NC-213 Progress Report for 2025

Title

Discrete Element Modeling (DEM) of Grain-to-Screw Conveyor Interaction for Predicting Effects of Inclination Angle and Moisture Content on Mass Flow Rate and Power Requirement

Investigators

Tekeste, M.Z., Associate Professor, Agricultural & Biosystems Engineering
Kusi Fordjour, N.A.M., Graduate Research Assistant, Agricultural & Biosystems Engineering
Obeng-Akrofi, G., Post-Doctoral Research Associate, Agricultural & Biosystems Engineering
Maier, D.E., Professor, Agricultural & Biosystems Engineering
IOWA STATE UNIVERSITY

Outputs/Research Updates

Screw conveyors, also known as screw augers, are mechanical devices that utilize a rotating helical screw blade within a tube to transport bulk materials, such as grains, along the axis of rotation. The conveying of granular and particulate materials is an important process in agriculture and food processing. Screw conveyors are used to convey free-flowing materials, such as grains, oilseeds, and feed ingredients, as well as difficult-to-handle fibrous materials and powders. Screw conveyors are utilized in various applications, including grain harvesting, transportation, storage, filling, and discharging in storage and drying operations, as well as in processing lines, due to their low initial cost and versatility to convey different bulk materials. Considerable research involving performance studies and guidelines has been conducted on the design, analysis, and performance prediction of screw conveyors, focusing on the analytical and empirical methods for estimating conveying capacity, torque, and power requirements based on auger geometry, rotational speed, inclinational angle, and bulk material properties.

The applicability of these analytical and empirical models for screw auger conveying performance is often limited by simplifying assumptions regarding material behavior, such as uniform bulk properties and steady-state flow conditions. In agricultural grain handling systems, variations in grain moisture content, system design, such as varying inclination screw angles, and operating conditions influence particle interactions, flow behavior, conveying efficiency, and power consumption. These effects are not clearly represented in the empirical design equations, resulting in uncertainties in performance predictions under variable operating conditions. This research focuses on these limitations by applying the DEM technique to simulate the material-to-material and material-to-system interactions (grain-grain and grain–screw auger interactions) under varying moisture content levels and auger inclination angles. By calibrating and validating a DEM-based corn particle model and comparing simulation outputs with analytical predictions and experimental data, the study aims to enhance the understanding and prediction of screw conveyor performance, thereby eliminating the need for physical and costly practical tests to ensure the efficiency of screw performance. The outcomes of this research contribute toward enhancing the reliability of screw conveyor performance analysis and supporting more informed design and operational decision-making in grain and bulk materials handling systems.

Outcomes/Impacts/Deliverables and updates of studies initiated in 2025

During 2025, research focused primarily on evaluating existing studies on screw conveying systems, with an emphasis on developing DEM corn model conveying performance, design considerations, and the application of Discrete Element Method (DEM) technique in modeling grain-to-screw interactions. The primary research outcomes during this period included a comprehensive review of analytical and computational approaches used to quantify screw conveyor capacity and power requirements, as well as an assessment of prior DEM-based studies. A DEM simulation workflow for conveying corn through a commercial screw auger was developed using EDEM-ALTAIR software. Further work is in progress to identify corn and geometry interaction modeling boundary conditions, calibration and validation strategies, and performance metrics relevant to screw conveying systems. These evaluations aim to inform the development of a digital twin of screw conveying using a DEM simulation framework and provide virtual engineering support to quantify the effects of screw conveyor design variables, operating parameters and variation of grain moisture contens on screw conveying efficiency (volumetric flow and power requirement). Future work is in progress to apply Artificial Intelligence (AI) machine learning models to integrate them into the DEM and Computionaly Fluid Dynamics (CFD)-DEM coupling methodology for optimizing mechanical and pnuematic bulk material handling systems.

Publications

Oral/Poster Presentations (Kusi Fordjour):

- Discrete Element Modeling (DEM) of Grain-to-Screw Conveyor Interaction. ABE 6010 Graduate Seminar—Three-Minute Graduate Research Oral Presentation, December 8, 2025. Iowa State University, Ames, IA.

Funding Source:

Funds were provided by the Iowa Agriculture and Home Economics Experiment Station, Iowa State University Kent Feed Mill & Grain Science Complex, and Department of Agricultural and Biosystems Engineering Soil Machine Dynamics Laboratory (SMDL), Ames, Iowa.