ASPECTS OF THE INFLUENCE OF THE NOMINAL SUPPLY VOLTAGE ON THE CAPACITIVE CURRENT PASSING THROUGH THE ELECTRIC LINES IN CABLE

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Abstract: The paper aims to conduct a case study on the influence of the supply voltage variation on the parameters of electric power cables of low voltage consumers . The argument which was the basis for the study, was the fact that the voltage variation is a parameter of quality of electricity supplied by the network operator and respecting the limits of its variation is regulated both by performance standards , and by the electricity supply contract between electricity suppliers and consumers, consumption per seat basis.

Key-word: Joule effect, electric cables, capacitive current, supply voltage, electric capacitive, suspected electricity

1.INTRODUCTION

The thermal effect of electricity is propagated in the transport and the distribution of electricity both for aerial electric wires and and cable electric lines. Compared to the way in which the transfer of heat (generated by Joule effect) between the afferent conductors for the two categories of power lines, at electrical lines in cable, the heat accumulated due to thermal effect, is given with difficulty in the environment due to insulation layer applied to both of each conductive part and the conductive assembly. Starting from this premise, it can be inferred that the electrical resistance of electrical conductors increases with the increasing temperature [1].

The electrical resistance of the conductors of the electrical cables are corrected for temperature variation. This correction of electrical resistance is achieved, starting from a reference value, value in literature relate to a temperature of 200 C (because the value of the resistivity of the conductive material is usually given by specialty literature a measure of temperatures of 20^0 C). Both the value of electrical resistance and reactance value associated to electrical conductors entering in the electric line cable configuration is determined by cable length (Ω / km) and the resistance and reactance specific.

Reactance and resistance values that are specific to electric cable lines can be determined by calculation, but can also be retrieved from tables of values, depending on section, type of construction and the nominal supply voltage.

2.DETERMINATION OF THE SUSCEPTANCE OF THE CAPACITIVE CURRENT IN THE ELECTRICAL CABLE LINES

The parameters of the case study are : reactance , conductance , and susceptance . The paper carried out a study on the influence of the nominal supply voltage on the capacitive current for electrical cables with different sections.

According to the value of the nominal voltage U_n, the reference values of the specific reactance used for the three-phased electrical cables are:[1]

- for $U_n \leq 1kV$ we have X_0=0,07÷0,08 [Ω/km]
- for $U_n = 6 \div 20kV$ we haveX_0=0,09÷1 [Ω/km]
- for $U_n > 20kV$ we have X_0=0,12 [Ω/km]

To calculate the specific capacitive susceptance of the electrical cables with different section and paper isolation, PVC respectively, it will be used the values of the service capacities afferent to those types of cables and the same characteristics. The following expression will be used[1] :

$$B_0 = \omega C_0 \cdot 10^{-6} [\text{S/km}] \quad (1)$$

Where:

- C_0-specific cable capacity $[\mu F/km]$;
- ω –pulsation(2пf).

According to the values of the specific capacity of the electrical cables(with paper isolation, PVC respectively and section of 2,5 mm^2, 4 mm^2, 6 mm^2, 10 mm^2, 16 mm^2, 25 mm^2, 35 mm^2 and 50 mm^2), values taken from the values tables and replacing them in the expression(1), we obtained the values of the specific susceptance(table 1) [1].

