeneous and
- strong non-homogeneous.

This clasification result from geometrical point of view and material properties of electrode system and appropriate distribution of electric field. Homogeneous electric field has constant electric field intensity in each point. Typical example of discharge originated in homogeneous electric field is so-called Townsend discharge and Reather-Meek discharge.

Slightly non-homogeneous electric field is very small different from homogeneous field. Non-homogeneous electric field originate mainly between electrodes with high difference of curve radius. Significant influence on discharge processes has space charge. During discharge processes in non-homogeneous electric field exist ionizing and de-ionizing processes. These have main influence on formation of discharge path and also on properties of discharge.

Ionization occur in the form of elastic or non-elastic collision of particles, photoionization and thermoionization. Deionizating processes are: recombination of particles, absorption of electrons and difuzion of ions.

2. CLASSIFICATION AND ANALYSIS OF DISCHARGE PHENOMENA IN NON-HOMOGENEOUS FIELD

Discharge processes are classified according to duration on temporary and steady. Steady discharges are divided into independent and non-independent. Sort criterion result from the condition which lead to generation and sustain of discharge path. Category of independent discharges include: silent discharge, corona discharge, spark discharge and arc discharge. Non-independent discharges require the source of charge carrier or source of energy for ionization of atoms.

Corona discharge exists surround electrodes with small curve radius which create non-homogeneou electric field in discharge path. Corona discharge existing only on one electrode we call unipolar. Corona discharge create by specific voltage which is called corona inception level. Under corona inception level exist only non-independent silent discharge in consequence of secondary discharging processes e.g. space, ultraviolet radiation. If voltage on the electrodes is higher then corona inception level plasma enlarges to oposite electrode and breakdown of discharge path occur. Corona discharge changes to spark discharge or arc discharge. Under DC voltage positive or negative corona discharge is created. Under AC voltage AC corona discharge is created which properties are dependend to time.

On the interface solid-gas material creeping discharge in non-homogeneous electric field is developed. This discharge act on the surface of insulation between electrodes. For these processes the best representation is Toepler model. Creeping discharges are undesirable because these discharges quickly degrades insulation and shutdown high voltage devices from operation. The advantage is that we have possibilities to eliminate for example by using different surface layers especially semiconducting layers.

Sparc discharge is temporary form of electric discharge in gas. This discharge manifest in the form of shined chanel which has high temperature and high level of thermal ionization.

3. MEASUREMENT IN NON-HOMOGENEOUS HV FIELD

Most of measurement method originate from the following discharge activity phenomena:

- electromagnetic,
- optic,
- acoustic.

Technical insulation materials which are used in the area of high voltage technique are realised from the solid, liquid and gas combination e.g. liquid-solid, gas-liquid, eventually gas-solid. On the interfaces of particular materials under specific condition surface discharges occures which produce noise.

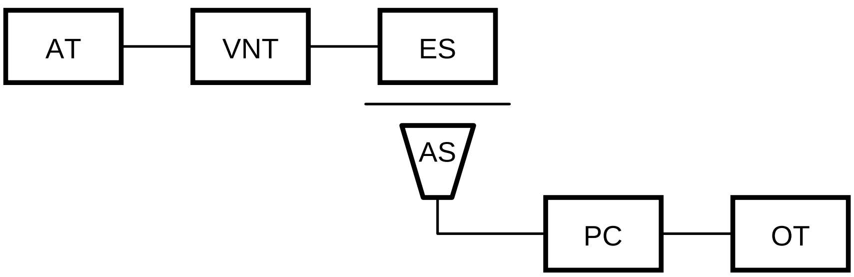

Fig. 1 Block diagram of scheme

AT – autotransformer, VNT – hv transformer, ES – electrode system, AS – acoustic sensor, PC – personal computer, OT – separate winding transformer

The utilisation of non-renewable energy sources is doubtful also from economical point of view, because of their high external costs, i.e. social, political, environmental and nuclear costs. These forgotten costs are not included in selling price and they are by much higher than actual electricity price (Fig. 2).

In the praxis following types of interfaces exists:

a) homogeneous electric field with explicitly tangential action of field on interface,
b) homogeneous electric field rectangular affect on interface of two insulant,
c) non-homogeneous electric field with tangential action of field and small normal part,
d) non-homogeneous electric field with tangential action with strong normal part.

For the operation the most dangerous is case (d). This case we applicated for measurement and acoustic signal analysis. On the figure 1 is block diagram of scheme and applicated electrode arrangement on figure. 2. Electrode arrangement applied in our experiment represent interfaces between solid and gas material. In the measurement according to Toepler different types of electrodes were applied, see figure 3. Electrodes A and B have cylindric design and were in contact with dielectric, electrode C has point shape with curve radius of 0,5 mm. Electrodes D–F are created from needles and their mutual distance (case E and F) is 5 mm.

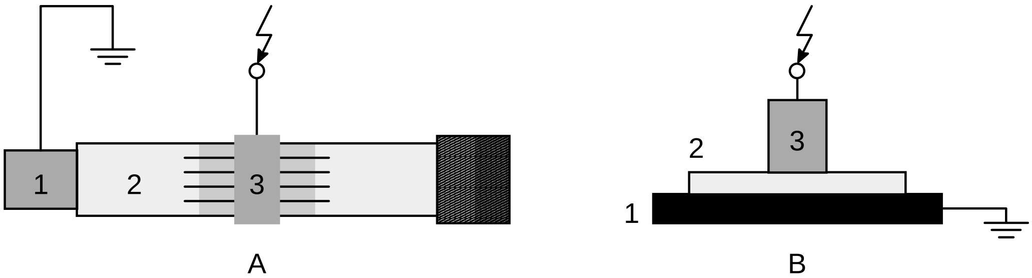

Fig. 2 Electrode system for non-homogeneous electric field creation
1 – earthed electrode, 2 – dielectric, 3 – electrode connected to high voltage; A – measurement of creeping discharges, B – measurement according to Toepler

AC voltage on the electrode system was applied with variable amplitude from 5 kV to 50 kV. Distance between acoustic sensor and electrode system was 30 cm. The signal from acoustic sensor was recorded on data medium and postprecessed.

