Method of Operation of a Plough and Tiling Device Designed for Coal Mining

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Abstract

Operating a Plough Scraper and a Tilting Device should be very easy and safe. As much as the installation and maintenance is cheaper it does not require too much for both operation and maintenance. Some systems are automated with the plant and needs no operator to operate manually. Non-automated systems need only 1 operator of part time basis to operate and only when the system is engaged or in lowered position. Interlocking for the 2 conveyors was ensured to protect the system from blockages and spillages. Once the scraper is lowered material is being scraped from the 4000 tpa conveyor to the 2000 tpa conveyor. The rest becomes just monitoring with no physical contact to the running system. When scraping is completed, the plough is lifted to allow material to pass straight to another feed being Eskom Medupi feed line. The system is easy to operate with 4 main buttons being Tilting Device lifting and lowering, Plough Scraper lifting and lowering. Once the Tilting Device is lifted and Plough lowered interlock kicks in to reduce the feed from the 4000 tpa. Once the Tilting Device is lowers with Plough lifted the interlocks is eliminated to now feed 4000 tpa.

Keywords
Tilting Device, Plough, Scraping Material, Cylinders and Hydraulic Power Pack

1. Introduction
Exxaro Grootegeluk coal mine is the only supplier power station coal to Eskom's Matimba and Medupi power stations in Lephalale area of the Limpopo province in South Africa. Exxaro Grootegeluk also supply metallurgical coal to local smelters and export first grade coal. Grootegeluk coal being the biggest Exxaro's coal mine and is having the biggest coal beneficiation plant in Africa. The mine extracts its coal from the open pit which is around their plant in Lephalale area. The coal is graded accordingly, crushed, screened, and washed before being supplied to different customers.

Due to high demand of power station coal in the country, decision was made to tap coal from Medupi power station conveyor line to load trains to be sold to either other power station or export purposes. Grootegeluk operation currently only has one silo to load trains but for metallurgical and export coal which are not that different in grade. Investigation was made on the cheaper and less down time method to tap coal from Medupi conveyor to the export silo so it can be transported by train. The point that had both advantages was at the intersection where Medupi conveyor (4000 tons per hour) passes above silo feed conveyor (2000 tons per hour).

Medupi provides power to many South Africans and cannot stop production as South African power grid is always under pressure to supply both South Africa and local countries, it is not possible to shut down the supply for more than 12 hours at any given time. Other methods to tap from the top conveyor to bottom have been considered including to install a suffocating/flip chute. This was going to require major structural and setup changes that can take more than a week or months with delays. Tilting plough was then seen as a quick way in within he available 12 hours a week shut.

The drive for this paper is to ensure proper and efficient operating methodology. No additional employees were hired for this additional equipment hence an efficient method had to be utilised to avoid staff shortage in other areas. The system is not fully manual but automated and interlocked to simplify the process. During scrapping an operator is still required at a centralised position to monitor the process flow. This is to ensure double safety as this system cannot afford to stop for any downtime of either spillage or blockages as they will affect the overall planned time of this feeds. Although fixed solid scrappers contributes to belt resistance that in turn contributes to more power utilisation, it is essential to ensure good contacts to remove all the material including the wet stuck powder on the belt before it passes the scraping section to avoid spillages and steel products corrosion (Seshagiri Rao & Ali, 2019).

1.1 Objective

The objective of this paper is to address the need for economical material transfer systems to do away with the old traditional transfer towers that are too costly and takes long time to execute.

2. System Operation

2.1 Operating Procedure

There are 2 operating procedures that run by during the test and operation of this system. Firstly, it was running by the summary which is the simplified and easy to follow process. This was developed to accommodate the low literature levels in the mining industry. Secondly it was ran using the professional drafted which is difficult to follow process. This type of procedure is not normally understood by people with no good educational background. One can say this one is the most detailed and safe one as it covers all aspects of the operation. The system was running and tested by both methods and both methods are detailed step-by-step in this paper. The reason for both being put to test was because it was evident that operators always go for the simplified way. So, the simplified way had to be formalized. Although the formalized simplified way does not cover the details hence the detailed and professional one's importance. Figure 1 shows a loaded conveyor (CNVR) approaching the Tilting Device and Plough Scrapper. Figure 2 shown the conveyor (CNVR) Tilted structure to scrap off coal and Figure 3 shows an empty conveyor (CNVR) after scraping off the coal by Tilting Device and Plough Scraper.

