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Groundnut seed flow analysis in a rotating seed coater with discrete element method

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Abstract

Coating of particulate solids by a thin film layer is of interest in many industrial applications such as seed and tablet coating. In seed processing, seeds are commonly coated with a protective coating layer consisting of fertilizers and disease control agents, such as pesticides and fungicides. Batch coaters are commonly used for this purpose. A typical coater consists of a horizontal axis cylindrical drum with a horizontal rotation and the coating material fed simultaneously after the seed. The seeds are driven around the drum in horizontal axis, and are mixed by three baffles; one on either side of the drum. In the present study, Distinct Element Method (DEM) simulations are used to model the seed coating process. Groundnut seed are used as a model material. The velocity of the seeds is predicted by the DEM, whereby the seeds are simulated as spheres inside a drum. It was observed that when the seed treatment drum was positioned at an angle of 45°, linear drum speed of 30 m/s the groundnut particles can attain a maximum velocity of 2.5 m/s.

Keywords: Seed coating, discrete element method, simulation, etc

Introduction

Seed quality is one of the most important factors determining successful crop establishment, productivity, and overall agricultural sustainability. The maintenance of high-quality seed depends on several environmental factors, including moisture content, temperature, relative humidity, and storage conditions. However, even under controlled storage conditions, seed quality may deteriorate due to seed-borne diseases, storage insects, and other pest infestations. Among the various approaches adopted for protecting seeds, chemical seed treatment has been recognized as one of the most economical and effective methods for improving seed quality and ensuring better crop performance. Since most seed treatment chemicals are toxic in nature, proper application methods and safety precautions are essential during treatment and subsequent handling of treated seeds.

Seed treatment is defined as the application of fungicides, insecticides, or combinations of chemicals to seeds to protect them from seed-borne and soil-borne pathogens and storage pests. It also includes various physical and biological approaches such as solar exposure and conditioning treatments. Treated seeds are subjected to specific processes intended to reduce, control, or repel disease-causing organisms, insects, and other pests that affect seed germination and early seedling growth. Pre-sowing seed treatments improve germination, enhance seedling vigour, prevent seed rot and seedling blight, protect seeds during storage, and provide resistance against soil and storage insects.

The movement of granular materials inside rotating equipment is difficult to characterize experimentally because of the complex interactions among particles and the continuous dynamic changes occurring during operation. Measurement of individual particle velocities and flow patterns inside a rotating seed treatment drum is particularly challenging. Therefore, numerical modelling approaches have become valuable tools for predicting particle behaviour and optimizing equipment design.

The Discrete Element Method (DEM) is one of the most widely used numerical techniques for analysing granular materials. DEM was initially developed by Cundall and Strack (1979) [3] for studying the behaviour of granular assemblies in rock mechanics and has subsequently been applied in various fields involving particle flow.

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Unlike continuum-based approaches, DEM considers particles as discrete elements and calculates particle interactions by solving Newton's laws of motion. The method incorporates particle size, shape, mass, rotational motion, and contact forces, making it suitable for investigating the dynamic behaviour of granular materials.

DEM has been successfully applied in different processing industries to evaluate mixing, segregation, and coating processes. In coating systems, controlling inter-particle coating variability is critical because variations in coating thickness or mass can influence the effectiveness of applied chemicals and nutrients. Studies on rotating coating devices have demonstrated the usefulness of DEM in predicting particle circulation, mixing behaviour, and coating uniformity. Pandey *et al.* investigated particle motion in a pan coating device using experimental observations and DEM simulations and reported that dynamic angle of repose was influenced by rotational speed and fill level. Li *et al.* used DEM combined with spray analysis to investigate the effect of particle size distribution on segregation and coating uniformity in an industrial paddle coater. Similarly, Sandadi *et al.* developed imaging techniques to evaluate circulation time, surface exposure time, and particle exposure during coating processes. Groundnut (*Arachis hypogaea* L.) is an important oilseed crop cultivated worldwide and is a major source of edible oil, protein, minerals, and vitamins. It contains approximately 48–50% oil and 26–28% protein and plays a significant role in agricultural economies, particularly in developing countries. India is one of the largest producers of groundnut, with major contributions from states such as Gujarat, Tamil Nadu, Andhra Pradesh, Karnataka, and Maharashtra. Due to its economic importance and nutritional value, maintaining high-quality groundnut seed through effective treatment and coating technologies is essential.

