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Design and Testing of a Conveyor Transfer Chute

Mechanical Project 478 Project Proposal

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2020

saam vorentoe · masiye phambili · forward together

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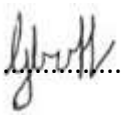
Signature:  .....

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Date: 2020/03/02 .....

Executive Summary

Title of Project
Design and Testing of a conveyor transfer chute.
Objectives
To develop a conveyor belt system that allows wet and sticky materials to flow against an impact plate for perpetuity. To develop methods to measure and observe the build-up of the WSM on the impact plate. To verify of the developed methods can be replicated in a DEM simulation.
What is current practice and what are its limitations?
Current DEM models are restricted to dry materials. There exists room for the development of a testing environment to measure and observe the baviour of wet and sticky materials.
What is new in this project?
This project will delve into the development of a testing environment for wet and sticky materials to, ultimately, parameterize DEM models.
If the project is successful, how will it make a difference?
The design process of products that interact with wet and sticky materials will greatly be simplified.
What are the risks to the project being a success? Why is it expected to be successful?
Measurements and observations can be insufficient. Time may constrain the thoroughness of the project. This project is expected to be successful if the careful consideration to the undertaken activities and time management is considered.
What contributions have/will other students made/make?
Literature surrounding wet and sticky materials and DEM models currently exist.
Which aspects of the project will carry on after completion and why?
Development of more intricate DEM models will take place. Time is a limiting factor in developing this model.
What arrangements have been/will be made to expedite continuation?
This design will be present in the DMRG laboratory for continued testing. The findings will also be documented in a thorough research project.

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1 Introduction

Transportation of granular materials on conveyor belts are limited, considering that conveyor belts are limited in the total length, maximum inclination angle and sudden changes in direction. Multiple conveyors are used to overcome the limitations of a conveyor belt to convey material between destinations. Transfer chutes are utilised in this application to transport bulk material from one conveyor to the next. Transfer chutes overcome limitations of changes in height and direction changes. Transfer chutes do, however, possess the risk of blocking when excess granular material is built-up on the chute. This is normally a serious problem when wet material is handled as the cohesive and adhesive forces are increased. The design of the chute is also of paramount importance when handling wet granular materials.

Figure 1: Build-up of WSM

The usage of Discrete Element Method (DEM) to simulate granular flow applications increased in popularity, especially with advances in computing power. The use of DEM has cost and time benefits when compared to traditional testing in the design phases.

Although there exist models for modelling wet and sticky materials (WSM) there remains room for refining these models. This is, especially, true when designing a setup to parameterise the flow of various WSM against transfer chutes.

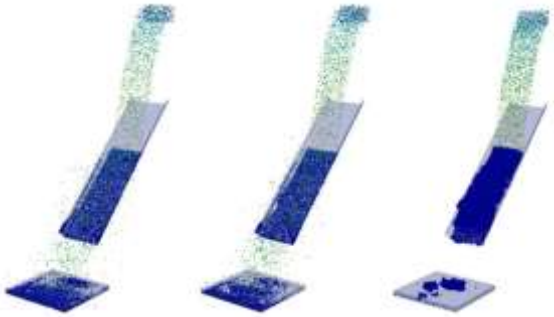

Figure 2: DEM model of bulk material flow

The proposal of this project is the design of a system where the flow of WSM against an impact plate can be observed and measured to perpetuity. The results of these observations and measurements will be used to parametrise a model that is to be implemented in a DEM model of WSM.

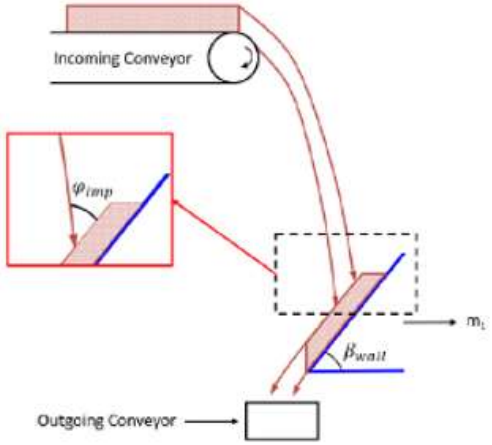

Figure 3: Diagram of testing setup

This document explains the project's objectives, motivation and planning. The steps that are planned in this study, as well as the expected costs and time scales for the study, are also outlined.