Figure 1: CNVR Loaded

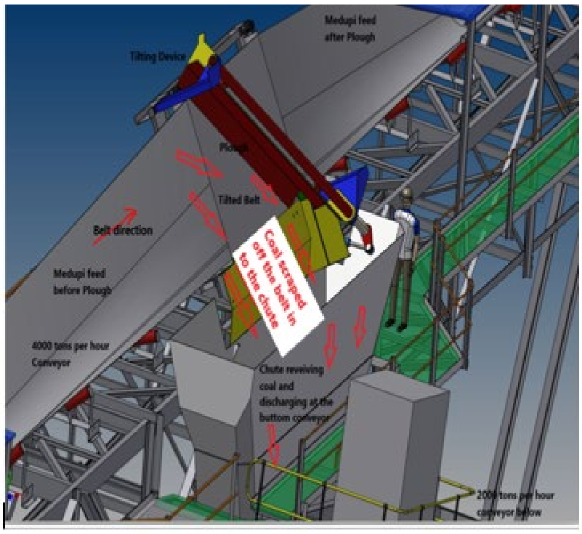


Figure 2: CNVR Tilted and Scraped

Figure 3: CNVR Empty

Conveyor belt comes with the power station coal from the mine plant

The power station coal from the plant is being scraped off by this Tilting Device and Plough Scraper into the collecting chute as shown by the red arrows. The belt is Tilted with the Plough places at an angle to Scrap off coal into the collecting chute

The conveyor belt passes empty as the material was Scaped off

2.2 Operating Procedure Summary

Although there is a long-detailed procedure for starting this system up, the summarized version was to make for easy-to-follow process by a simple operator being able to operate the plant but having no educational background that required intensive thinking and analysis. Plant operators are normally older people with no educational background and newer ones only have matric (school leaving certificate). Operating methods needs to be very simple to be followed, hence the simplified way followed during the operation of this system. There are two critical operators for this system. Others are just supporting throughout the line with radio operation reporting to the 2 main ones. This procedure was drafted for this two specifically. The following procedure worked well during startup and operation of the system and is the most preferred document by operators due to its simplicity.

2.2.1 Operator 1 (LOS Operating Procedure)

- TFR announced the train has arrived and ready for Power Station Coal load up.
- Yardmasters give instruction to LOS 1 operator to fill up the silo when the train arrive at Grootegeluk Mine.
- LOS 1 operator informed the lab about the train, to register and for them to take samples.
- LOS 1 operator and Matimba control room switched all sectional hand radios to Matimba channel to avoid congestion of communication on Medupi radio channel
- LOS 1 operator registered a train on computer
- LOS 1 operator made sure the silo is empty.
- LOS 1 operator called the outside area P6 from Rail Dispatch operator to go to the plough.
- Matimba control room switched the plough to maintenance (to test in manually first)
- Foreman ensured Matimba Medupi feed is cut.
- P6 tested the plough when the conveyor was empty and give the go ahead to LOS 1 operator to start feeding the Tilting Plough system to load the Export coal (our system)
- LOS 1 operator ensured that all interlocks is good by run test them.
- LOS 1 operator started the Export coal conveyor (2500 tpa)
- LOS 1 operator asked Matimba control room, to monitor the reclaimer to have maximum feed of 2000 tons per hour which is set to 2m/s (±57%) in the VSD (variable speed drive).
- P6 operator ensured the conveyor is Tilted with the Plough engaged, ready to scrap off coal.
- P6 operator always stayed close to the Tilted Plough, checking for spillage, blockages, or any abnormal behaviors on the system.
- In emergency the P6 stop the conveyor by pulling the pull wire.
- When silo was full LOS operator started with the train loading process.
- If train is not ready to be loaded LOS 1 operator uses radio to Matimba control room to cut the feed, to avoid silo overfeeding.
- LOS 1 Operator controlled silo level to have the silo empty when last wagon is full, to ensure Power Station coal is all out before train leaves so the 2500 tpa conveyor and silo can be used for normal production without excess coal that will contaminate the coal being normally loaded.
- LOS 1 operator informed the P6 operator to disengage the scraping system when loading was completed.
- LOS 1 operator informed Matimba control room that loading is completed.
- LOS 1 operator did all paperwork as required by mine operating procedure for operating the systems.
- LOS 1 operator used the last spare 5 empty wagons to purge/flush the silo to ensure there is no excess material left in the silo to avoid contamination of the new material being conveyed as of normal operations. Transnet Rail was requested to bring 5 extra wagons for purging purposes.
- LOS 1 operator informed the train to leave as the loading was completed.
- LOS 1 left the site as scrapping was completed.

