THE UNIVERSITY OF NEWCASTLE AUSTRALIA

TUNRA BULK SOLIDS

DEM Analysis on Hopper Wall Loads during Eccentric Discharge

Project Scope

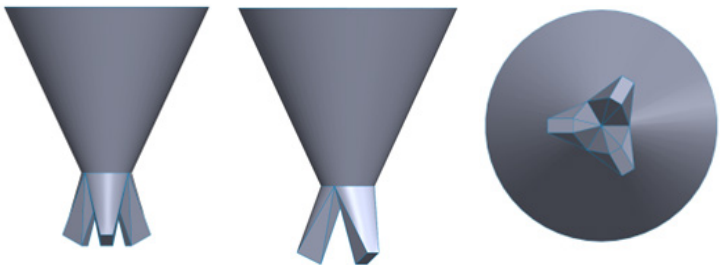
Problem: Understanding how wall loads are affected by eccentric discharge in bin and hopper design.

Equipment: Hoppers

Aim: To investigate the nature of flow and hopper wall loads induced by eccentric discharge in bin and hopper design when using DEM to predict flow patterns and pressure distributions around the circumferential direction of the hopper during discharge.

Understanding how wall loads are affected by eccentric discharge is an important aspect of bin and hopper design. Eccentric loads on vertical walls in the cylindrical section can be estimated in a straightforward manner using Australian standard AS3774 (1996) and Eurocode EN 1991-4 (2006). However, the determination of the eccentric loads on a hopper can be much more complicated due to the non-vertical walls.

In this project, Discrete Element Method (DEM) simulations were employed to forecast pressure distributions along the circumferential direction of a hopper during material discharge from a three-legged hopper configuration, as shown in Figure 1.



(a) Side View 1 (b) Side View 2 (c) Plan View

Figure 1: Configuration of the Simulated Hopper

Single Leg Chute in Operation

Wall loads were investigated during material discharge from a single leg chute, with DEM simulations conducted. The discharge occurred through an offset flow channel, resulting in stationary material on the opposite side of the hopper walls, away from the operational chute.

Near the hopper bottom, higher normal forces were observed on the far side compared to the near side. This phenomenon was reminiscent of findings in cylindrical sections and aligned with the asymmetric material flow patterns induced by eccentric discharge, affecting the structural integrity of the hopper. The normal loads on the upper section were relatively uniform, indicating diminished influence from eccentric discharge at the hopper's upper periphery.

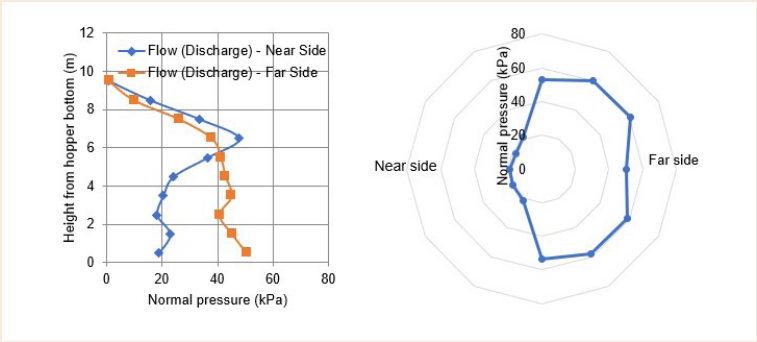


Figure 2: Numerical Results for Normal Pressure during Eccentric Discharge (Left) and Pressure Distribution around Hopper Periphery at Hopper Bottom (Right) - One Leg Chute Discharging

Dual Leg Chute in Operation

Material discharge involved two leg chutes in the hopper, featuring a larger flow channel area than the single-leg chute scenario. Similar trends to the single-leg chute case were observed, with higher loads on the far side near the hopper bottom. The eccentric discharge effect was again evident, impacting normal pressure distributions around the hopper's periphery. Notably, the extended flow channel in this configuration reduced pressure over a larger circumferential range, owing to the doubled flow channel area resulting from dual-leg discharge.

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These DEM-based findings highlight the non-uniformity and eccentricity in wall load distributions during eccentric discharge scenarios in hoppers, particularly near the hopper bottom. These variations emphasize the necessity of accounting for eccentric discharge-induced stress non-uniformities when designing hoppers. These insights contribute to an enhanced understanding of eccentric load behaviour in hoppers, supporting improved hopper design practices.

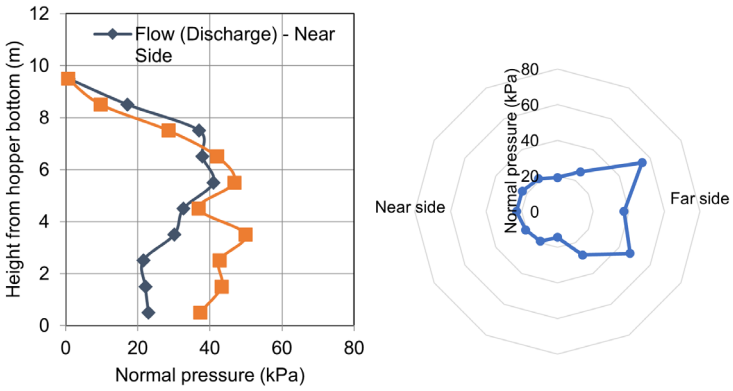

Figure 3: Numerical Results for Normal Pressure during Eccentric Discharge (Left) and Pressure Distribution around Hopper Periphery at Hopper Bottom (Right) - Two Leg Chutes Discharging

References

Bin Chen, Alan W. Roberts, T.J.Donohue, Brendan Beh, TUNRA Bulk Solids, The University of Newcastle, Australia , Jie Guo, Center for Bulk Solids and Particulate Technologies, DEM Analysis on Hopper Wall Loads during Eccentric Discharge, CHoPS 2018.

DEM Analysis on Hopper Wall Loads during Eccentric Discharge, ABHR, 2023.

Why TUNRA Bulk Solids?

Experience and Expertise

We have provided expert solutions to industry for over 45 years and are the leading organisation for materials handling research and consulting in Australia and internationally

Research and Development

We have a proven track record in research and development through the close association with The University of Newcastle

Quality Service

We have highly qualified, well-trained and specialist staff that are committed to delivering excellence

First Class Facilities

Our laboratory is a state of the art facility located within the Newcastle Institute of Energy and Resources (NIER) at The University of Newcastle

Industry Standards

We are accredited to ISO 9001, ISO 45001 and ISO 14001

Independent

We are independent and not for profit