2 Objectives

As mentioned above, this project is aimed at the design of a system where the flow of WSM against an impact plate can be observed and measured. The objectives of the project are therefore:

2.1 Develop a conveyor belt system that allows WSM to flow against an impact plate for perpetuity.

2.2 Develop methods to measure and observe the build-up of the WSM on the impact plate.

2.3 Verify if the developed methods can be replicated in a DEM simulation.

3 Motivation

The industrial sector that utilises conveyor systems is enormous. The running cost of such a system is significant to the overall financial situation. Downtime on these systems can accumulate to a large portion of lost income.

Optimising these setups will lead to an increased profit. This will also serve to minimise the wastage of the bulk materials that are conveyed.

This research can also lay the groundwork for modelling the behaviour of WSM. This has an application that is very wide. This application is not only limited to conveyor systems as this material is found in numerous environments.

4 Planned Activities

The following activities are anticipated for the execution of the project. Costs and time scales associated with each activity are given in Appendix A.

4.1 Review Literature

Study the literature on all facets of the project. This would entail reviewing literature on: Conveyors and conveyor operations, the behaviour of WSM, testing environments to measure and observe the behaviour of WSM, DEM modelling, simulating WSM using DEM models.

4.2 Source a Conveyor System

A basic conveyor system is to be sourced from a manufacturer. This system will compromise two basic conveyor systems without any stands. The stands will be manufactured in-house after the necessary specifications are determined

4.3 Compile Design Requirement for Infintie Loop Conveyor System

Determine the requirements for the infinite loop conveyor system to be suitable for application in a testing environment. A list of evaluation criteria is to be compiled to evaluate different concepts.

4.4 Compile Design Requirements for the Shoot and Impact Plate Setup

Determine the requirements for the shoot and impact plate setup to be suitable for application in a testing environment. A list of evaluation criteria is to be compiled to evaluate different concepts.

4.5 Investigate Concepts for the Infinite Loop Conveyor System

A set of concepts for the infinite loop conveyor system is to be formulated. Each concept is to be analysed according to the outlined evaluation criteria set in 4.3 and compared to the different concepts. A shortlist of the most promising concepts is to be compiled.

4.6 Investigate Concepts for the Shoot and Impact Plate System

A set of concepts for the shoot and impact plate system is to be formulated. Each concept is to be analysed according to the outlined evaluation criteria set in 4.5 and compared to the different concepts. A shortlist of the most promising concepts is to be compiled.

4.7 Select Preferred Infinite Loop Conveyor System Concept

A fully motivated choice is to be made on the preferred concept for the infinite loop conveyor system.

4.8 Select Preferred Shoot and Impact Plate System

A fully motivated choice is to be made on the preferred concept for the infinite loop conveyor system.

4.9 Design Review of Infinite Loop Conveyor System

The findings of the infinite loop conveyor system concept selection is to be presented to the technical advisor to obtain approval.

4.10 Design Review Shoot and Impact Plate System

The findings of the shoot and impact plate system is to be presented to the technical advisor to obtain approval.

4.11 Design Infinite Loop Conveyor System

Design an infinite loop conveyor system using the outlined design process.

4.12 Design Shoot and Impact Plate System

Design a shoot and impact plate system using the outlined design process.

4.13 Manufacture Additional Components of the Infinite Loop Conveyor System

The additional components of the infinite loop conveyor system is to be manufactured that was not bought out

4.14 Manufacture Shoot and Impact Plate System

The shoot and impact plate setup is to be manufactured.

4.15 Assemble System

All manufacture parts of the final are to be assembled.

