ON COUNTING ARC RESISTANCE IN CIRCUIT-BREAKERS WHILE SIMULATING SWITCHING PROCESSES

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Necessity of counting arc resistance in circuit-breakers while simulating switching processes has been researched. It has been stated that neglecting of arc phenomenon may lead to a worsening of adequacy and change magnitudes of calculated voltages.

I. Introduction

The experience of simulation switching processes in electrical systems is developing with a widening of a number of counting phenomena, conditions and parameters, especially concerned to circuit-breakers. In the very early researches a circuit-breaker was presented as an ideal switch with zero resistance in the "On" position and zero conductivity in the "Off" position. Further researches had required more detailed counting the factors have influence on switching processes. For instance, existing of so called current chopping phenomenon had demanded to count a current interruption taken place not in zero point but in certain preceding instant before the natural zero [1-3]. Moreover, repeated re-ignitions of arc required a counting of a law of the circuit-breaker's dielectrical strength restoration [4-6]. Besides, while modeling numerically processes under consideration it is desirable to count existence of certain maximum frequency of interrupted current when arc quenching is still possible [7] (in some particular cases this ability may not be counted [8]).

II. Target settings

Let us now consider a necessity of a counting an arc resistance in circuit-breakers while simulating switching processes. Arc characteristics and behavior are usually investigated in works dedicated to a design of high-voltage circuit-breakers themselves (e.g. see [1]). In works devoted to an interaction of circuit-breakers with electrical networks these matters are touched just rarely [9, 10].

At first, it may seem that counting of the arc resistance can lead just to unnecessary improving of adequacy because of a little or very little contribution of the arc resistance into the longitudinal impedance of a switching-off network. Indeed numerical values of an arc resistance is little enough relatively a resistance of a switching-off network. But this matter has other sides like this:

- a longitudinal resistance of a switching-off circuit consisting just from a resistance of a voltage source (transformer or autotransformer) [2] is comparable with the arc resistance. It means that arc resistance can intensify a damping of free high-frequency component of voltages and currents.
- existence of the arc resistance into the impedance of the switching-off network leads to a slight changing of the interrupted current and steady-state voltage on the capacitor banks and intercontact voltage.

In one's turn above-minded reasons may cause a certain change of transitional process from the point of view numbers of repeated re-ignitions and times they may occur.

Below we will consider possible differences of the switching-off process simulating taking and not taking into account an arc resistance in circuit-breakers. The research had been carried out for the switching-offs the capacitor banks (network is shown in the fig.1, parameters and switching conditions were given in [2]).

For an arc resistance modeling we have used the u-i curves given in [11]. According to devised simulation model we set conductance of circuit-breaker as a function of intercontact potential difference.

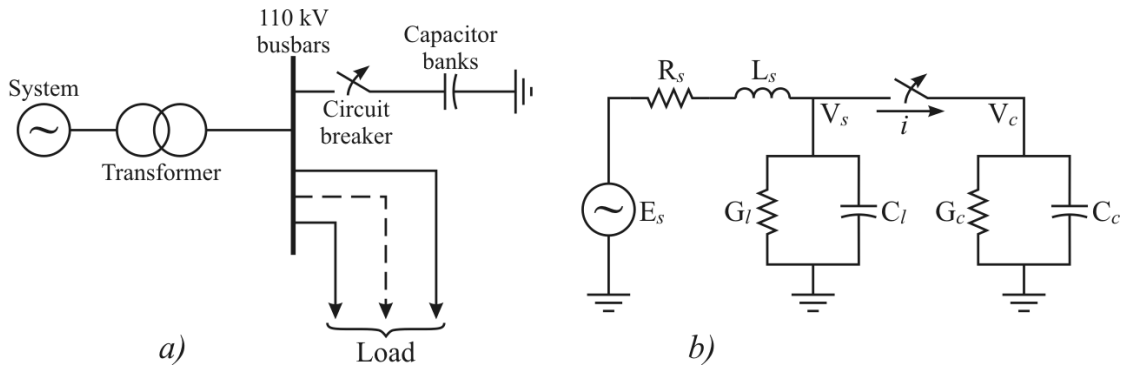

Fig.1. The scheme and the network under consideration:
a) connection scheme; b) simulated network (index *s* concerns to the source parameters, *l* – to the load parameters, *c* – to the capacitor banks parameters. With *R*, *L*, *G*, *C* are correspondingly denoted the resistance, inductance, conductivity and capacitance).

