Aspects Concerning the Plastics Used in the Insulation of the Conductors and the Electrical Cables

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This paper is aimed to the identification of the plastics used in the insulation of the conductors and the electrical cables and depending on their characteristics , the influence exercised on power losses in the dielectric of the cables . Solid organic synthetic insulating materials that are used in electrotechnics , represents a sensitive group larger than natural materials . According to current statistics , it is clear that solid synthetic materials are implemented in a majority share in achieving equipment and electrical installations insulation being in the configuration of generation, transmission and distribution of electricity systems.

Keywords: plastic , polyvinylchloride , insulation, electrical cable , thermal stability

Plastics produced in the technological flow schemes of modernization and reconditioning, allow the obtaining of finished products relatively cheap and of benchmarks complex configuration that have superior insulating characteristics and satisfactory mechanical properties .

Plastics are two main configuration [1-3] : the binding material and addition .

The binding material is an active component that is intended to achieve the mechanical connection between the particles of plastics and at the same time causes its basic characteristics . By the connecting material it is meant any macromolecular organic combination .On the technological flow lines of the factories producing plastics, plastics frequently include only articles with macromolecular organic synthetic binding matters (combination) which is called polymer [1-3] .

All polymers obtained by polycondensation have very good insulating properties i.e.: the electrical resistivity (ρ = 109-1015) ;the intensity of electrical field (E_{str} = 12 to 30 MV / m) and relative permittivity (εr = 3.5 to 9.5) [1-3] . Although there are very good insulating properties this class of polymers have the disadvantage of important dielectric losses and only in the case of separate variants, the dielectric loss tangent of the angle (tgδ) is tenths of thousandths and presents interest to high-frequency technique .

The mechanical properties of the polymers obtained by polycondensation are good, some of them being hard and more brittle, and others - more elastic and flexible. With few exceptions they are characterized by small stability oils, water repellency and wettability [1-3] .

The thermal stability of the polymers obtained by the polycondensation is different and on average, it is more pronounced when compared with the thermal stability of the polymer obtained by polymerization . Some of these are thermoplastic and others can acquire the thermosetting condition. Taking into account the presence of thermosetting state and averaged more pronounced thermal stability at resulting polymers by polycondensation , it can be said that their importance for electrotechnics is higher than of polymers obtained by polymerization [1-3] .

The addition is the inactive component and has the characteristic that its particles are bound to the binding substance .Addition used typically leads to cheaper plastic because its value is relatively small . In the manufacture of plastics it is used as filler even the waste (wood chips, chalk, asbestos, paper, textile, etc.) resulting from other technological flow schemes [1-3] .

However the characteristics of plastic articles, are highly affected by the filler material used . Depending on the case , this influence can be positive or negative . Thus, for example, a filler can improve the mechanical characteristics and another to deteriorate more. The electrical characteristics are often worse.

In addition to the basic material ,plastics contain other additional materials . With their help some special purposes are reached, targeting technology and the finished product. These substances may also be pigments (dyes), and catalysts. A certain part of modern plastic products contain no additives [1-3].

From material connection is also established the name of plastics . The plastics classification may be made according to the nature of the bonding material and the configuration of the product . According to the character of the bonding material, plastics can divide into two categories : thermoplastics and thermosetting . After the configuration of the finished product made from plastics we have [1-3]: complex -shaped products (shaped products) and products with unchanging cross-section (plates, sheets , bars, pipes, etc.) .

In the technological flow of producing thermoplastic plastic articles,the pressed mixture is in the form of granules or powder . Also can be used row secondary materials of thermoplastic parts in broken state . Thermoplasticity allows the mixture to heat and to maintain soft or liquid state. The process itself is called spraying or extrusion, and the corresponding spraying devices or extrusion machines [1-3] .

The raw materials of polymers are obtained are various, but often it starts from a given blank , which is about the simplest chemical combination - monomer . After that , by means of appropriate technology, from single molecules of the monomer there were synthesized even polymers. They have large molecules and in some cases complex molecules, fixed to the chains (chains), which are repeated.The name given to the polymer is formed by adding to the name monomer the particle " poly" , such as polyethylene, polystyrene, polyvinylchloride , etc. [1-3] .

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From natural organic materials , only natural gums and cellulose have such a structure and are natural polymers . Natural resins are not polymers, but only complex chemical combinations. They can not always achieve a delimitation of the notion of complex chemical mix and synthetic polimer. Polimers sometimes are called “ synthetic resins“ because some external properties resemble those of natural resins. Unlike the natural ones, however , besides the amorphous phase very often include the crystalline phase highly developed , comprising sometimes 70 % or more of their structure [1-3] .

In principle any polymer can be obtained from the corresponding monomer by one of two basic chemical processes called polymerization and polycondensation . By polymerization, in the composition of the polymer remains the same percentage content of chemical elements, as well in the monomer, which is neither separated or join any additional chemical compounds [1-3] .

