خواص العزل للاطيان ذات المحتوى الالوميني العالي

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الخلاصة

تم دراسة الخواص الكهربائية للمنتجات عالية الالومينا وكذلك الخواص الاخرى ذات العلاقة كالمسامية والخواص الميكانيكية عند درجات حرارية (٢٠،٥٠،٧٠،٩٠) م ، ويستنتج من هذه الدراسة بأن ثابت العزل الكهربائي للمنتجات عالية الالومينا يتحسن بزيادة الالومينا في الاطيان النارية والتي تجعلها مناسبة الاستخدام لاغراض العزل . وكذلك تبين بان الاطيان النارية مقبولة للاستخدام كعوازل كهربائية وان هذا المنتج يحتاج الى مزيد من الدراسات لغرض جعله مناسبا للاغراض الصناعية الاخرى .

Dielectric Properties of High Alumina Fire Clay

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Abstract :

This work is concerned with the examination of the electrical properties of high ahumina content product as well as the other related properties such as porosity and mechanical properties at temperatures (٢٠, ٥٠, ٧٠, ٩٠) C. It can be concluded from this investigation that, the dielectric behavior of the high alumina product was improved with increasing the alumina content in the fire clay product which make sure to be used for dielectric purposes. Also this work showed that the fire clay end product is generally accepted as electrical insulator.
This product still needs further improvement if it is to be used for industrial purpose applications.

Introduction :

Like other types of inorganic insulations, high alumina tire product is characterized by excellent chemical and dielectric stabilizes over a wide range of operating temperature, under comperession load and severe ambient conditions. One cannot overlook the mechanical properties of insulators specially those used in high voltage where they are subjected to high mechanical stresses. The effects of firing temperature on bending strength of porcelains have been studied by (١). It was found that the bulk density of ceramic material was increased with increasing firing temperature (٢١). Also the mechanical properties were improved by decreasing the partial size (٣).

The alumina - silica phase relations of samples annealed in oxygen and quenched were studied by optical microscopy, image analysis, X-ray diffraction and the electron microphone.
The solid solution boundaries of sulfite changed with increasing temperature and joined at ١٨٩٠ C, and a composition of ٧٧,١ ٥ wt% alumina. The melting point of sulfite was ١٨٩٠ C with a percentage between ٧٦,٥ and ٧٧,٠wt.% alumina.(٤).
Aksay and Pask (٥), also studied the effect of cooling rate.
The precipitation of alumina was cooling - rate dependent.
Alumina -fused silica diffusion couples rapidly cooled formed sulfite and glass. And when slowly cooled formed alumina and glass.
The solubility constants and standard free energies of formation for various high alumina minerals and clay minerals were calculated from data on the concentrations of ions dissolved in aqueous solution from those minerals (٦).
The aim of this work was to verify that dielectric constant and other electric properties is affected by density (porosity) and testing factors including the effect of voltage frequency and temperature. The temperature effect is one of the most important characteristics of the dielectric constant value in ceramic insulators.

Experimental :

Sample Preparation

The raw materials selected for the present study were high alumina with ٩٥٪ purity from Ferak Co. Ltd. and Dwechla Kaolin Clay. It is subjected to a grinding process using a laboratory ball mill, till reached the required degree of finest.
The grinding Kaolin raw material was then screened by mean of sieves.
Many samples of high alumina fare clay (AL٢O٣ content >٧٠٪) were prepared. Mixing was carried out by means of a ball mill

for a period of ٣hrs. The mixture was then granulated

by adding (٦-٩٪) of a water and binder. Test specimens were formed by a dry pressing method, in which the granulated batch was fed to a die which was compressed by a hydraulic press to stain a specimen with dimensions of pressure of ٥٠٠ kg/cm٢ to obtain apecimen with dimensions of (٣٠mm) radius and (١٠mm) thickness. A١١ samples were of similar shape, except those used for compressive strength tests, which were cylinder of ٣cm height and ٣cm diameter. Apparent porosity of the testes samples was controlled by varying the firing temperature at which the samples were prepared. The specimens were then dried for ٢٤ hrs, at ١ ١٠ C in a laboratory- drying oven. After drying, they were fired in an electric furnace being heated to ١٢٠٠, ١٣٠٠, ١٤٠٠, ١٥٠٠ C at a rate ٢٠٠ C\h and soaked for ٢hr at a fixed temperature before furnace cooling. During the high temperature firing operation of ceramic bodies there are three major types of change. The water of crystallization removal and a re-arrangement in chemical structure occurs. These changes together with solid state chemical reaction between constituent members of the mixture produce the end product of industrial use (٧)

