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ANALYSIS OF CORRELATIONS BETWEEN THE INFLUENCE OF ELECTROSTATIC FIELD AND OF PRESSURE ON THE DIELECTRIC PERMITIVITY OF GRAIN

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A b s t r a c t. The paper presents description of a test stand to relations between electric permitivity of grain on pressure and intensity of electrostatic field. On the basis of measurements, it has been found that electric permitivity of grain decreases under the influence of pressure and increases as the electrostatic field intensity rises. Moreover, the test results allow for the conclusion that striction forces occurring in grain under the influence of electrostatic field, are tensile forces.

K e y w o r d s: energy savings, heterogeneous dielectrics, grain, striction forces, electric permitivity

INTRODUCTION

Electric properties of grain deserve attention for many reasons. They enable indirect determination of humidity because of high correlation between electric permitivity and humidity. Hence, it is possible to automatise humidity measurements and to optimise energy consumption. Electric premitivity and loss of grain are the main parameters that determine energy absorption in dielectric drying processes. Electric field causes changes in the overall dimensions of solid bodies. This phenomenon is known as electrostriction in the solid-state electrodynamics and physics. These changes, however, are very small and difficult to measure. This can lead to lower moisture retention in grain and thus reduce energy consumption in convective drying processes.

TEST STAND

Figure 1 presents a layout of a test stand that has been constructed to determine the influence of electrostatic field intensity and pressure on the electric permitivity of grain.

Biological origin of seeds makes them very varied in their physical and structural properties which makes repeatable results hardly available. Test procedures that were worked out ensure an accurate humidity determination. Selection of grain seeds carried out on the classifying screens and elimination of cracked seeds allowed the author to obtain repeatable results. This test stand enables indirect determination of the character of striction forces that occur in grain.

An electrostatic field is generated in the measuring chamber. The measuring chamber has been designed and constructed as a flat capacitor (Fig. 2). The tested dielectrics (grain seeds) are put into it. Mechanical stresses are generated in a pressure vessel (Fig. 3). Electric measurements were taken according to the procedures especially designed for this purpose. Electric permitivity is determined indirectly through the capacity measurements of an empty capacitor and a capacitor filled with tested seeds:

$$\varepsilon_r = \frac{C}{C_0}, \; C = \frac{\varepsilon_0 \varepsilon_r S}{d},$$

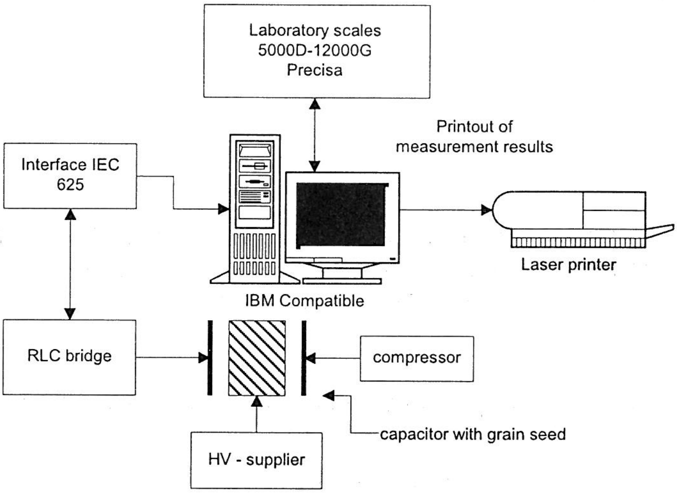


Fig. 1. Test stand.

where: C - capacity of the capacitor filled with seeds, F; C_0 - capacity of the empty capacitor, F; S - area of the capacitor plates, m^2; d - spacing between capacitor plates, m; ε_r - dielectric constant; ε_0 - permitivity of free space, F/m.

As the tested objects are small, the procedures are based on the mean grain mass.

ANALYSIS OF TEST RESULTS

Three species of grain were tested: barley, wheat and rye. The correlation function is used to determine relations between mechanical stresses and the stresses resulting from electrostatic field. Positive values of the correlation coefficient indicate that the increase/decrease under pressure is accompanied by the increase/decrease under the influence of electrostatic field. In the case when high permitivity increments under one of the inputs were accompanied by the decrements under other inputs, there was a negative correlation between them. When these values were strongly related to one another, the correlation coefficient values were close to ±1.

The character of changes in the electric permitivity under the influence of pressure appeared to be different from the changes under the influence of electrostatic field which was also confirmed by negative correlations. Under

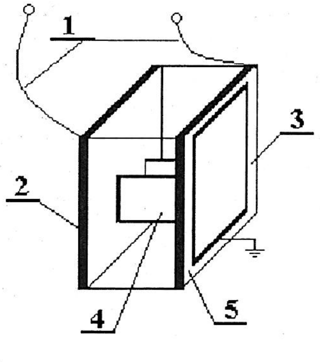


Fig. 2. Flat capacitor: 1 - capacitor leads, 2, 3 - capacitor plates, 4 - grain chamber, 5 - screen.

