DEFINING THE PARAMETERS OF EQUIVALENT ELECTRIC - FILTER REPLACEMENT SCHEME

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Abstract. *In the present study the parameters of an equivalent replacement scheme of a tube type test specimen electric filter has been defined and it's capacitance and resistance have been determined. The study shows that this resistance has clearly defined nonlinear character. The results could be used either for designing and sizing of high voltage sources and power electric-filters, or to study the work of these electricity-filters in different modes.*

Keywords: *electric filter, parameters, active resistance, nonlinearity.*

1. INTRODUCTION

The electric filters are high-tech equipment and are a common solution for filtration of air and gas emissions from solid and liquid particles. Their advantages compared to the other dust collectors are undisputed – high efficiency, low consumption, universality, fast and easy cleaning [3]. Their investigation and optimization for different modes could become much easier if a corresponding equivalent replacement scheme is used. The effect of collecting dust is a consequence of the corona discharge between the two electrodes of these devices, but for gas environments the U-I characteristic has a strong nonlinear character [4]. The resistance of an electric filter for its working section also is non-linear. This requires the usage of methods for analysis of nonlinear circuits to be used during investigation and optimization.

The goal of this study is to define and investigate the parameters of an equivalent replacement circuit of an electric filter: active resistance, capacitance for its working section of voltage variation of the corona discharge.

2. STATE-OF-THE-ART

Electric filter: it's structure is based on a classical electric filter scheme of a tube type, shown on fig. 1 [2].

On top of the corona electrode (4), connected with the positive high voltage end (2), are installed circular copper plates (5) with diameter 5 mm, determining the fixed discharge points. The fan (3) provides air flow through the electric filter, who's length and diameter of the sedimentation electrode are 720 mm and 110 mm respectively. Using the autotransformer (6) parametrically is altered the rotating frequency of the fan (3). This construction allows to begin a corona discharge with minimal voltage U_{cr} = 10 kV. This defines the main requirement towards the high voltage source: to provide DC voltage U > 10 kV for the different working modes of the electric filter. It is also presented with an equivalent replacement scheme (fig. 2). The capacitor reflects the capacity $C_{EΦ}$ between the two electrodes and the resistor $R_{EΦ}$ – the active resistance between them during a corona discharge.