Property measurement :

Apparent porosity and apparent density of the fired samples were determined by the archimed's immersion technique , involving boiling the samples in water for ٢ hr , th. ey are determined by the following expressions (٨،٩)

$$ApparentPorosity = \frac{W_S - W_d}{W_S - W_i}$$

(1)

$$AppareDensity = \frac{W_d}{W_d - W_i}$$

(2)

where Ws represents the weight of the sample when it is saturated with water , Wd is the weight of the dry sample , and the Wi represents the weight of the sample when it is immersed and hanged in the water .

Compressive strength was measured by using a hydraulic press.Finally, dielectric constant, dielectric loss and conductivity of fired samples were measured by W'TW-type DK ٠٥ device for low frequencies (The measuring frequency range is from ٣٠ Hz to ١٠٠ KHz) after mounting the sample in the cell MFM٥T type. The dielectric constant can be calculated from the following equations

$$\varepsilon = \frac{Cd}{A\ \varepsilon_o} \quad (3)$$

where C represents the capacitance of the sample, Eo is the perceptivity of the air , d is the thickness of the sample and A represents the area. Also the resistivity p of the sample can be determined :

$$\rho = R\ \frac{A}{d} \quad (4)$$

where R represents the resistance of the sample .

Results and Discussion :

I-Firing effect on the dielectric constant of test specimens ; The effect of firing temperature on the dielectric constant of high alumina tire clay product is shown in Fig. (١). It can be seen that an increase in firing temperature resulted in an increase in dielectric constant. Also it can be noted that the highest value of dielectric constant was obtained at a firing temperature of ١ ٥٠٠ C which resulted in a reduction in percentage of porosity (١٠) .

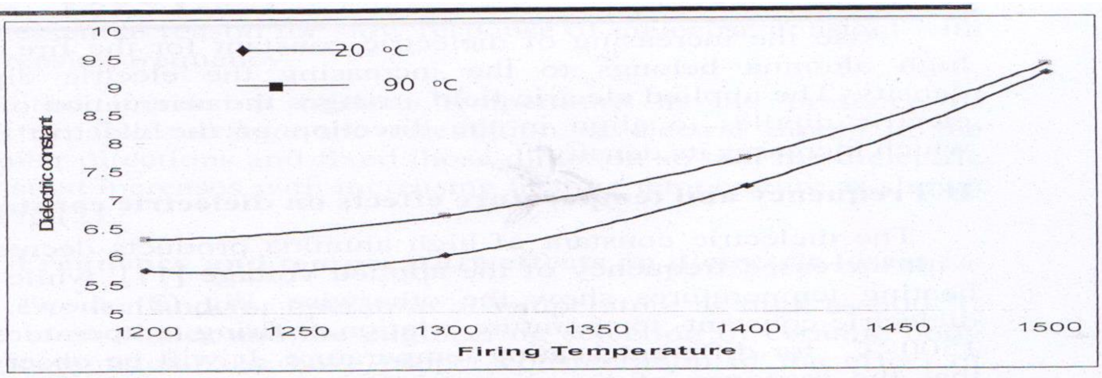

Fig.(1): The effect of firing temperature on the dielectric constant of high alumina fire clay product

The effect of firing temperature on the physical properties of fir clay product is shown in table (1) .

Table (1): show the effect of firing temperature on the physical properties of fire clay product

Firing Temp. (°C)	Apparent Density g/cm^3	Apparent Porosity %	Compressive Strength kg/cm^2
1200	2.6	22	240
1300	2.95	12	280
1400	3.35	6	330
1500	3.49	0	370

temperature, which leads to the nearing the particles and decreases the porosity. These factors improve the dielectric constant, which increases with increasing firing temperature .
Also the increasing of dielectric constant for the fire clay high alumina belongs to the increasing the electric dipole density the applied electric field arranges the orientation of the electric

dipoles to align in the direction of the electric field which increases its density .

ll-Frequency and temperature effects on dielectric constant: The dielectric constant of high alumina products decreases with increased frequency of the applied voltage (١ ١), while the heating temperatures show the otherwise. Fig (٢) shows the dielectric consent- temperature relation at firing temperature of l ٥٠٠ C for different heating temperature. It will be observed that the response of the dielectric constant to an increasing temperature is a slow at temperature above room temperature ٢٥ C (١٢) .