Although seed treatment drums are widely used commercially, limited information is available regarding the particle flow behaviour and velocity distribution of groundnut seeds inside rotating seed treatment equipment. The complex interactions between seed particles and drum components make experimental determination of flow characteristics difficult. Hence, numerical simulation using DEM provides an effective approach for analysing seed movement, optimizing drum design, and improving coating uniformity.

Therefore, the present study aims to calibrate the DEM parameters required for modelling groundnut seed behaviour and simulate particle movement inside a seed treatment drum to determine the velocity profile of groundnut particles. The specific objectives of the study are to calibrate DEM properties required for modelling groundnut, including physical and interaction properties and mixing behaviour. The study also about simulating particle movement inside a seed treatment drum and determine the velocity profile of groundnut particles.

Materials and Methods

Raw Materials

The ground seed for experiment was procured from Sangareddy, Medak. The seed was cleaned and stored in plastic containers for the use.

Size and shape

The size of the black pepper was measured with a dial type thickness gauge having accuracy of $\pm 0.01\text{mm}$. 100 seeds were randomly selected and measurements were taken at three different orientations.

Seed drum description: Seed treatment drum is made of angle iron frame and G. I. sheet made drum. Bearings provided with this implement make it easy to use. In one batch 10-15kg of seed can be treated with chemicals. The drum is provided with four number of G. I. sheet made fins placed all along the length at an angle of 90° from each other. This special arrangement of fins makes this seed treatment drum very efficient. The drum and frame of this equipment are strong and durable. Seed treatment drum is the liking of the farmers.

The seed treatment drum consists of frame, handle and cylindrical drum. The cylindrical drum is mounted on a tri-pod angle iron frame. Three piece of mild steel flat are welded inside the drum for helping in uniform mixing. Prior to start mixing of chemicals, workers are advised for wearing plastic hand gloves and mask on nose for health protection. After Adding chemicals in drum, add little water, close the lid of drum tightly and rotate the drum for 20 to 25 revolutions. After 1-2 minutes of completing the work, open the lid and take the treated seed in a separate bag/container. A batch of 20kg seeds takes about 5-6 minute for complete operation.



Fig 1: Model of the seed treatment drum simulated

Simulation Methodology: It is essential to know the accurate set of DEM parameters to model the bulk behavior of the material (Coetzee, 2016) [2]. DEM input parameters can be categorized as material properties and interaction properties. Size, shape, particle density, Young's modulus, shear modulus and Poisson's ratio constitute material properties, whereas, interaction properties include the coefficient of restitution, static friction, rolling friction between particle to particle contact and particle to surface contact respectively (Boac *et al.*, 2010) [1]. EDEM 2.4.1 Academic Version from DEM Solutions was used in this study. The DEM parameters for the work were found from Generic EDEM Material Model (GEMM) Database. The GEMM database contains thousands of material models representing a wide range of materials such as rocks, soils and ores. EDEM software is made of three core components: EDEM Creator, Simulator and Analyst.

Bulk density (ρ_b)

The bulk density was determined by filling a container of a known volume with a sample of the bulk material. The bulk mass, m , of the material was used together with the container volume, to calculate the bulk density,

$$\rho_b = m / V_b.$$

Angle of repose

The angle of repose was also used experimentally and numerically to see which method was more accurate in this case. The angle of repose or critical angle of repose, of a granular material is the steepest angle of descent or dip relative to the horizontal plane to which a material can be piled without slumping. At this angle, the material on the slope face is on the

verge of sliding. The angle of repose can range from 0° to 90°.