By polycondensation water and other some substances usualy are separated as secondary products. Depending on the processes by which it is produced, synthetic polymers can be separated into two groups: polycondensates and polymerized. Linear polymers and derivatives (and amorphous and crystalline) depending on the ambient temperature can pass in three physical states: glassy , highly elastic and plastic. These three states are the external expression of appropriate structural conditions. Figure 1 presents the so-called thermo-dependence , from which are best seen three states [1-3].

In the abscissa the temperature is given in Celsius degrees (°C), and on the ordinate the residual deformation, which is obtained after the release of the mechanical load, it is always one and the same. The residual deformation is measured after the time set, in which is achived relaxation (relaxation) structure. In figure 1 is highlighted the fully developed thermo- dependence for linear polymers and derivatives [1-3]. Glassy state corresponds to the low temperature of the coordinate system to θst temperature. Θst temperature is called the temperature of glass. In the glassy state the deformations are small in general, including remanent ones [1-3] .

In the temperature range from θ_{st} to θ_{spl} it is highlighed the high- elasticity, where are large elastic deformations , but plastic deformations (remanent) are very small. Temperature θ_s is called transition temperature in the plastic state . Plastic state starts at θ_{spl} and extends to high temperatures.In the plastic state are exercised residual deformations (plastics) high and ever increasing [1-3] .

As stated above, feature 1 covers both crystalline polymers and amorphous. It should be noted that their character is determined solely by the amorphous phase . However ,it has to be mentioned that frequently ,somewhere in the plastic state must be the melting temperature θ_t of the crystalline phase. If the polymer is completely crystalline ,the thermomechanical dependence does not have the required three states. All the polymers obtained by polymerization have good insulating qualities , among we can mention [1-3]: $\rho = 10^{10}–10^{16}\ \Omega m$ (from $10^{15}–10^{18}\ \Omega m$ at polytetrafluoroethylene) ;); $E_{str} = 25 \div 60$ MV/m and $\varepsilon_r = 2 \div 4{,}5$.

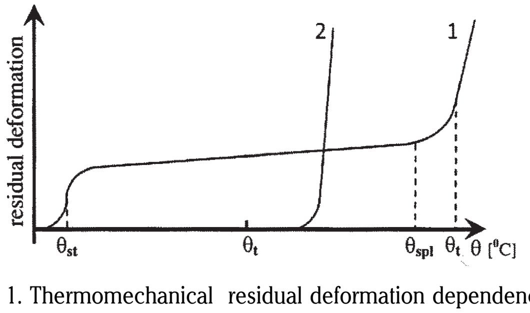

Fig. 1. Thermomechanical residual deformation dependence = f (θ) that highlights states: glassy, highly elastic, plastic and linear polymers and derivatives(and amorphous and crystalline) [1-3]

The largest category of cables used in the supply of electrical installations and electrical equipment have polyvinylchloride insulation . Polyvinylchloride is vinylchloride polymer $CH_2=CHCl$, with mixed structure , but with relatively low participation of crystalline phase (10-35) % [1-3]. Polyvinylchloride form almost opaque white solid elastic mass. Its electrical characteristics are good , except for dielectric losses , which in addition to being large , are strongly influenced by temperature. It has thermal stability of the Y class (90 ° C) [1-3]. At electrical arc contact, polyvinylchloride releases turbulent gas ,which is why it possess the known arc stability quality and extinction [1-3] .

Polyvinylchloride is suitable for low frequency isolation at low heating temperature .It exceeds the polyethylene after higher stability in aggressive environments . It is used mainly in the form of plastic known worldwide by the initials PVC [1-3] . Polyvinylchloride plastics can be coloured in a variety of colours.

Experimental part

Based on the foregoing in this paper it will be performed a calculation for determining the dielectric loss power of two cables whose conductors have different insulation (paper, PVC) . Insulation of the conductors that are entering in the configuration of electrical cables for electricity supply consists of one or more layers of insulating material. Insulation of electrical conductors and electrical cables default is essential to ensure their reliability and to prevent the occurrence of the fault and fault regimes. When choosing the type of insulation of the electric cables from the beginning of the design are taken into account the following factors: voltage, dielectric performance of the cable, temperature, reaction to fire and flame, the reliability of underground line, assembly technology, investment cost . To observe the influence of plastics that make up the electrical cable insulation on power loss we will start from the expression of these losses [4-9]:

$$Pel\,\Delta = \omega\ .\ C\ ..\ U2\ tg\ (\delta)\ [W] \qquad (1)$$

where:

- ω - frequency [rad / s]
- C - capacity [μ / km]
- U - rated supply voltage [V]
- tg (δ) - tangent of the angle of the loose ends together in dielectric power cable

Pulse value will result from the relationship [4-8]:

$$\omega = 2\,\pi\ ..\ f \qquad (2)$$

where f is the frequency Power System. Its value is 50Hz.

Substituting frequency value in (2) it will result that the pulsation is:

$$\omega = 314$$

Table 1 presents the characteristics of the most widely used types of electrical cables [4-9].