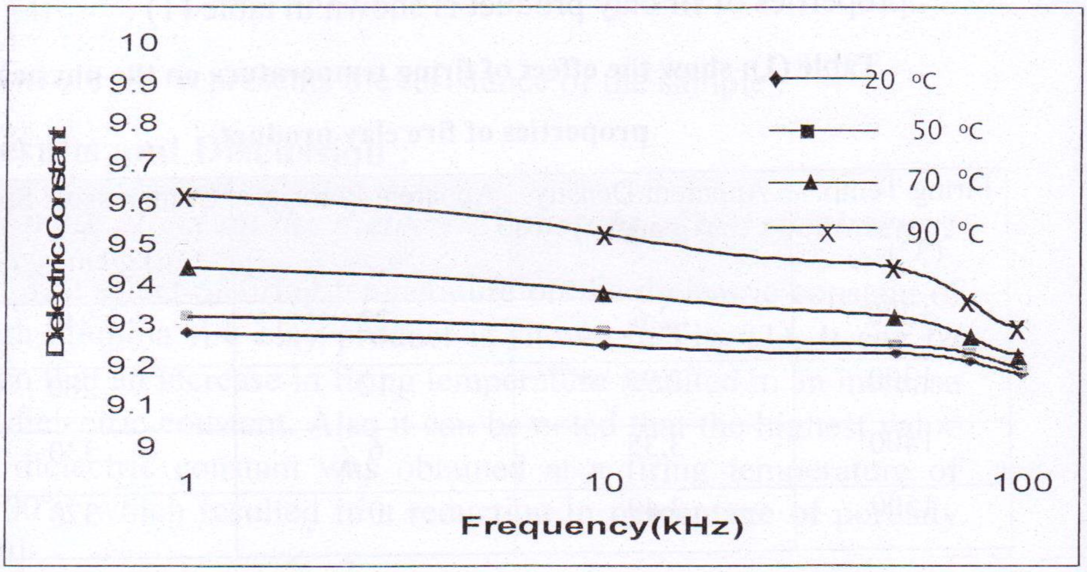

Fig.(2): The effect of frequency on the dielectric constant of high alumina fire clay product at firing temperature 1500 °C for different heating temperature.

The polarization of space charge takes place at low frequency and minimized at high frequency, which leads to the stabilization of dielectric constant at high frequencies. This is

the essential reason for slow response of dielectric constant with increasing frequency.

The increasing heating temperature in the presence of electric field arrange the orientation of electric dipole in the regular directions and fixed those direction so that the dielectric constant increases with increasing heating temperature as shown in Fig.(٢).

III-Frequency and temperature effects on dielectric losses :

The demand for operation at temperature as high as ٢٠٠ C and even higher and the engineering selection of ceramic body for commercial use have proper consideration of the effect of temperature on the dielectric loss value. The localized accumulation of heat under such conditions leads to the rapid destruction of the dielectric & mechanical properties of tire clay product structure. Fig٣ illustrates the effect of frequency on a high alumina product tested at temperature from ٢٠ C to ٩٠ C which exhibit a decrease in dielectric loss with increasing frequency from ١ KHz to ١٠٠ KHz and increase with increasing heating temperature from ٢٠ C to ٩٠ C .It is noted that there is a slow decrease in dielectric loss of the fire products with an increasing in frequency of the applied voltage Fig (٣). The presence of structural porosity leading to ionization and electrical discharge within the ceramic products will contribute to the dielectric loss.

