MULTIPHYSICS SIMULATION OF A HYBRID DRYER FOR CEREAL SEEDS

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INTRODUCTION

A multiphysics simulation of gas-solid flow in an electromagnetic field through an innovative hybrid dryer model was performed by coupling the Discrete Element Method (DEM) and Computational Fluid Dynamics (CFD) methods. In this simulation, the discrete particle phase (corn seeds) was modeled with DEM and the continuous gas phase (hot air) was modeled with CFD. The coupling of (EM) electromagnetic fields and heat transfer resulting from the CFD model was aimed at simulated the microwave heating of cereal seeds in the dryer. The hybrid dryer is equipped with three magnetrons at a power of 800 W each and a frequency of 2.45 GHz. The simulation results showed that at a pneumatic conveying velocity of the corn seeds, the residence time required for the seeds to be dried in the microwave dryer is obtained. The geometry of the hybrid dryer, with a reduced section at the discharge end of the dry seeds and an inclination of 5º to the longitudinal axis in the discharge direction, causes a circular movement of the seeds in the first half of the dryer, and then their deposition in the lower part of the second half. Through the action of the electromagnetic field in the dryer, the temperature in the seed layer is evenly distributed with a maximum value of 44°C after a period of 9-12 seconds. By losing moisture, the seeds become lighter, being carried around the upper seed layer and discharged from the dryer every 3-4 seconds when the corn seed feed rate is 500 kg/h.

MATERIAL AND METHODS

The hybrid cereal seed drying equipment is multiphysics simulated by coupling three different models such as CFD-DEM-EM. As a working principle, this equipment is based on the pneumatic transport of cereal seeds with hot air at 35-45°C inside the truncated cone dryer, where they are moved for a sufficiently long time so that the microwave energy heats and dries the seeds volumetrically. The geometric model of the multiphysics simulated equipment, figure 1.