Table 1

Section (mm^2)	Specific resistance (Ω/km)				Inductive reactance of cables with 3 conductors (Ω/km)			Sevice capacity of cables C_0 $[\mu F/km$				Specific capacitive susceptance $B_0[\mu F/km]$	
	Cu		Al					Paper isolation			PVC	Paper isolation	PVC
	20^{0}C	70^{0}C	20^{0}C	70^{0}C	0,6-1 [kV]	3,6-6 [kV]	11,6-20 [kV]	0,6-1 [kV	3,6-6 [kV]	1,6-20 [kV]	3,6-6 [kV]	0,6-1 [kV]	3,6-6 [kV]
2,5	7,14	12,1	12,1	14,5	-	-	-	0,105	-	-	-	32,97$\cdot 10^{-6}$	
4	4,46	7,58	7,58	9,1	-	-	-	0,125	-	-	-	39,25$\cdot 10^{-6}$	
6	2,98	5,05	5,05	6,06	0,102	0,144	-	0,140	-	-	-	43,96$\cdot 10^{-6}$	
10	1,79	3,03	3,03	3,64	0,095	0,133	0,143	0,155	0,19	-	-	48,67$\cdot 10^{-6}$	
16	1,12	1,89	1,89	2,27	0,090	0,123	0,132	0,180	0,215	-	-	56,52$\cdot 10^{-6}$	
25	0,71	1,21	1,21	1,46	0,086	0,111	0,123	0,200	0,255	0,165	0,43	62,8$\cdot 10^{-6}$	135,02$\cdot 10^{-6}$
35	0,51	0,61	0,86	1,04	0,083	0,106	0,118	0,325	0,275	0,18	0,484	102,05$\cdot 10^{-6}$	151,97$\cdot 10^{-6}$
50	0,35	0,42	0,60	0,72	0,081	0,100	0,118	0,350	0,330	0,20	0,581	109,9$\cdot 10^{-6}$	182,43$\cdot 10^{-6}$

According with the value of the specific susceptance, calculated in table 1, we have determined the value of the capacitive current for the electrical cables with paper isolation, PVC respectively, (with the section of 2,5 mm^2, 4 mm^2, 6 mm^2, 10 mm^2, 16 mm^2, 25 mm^2, 35 mm^2 și 50 mm^2), according to the possibility of supply voltage variation in the allowed limit by the regulations in force, regarding the quality parameters of the electrical energy supplied by the network operator. The value of the capacitive currents that additionally passes through the electrical cable lines, depends of the constructive type of the cable but mostly it depends on the isolation type. (for paper isolation and polyethylene, the values are lower while for the PVC isolations we have higher values). We can calculate the value of this currents using the relation[1-2]:

$$I_{co} = \frac{U_n}{\sqrt{3}} B_0 \quad \text{[A/km]} \quad (2)$$

Applying the relation (1) and considering that the voltage varies in a percent of ± 10 % ,we have obtained for the additional capacitive currents the values stored in table 2.

Table 2

No.	Section (mm^2)	Nominal voltage U_n[V]	Specific capacitive susceptance $B_0[\mu F/km]$		Capacitive currents I_{co}[A/km]	
			Paper isolation	PVC	Paper isolation	PVC
1	2,5	360	$32{,}97\cdot 10^{-6}$		$6{,}86\cdot 10^{-3}$	
2	4	370	$39{,}25\cdot 10^{-6}$		$8{,}39\cdot 10^{-3}$	
3	6	380	$43{,}96\cdot 10^{-6}$		$9{,}65\cdot 10^{-3}$	
4	10	390	$48{,}67\cdot 10^{-6}$		$10{,}97\cdot 10^{-3}$	
5	16	400	$56{,}52\cdot 10^{-6}$		$13{,}07\cdot 10^{-3}$	
6	25	410	$62{,}8\cdot 10^{-6}$	$135{,}02\cdot 10^{-6}$	$14{,}88\cdot 10^{-3}$	$31{,}99\cdot 10^{-3}$
7	35	420	$102{,}05\cdot 10^{-6}$	$151{,}97\cdot 10^{-6}$	$24{,}77\cdot 10^{-3}$	$36{,}89\cdot 10^{-3}$
8	50	440	$109{,}9\cdot 10^{-6}$	$182{,}43\cdot 10^{-6}$	$27{,}95\cdot 10^{-3}$	$46{,}39\cdot 10^{-3}$

In figure 1 it is presented the variation graph of the capacitive current according to the supply voltage, for the electric cables with paper isolation .