The angle of repose was measured by filling a bottomless tapered cylindrical container with material. The container had a lower diameter of 200mm and upper diameter of 220mm with a height of 500mm. The container was then slowly lifted vertically to allow the material to exit at the bottom and form a static pile. Angle of repose is the steepest angle at which a sloping surface formed of loose material is stable. The height of the pile is measured from base to top.

The equation for calculating the angle of repose is:

$$\text{Angle of repose} = \tan^{-1}(2h/d).$$

Where, h is height of the pile and d is diameter of the pile



Fig 2: Layout of EDEM creator in the software.

Results and Discussion: The results obtained from the various tests conducted during the experiments are as follows

Bulk density (ρ_b): The bulk density was calculated with a known volume of the container. The average of three replications is 648.06kg/m³.

Angle of Repose

The angle of the pile was measured at eight different positions and the experiment repeated four times. The angle of repose ranged between 26.1° and 25.2° with an average value of 25.4°.

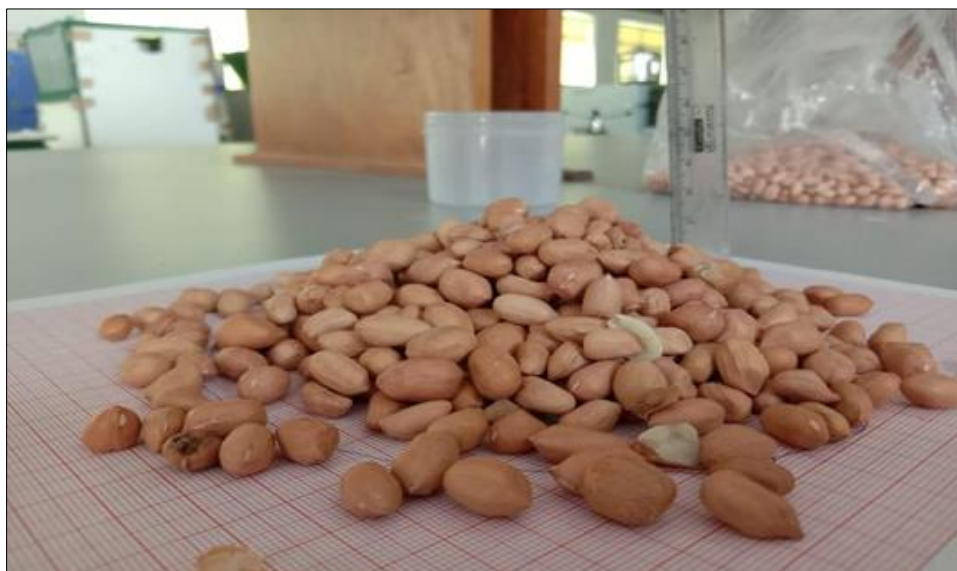


Fig 3: Angle of repose test of groundnuts.

Velocity of the groundnut particles simulated with DEM

The drum was given a rotational motion in the DEM and velocity profiles formed during the simulation was studied. The velocity of the simulated particles varied between 0.2 and 2.5 m/s. The results showed that initially the velocity increased constantly until 0.23 s and stabilized afterwards with minor fluctuations as shown in the Fig. 4.2. Average velocities at different time steps showed a steady increase with time. However, it should be observed that the average velocity of the particles is much lesser than the

maximum velocities which are in the order of 0.5 to 0.9 m/s only. It can be observed that, the minimum velocities of the particles are less than 0.25 m/s only. The range of minimum velocities indicate that during the simulation there are always some particles which might be having minimal movement. The simulations results showed an understanding of particles velocities in a rotating drum. The velocity profiles can be used as guide to set the rpm of the rotating drum.