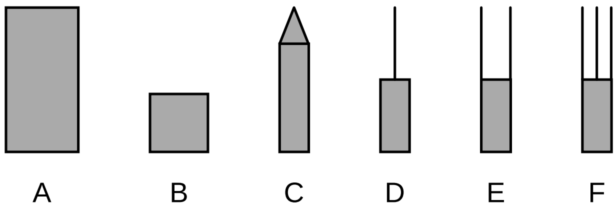

Fig. 3 Types of electrodes in measurement according to Toepler

4. CONCLUSIONS

For evaluation of measured acoustic signal frequency analysis with FFT was applicated. The amplitude of signal is relatively equally distributed over acoustic band. However, contains several extremes which vary in accordance with the shape of electrode, its distance from grounded electrode and amplitude of applied voltage. Measured characteristics are nearly directly proportional with applied voltage.

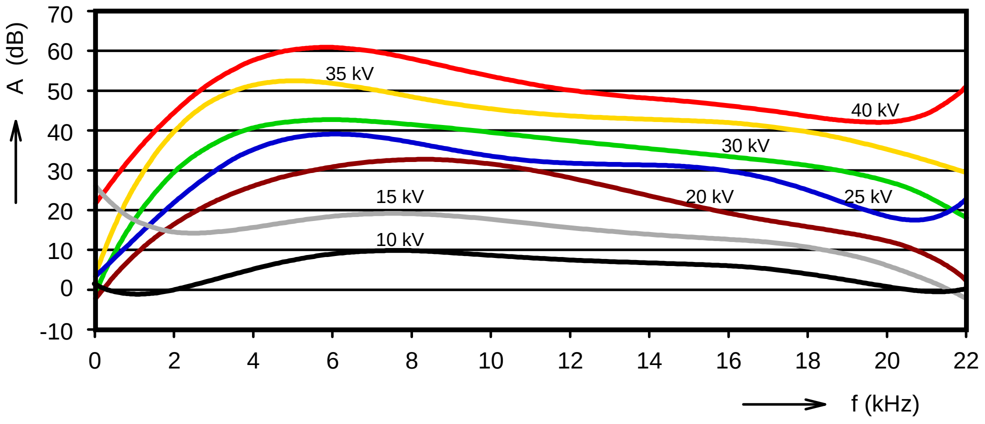

Fig. 4 Frequency characteristic of signal from acoustic sensor for all measured voltage levels

On the figure 4 an increase in amplitudes of particular frequencies for given voltages and electrode system on figure 2B with electrode A according to figure 3 is shown. On the figure 5 comparison of amplitude growth for frequencies 1 kHz, 5 kHz, 10 kHz, 15 kHz and 20 kHz and electrode system according figure 2B with electrode E and distance of 2 cm from grounded electrode is shown. On figures we can see that frequencies 5 kHz a 10 kHz dominate. 1 kHz frequency was compared with another frequencies because represent ambient acoustic noise. Similar characteristics with other electrode systems and appropriate distances were measured.

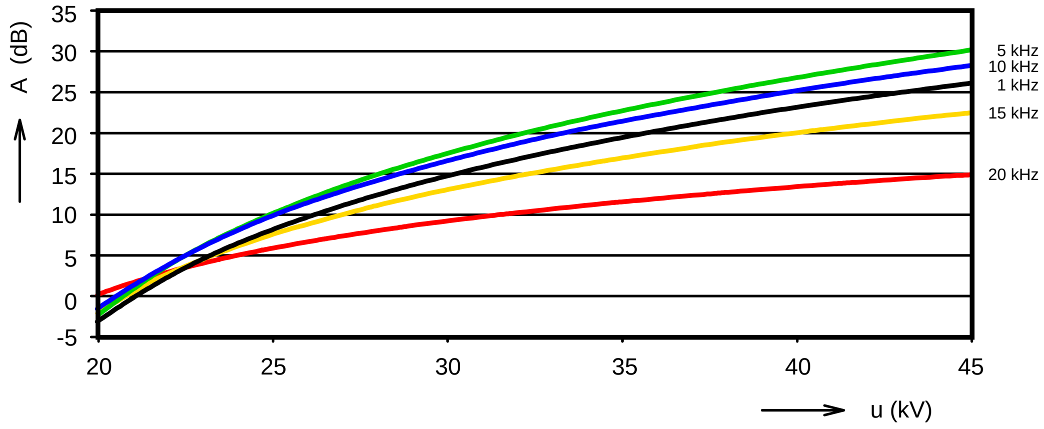

Fig. 5 Increase in amplitudes of particular frequencies for given voltages and electrode system on figure 2B with elektrode E and distance 2 cm from grounded electrode

However measurement of discharge activity in acoustic band is strongly affected with acoustic background of surrounding environment and therefore its practical application is delimited on objects with low ambient acoustic noise. In the case of high ambient acoustic noise exist reason for solution of this problem from environmental point of view. Advantage of this method consist in simplicity of quantitative as well as ability of immediate qualitative evaluation. In environments with strong noise it is better to orient on measurement of signals in ultrasonic band.

5. REFERENCES

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