This paper performs study on two low voltage cables (U <1 kV) of paper insulation, PVC respectively, for different sections whose values are shown sequentially in table 2 [4-9].

It is known that in all equipment and electrical machinery (cables , transformers , motors, switchgear ,

Table 1

Nr. crt.	Type of power cable	Dielectric loss angle tangent tg(δ)	Intensity of electric field E [kV/m]	Grade of thermal stability	Relative permittivity
1.	Cables with paper insulation	0,03-0,04	20-30	Y (90°C)	4
2.	Cables with polyethyl-ene insulation	0,0002-0,0005	25-60	Y (90°C)	2-4,5
3.	Electric cables PVC insulated	0,0002-0,0005	25-60	Y (90°C)	2-4,5
4.	Rubber insulated electric cables	0,02-0,1	20-30	Y (80°C)	3-7

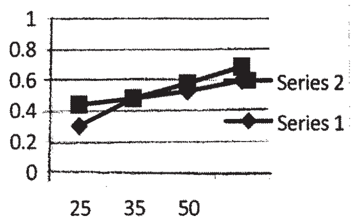

Fig.2. The graph of the power loss variation in the power cables depending on the nature and the on section of the insulation. related.

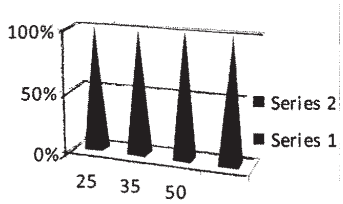

Fig. 3. Differences in percentage of power losses in electrical cables depending on the nature and the section of the insulation

Table 2

Nr. crt.	Type of power cable	Electric cable sections [mmp]	Rated supply voltage U [V]	Electric cable service capacity C [kV/km]
1.	Cables with paper insulation	25	400	0,2
2.	Cables with paper insulation	35	400	0,325
3.	Cables with paper insulation	50	400	0,35
4.	Cables with PVC insulation	25	400	0,43
5.	Cables with PVC insulation	35	400	0,484
6.	Cables with PVC insulation	50	400	0,581

Table 3

Nr. crt.	Type of power cable	Electric cable sections s [mmp]	Dielectric loss power of the two types of cables C [kV/km]
1.	Cables with paper insulation	25	0,3014
2.	Cables with paper insulation	35	0,4898
3.	Cables with paper insulation	50	0,5275
4.	Cables with PVC insulation	25	0,432
5.	Cables with PVC insulation	35	0,4863
6.	Cables with PVC insulation	50	0,5837

etc.) that establish electrical capabilities and that feature some type of dielectric (solid liquid gas) occurs power and elctricity losses [10-15]. The value of these power and electricity losses influences the energy efficiency of both equipment and electrical machinery and also transport systems and power distribution as a whole. The value of these losses is influenced by electrical parameters, and by the nature of the materials used in making insulating dielectrics [10-15]. In the operation of electrical transmission and distribution networks of electricity from source to consumer , an important role has the layout (positioning) of electric cables, regardless of the insulating material used to avoid fires caused by external causes [16].

Results and discussions

Taking into account the parameters summarized in table 2 for the three different sections of both types of cables, the aid of the expression (1) will lead to losses in the dielectric strength of the electrical cables which are given in table 3.

The values for the dielectric loss of power in the paper insulation, respectively PVC electrical cable sections 25, 35, and 50 mm$_{‸}$, are constructed to change the characteristics shown in figure 2.

Figure 3 presents the percentage differences between the dielectric power loss in two cables depending on insulation materials (paper, PVC).

Conclusions

Plastics produced in the flow schemes modernization and refurbished process, will produce finished products relatively cheap and benchmarks complex configuration that present superior insulating characteristics and satisfactory mechanical properties .

All polymers obtained by polycondensation have very good insulating properties of which can be mentioned: the electrical resistivity (ρ = 109-1015) ; the intensity of the electrical field (Estr=12 to 30 MV / m) and relative permittivity (εr = 3.5 to 9.5) [1-3] .

Although insulating properties are very good, this class of polymers have the disadvantage of dielectric losses and only in separate variants the dielectric loss tangent of the angle (tgδ) is tenths of thousandths and of interest to high-frequency technique .

Polyvinylchloride has good electrical characteristics , excluding losses in the dielectric, which in addition to being large, are strongly influenced by temperature. Polyvinyl-chloride is suitable for low frequency isolation at low temperature heating and has a higher thermal stability than the polyethylene in aggressive environments. It is used mainly in the form of plastic known worldwide by the initials PVC .

After calculations made to determine the dielectric power loss of two cables with different insulation (paper, PVC) it is observed that the amount of this loss increases at the same time with increasing of conductors section that are entering in the configuration of the section cables.

From the tables of values obtained by calculating the power losses and also from the graphs of the variation is found that the dielectric loss power cable with PVC insulation are greater than the losses in the dielectric power cable insulation paper .

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