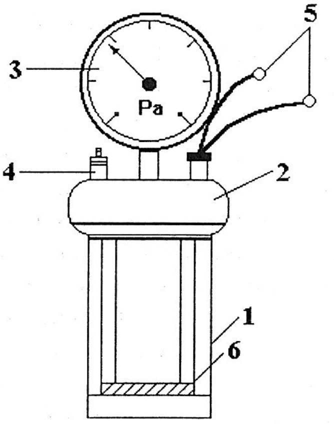
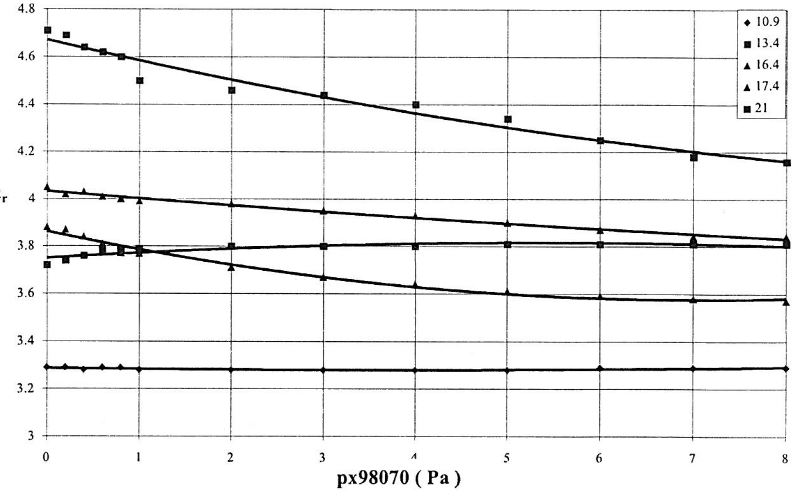


Fig. 3. Diagram of the pressure vessel and the measuring capacitor: 1 - steel cylinder, 2 - cover, 3 - manometer, 4 - valve, 5 -capacitor leads, 6 - measuring capacitor.

the influence of pressure electric permitivity of grain decreases but under the influence of electrostatic field - it increases. Substantial changes under the influence of the inputs mentioned above were particularly visible at the humidity level of $w_{\%}$>16% (Fig. 4a).

A strong positive correlation was found for barley and wheat at the humidity of $w_{\%}$>16.4% on the basis of computations that correlated electric permitivity changes under the influence of pressure with grain species (correlation coefficient close to 1 throughout the whole range of pressure levels). Moreover, a strong positive correlation was found for barley and wheat at the humidity level of $w_{\%}$>16.4% (correlation coefficient close to 1 throughout the whole range of pressure levels) and of 18.2 % (within the range < 0.35 > kVm^{-1}) on the basis of computations that correlated changes in the electric permitivity under the influence of electrostatic field with the species of grain (Fig. 4b).

a



b

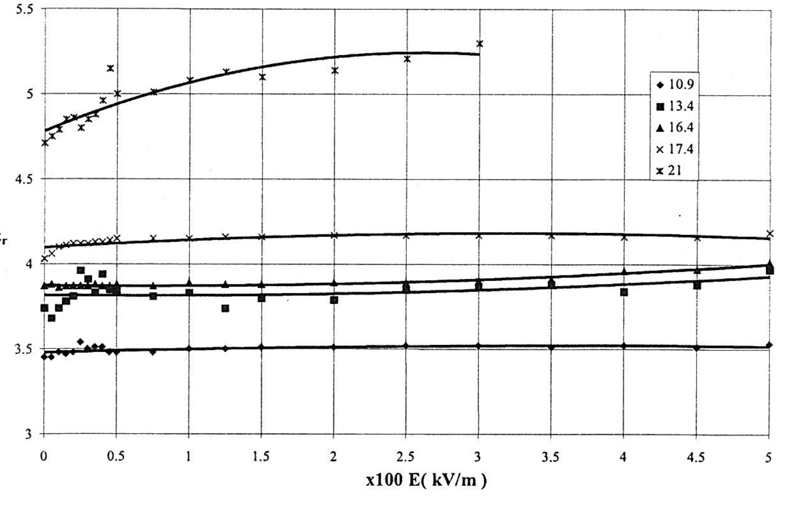


Fig. 4. Relation between wheat electric permitivity vs. pressure (a) and electrostatic field intensity (b).

Test results were statistically evaluated. T-Student distribution was used and confidence intervals and random errors were determined. The statistical analysis proved significance of the results obtained.

CONCLUSIONS

From the tests on electric permitivity in heterogeneous dielectrics vs. mechanical stresses

1. The value of electric permitivity value of dielectrics depends on mechanical stresses.
2. Changes in the permitivity depend on the humidity of dielectrics.
3. Permitivity of dielectrics decreases with an increasing pressure when compared to permitivity when there are no mechanical stresses (the more intensely the higher the humidity was before the test);
4. The following reduction in the electric permitivity was obtained:

$\Delta\varepsilon$ = - 8.6 % for barley at the humidity level of $w_{\%}$ = 16.4 %;

$\Delta\varepsilon$ = - 11.7 % for wheat at the humidity level of $w_{\%}$ = 21 %;

$\Delta\varepsilon$ = - 7.5 % for rye at the humidity level of $w_{\%}$ = 18.6 %.

From the tests of electric permitivity in heterogeneous dielectrics vs. electrostatic field intensity

1. The value of electric permitivity of dielectrics depends on the intensity of the electrostatic field.
2. The influence of electrostatic field is more intensive for the dielectrics with higher humidity levels ($w_{\%}$>16.4%).
3. When the intensity increases within the range 0 - 500 kV/m, permitivity of dielectrics increases, too:

$\Delta\varepsilon$ = 11.7 % for barley at the humidity level of $w_{\%}$ = 17.2 %;

$\Delta\varepsilon$ ` = 12.4 % for wheat at the humidity level of $w_{\%}$ = 21 %;

$\Delta\varepsilon$ = 9.3 % for rye at the humidity level of $w_{\%}$ = 13.4 %.

4. The conclusion is as follows: an electrostatic field causes tensile stresses. They result from the fact that the forces occurring in the system tend to increase electrostatic energy for voltage inputs. Since grain permitivity is higher than the permitivity of air, forces that act on a grain seed will cause its enlargement. This is true for the dielectrics that are not mixtures. Volume fractions of individual seed layers (especially - the layer of the largest volume fraction, i.e., a kernel, are decisive for the direction of changes in the volume of seeds (positive or negative).

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