Using the Electrical Field Analysis for Assessment of the Influence of Paper Insulation on Discharge Initiation in Oil

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Introduction: On the basis of experimental works performed for two model electrode setups (with insulated by paper HV electrode and with bare HV electrode having the same outer dimensions as the insulated one) hypothesis, that weak points in oil are responsible for discharge initiation, was formed [1]. This hypothesis was based on equality of measured and statistically estimated times to initiation (Table 1).

Voltage polarity	**Positive (+)**				**Negative (-)**			
Electrode type	Insulated		Bare		Insulated		Bare	
Testing Voltage	190 kV				192 kV			
Parameters [μs]	t_d	σ	t_d	σ	t_d	σ	t_d	σ
	4.9	**1.4**	**5.0**	**1.3**	**4.6**	**1.8**	**4.7**	**1.4**
Confidence intervals [μs]	4.4 < t_d < 5.6	0.8 < t_d < 2.3	4.2 < t_d < 6.2	0.3 < t_d < 2.9	3.8 < t_d < 5.5	0.9 < t_d < 3.1	3.7 < t_d < 6.2	0.2 < t_d < 3.5

Table 1. Experimentally measured times to initiation of discharges in mineral oil – parameters of log-normal distribution

Computational Methods: In order to confirm presented hypothesis, the maximum values of electrical field stress for both electrode setups were calculated. After shaping both the setups, boundary values were determined.
Electrical permittivity:
- 2,2 for used oil insulation,
- 4 for paper insulation on HV electrode and insulating plate placed on grounded electrode.

Potential of HV electrode: 190 kV - it was a value obtained as an inception voltage during experimental works.

Results: In Figure 1 the shaped electrode setup with bare HV electrode was presented together with the results of calculated electrical field distribution. Because differences in both setups were small, only one setup was shown.
Obtained results were in accordance with assumptions. Maximum electrical field stress were as in Table 2.

Electrode type	**Maximum electrical field stress**
Insulated	0,4 MV/cm
Bare	0,42 MV/cm

Table 2. Maximum values of electrical field stress obtained on the basis of simulating works

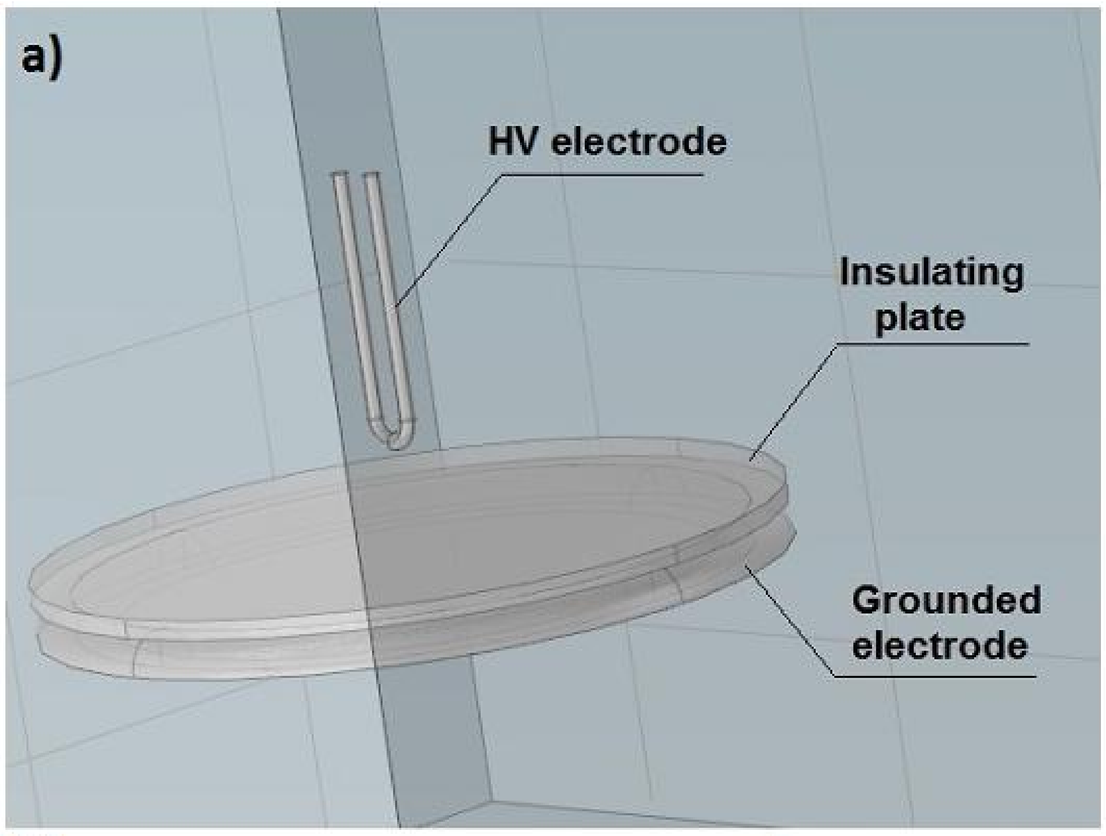

Figure 1. General view of setup with bare HV electrode (a) and result of simulation in x-y axis (b) and y-z axis (c)

Conclusions: COMSOL Multyphysics software perfectly fulfilled its role in considered issues. Thanks to realized calculations confirmation of hypothesis from experimental works was obtained. Support the laboratory studies by numerical calculations is a good way to increase a value of performed scientific works.

References:
1. P. Rozga, The influence of paper insulation on the prebreakdown phenomena in mineral oil under lightning impulse, IEEE Trans. Diel. Electr. Insul., Vol. 11, pp. 720-727 (2011)