2.2.2 Operator 2 (P6 Outside Operator)

- LOS 1 operator instructed the P6 to go to the hydraulic power pack for inspection and monitoring.
- P6 checked for spillages and any blockages at surrounding area before starting the system.
- LOS 1 operator give instruction to P6 to test the plough before operations.
- P6 test radio communication to LOS 1 operator to ensure there is no signal issues that cannot afford to happen once the system is operational.
- P6 checked if the Medupi collecting conveyor is empty to avoid overloading on the 2500 tpa conveyor.
- P6 lowered the plough by pressing the lower button until the lower limit is active.
- P6 raised the plough by pressing the lower button until the upper limit is active.
- P6 lowered the plough again to see if everything was OK.
- P6 asked the LOS 1 operator to start the LOS feed conveyor.

- P6 checked constantly for spillages or blockages during the loading process.
- P6 stop the Medupi feed conveyor with pull wire whenever there is suspected abnormality. This was to ensure no bigger problems are created with the intension of stopping before things get worse.
- P6 never leaved the process unattended.
- P6 got information from LOS 1 operator that the last wagon has been loaded.
- P6 lowered the tilting device and raised the plough to stop scrapping and the material left on the belt was conveyed to Medupi feed bin.
- P6 checked for spillages and called cleaners to clean areas with little spillages.
- P6 left the area as operation was done.

2.2.3 Foreman (Process Overseer)

- Ensure all is well with everyone in their place.
- Ensure efficient communication between operators as they preparing to switch.
- Ensure all is set up the way they traying to set up either engaging or disengaging the Tilting Device and Plough.
- Ensure no contamination on both the Power Station coal and Export coal.

2.2.4 Operating Procedure (Detailed and Technical)

The detailed operating procedure is the main document the simplified method was extracted from. This detailed one was used to oversee~~r~~ everything during the startup process. It was used by management as they needed to check the details for the success of this project and to also support the operators using their simplified method. Any cleaning system should include at least five types of performances including but not limited to high cleaning efficiency, prevent belt damage, to be safe to operate, to have long service life, and be easy to maintain (Golka, et al., 2006)

2.3 General Manner in Which Device was Operated

The belt tilting device is equipped with a hydraulic power pack that powers the hydraulic cylinder of the tilting frame and the cylinder of the belt plough/scraper. The power pack and tilting action can be done manually from the field if SCADA is not used (It was done manually and automatically during commissioning and initial operating stages of the operation). The power pack is equipped with a control panel mounted in the field. The control panel has the following buttons/selectors:

- Manual/Auto selector button
- Auto-up button
- Auto-down button
- Tilt cylinder manual up button
- Tilt cylinder manual down button
- Plough cylinder manual up button
- Plough cylinder manual down button

2.4 Normal Operation Condition

2.4.1 Tilting the Belt

Under normal operating conditions the plant operator goes to the field and does the necessary inspection to ensure all pre-requisites for tilting and plough are met. Once it was determined that the belt can be tilted safely, steps as on Table 1 takes place:

Table 1: Tilting the Belt

Operator action	**System response**
Ensured selector button is in auto	Run automatic tilting sequence when auto buttons are pressed
Pressed auto-up button	The auto button is a non-latching command that does the following: - Start pump and run power pack in idle. - Actuate the tilt cylinder valve to tilt the belt. This valve must be actuated until the limit switch gives indication that the belt is in tilted position. - Once tilt limit is reached, the tilt cylinder valve returned to neutral

	- Then the plough cylinder valve was actuated to lower the plough until the limit switch was reached. - Once the plough lower limit switch was reached the plough cylinder valve returned to neutral position. - The pump was stopped.

