COMPUTER MODELLING OF THE ELECTRIC FIELD ARISING IN A DEVICE FOR PRE-SOWING ELECTROMAGNETIC TREATMENT OF THE SEEDS OF CEREAL GRAINS

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Abstract: *With the help of the software product FEMM 4.2, computer model was built of the electric field of a screw device for pre-sowing electromagnetic treatment of seeds of cereal grains. Comparison was made of the results obtained from the computer models of the electric field with the results achieved by other authors through experiments. It was established that the electric field strength value was highest in the area just under the tip of the screw. The obtained results have allowed further studies to be carried out on optimization of the active electrode shape.*

Key words: *FEMM 4.2 software product, lines of force, electric field strength.*

1. INTRODUCTION

The analysis of the unconventional ways for increasing the yields of agricultural crops reveals the use of magnetic [7,8], electrical and electromagnetic fields [6].

In its nature, the planet Earth's field is electromagnetic. The animate and inanimate nature of the Earth exists in it. Therefore, for stimulating pre-sowing treatment of seeds the authors of the device [5] have used an electromagnetic field, but such with power frequency.

The device [5] for pre-sowing electromagnetic treatment of seeds of cereal grains (Fig. 1.) consists of a metal screw and shaft representing the active electrode, and a metal casing (with internal dielectric coating of Hostaphan) insulated from the screw and shaft – the inactive electrode.

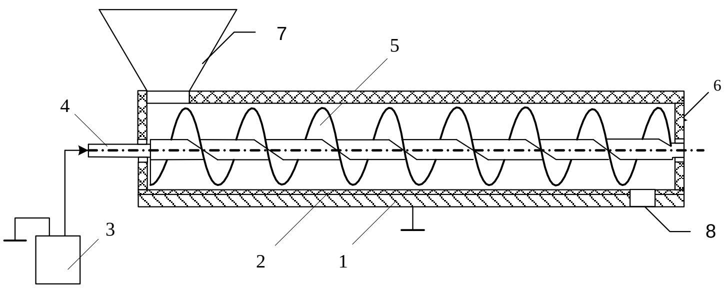

Fig. 1. Device for pre-sowing electromagnetic treatment of seed material: 1 – metal casing; 2 – dielectric coating; 3 – high voltage source; 4 – shaft; 5 – metal screw; 6 – insulation flanges; 7 – inlet opening; 8 – outlet opening

From Fig.1. it can be concluded that the medium between the electrodes mentioned above is non-uniform. The inter-electrode space of the device for pre-sowing electromagnetic treatment is filled with grain piles consisting of seeds with air in between, as well as air in the unoccupied, free from grain piles, space.

The above described, complex in design, electrodes, and the non-uniformity of the dielectric space between them make the task of analytical calculation of the electric field of the device extremely difficult and involving many assumptions. All this leads to inaccuracies that affect the quality of calculations of the field.

The author [4], taking into consideration the occurring inaccuracies in the analytical calculations of the field, has adopted the experimental approach of examining the electric field without introducing any assumptions. This experimental approach, however, is associated with the building up of a model in accurate scale of the complex device. The foregoing could be defined as a disadvantage. The model is placed in a water tub at low voltage – 16 V. This could also be considered a disadvantage.

There is also another approach to study the electric field, and that is to create a computer model of the electric field arising in the device.

Many other computer programs are known [1], which make the task feasible, but these are either very expensive or too complex to master. For this reason, the software product Finite Element Method Magnetics (FEMM) [10] was selected to create a computer model of the electric field arising in the device. As the name of the product suggests, first a network of finite elements is built, and then the space occupied by the field is broken down, with the help of straight and curved lines, to separate parts that have sufficiently small yet finite dimensions. These parts are known as *finite elements* [1].

The analysis reveals that the main advantage of the software product FEMM [10] is that with its help it is possible to build computer models of devices with actual dimensions, which fully resolves the issue of development of expensive and complex models.

The purpose of the study is to use the software product FEMM to create a computer model of the electric field arising in the device when there is no seed in its inter-electrode space.