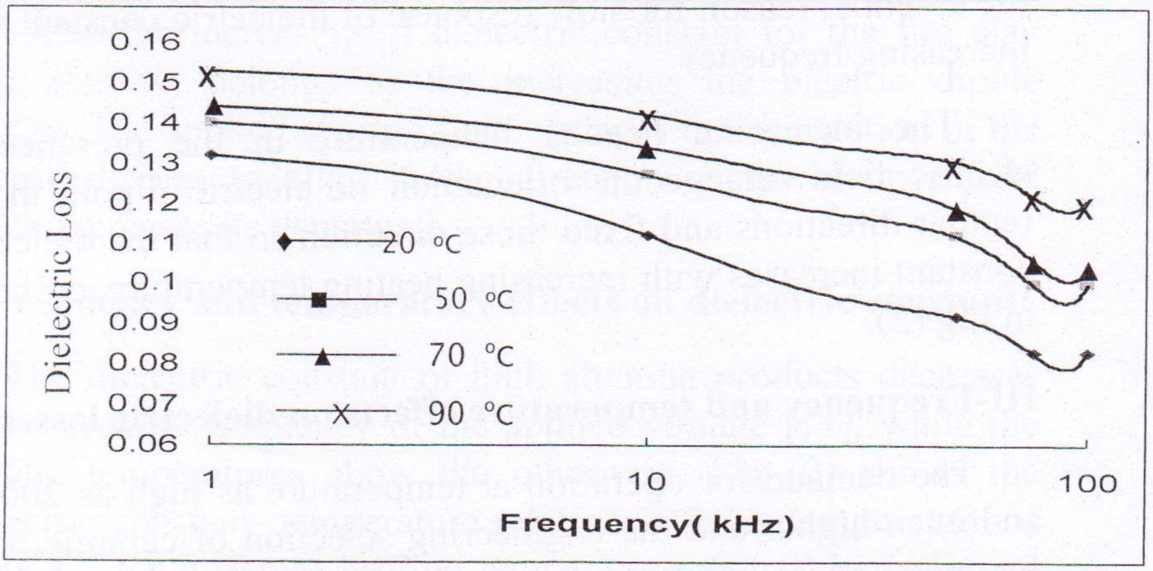

Fig.(3): The effect of frequency on the dielectric losses of a high lumina product fired at 1500 °C and tested at different temperature.

١V- Electrical Resistivity :

The resistivity- temperature relation in ceramic bodies is best illustrated by taking advantage of the linear relation exists when the resistivity is plotted as a function of the absolute temperature as shown in Fig. ٤. It can be seen that the resistivity of high alumina insulator decreases with increasing temperature (١٢،١٣|.

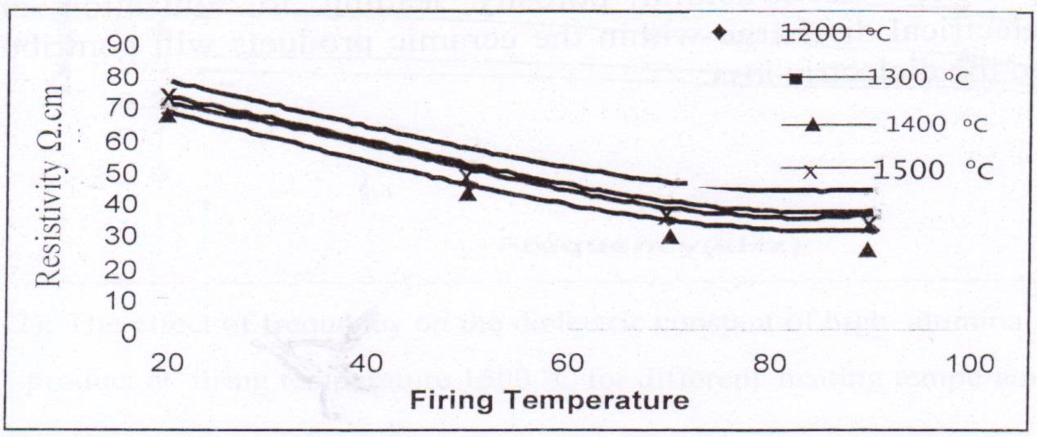

Fig.(4): The relation between the resistively & temperature for high alumina insulator

Mechanical Properties :

The compressive strength test was one of the mechanical test which was performed. It was found that the compressive strength increases with increasing temperature as in Fig.(٥). The strength of ceramic is affected by the residual stresses that are reducing by the increasing of tiring temperature. But the density of the high alumina product behaves opposite to that of the residual stresses. Those factors cause increasing of compressive strength with increasing firing temperature.

