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Optimization of the Design of a Chamber for Pre-Sowing Electric Treatment of Field Crop Seeds

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GOAL OF THE STUDY

By applying electric [1,2] and magnetic fields [3,4] for pre-sowing treatment of seeds of maize [5], wheat [6], triticale [7,8], sunflower [9], cotton, [10,11], rape [12], vegetable crops [13,14], etc., a positive effect on the sowing properties of the seeds was achieved.

The preliminary studies [15] carried out revealed certain shortcomings in the design of the working chamber used for pre-sowing electromagnetic treatment of field crop seeds [16,17].

For the optimization of the shape of the working chamber, modelling of the electric field of the metal screw-to-chamber casing electrode system was performed. The modelling was performed in the Finite Element Method Magnetics (FEMM) software environment [18]. Using the model of the electric field in the treatment chamber, the problem zones could be identified and thus technical solutions could be sought to mitigate the identified shortcomings in the chamber design.

The aim of the study was to optimize the design of the working chamber for pre-sowing electromagnetic treatment of field crop seeds.seeds.

METHODOLOGY OF THE INVESTIGATION

The design of the working chamber used for pre-sowing electromagnetic treatment of field crop seeds is shown in Fig.1 [15]. In this arrangement [19], the working chamber for seed treatment consisted of a metal screw and shaft representing the active electrode, and a metal casing. The metal casing was the inactive electrode (with an internal dielectric lining of Hostaphan), which was isolated from the screw and shaft.

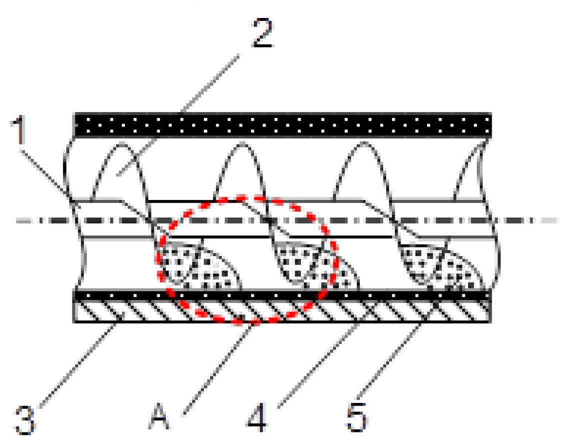

Fig.1. Device for pre-sowing electromagnetic treatment of seed material: 1 – shaft; 2 – metal screw; 3 – metal casing; 4 – dielectric coating; 5 – seed material

According to the specific features of the FEMM software [20], the optimization was done considering the elements of the electric field arising in the screw-to-shaft/casing inter-electrode system.

The analysis of the models obtained in [15] showed that the pattern of the field remained unchanged when different voltages were applied to the active electrode. Therefore, in order to optimize the working chamber, it would be sufficient to study the electric field models at a given voltage value.

According to [21,22], while modelling the field using the FEMM software, the active electrode of the device was set to a voltage value of 1.6kV and the inactive electrode (the casing of the screw device) to 0kV. The described voltage value of 1.6kV was adopted as a result of many years of research [6,16] on the effectiveness of pre-sowing electromagnetic treatment of maize, wheat and triticale seeds.

The values for the electric field voltage and strength in the inter-electrode space, which were obtained in the modelling process, are represented by different colours. To ensure proper reading of the values, a colour legend is shown at the side of each model with the values for the corresponding electric field parameter for each of the colours.

MAIN RESULTS FROM THE STUDY

The computer modelling [15] of the electric field occurring in the treatment device was analysed and the results showed that in the area around the screw the equipotential lines were not parallel to the shaft and converged below the screw tip. Therefore, the electric field in this area was less uniform compared to the rest of the inter-electrode space.

The above considerations led to the conclusion that in order to obtain a more uniform effect of the electric field on the seeds, ways had to be sought to reduce its non-uniformity in the area around the screw.

An analysis of the equipotential lines of the mathematically modelled electric field was performed when there were no seeds in the treatment device (Fig.2). It was found that three characteristic zones could be distinguished in the inter-electrode space of the device chamber. These zones, labelled ‘A’, ‘B’, and ‘C’ are presented in Fig. 2. The first zone (zone 'A') covered an area of 20x20 mm around the screw tip. Zone 'B' was also located around the screw but in the area where the screw is welded to the shaft, and had the same dimensions as zone 'A'. The third zone (zone "B") occupied the middle part of the inter-electrode space and had dimensions 50x40 mm. The dimensions of this zone were determined by the design of the treatment device and by the shapes of zones 'A' and 'B'.