4.16 Develop testing method to observe and measure build-up of WSM on impact plate system

A methodology to measure and observe the behaviour of the WSM is to be developed.

4.17 Parameterise DEM Model to Validate Experimental Results

The experimental results are to be used in a DEM Model to compare this to the experimental results.

4.18 Finalise Report

Document the whole investigation, including the preparatory study, the investigative procedures and the results obtained in each activity. A recommendation will finally be made regarding validity of the parameterised model.

5 Project Risk Assessment

This section considers the significant risks that could prevent the successful completion of the project.

The main risk to the project is that the setup will not allow for adequate measurement and observation of the WSM that flows against the impact plate. Enough measurements and observations are to be made to characterise the behaviour to parameterise an accurate DEM model.

The above risk will be mitigated by careful considerations of the requirements of the project. A thorough analysis of what is needed to measure and observe the WSM flow must be undergone.

There is a risk that the project will exceed the outlined time limit.

This risk can be mitigated by diminishing the time spent to parameterise a DEM model. This activity does not strictly fall into the scope of the project.

6 Conclusions

There exists a need to model WSM using DEM software. There are several benefits to using this method if it is refined. The proposed project aims to develop a testing facility to measure and observe the behaviour of WSM to ultimately calibrate a DEM model.

The project team is equipped with the necessary expertise to complete the project sufficiently. A tot cost of R 310 800 is expected to be occurred. R 60 000 will be capital expenditure to upgrade the lab facility. The project is expected to take 8 months up to completion. Measures are put in place to address any project risks.

7 References

Carr, M. J., Chen, W., Williams, K. & Katterfeld, A., 2016. *Comparative Investigation on Modelling Wet and Sticky,* s.l.: s.n.

Carr, M. J. et al., 2019. *Calibration Procedure of Discrete Element Method (DEM) Parameters for Cohesive Bulk Materials,* Queensland: s.n.

Carr, M. et al., 2018. *Discrete Element Modelling of Problematic Bulk Materials Onto Impact Plates,* s.l.: s.n.

Appendix A Planning Details

This appendix gives the estimated cost to complete the project in Table A.1 and a Gantt chart for all the activities in Figure A.1.

Table A.1: Estimated Cost per Activity

Activity	Engineering Time		Running Costs	Facility Use	Capital Costs	MMW		MMW	Total
						Labour		Material	
	hr	R	R	R	R	hr	R	R	R
Review Literature	25	10 000	100						10 100
Source a Conveyor System	10	4 000			60 000				4 000
Compile Design Requirement for Infinite Loop Conveyor System	10	4 000							4 000
Compile Design Requirements for the Shoot and Impact Plate Setup	10	4 000							4 000
Investigate Concepts for the Infinite Loop Conveyor System	15	6 000	100						6 100
Investigate Concepts for the Shoot and Impact Plate System	15	6 000	100						6 100
Select Preferred Infinite Loop Conveyor System Concept	10	4 000							4 000
Select Preferred Shoot and Impact Plate System	10	4 000							4 000
Design Review of Infinite Loop Conveyor System	5	2 000		500					2 000

Design Review Shoot and Impact Plate System	5	2 000		500					2 000
Design Infinite Loop Conveyor System	25	10 000							10 000
Design Shoot and Impact Plate System	25	10 000							10 000
Manufacture Additional Components of the Infinite Loop Conveyor System	20	8 000				50	15 000	2 000	25 000
Manufacture Shoot and Impact Plate System	20	8 000				50	15 000	2 000	25 000
Assemble System	25	10 000	500	500					11 000
Develop testing method to observe and measure build-up of WSM on impact plate system	100	40 000		1 000					41 000
Parameterise DEM Model to Validate Experimental Results	100	40 000		1 000					41 000
Finalise Report	100	40 000	500						40 500
Total	**530**	**212 000**	**1 300**	**3 500**	**60 000**	**100**	**30 000**	**4 000**	**310 800**