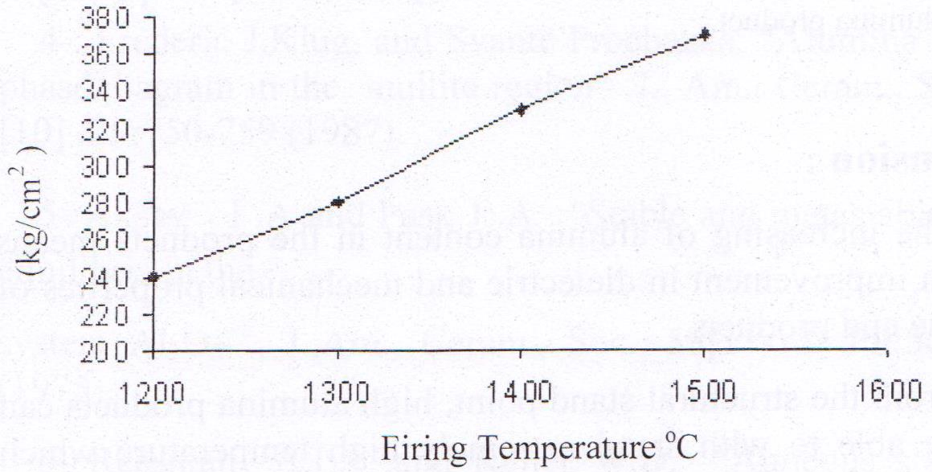

Fig.(5):The relation between the compressive strength and the firing temperature for a high alumina product.

Also the density increases with increasing temperature as in Fig.(٦), on the other hand the porosity decreases with increasing firing temperature which means that the density is inversely proportional with porosity .

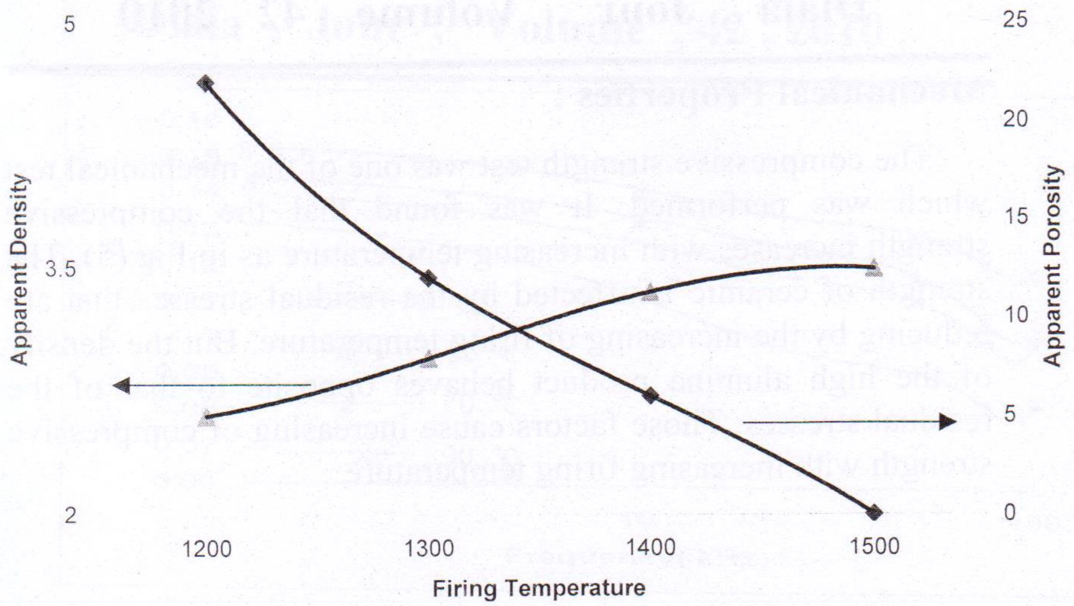

Fig.(6): The effect of temperature at the apparent density and porosity of a high alumina product.

Conclusion :

١ . The increasing of alumina content in the products means an improvement in dielectric and mechanical properties of the end products.

٢. From the structural stand point, high alumina products can be able to with stand extremely high temperature which extend its uses an electrical insulator.

٣. The presence of a porous structure leads to increased dielectric loss of the end product when they operated in humid atmosphere.

٤. According to their preparation and sintering condition there are acceptable values for dielectric parameter as compared with the characteristic of electrical insulators can be obtained.

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