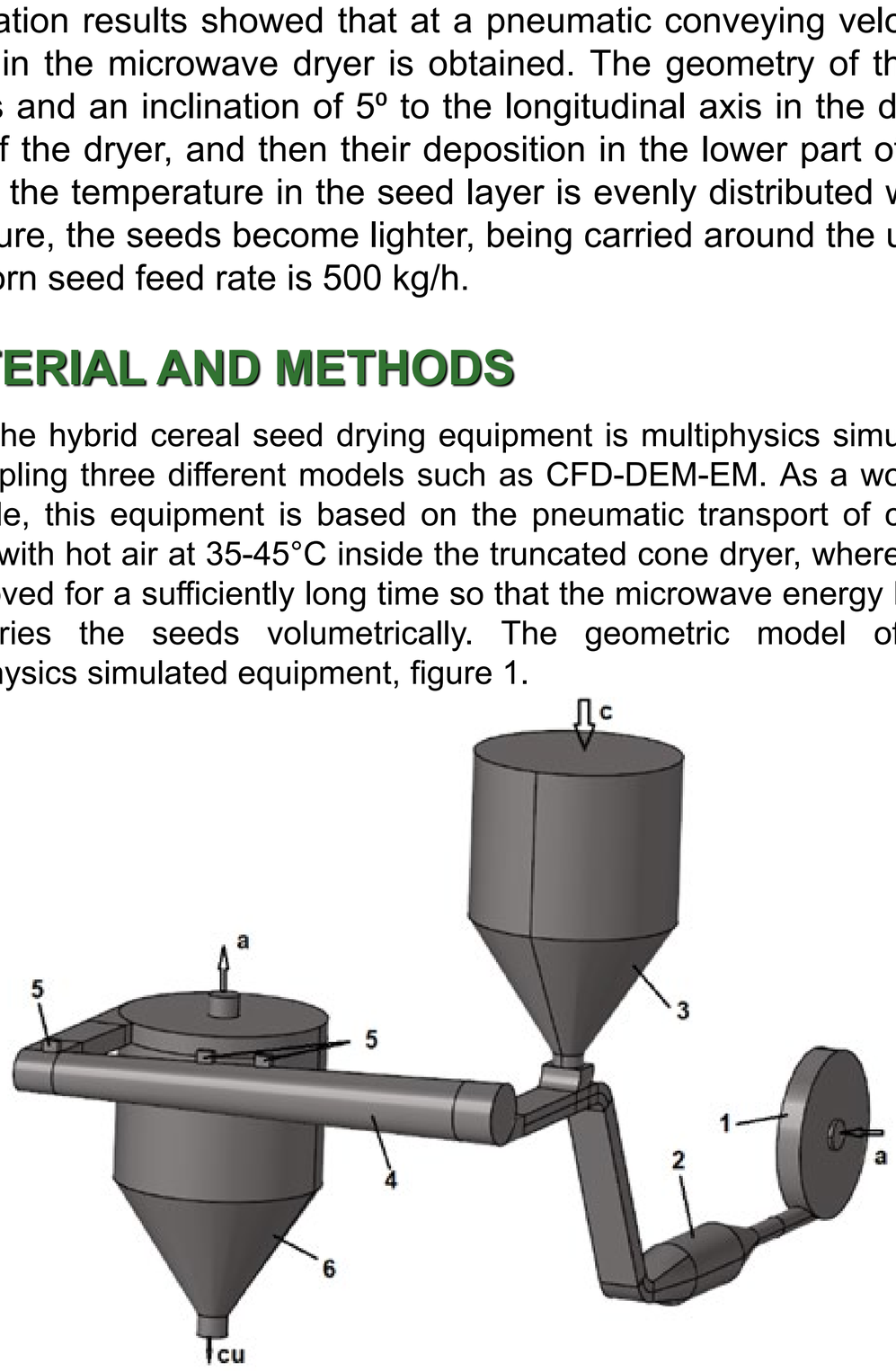

Figure 1. Hybrid dryer geometric model (1 fan; 2 electric heating element; 3 seed bin feed; 4 lock; 5 truncated cone dryer; 6 waveguides with antennas; 7 cyclone; a air; s wet seeds; ds dried seeds)

The circulation of the heterogeneous air-seed mixture required the coupled use of CFD-DEM models, and for the thermal effect of microwaves, the coupling later of the EM model was required, for the distribution of the electromagnetic field and its caloric effect on the seeds, figure 2.

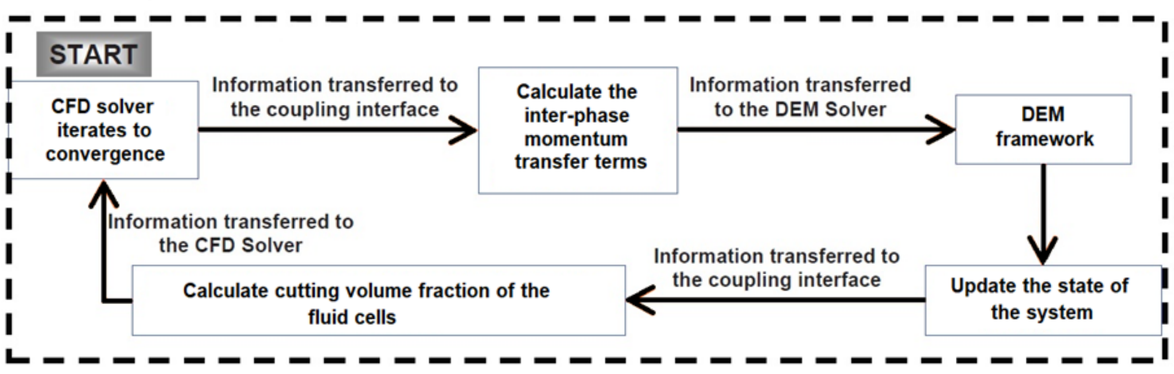

Figure 2. CFD-DEM coupling simulation

RESULTS AND DISCUSSIONS

Through the multiphysics simulation of the hybrid dryer, the circulation of the heterogeneous mixture hot air-seeds is obtained, represented by the path lines (figure 3), and the trajectories of the seeds in the dryer (figure 4).