The analysis of Fig.2. shows that the electric field in zone ‘C’ could be regarded as uniform i.e. the seeds located in this area were placed under identical conditions and could be expected to undergo uniform and efficient pre-sowing treatment.
However, the same couldn’t be argued for zones 'A' and 'B'. In these zones, the electric field was less uniform than in the rest of the inter-electrode space (zone 'C'). Therefore, the seeds treated in them were not placed under identical conditions and the impact on them would not be uniform and sufficiently effective. For this reason, zones 'A' and 'B' were defined as problem zones.
The fact that in zone ‘B’ the electric field was uniform at first sight, rendered the defining of this zone as a problem one pointless.
The analysis of equipotential lines in zone ‘B’ showed that the value of the applied voltage was highest there. The distance between the equipotential lines in this zone was larger in comparison with the rest of the inter-electrode space, and the electric field strength was very low. Hence, it could be concluded that the seeds falling in this zone would not be subjected to a sufficiently effective pre-sowing impact.
From the above considerations, the following conclusions could be drawn:
- For zone ‘A’, technical solutions should be sought such that the non-uniformity coefficient obtains values of . In this way, the electric field would be uniform and the seeds in it would be placed under identical conditions.
- For zone ‘B’ it was necessary to look for technical solutions to "converge" the equipotential lines. This would increase the electric field strength and the seeds in this area would experience an effective pre-sowing impact.

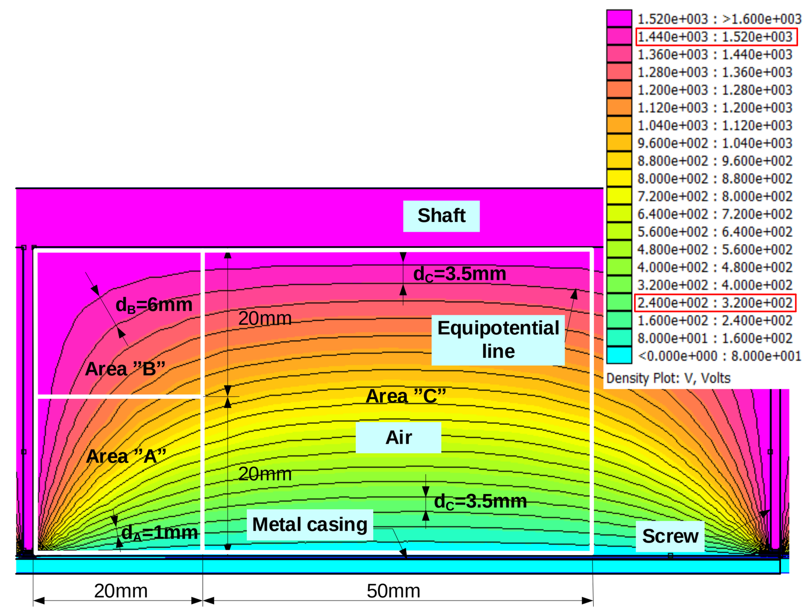

Fig.2. Computer model of the equipotential lines in the electric field and characteristic zones of the inter-electrode space in the treatment chamber