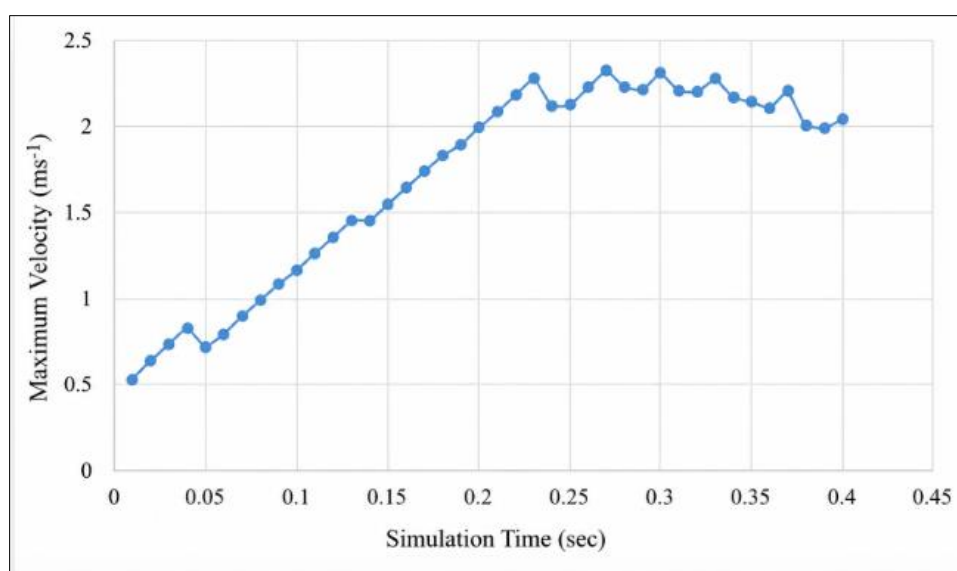


Fig 4: Variation of maximum velocity of the particles with simulation time

4. Summary and Conclusions: Seed treatment is an important process in the seed industry to improve seed germination and vigour. The performance of a seed treatment drum (seed coater) depends on its design and operating parameters, which must be optimized according to seed properties to avoid seed damage and ensure uniform coating. Conventional experimental methods have limitations in measuring important parameters such as particle velocity and impact forces inside the drum.

The Discrete Element Method (DEM) provides an effective numerical approach for analysing granular particle behaviour in

seed coaters. In DEM simulations, seed particles are represented by discrete elements, and their movement characteristics such as maximum, minimum, and average velocities can be predicted at different operating conditions. The study of groundnut seed movement using DEM showed that drum angle and rotational speed significantly influence particle velocity. At a drum inclination of 45° and a linear drum speed of 30 m s⁻¹, groundnut particles attained a maximum velocity of 2.5 m s⁻¹, demonstrating the usefulness of DEM in optimizing seed treatment drum performance.