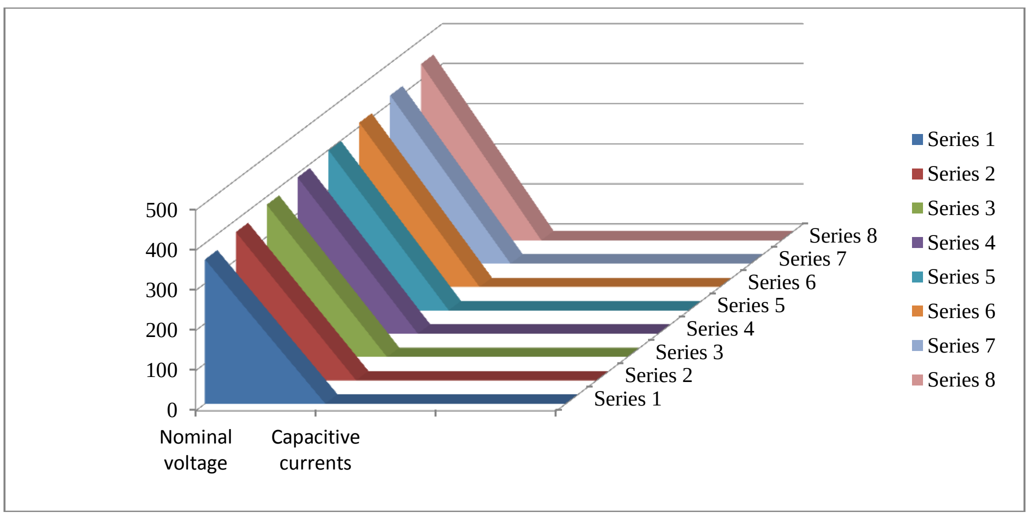

Figure 1. The variation graph of the capacitive current according to the supply voltage, for the electric cables with paper isolation.

In figure 2 it is presented the variation graph of the capacitive current according to the supply voltage, for the electric cables with PVC.

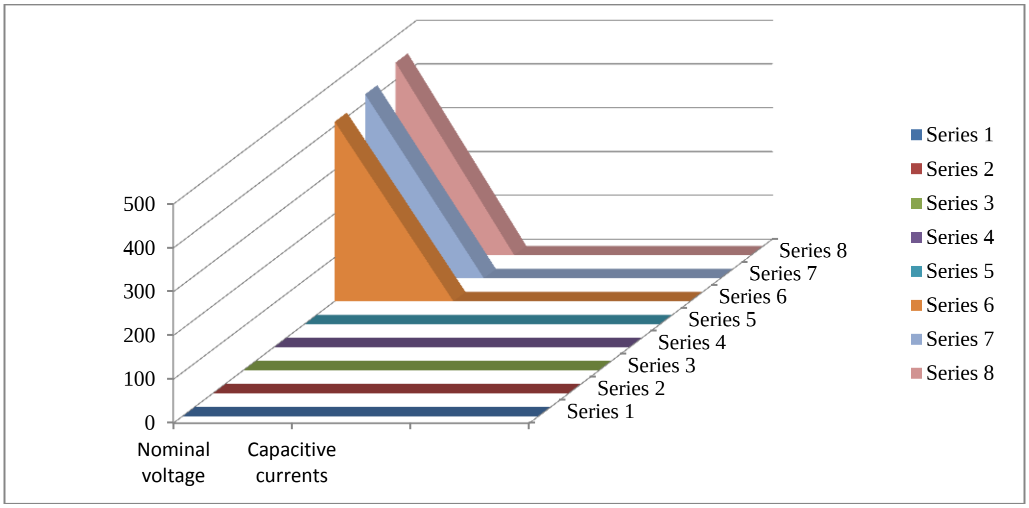

Figure 2. The variation graph of the capacitive current according to the supply voltage, for the electric cables with PVC.

3. CONCLUSIONS

From the variation graphs of the capacitive current according to the supply voltage , for electrical cables insulated with paper or PVC, we can draw the following conclusions:

1. Supply voltage variation directly affects capacitive current circulated through electrical cable lines .
2. The capacitive current value depends on the type of insulation (paper isolation , polyethylene , PVC) .
3. Capacitive current value circulated by electric cable lines is higher, as the cable section entering in the electric cables configuration is greater .
4. Capacitive current value is higher for PVC insulated electrical cables than paper insulated cables .

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