2. METHODS AND MATERIALS

To achieve the purpose, the software product FEMM 4.2 is used. It is unlimitedly accessible on the Web. Once the actual geometrical dimensions of the device are drawn, for each element of the model (steel, air and Hostaphan) its absolute permittivity ε_r is taken into account. The product library [10] contains the permittivity values of steel and air. Since Hostaphan is not present in the library, its dielectric permittivity value is input manually, according to [9] it is $\varepsilon_r = 2$.

As stated in [6], voltage of value 1,6kV is supplied to the active electrode of the device, while the voltage supplied to the inactive electrode (the screw device metal casing) is set to 0kV. The described voltage value of 1,6kV is adopted on the basis of many years of research conducted on the efficiency of pre-sowing electromagnetic treatment of maize and wheat seeds.

3. RESULTS FROM RESEARCHING

Fig. 2a) and 2b) respectively represent the images obtained from the computer modelling and the experimental study [2] of the electric field of the device when full of seeds and when empty.

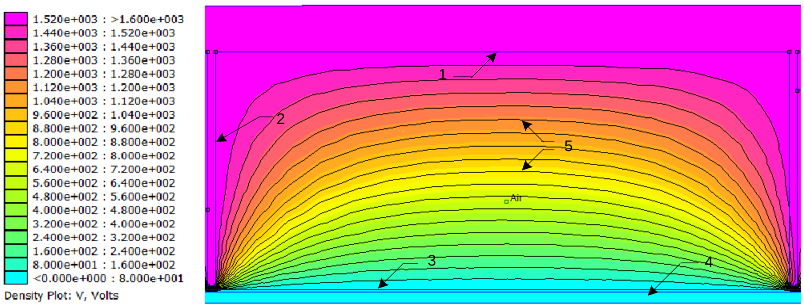

Fig.2a) Computer model of the equipotential lines of the electric field of the treatment device with no seeds in it:
1 – shaft; 2 – vertex of screw; 3 – Hostaphan; 4 – metal casing; 5 – equipotential lines

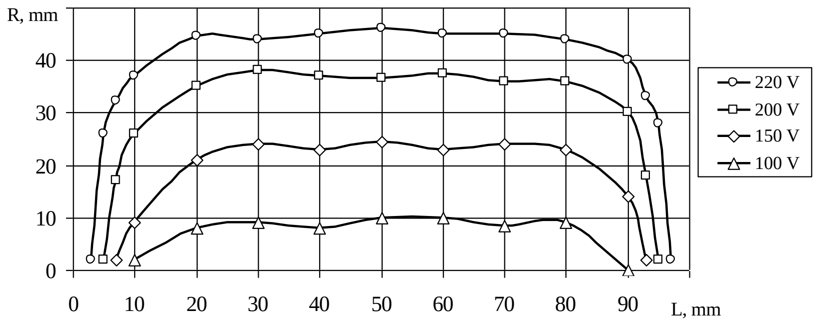

Fig. 2b) Results of the experimental study of the field [4] – equipotential lines
L – distance between two adjacent vertices of the screw; R – radius of the screw (distance from the screw shaft to the casing)

The analysis of the images shown in the two figures above reveals a substantial similarity between the theoretically and experimentally obtained equipotential lines of the field of the screw device, when it does not contain any seeds.

Furthermore, the analysis of the images in the two figures shows that in the air space, i.e. in the middle of the distance between two adjacent vertices of the screw, the equipotential lines are almost parallel to the shaft and its surrounding metal casing. The closer they get to the surface of the screw, the equipotential lines are distorted and tend to copy its form.

It is worth noting that in the experimental approach [2], the resulting equipotential lines between two adjacent vertices of the screw are not strictly parallel. This could be attributable to the distorting effect of the probe brought into the field, which the authors [3,4] use to take measurements, as well as to the resulting electric volume charges between the electrodes. The latter is a significant shortcoming of the experimental approach in comparison with the computer modelling of the field.

