International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET207415

Stress Analysis and Design Validation of Chute using DEM Software

MSSR Ravikiran#1, Sadige Akhil Prasad*2
[1]Mechanical Engineering Department, Sreenidhi Institute of Science and Technology, Hyderabad, Telangana, India
ravikiranmssr@sreenidhi.edu.in[1]
[2]Mechanical Engineering Department, Sreenidhi Institute of Science and Technology, Hyderabad, Telangana, India
akhilprasadsadige007@gmail.com[2]

Article Info
Volume 7 Issue 4
Page Number: 68-72
Publication Issue :
July-August-2020

Article History
Accepted : 01 July 2020
Published : 07 July 2020

ABSTRACT

The discrete element method (DEM) is attracting growing attention for the simulation of industrial Bulk solid flow; much of the earlier DEM modelling has considered two-dimensional (2D) flows and used circular particles. The DEM maintains the individual record (velocities, forces, etc.) of particles in flow and stress on equipment. This will enable the designer to know the problems in the design. Transfer chute is used in many industries to facilitate bulk material from one conveyor belt to another or for guide flow from a delivery point (feeder, screw conveyor) into a process or equipment (centrifuge, screener, etc.). Although the transfer chute itself may appear to be a low-cost part of the equipment train, it can easily become costly in maintenance due to plugging, abrasive wear, segregation, etc. The objective of this study is to analyse the stress distribution in a transfer chute when it is in use and to validate design is free from plugging. The modelling was done using the CREO PARAMETRIC software as per Industry standards. The Chute was modelled and simulated using the ROCKY DEM software. In the present research work, a discrete element analysis procedure is used in the ROCKY DEM simulation to predict the level of stress and velocities of particles.

Keywords : Discrete Element Method (DEM), Bulk Solid, Transfer Chute, Rocky DEM, Bulk solid handling equipment

I. INTRODUCTION

Transfer chute is bulk solid handling equipment is used in almost all industries. It facilitates the transfer of bulk material from the conveyor to another. In simpler words, it guides bulk solid flow from a delivery point (feeder, screw conveyor) into process or equipment (centrifuge, screener, etc.). The movement of the material in the chute takes place due to gravity. Feed chutes and transfer chutes are the most common types of chutes. Feed chutes are built to accelerate the material and transfer chutes are used for the transfer of material. The design of transfer chute is done based on "rule of thumb which are industrially accepted. There are many rules of thumb for developing a convectional transfer chute based on experience and engineering principles. Sometimes these rules are overlapping or conflict. Chute design is a combination of science and art, so it always better to consult an expert or validate the design using DEM software.

A convectional transfer chute is generally an assembly of four parts. They are listed below and represented in figure 1

- Head chute: the area surrounding the head pulley of the feeding conveyor belt
- Drop chute: The area where is guided in its free fall.
- Loading zone: the area where the material is guided onto the receiver conveyor belt.
- Settling zone: an extension area of the chute for dust settlement.

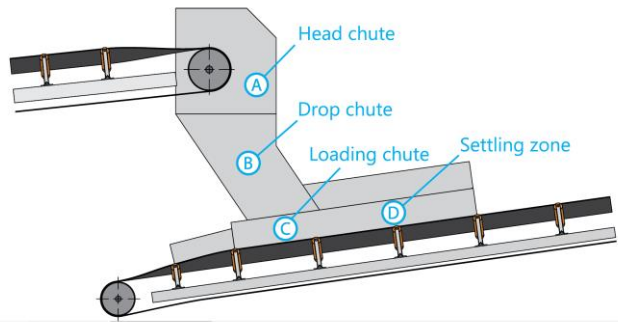

Figure 1. A convectional transfer chute consisting of four parts

II. DESIGN

A. DETERMINING THE AREA OF THE CROSS-SECTION OF CHUTE

The first step in designing a chute is to determine the cross-sectional area of the chute. It is very important to calculate the cross section to prevent the bulk material from getting stuck or blocked. The minimum area of cross-section of the chute. Material stream speed 3m/s, Bulk density of the material Iron-ore 2.5 t/m^3.Conveyor belt design capacity of 2200 t/h. with these parameters, we will be able to calculate the area of cross-section. The belt is 1200mm wide with troughing idlers. The CEMA 2/3 rule results in a chute 800 mm wide. The cross-section of the chute is assumed to be rectangular. The minimum area of the cross-section 800x840 mm Sometimes, the body should have an area that is at least 4 times the area of the material flow profile.