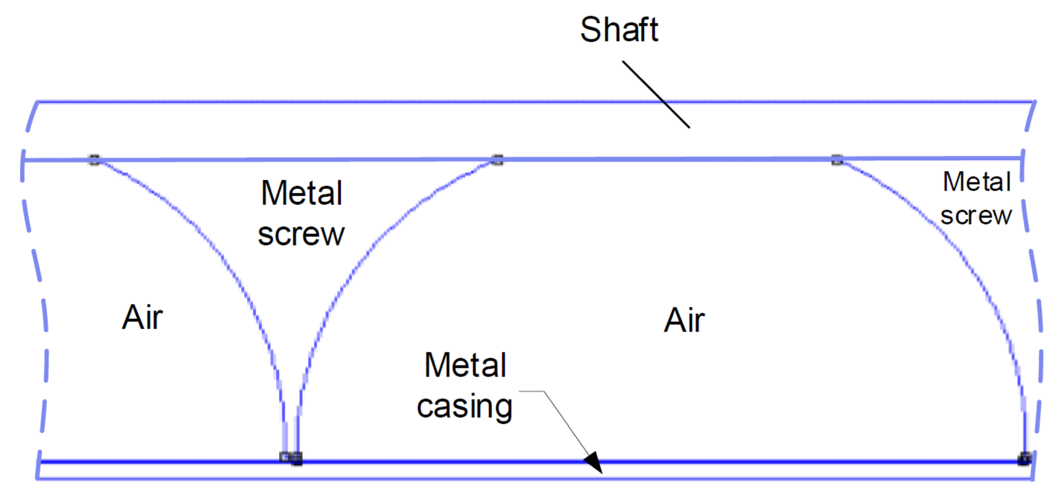

Fig.3. General view of the longitudinal section of the modified metal screw

Working chamber optimization

One possible technical solution for the problem zones ‘A’ and ‘B’ was to replace the existing metal screw with a modified metal screw whose longitudinal section shape followed the curves of the equipotential lines of the electric field arising in the device. A general view of the design of the working chamber with the modified screw is shown in Fig.3.
The electric field in the new working chamber with modified active electrode was modelled in the software environment (FEMM). Fig.4. shows the obtained image from the performed computer modelling of the electric field of the device when empty from seeds.

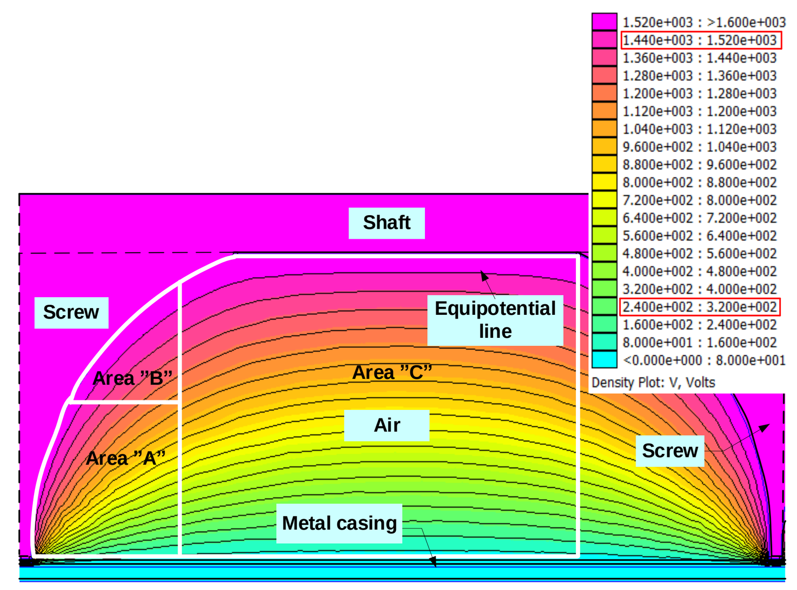

Fig.4. Characteristic zones of a device with a metal screw whose longitudinal section follows the curves of the equipotential lines

The analysis of the two figures (Fig.2 and Fig.4) reveals that, in comparison with the conventional metal screw, the electric field non-uniformities for the problem zones ‘A’ and "B" and the non-problem zone ‘C’ were largely commensurate in the modified screw chamber (Fig.4). Here again, zone "C" had the largest size and the again field was most uniform in this zone.

In contrast to the case with the conventional screw, the problem zones ‘A’ and ‘B’ were no longer square in shape and their area was considerably reduced. The electric field strength of zone ‘B’ had now changed (increased). Its electric field uniformity was similar to that of zone "C". Consequently, zone "B" was no longer a problem one. Only a small part of zone ‘A’ still expressed certain non-uniformity. This suggested that it was less likely that any of the treated seeds would not experience the proper effect of the electric field.

As a consequence of the electric field modelling, a technical solution was proposed to replace the existing screw with a modified metal screw whose longitudinal section copied the equipotential voltage lines, making the field in the working chamber much more uniform and thus increasing the efficiency of the pre-sowing treatment of seeds.

CONCLUSIONS

1. The computer model of the electric field, developed in the FEMM software environment, allowed optimization of the working chamber of the device for pre-sowing treatment of field crop seeds.

2. A technical solution was proposed to replace the existing screw with a modified metal screw. The shape of the longitudinal section of the modified screw followed the curves of the equipotential lines of the electric field arising in the working chamber of the device.

3. With the new type of screw, the problem zones ‘A’ and ‘B’ were no longer square in shape, with zone ‘B’ being nearly twice as small in size and with a much more uniform field. It can be, therefore, concluded that in a device with this type of screw (active electrode) the treated seeds will be subjected to an effective pre-sowing impact.