Another disadvantage reported by the authors of [2,4] is that during the experimental study of the field of the device it has been technically impossible (the distance between the tip of the screw and the Hostaphan coating is 0,5mm) to study the equipotential lines in the section where the vertex of the screw is closest to the casing.

After the model of the field is built and the scale is repeatedly increased, in the programming environment FEMM are successfully obtained the equipotential lines of the filed particularly in the area below the vertex of the screw. They are represented in

Fig.3

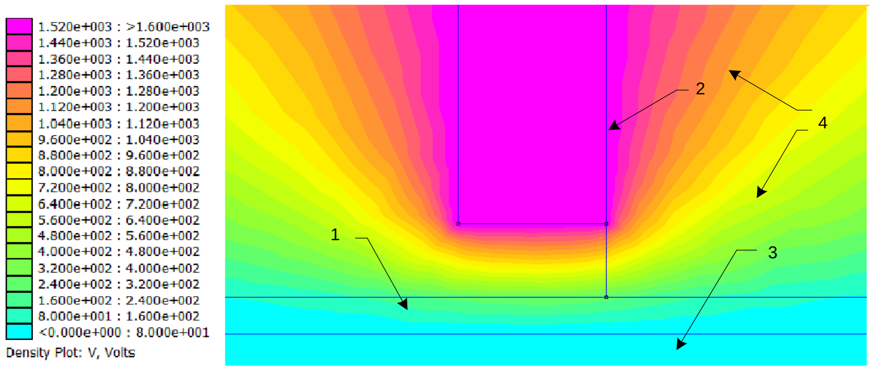

Fig. 3 Model of the equipotential lines of the electric field of the treatment device in the area below the vertex of the screw:
1 – Hostaphan; 2 – vertex of the screw; 3 – metal casing; 4 – equipotential lines

The authors of [2,3,4] raise the hypothesis, that the described proximity of the vertex of the screw gives reason to assert that the field strength is highest in this area.

With the help of the FEMM software program and the created computer model of the filed arising in the device when empty, the field strength values of the field in the space between the vertex of the screw and the casing are shown in Fig. 4.

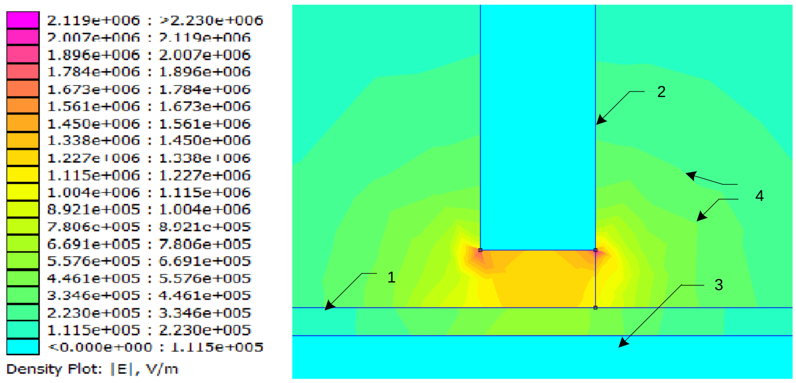

Fig.4 Model of the electric field strength in the area below the vertex of the thread: 1 – Hostaphan; 2 – vertex of screw; 3 – metal casing; 4 – equipotential lines

4. CONCLUSION

1. The development of computer models in the FEMM 4.2. programming environment allows the visualizaton of images of the electric fields of different devices in their actual size, without the need for complex models and analytical calculations.

2. A computer model is developed of the electric field of a device for pre-sowing electromagnetic treatment of seed material with its inter-electrode space empty. The built model correlates with the experimentally obtained by the authors of [2,3,4].

3. The proposed model makes it possible to visualize the equipotential lines in the area below the vertex of the screw. Based on that, the hypotheses raised by the authors [2,4,5] are confirmed.

4. Confirmation is received for the hypothesis raised by the authors [2,3,4] that the field strength is highest in the area below the vertex of the screw of the treatment device. Through computer modelling it is established that, with the set voltage value 1,6 kV, the field strength value reaches up to $2{,}23.10^{6}$ V/m

images of the field,

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