B. DESIGNING THE STRAIGHT CHUTE'S HOOD

The path of the bulk material takes it is discharged from the delivery conveyor, which is referred to as Trajectory. The trajectory is affected by the speed of the belt, the inclination angle of the discharging belt, and the profile of the material on the belt. The head pulley diameter and face width will help in determining the width and height of the head chute Find the trajectory of the bulk material leaving the conveyor belt. The angle made by the velocity vector just at the point where it loses contact will roller is 0°, as there is no adhesion of particles.

Velocity = 3m/s

Angle made with horizontal = 0°

Horizontal distance covered in time t = 3t

Vertical distance covered in time t is = $-\frac{1}{2}gt^2$

The trajectory equation is $Y= -\frac{1}{2} * g * \left(\frac{X}{3}\right)^2$

Taking the width of the chute to be 1.3 meters.

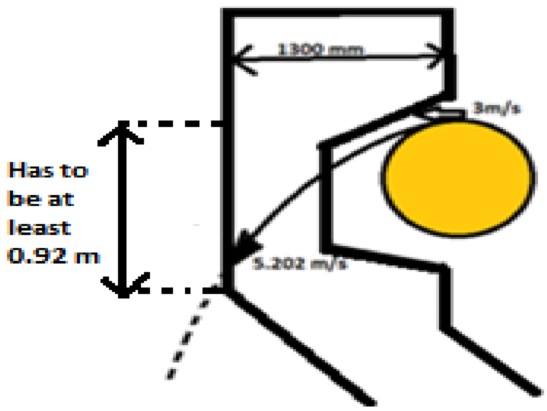

Figure 2. Trajectory path of bulk material

C. DETERMINING VALLEY ANGLE AND DROP ANGLE OF CHUTE:

The valley angle is an important parameter in the design of a chute. The main purpose of the valley angle is to reduce the kinetic energy of the particles before they enter the chute. The steeper the valley angle needs to be to reduce the adherence of the carryback. the steeper the wall angles with even steeper pitches are required. The valley angle of the chute hood was 61.5°. The valley angle should be greater than the wall angle of friction (25°) and the internal angle of wall friction (40°) of the chute liner. The chute drop angle was taken at 60.5°.The chute drop angle is just reduced so that the material can flow easily. The thumb rules for determining the valley and drop angle are conflicting in nature. They can be verified by simulating flow in a DEM environment.

D. DETERMINING THE INCLINATION OF THE SPOON OF CHUTE

Spoon in a chute to reduce the impact pressure on the chute. The minimum value of the spoon is approximately 50°. To ensure that this already highly adhesive carries back returns to the main flow, the angle the chute makes to the ground has to be very steep. This angle, called the valley angle, has to be at least 70°.

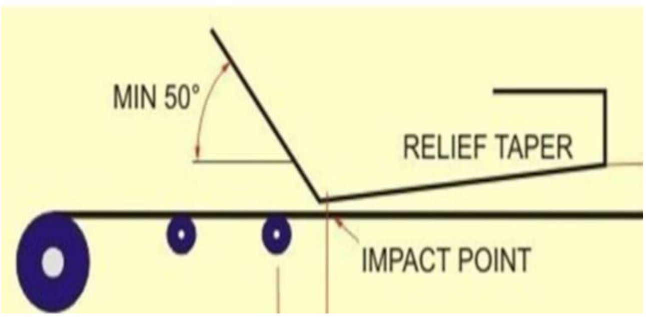

Figure 3. minimum spoon angle of the chute

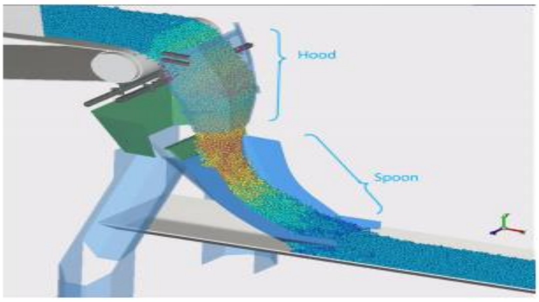

Figure 4. Chute showing Hood and Spoon

CHUTE LINER: The selection of the liner depends on the conveyed material and conditions. The thickness depends on the characteristics and volume of the material moving through the chute.

