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

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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 filled with seeds. 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 intensity of the electric field in the space occupied by the seeds is different in different parts of this space and is bigger than that in the free space of the screw device. 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, seeds.*

1. INTRODUCTION

In [6], the results are shown of a study on the electric field arising in the device [4] for pre-sowing electromagnetic treatment of seeds of cereal grains. The pre-sowing electromagnetic treatment is performed in order to increase the yields.

The device [4] for pre-sowing electromagnetic treatment of seeds of cereal grains consists of a metal screw and shaft that represent an active electrode, and a metal casing (with internal dielectric coating of Hostaphan) insulated from the screw and shaft – an inactive electrode.

In [6] it is described that the medium between the electrodes of the device is non-uniform since the inter-electrode space of the pre-sowing electromagnetic treatment device is occupied by grain piles. They consist of seeds and air in between, as well as air in the free space, unoccupied by the grain piles.

After proper modelling is preformed, in [6] it is established that when the device [4] is not full of seeds, the electric field model correlates with the experimentally obtained images of the field by the authors of [1,3]. Furthermore, in the air space, 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 can be assumed that filling the device with a mixture of cereal grains in the form of grain piles will result in distortion of the electric field.

As well as in [6], the field is modelled using the Finite Element Method Magnetics (FEMM) [8]. The main advantage of this software product is that it helps create computer models of devices in their actual size, thereby fully resolving 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 with its inter-electrode space full of seeds (grain piles).

2.METHODS AND MATERIALS

To achieve the purpose, the device [4] "is filled" with grain piles located in front of each thread in the direction of movement of seeds. Once the actual geometrical dimensions of the device are drawn, for each element of the model (steel, air, seeds and Hostaphan) its absolute permittivity ε_{rc} is determined. Steel and air are included in the product library [8] with their permittivity values. Since seeds and Hostaphan are not present in the library, their dielectric permittivity values are input manually, considering that according to [1] for maize seed it is ε_{rc} = (6.4 ... 6.9), and according to [7] for Hostaphan it is ε_{rc} = 2.

According to [5,6], the voltage supplied to the active electrode of the device is 1,6kV, while the voltage supplied to the inactive electrode (the screw device metal casing) is set to 0kV. The specified voltage value of 1,6kV is adopted based on the fact that after many years of research it is proven to have contributed to the greatest extent for the efficiency of the pre-sowing electromagnetic treatment of maize and wheat seeds.

As specified in [1], the productivity of the electromagnetic treatment of seeds is determined not only by the applied voltage and the resting time of the seeds into the active zone of the chamber but also by the level of occupancy of the treatment device. In [2,4] it is reported that in order to allow seed sprouts to change their position relative to the equipotential lines and lines of force of the field it is necessary that the so-called "grain pile" is formed in the inter-electrode space and that it occupies about 30% of that space. The analysis of the location of an individual seed seen in X-ray images [2] shows that during the pre-sowing treatment it changes its position, and thus the position of the shoot, relative to the electric field. In this way an effective impact of the field is ensured upon the individual seed and its living part – the sprout.

3.RESULTS FROM RESEARCHING

Fig. 1a) shows the resulting image of the performed computer modelling, and 1b) – the image of the experimental study [3] of the electric field of the device when full of seeds forming a grain pile

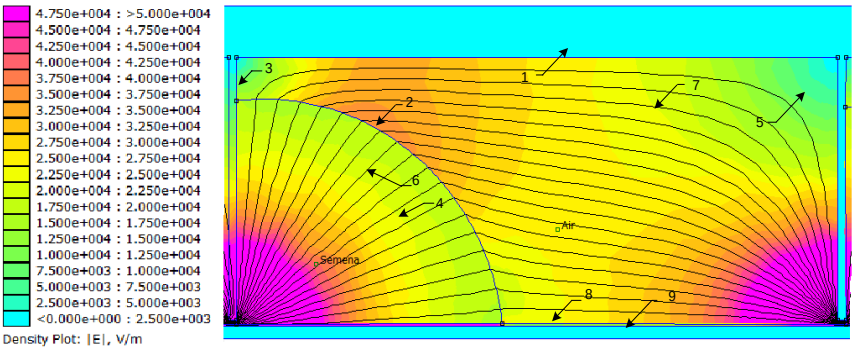

Fig. 1a) Computer model of the image of the field of the treatment device with seeds present (in the form of grain piles) in the inter-electrode space (the denotations 1 to 9 are explained under Fig. 1b).