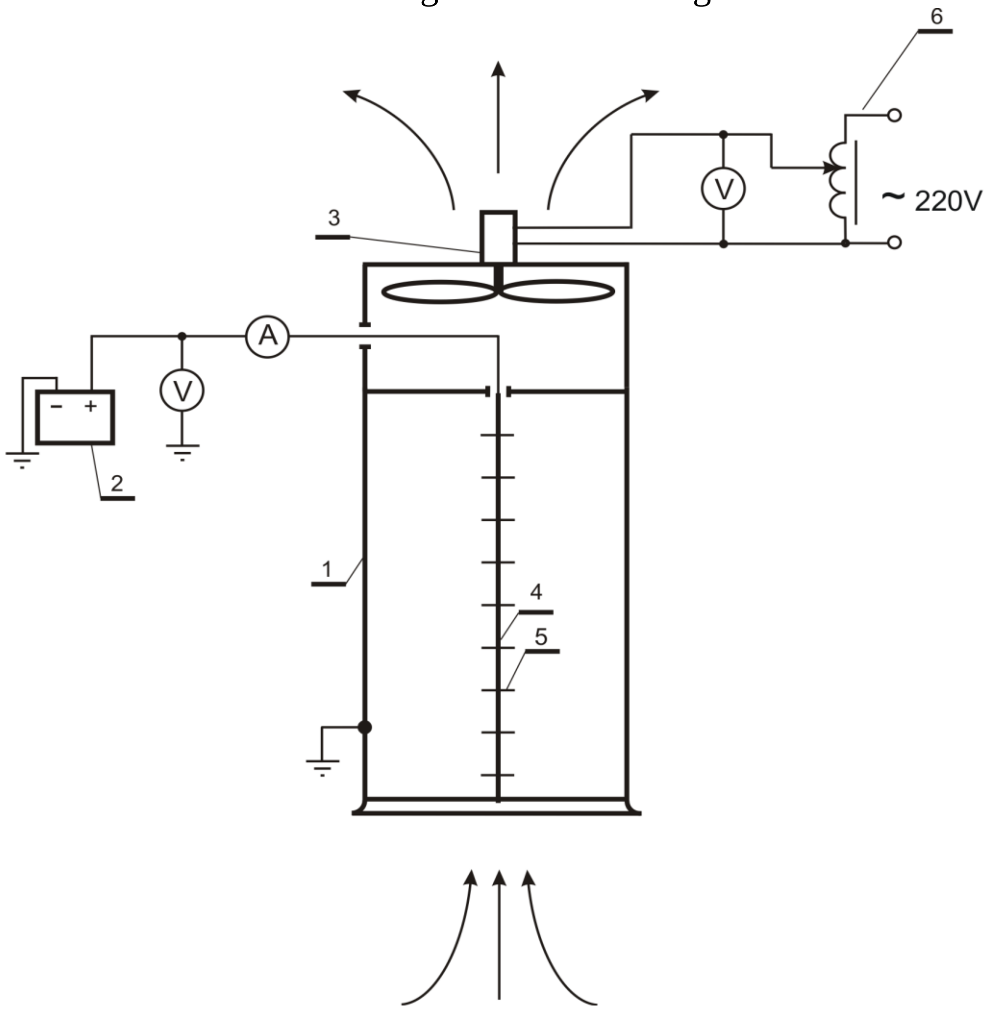

Fig. 1. Schematics of the test specimen electric filter: 1 – sedimentation electrode; 2 – high voltage source; 3 – fan; 4 – corona electrode; 5 – fixed points for discharge (pressed circular copper plates); 6 – autotransformer; 7 – isolator.

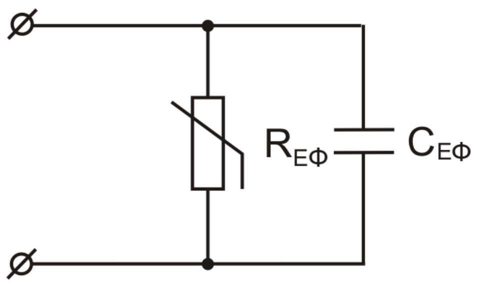

Fig. 2. Equivalent replacement scheme of the electric filter

3. RESULTS

The capacitance of the electric filter ($C_{EΦ}$) is directly measured to be $C_{EΦ}$ = 15 pF. The experimental values of the current (I) and the active resistance ($R_{EΦ}$) of the electric filter, according to the corona discharge voltage (U) in the diapason U= (10÷16), kV, are presented in table 1. The work of the electric filter has been investigated for the same voltage diapason [1]. The dependencies I (U) and $R_{EΦ}$ = f (U) are presented on fig. 3 and fig. 4. They show that the increase of U leads to an increase of I and a decrease of $R_{EΦ}$. Both dependency have strong nonlinear character. This is caused by the intensive impact ionization, which occur on the surface of the corona electrode of the electric filter during voltage increase.

Table 1. Experimental results of the current I, the resistance $R_{EΦ}$ of the test specimen electric filter, ass a function of the voltage U

U, kV	10	12	14	16
I, μA	30	120	250	420
$R_{EΦ}$, MΩ	330	100	56	38

After a statistical processing of the experimental data with one quantity controllable factor, for the U-I characteristic of the electric filter from fig. 3 has been obtained a mathematical model – a second order polynomial (1), with a significance level α = 0,05 confidence level P = 0,95.

The analytical curve of the polynomial, is presented on fig. 5. It has been obtained using the statistical software STATISTIKA10.

$$U = 9{,}3507 + 23{,}3612 \, . \, I - 18{,}0756 \, . \, I^{2}, \text{кV}. \tag{1}$$

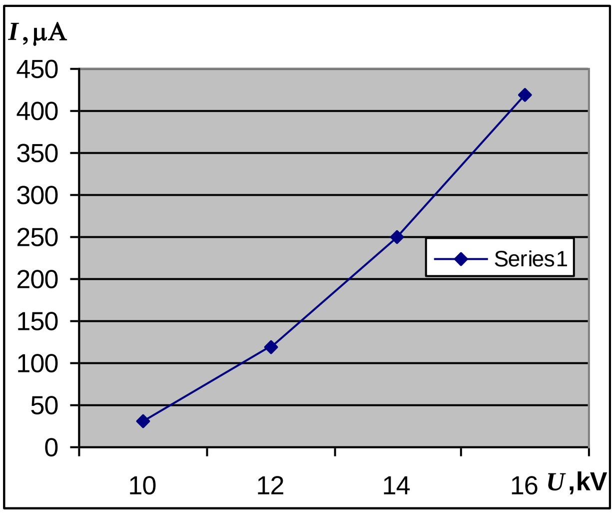

Fig. 3. The current I through the electrical filter as a function of the corona discharge voltage U