Conveyor belts were arranged at a troughing angle of 30°. The troughing angle of the belt prevents the spillage of the bulk material. The drop height should be kept as minimal as possible; however, the Hood and spoon designs use gravity to maintain the material flow speed and often require greater drop heights to implement them.

E. FINAL DESIGN OF CHUTE:

The final design of the chute (Two Dimensional) is shown in figure 5. All dimensions in the drawing are millimetres. Also, some space will be left for maintenance the convenience of pulley and pulley lagging as well as access to the shaft bushing, should be considered in making this decision.

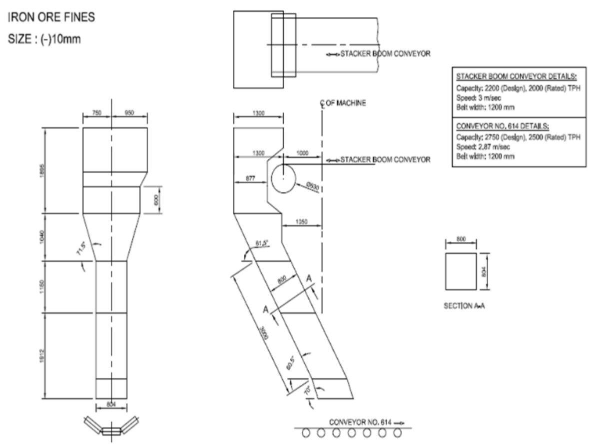

Figure 5. The final design of Transfer Chute

F. MODELING METHODOLOGIES FOR CHUTE

Modelling methodology	Description	Model type
Discrete element method	Timestep based particle and geometry modelling and calculating interacting forces	Granular flow by modelling motion and collisions of discrete particles
CFD Eulerian-Eulerian	Predicting fluid flow behaviour using Navier-Stokes equations	Granular flow as a continuous mass
Coupled DEM-CFD	Coupling of numerical methods to predict granular flow and air flows	Granular flow as particles or fluid and airflow as fluid flow

Table 1: Overview of modelling methodologies

Discrete Element Method As explained above, the basic principle of DEM is to model every individual particle as a separate entity that undergoes a variety of forces as in reality. These forces include gravity, interparticle contact forces, particle-to-wall contact forces, and cohesive and adhesive forces in particles (if applicable). After every time step in a simulation, these forces and their resultant displacements are calculated, making DEM simulations very computationally intensive. ANSYS cannot be used in place of DEM because ANSYS treats a material as a continuum element instead of treating bulk material as a discrete element.

For DEM simulation, we need to import the 3d model in *.stl into DEM software. In the simulation configuration, we need to set all parameters like the velocity of the feed conveyor and receiving material and mass flow rate from the inlet. The interaction between the materials should be given as per the standards. Mention size distribution per sample of iron-ore. This simulation is time-dependent to minimize the simulation time to reduce the number of particles in the simulation.

III. RESULTS

NORMAL STRESS:

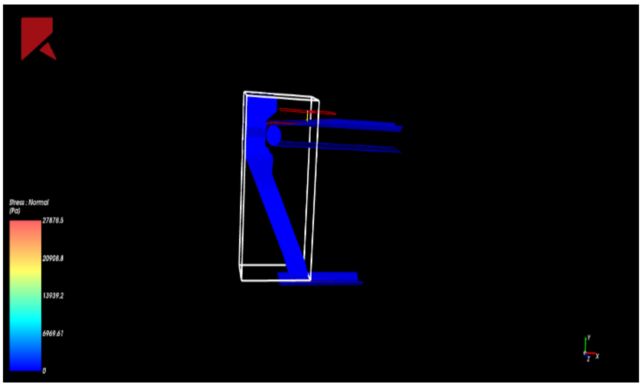

Figure 6. Normal stress acting chute (in usage)