2.4.2 Returning belt to flat position

Under normal operating conditions the plant operator goes to the field and performs the necessary inspection to ensure all prerequisites for returning the belt to normal position are met. Once it was determined that the belt can be returned safely, steps as in Table 2 takes place:

Table 2: Returning Belt to Flat Position

Operator action	**System response**
Ensured selector button was in auto	Run automatic tilting sequence when auto buttons were pressed
Press auto-down button	The auto button was on a non- latching command that was to do the following: - Start the pump - Actuate the tilt cylinder valve to return the belt to the horizontal position. This valve must be actuated until the limit switch gives indication that the belt is in the horizontal position - Once tilt limit was reached, the tilt cylinder valve was then returned to neutral position. - Then the plough cylinder valve was actuated to lift the plough until the limit switch was reach - Once the plough upper limit switch was reached the plough cylinder valve was returned to neutral position. - The hydraulic pump was stopped

2.4.3 Prerequisites for Tilting Device and Plough Scraper Operations

Before the belt was tilted, the following conditions were met.

- Medupi feed conveyor was stopped
- Medupi feed conveyor was empty.
- Reclaimer was set on VSD to feed 2000 tons per hour which is at 2m/s (±57%).
- Export coal conveyor was empty
- Export coal conveyor did not receive feed from the original or Export coal feed.

2.4.4 General Operation of the System and its Intended Results

In general, the system works as it should. It delivers the intended results, and it is still time and cost effective to install. If improvements can be made on the grey areas, then the system will be excellent for the job. Power station coal is being scraped off from Medupi feed whenever process requires. All equipment's are still withing their expected life.

3. Challenges

3.1 Spillage on the Flattened Section

The area that is flattened to accommodate the scrapping section spills when the conveyor feeds Medupi with maximum feed. The flattened area is the only area that does not remain back to original state when the Tilting Plough is not running. This spillage is about 2% of the feed at that time of maximum feed. We recover the spillage and reload it to the Medupi feed on regular bases to avoid material losses. Since the spillages are foaling down on the structure that has access stairs on. It makes it difficult to go up the stairs during maximum feed as material keeps dropping to the ground. Alternative route of moving along the length of the 4000 tpa conveyor is used.

3.2 Flattering Idlers Failing

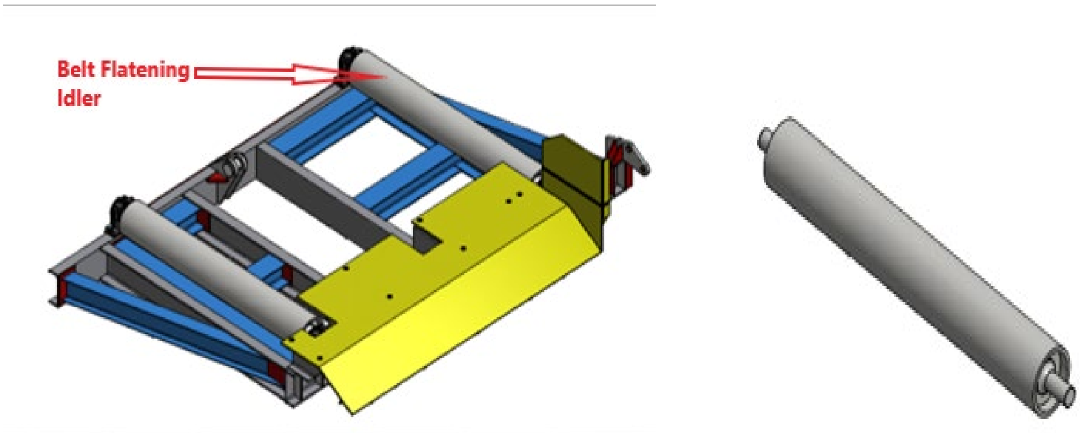


Figure 4: Belt Flattening Idlers

Figure 5: Jammed Idler Worn by Running Conveyor (Skecon, 2021)

These flattening idlers shown in Figure 4 keep failing as they continuously engaged even if Tilting Plough is not engaged. Figure 5 shows failed idlers (Skecon, 2021). The idlers are designed to run 30 000 hours. The 30 000 hours is counting also when Medupi feed is running making it to cover lot of hours unnecessarily. It was going to be ideal if these idlers were made to disengage when not required so they only utilized when needed. The other factor that is failing them is they were designed as idlers with a lower life of 30 000 hours additionally they are not coping with the flattening force continuously applied to them. It would be ideal to have made them rollers since they have a longer life of about 100 000 hours. Rollers can also withstand flattening forces as compared to idlers. It is to be noted that each time a flattening idler fails the whole Medupi feed need to stop to replace it. When flattening idlers fail without notice there are more spillages and the material courses friction that is a fire hazard. Only smoke was noted so far and is not yet evident if the smoke can result in fire if not attended to. Most idlers are designed to have Bearing Assembly and a Seal in Accordance with the Invention of the Central Mining (Sust, 2013).