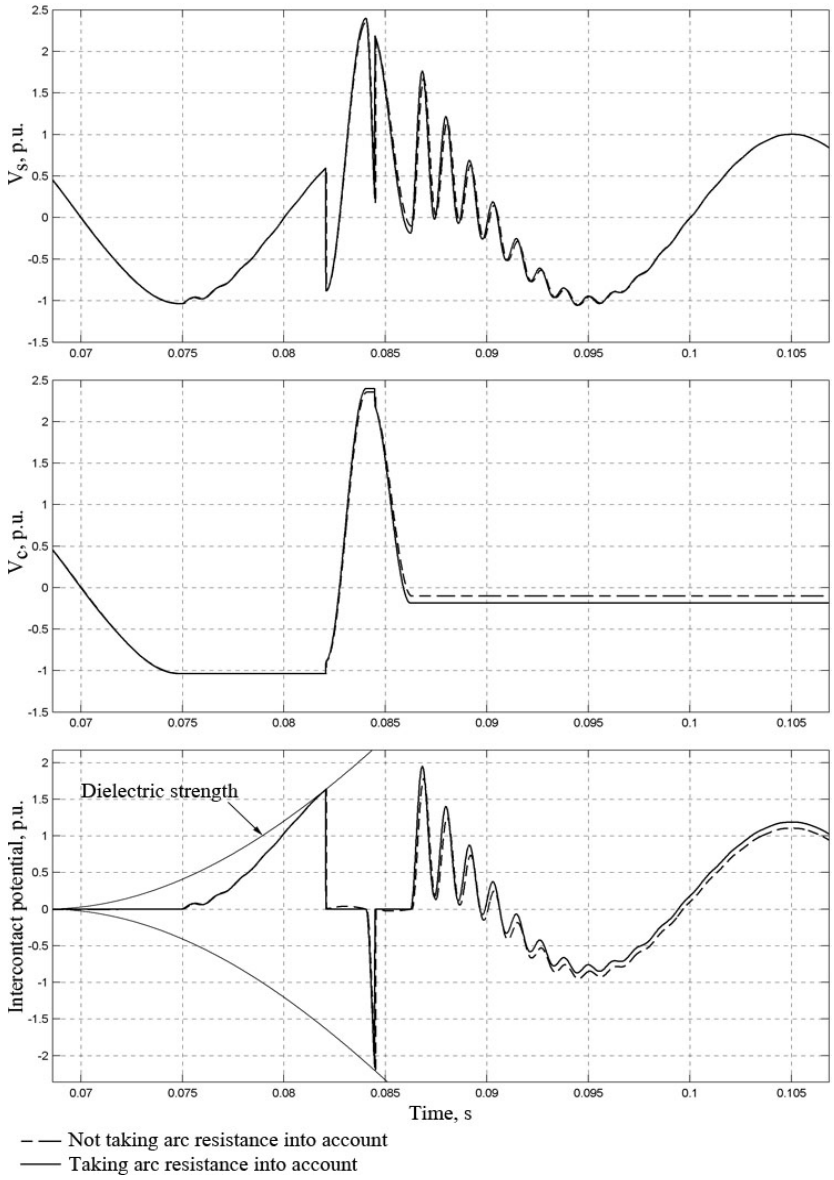

Fig.2. The calculated curves of voltages while switching-off the capacitor banks (see fig.1).

III. Results obtained and discussion

Let us now analyze some noticeable results obtained.

Our researches showed that distinction conditioned by the arc factor can be evaluated as (2÷3) % for the magnitudes of overvoltages and (3÷5) % for the intercontact voltages' magnitudes.

In the fig. 2 the calculated curves of voltages, intercontact potential difference and restored dielectrical strength, obtained with the MATLAB use for the cases of not counting the arc resistance (conductance) and it's counting are presented. The corresponding conditions are: the mean speed of the dielectric strength restoration – 25 kV/ms, the law of restoration – cosine [5], the complete switching-off time – 50ms. Recollect that such parameters concern rather to autocompression circuit breakers [12]. Note that ways of modeling dielectric strength restoration and corresponded mathematical expressions were presented in [6]. Note also that parameters of co-sinusoidal law were obtained on the base of mechanical research given in [13].

As we can state neglecting arc resistance in circuit-breakers while simulating switching transients leads to an underestimation the calculated values of overvoltages. Expressing by the other words we can say that despite of expectations counting of arc resistance, which in general is a dissipative factor, causes the increasing of calculated overvoltages' magnitudes.

In the some time neglecting arc resistance leads to an overestimation the calculated values of intercontact voltages. As a result if not take the arc resistance into account a curve of intercontact voltage will pass slightly above rather than for the case of taking the arc resistance into account.

In the fig. 3 the dependence of the intercontact potential differences' ratios from the contact separation's beginning time is given. The simulations had been carried out for the above shown conditions. This curves show a similarity of the processes occurred but with a certain time difference and of course with different ratios of intercontact voltages while taking and not taking arc resistance into account.

Fig. 3. The dependence of the intercontact potential differences' ratios from the contact separation's beginning time

However arc is real physical phenomenon taking place with all the switchings of the high-voltage circuit-breakers and neglecting of it may reduce calculated magnitudes of

overvoltages, artificially increase the magnitudes of intercontact potential differences and, in general, change behavior of all the voltages and currents it seems important and desirable to count arc resistance (conductance) while simulating switching processes accompanied with arc re-ignitions. Just such models may claim for a certain adequacy.

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KOMPÜTER MODELLƏŞDIRMƏSINDƏ AÇARLARDAKI QÖVSÜN MÜQAVIMƏTININ NƏZƏRƏ ALINMASI HAQQINDA

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Kompüter modelləşdirməsində açarlardakı qövsün aktiv müqavimətinin nəzərə alınması məqsədəuyğunluğu tədqiq edilmişdir. Qövs müqavimətinin nəzərə alınmaması nəticəsində hesabi ifrat gərginliklərinin alçalması, bərpa olunan gərginliklərin isə yüksəlməsinin mümkün olması aşkar edilmişdir.

ОБ УЧЕТЕ СОПРОТИВЛЕНИЯ ДУГИ В ВЫКЛЮЧАТЕЛЯХ ПРИ КОМПЬЮТЕРНОМ МОДЕЛИРОВАНИИ КОММУТАЦИОННЫХ ПРОЦЕССОВ

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Рассмотрена необходимость учёта активного сопротивления дуги в выключателях при компьютерном моделировании коммутационных процессов. Показано, что неучет активного сопротивления дуги может приводить к занижению расчетных перенапряжений. В то-же время установлено, что неучет дуги ведет к завышению расчетных восстанавливающихся напряжений.