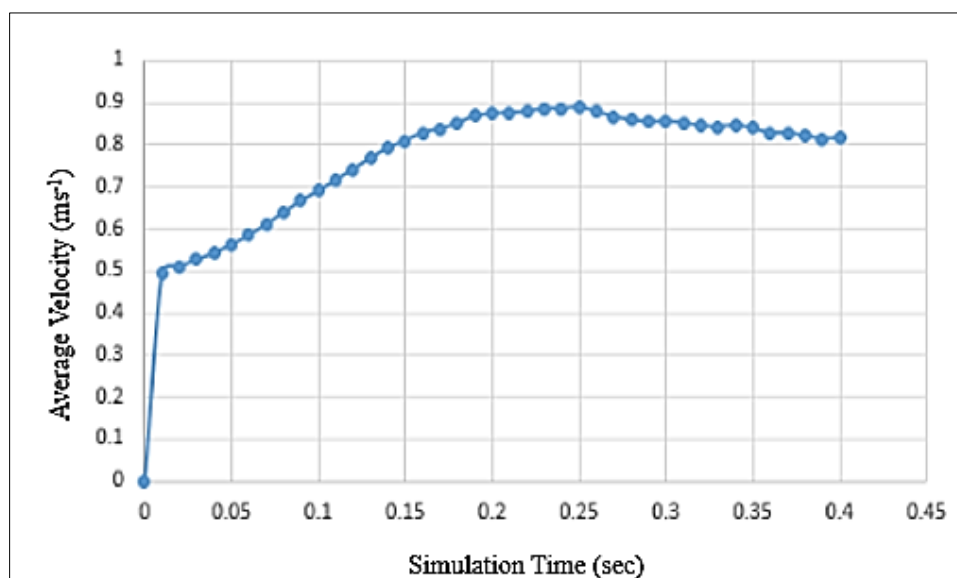


Fig 5: Variation of average velocity of the particles with simulation time

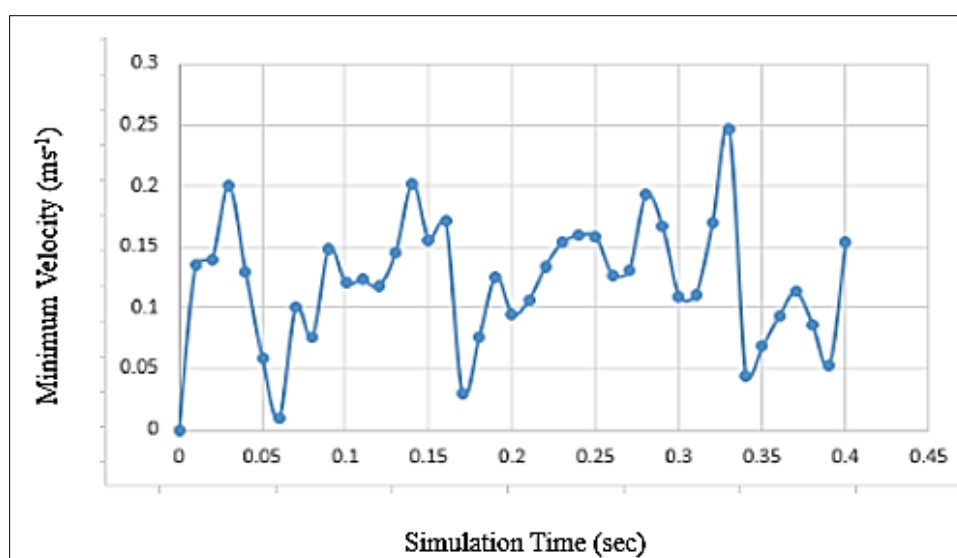


Fig 6: Variation of minimum velocity of the particles with simulation time

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References

1. Boac JM, Casada ME, Maghirang RG, Harner JP. Material and interaction properties of selected grains and oilseeds for discrete element method modelling. *Transactions of the ASABE*. 2010;53(4):1201-1216.
2. Coetzee CJ. Calibration of the discrete element method and the effect of particle shape. *Powder Technology*. 2016;297:50-70.
3. Cundall PA, Strack ODL. A discrete numerical model for granular assemblies. *Géotechnique*. 1979;29(1):47-65.
4. DEM Solutions Ltd. EDEM 2.4.1 Academic User Guide. Edinburgh (UK): DEM Solutions Ltd.; 2013.
5. EDEM Solutions. Generic EDEM Material Model (GEMM) Database. Edinburgh (UK): DEM Solutions Ltd.; 2016.
6. Li J, Webb C, Pandiella SS, Campbell GM. A numerical simulation of segregation and coating in a pan coating system using the discrete element method. *Chemical Engineering Science*. 2005;60(21):6002-6013.
7. Pandey R, Mujumdar AS, Mujumdar A. Discrete element modelling of particle motion in a rotating pan coating device. *Advanced Powder Technology*. 2012;23(4):520-529.
8. Sandadi S, Das M, Deen NG. Experimental and numerical investigation of particle mixing and coating behaviour in rotating drum systems. *Powder Technology*. 2016;301:1078-1089.