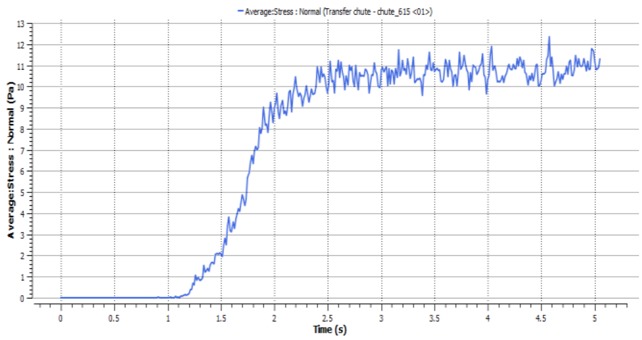

Figure 7. Average normal stress v/s time graph plot

Maximum normal stress: 27878.5 Pa

Minimum normal stress: 6969.61 Pa

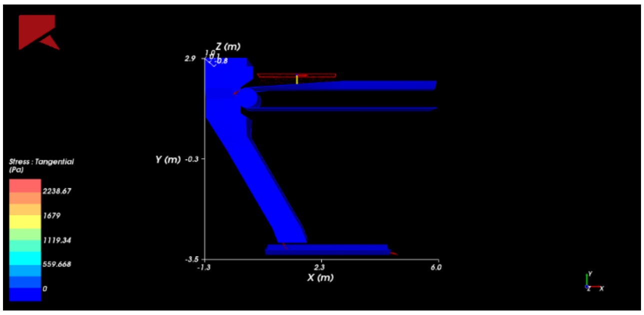

Figure 8. Tangential stress acting on chute(in usage)

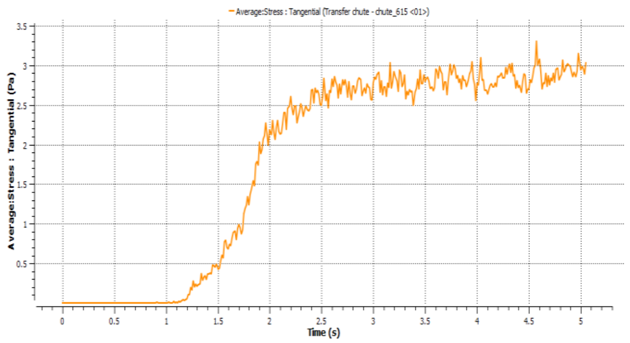

Figure 9: Average tangential stress v/s time plot graph

Maximum tangential stress: 2238.67 Pa

Minimum tangential stress: 559.668 Pa

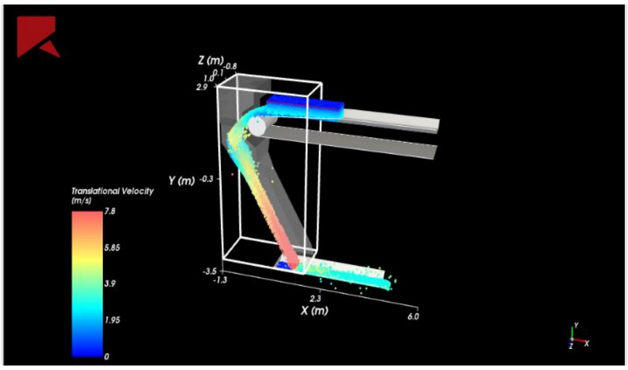

Figure 10: Translational velocity of particles (Bulk solid)

Maximum translational velocity: 7.8 m/s

Minimum translational velocity: 1.95 m/s

IV. CONCLUSIONS

1. Stress is greater in the impact point region where particles collide with the liner of the chute.
2. Wear and tear are also maximum at this impact point.
3. By general observation of this DEM simulation, there is no blockage of particles. The blockage of particles is subjected to moisture in the bulk material.
4. The abrasive nature of iron ore will erode the liner of the chute.
5. The chute is designed based on the thumb rules that are mentioned by many engineers. The DEM can be used for design validation.
6. DEM can be extensively used for stress analysis and design validation. It can be further used to verify the angle of repose of bulk materials.

V. REFERENCES

[1]. Conveyor Equipment Manufacturers Association (CEMA). (2005). BELT CONVEYORS for BULK MATERIALS, Sixth Edition. Naples, Florida.

[2]. Martin Marietta Corporation. Dust Control Handbook for Mineral Processing.

[3]. Morrison, J.N., Jr. (1971). "Environmental control Applied to Belt Conveyor Transfer Points." In Bulk Material Handling: Volume 1. The University of Pittsburgh.

[4]. Taylor, H.J. (1989). Guide to the Design of Transfer Chutes and Chute Linings for Bulk Materials. The Mechanical Handling Engineers' Association.

Cite this article as :

MSSR Ravikiran, Sadige Akhil Prasad, "Stress Analysis and Design Validation of Chute using DEM Software", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 7 Issue 4, pp. 68-72, July-August 2020. Available at doi : https://doi.org/10.32628/IJSRSET207415
Journal URL : http://ijsrset.com/IJSRSET207415