DEPENDENCE OF ELECTRICAL STRENGTH OF PRESSED CRYSTALLINE POWDERS ON FILLING FACTOR AND DIELECTRIC CONSTANT OF CRYSTALS

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UDC 537.226:621.315.61-496

Experimental results of determination of the dependence of the electrical strength of several pressed crystalline powders, differing considerably in dielectric constant, on the filling factor are given. The obtained data are attributed to the distribution of the electric field within a two-phase dielectric.

Most of the dielectrics used in practice have an inhomogeneous structure. Examples of this are paper, ceramics, pressed powders, foam plastics, etc. Hence, the investigation of the breakdown of inhomogeneous dielectrics has attracted and continues to attract the interest of research workers [1-4]. Pressed crystalline powders are two-phase dielectrics: Part of the volume is made up of crystals of the substance, and the rest consists of air. It is of interest to find out how the electrical strength of pressed crystalline powders depends on the filling factor and dielectric constant of the crystals. This paper is devoted to the clarification of this question.

Figure 1 shows plots of the electrical strength of pressed powders of several dielectrics against the filling factor k, i.e., against the relative volume of the crystals in the pressed powder. The electrical strength was determined by the oscillographic method. A rectangular voltage pulse of duration 10^{-7} sec was applied to the electrodes. The substances selected for investigation were dielectrics which differ considerably in dielectric constant: PETN ($\varepsilon = 2.6$; curve 1), rock salt ($\varepsilon = 6$, curve 2), lead azide ($\varepsilon = 20$; curve 3), and barium titanate ($\varepsilon = 1200$; curve 4). The mean size of the crystals of the powders before pressing was the same (2-3 μ). The investigated substances included two explosive (lead azide and PETN) and two nonexplosive (rock salt and barium titanate) crystalline substances.

The graphs in Fig. 1 show that: a) the plots of electrical strength E against k for all the investigated substances have a minimum at the same value of k ($k \approx 0.35$ for crystals of the indicated size); b) the electrical strength of the pressed powder is less for a particular value of k, the greater the dielectric constant of the crystals of the substance; c) the relationship $E = f(k)$ for the explosive powders has the same form as that for inert dielectric powders; d) the electrical strength of the pressed powders is usually lower than the electrical strength of air at atmospheric pressure for the same values of interelectrode spacing and duration of voltage pulse. It is only at relatively large values of k that the electrical strength of the pressed powder becomes higher than that of air (at $k > 50\%$ for PETN, at $k > 75\%$ for lead azide).

It was shown experimentally in [5] for the case of pressed lead azide that breakdown occurs via the air phase. This result can be extended to other pressed powders. Since the dielectric constant of air is less than the dielectric constant of the crystals, the field in the air gaps is greater than in the crystals, since at the uncharged interface of two different media the normal component of the electrical induction is continuous [6]:

$$D_n = D_{n*}; \quad \varepsilon E_n = \varepsilon_* E_{n*}.$$

For a particular value of the mean electric field in the pressed powder (i.e., for a particular potential difference between the electrodes) the greater the dielectric constant of the crystals, the greater the field in

Moscow. Translated from Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, No. 2, pp. 159-161, March-April, 1975. Original article submitted April 25, 1974.

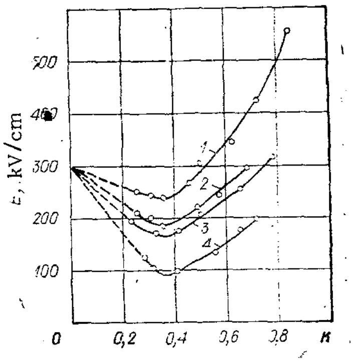

Fig. 1

the air gaps between the crystals. Since breakdown occurs via the air gaps (channels), the curves of E =*f* (k) are lower when the dielectric constant is greater, since the particular electric field in the air gaps required for breakdown is attained at a lower mean field (with a lower potential difference between the electrodes). With increase in the filling factor the field in the air gaps between the crystals increases [5], which leads to reduction of the electrical strength of pressed powders with increase in the filling factor (the parts of the relationships E =*f* (k) on the left of the minimum).

On the right-hand portions of the relationships E =*f* (k) the order of the materials as regards electrical strength is the same as on the left: The greater the dielectric constant of the powder crystals, the lower the electrical strength of the pressed powder. With increase in k, however, the electrical strength of the pressed powder increases. An explanation of this experimental fact was given in [5] on the basis of an examination of the conditions of development of the electron avalanche in the narrow air channels of the pressed crystalline powder. If the cross section of the air channel becomes smaller than the electron avalanche with increase in k, the development of the avalanche is hindered, since the electrons give up their kinetic energy to the walls (crystals). To cause breakdown in such conditions the field must be increased, which leads to an increase in electron velocity and reduction of the cross-sectional diameter of the elementary electron avalanche.

Thus, the electrical strength of pressed powders of dielectric materials subjected to brief applications of an electric field depends on the dielectric constant of the powder material and the filling factor (for particular crystal sizes).

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