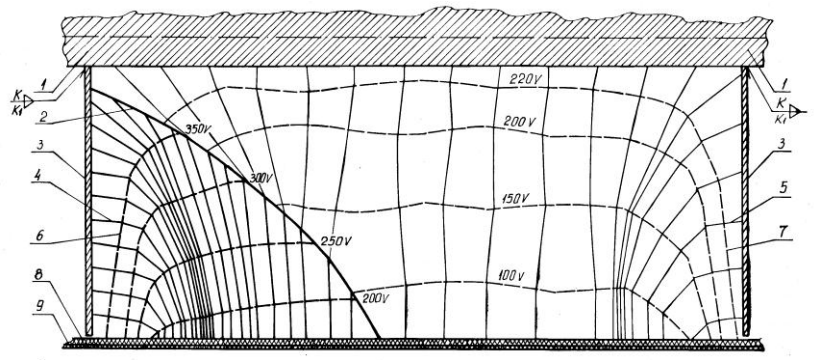

Fig. 1b) Experimentally obtained image of the electric field in the treatment device when full of seeds forming grain piles [3]:
1 – shaft; 2 – grain pile surface; 3 – screw; 4,6 – line of force and equipotential line in the grain pile; 5,7 – line of force and equipotential line in the air space; 8 – dielectric coating of the casing; 9 – metal casing

In the left part of Fig.1a) the colour backgrounds show the values of electric field strength for the different areas of the inter-electrode space. For instance, for the area surrounding the shaft (shown in blue) the field strength value is about 0 V/m, and for the area around the vertex of the screw (shown in pink) it reaches up to 50000 V/m.

The analysis of the two figures above reveals that the presence of seeds "distorts" the electric field, and its equipotential lines in the air space between two adjacent vertices of the screw are no longer parallel to the shaft of the device, as shown in [6].

Interesting is also the area around the surface of the grain pile, seen in a thick black line in Fig.1b, and as an idealized image in Fig. 1a, which represents a computer model of the field of the treatment device with seeds present in the inter-electrode space.

The obtained computer model (Fig. 1a) confirms the authors' assertions [1,2,3] that the concentration of lines of force in the grain pile is higher than in the remaining part of the inter-electrode space.

From Fig.1 and Fig.1b it can be concluded that in the area around the surface of the grain pile the equipotential lines are refracted. The latter could be explained with the boundary between the two dielectric media – seeds having air space in between, and air. The refraction of the equipotential lines is observed also in the area below the thread (Fig. 2).

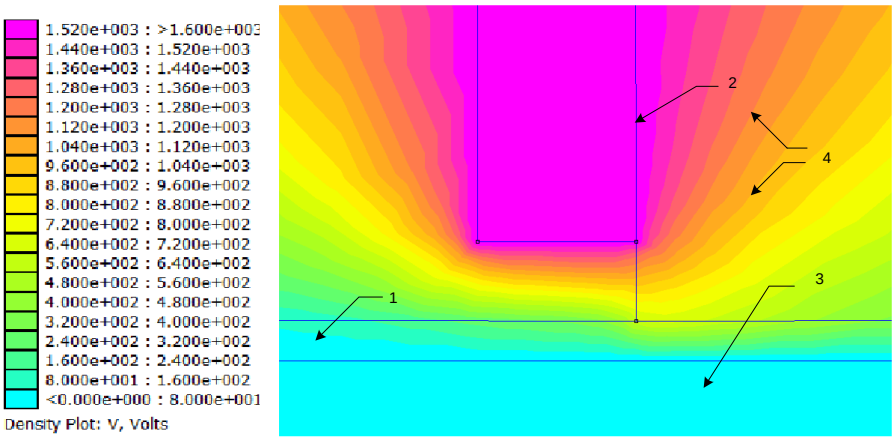

Fig. 2. Image of the electric field of the treatment device in the area below the thread, with seeds present in the device: 1 – Hostaphan; 2 – vertex of the screw; 3 – metal casing; 4 – equipotential lines

The analysis of the results in fig. 2 reveals that the equipotential lines pass under the vertex of the screw, i.e. this is where they are concentrated. From [4,5] it is known that in this exact area the grain pile is located. The latter is a prerequisite for a non-uniform treatment of the seeds. This observation suggests that ways should be sought to limit the size of this area or to optimize the screw.

5. CONCLUSION

1. A computer model is developed of the electric field of a device for pre-sowing electromagnetic treatment of seeds, when seeds are present in its inter-electrode space. The built model correlates with the experimentally obtained images of the field by the authors of [1,2,3] and proves that the presence of a grain-air mixture in the treatment device distorts the electric field.

2. The proposed computer 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 [1,2,3] are confirmed.

3. The obtained results reveal a possibility for further studies aimed at optimizing the active electrode – the screw of the treatment device.

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