ID	Task Name	Duration	Start	Finish	Predecessors
1	Review Literature	21 days	Mon 20/03/0	Sun 20/03/29	
2	Source a Conveyor System	44 days	Mon 20/03/0	Thu 20/04/30	
3	Compile Design Requirement for Infintie Loop Conveyor System	10 days	Fri 20/05/01	Thu 20/05/14	2,1
4	Compile Design Requirements for the Shoot and Impact Plate Setup	10 days	Mon 20/03/30	Fri 20/04/10	1
5	Investigate Concepts for the Infinite Loop Conveyor System	20 days	Fri 20/05/15	Thu 20/06/11	3
6	Investigate Concepts for the Shoot and Impact Plate System	20 days	Mon 20/04/13	Fri 20/05/08	4
7	Select Preferred Infinite Loop Conveyor System Concept	5 days	Fri 20/06/12	Thu 20/06/18	5
8	Select Preferred Shoot and Impact Plate System	5 days	Mon 20/05/1	Fri 20/05/15	6
9	Design Review of Infinite Loop Conveyor System	2 days	Fri 20/06/19	Mon 20/06/2	7
10	Design Review Shoot and Impact Plate System	2 days	Mon 20/05/1	Tue 20/05/1	8
11	Design Infinite Loop Conveyor System	12 days	Tue 20/06/2	Wed 20/07/0	9
12	Design Shoot and Impact Plate System	12 days	Wed 20/05/2	Thu 20/06/0	10
13	Manufacture Additional Components of the Infinite Loop Conveyor System	21 days	Thu 20/07/09	Thu 20/08/06	11
14	Manufacture Shoot and Impact Plate System	21 days	Fri 20/06/05	Fri 20/07/03	12
15	Assemble System	2 days	Fri 20/08/07	Mon 20/08/1	14,13,2
16	Develop testing method to observe and measure build-up of WSM on impact plate system	26 days	Tue 20/08/11	Tue 20/09/15	15
17	Parameterise DEM Model to Validate Experimental Results	28 days	Wed 20/09/16	Fri 20/10/23	16

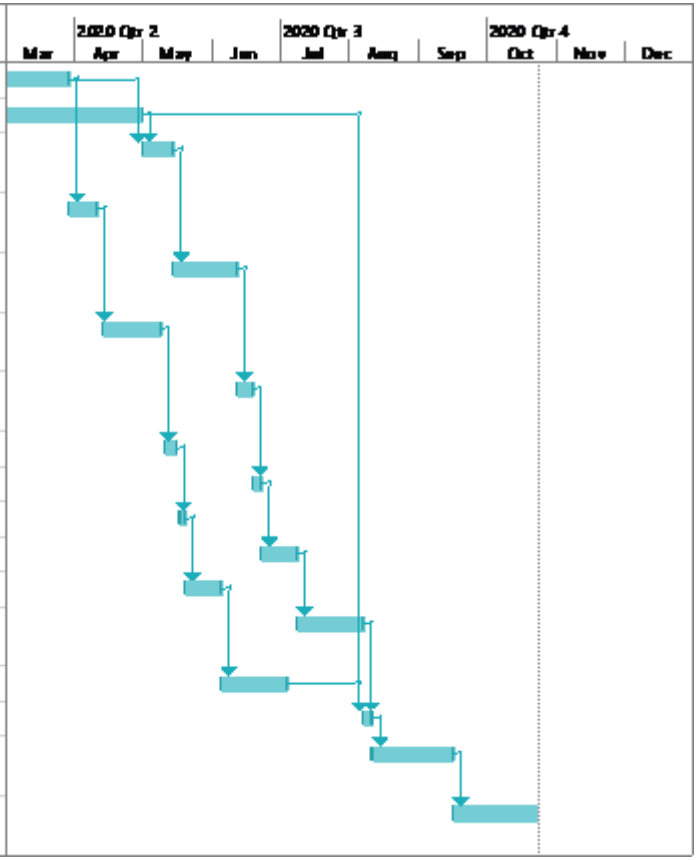

Figure A.1: Gantt Chart