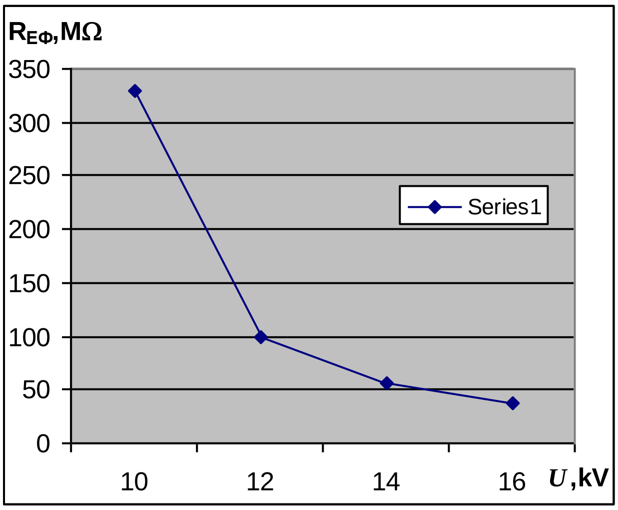

Fig. 4. The active resistance $R_{EΦ}$ of the electric filter as a function of the corona discharge voltage U

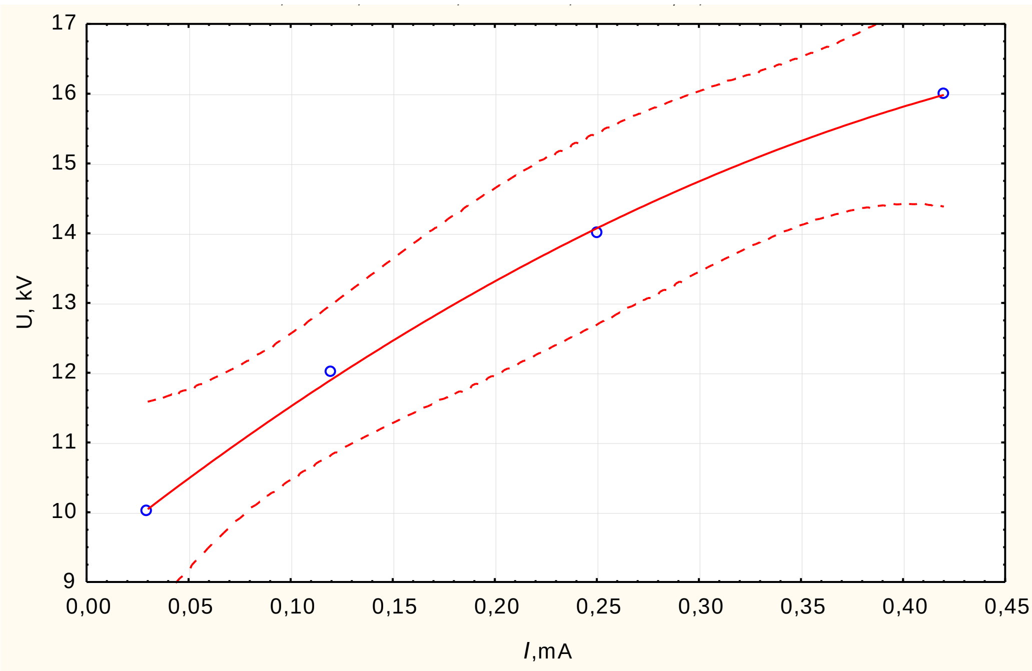

Fig. 5. Analytical curve of the determined polynomial

4. CONCLUSIONS

The experimental data shows that the active resistance of the used electric filter test specimen of tube type is strongly nonlinear for the working section of the corona discharge voltage. This requires the usage of nonlinear methods for circuit analysis to be used.

A mathematical model has been determined, describing the U-I dependency. The obtained results can be used for design and sizing of high voltage sources for electric filters, as well as for study of the working modes of such equipment.

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