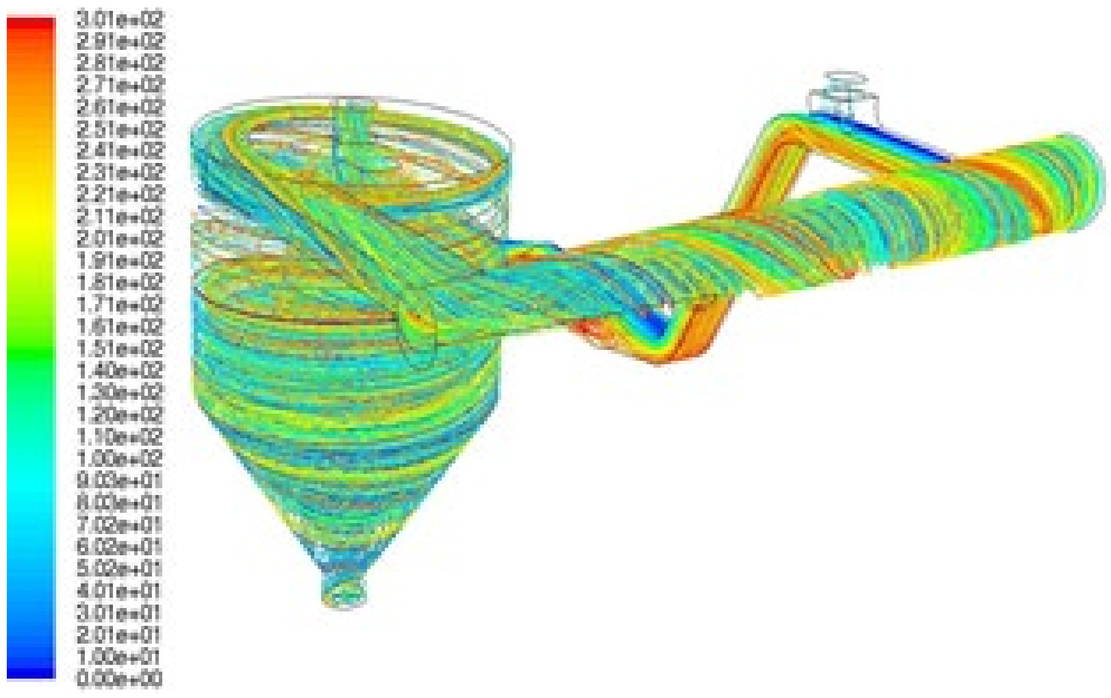

Figure 3. Pathlines for warm air in the hybrid dryer (-)

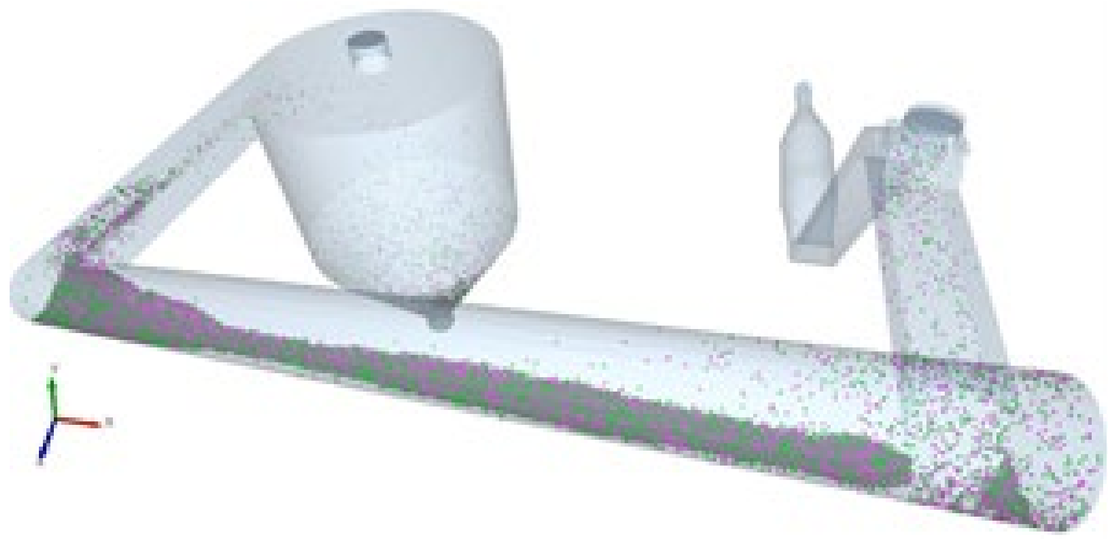

Figure 4. Distribution of corn seeds in the hybrid dryer

The circulation of the heterogeneous mixture of air and seeds inside the conical dryer is in a vortex form, and the seeds are deposited at the base of the dryer where the microwave antennas are located, so that their energy acts volumetrically heating and drying the seeds.

CONCLUSIONS

- The multiphysics simulation offers the possibility to use three different models in combination, so that the movement of warm air pathlines and the trajectory of the seeds can be predicted.

ACKNOWLEDGEMENT

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