3.3 Belt Tracking or Training

The flattening idlers make the belt to be imbalanced due to the flattened section. The belt keeps losing its track and required frequent belt tracking activities. Before this installation there was no belt tracking challenges to this belt. Now that the flattened section is added, frequent belt tracking is required. Artisans are allocated additional hours to frequently inspect and track the belt whenever it loses its track. Having idlers or rollers that disengage when not in use will also eliminate this problem if implemented. This will ensure idlers and rollers only work when the Tilting Device and Plough are engaged. There are many causes to belt failure. In this set up the belt failure was mostly due to belt tracking challenges due to flattening rollers. Figure 6 shows some of the belt failures resulting from belt tracking.

Figure 6: Example of Destructive Damage of the Rubber-Textile Conveyor Belt (Velmurugan, et al., 2021).

3.4 General Increased Downtimes to Medupi Feed

All these challenges detailed in this paper contributes to the increased down times as compared to when the Tilting Plough was not yet installed. Belt tracking and failing idlers cause unnecessary downtime to the Medupi Feed System. All these downtimes are costing company money for labor and spares including the lost feed that they were to sell to the customers (Eskom Medupi Power Station). Cleaning of spillage does not stop the plant if frequently cleaned but does cost money of the plant and labor used to clean. It also adds additional feed as a result of double handling of this recycling action to get the material back online.

4. Possible Solutions

4.1 Spillage

Installation of skirtings on the side of the flattened section can eliminate spillages. Although installing the disengaging rollers/idlers when the scraping action is not activated would work better. It is much simple and fast to design a skirting frame and install the skirtings that are movable to avoid spillage. The movable option is only required on the scraped section to adjust or open or be removed during scraping action. It would be easy to adjust either up or sideways as is much simple and requires less effort to engage and disengage. Removing the skirtings option will work but it is going to be labor intensive which might need a person/s for some time to hold and carefully remove every time they not needed. The option of removing will also expose the team to risks of injuries every time physical work requires (either fitting or removing). Some belt failure causes were by belt tracking (Velmurugan, et al., 2021).

The other expensive method could be to make them automated to be controlled by the hydraulic system. This can be interlinked to the scraping system that when it kicks in it opens automatically. Several options can be considered other than making the rollers to engage or disengage. For as long as the idlers do not engage and disengage, their failing challenges will remain in place. Skirting option only solves the spillage problem in the section and not the failing idlers one. The failing idlers is addressed in the Flattening Idlers Failing section.

4.2 Sequence Interlocking

4.2.1 Interlocks

The interlocks work perfectly and each time the Tilting Device and Plough system kicks in, the Medupi feed set up disengages for the new sequence to kick in. The 4000 tpa Medupi feed runs first to clear off the material on the belt, then followed by the 2000/2500 tpa running, followed by Tilting Device and Plough engaging, then the reclaimer feeding at a reduced rate of 2000 tpa. If the 2000tpa conveyor trips the whole system trips. If the Tilting Device or Plough are not working properly the whole system stops. This is to ensure no overloads or spillages occurs during miscommunication of software's resulting in longer down times of overload and spillages to the system.

4.2.2 Belt in horizontal position

When the belt is in horizontal position all interlocks of current equipment remained as is, except for the following:

Medupi feed conveyor (4000 tpa) have the following additional interlocks:

- Belt tilting frame lower limit switch: When switch was not activated (i.e., belt in lower position), the belt could not start or if switch lost contact while belt was running, the belt tripped.
- Plough upper limit switch: When switch was not activated (i.e., plough in raised position), the belt could not start up or if switch lost contact while belt was running, the belt tripped.

4.2.3 Belt in tilted position

When the belt is in the tilted position, the following interlocks applied:
Medupi collecting conveyor (4000 tpa)

- This belt was interlocked with the running signal of the Export conveyor (2500 tpa). The Export coal belt was running for the Medupi collecting to be able to start. If Export coal conveyor stops, the Medupi feed conveyor automatically stops.
- Belt tilting frame upper limit switch: When switch was not activated (i.e., belt in tilted position), the belt could not start or when switch lost contact while belt was running, the belt tripped.
- Plough lower limit switch: When switch was not activated (i.e., plough in lowered position), the belt could not start up or when switch lost contact while belt was running, the belt then tripped.
- Blocked chute detector in new transfer chute. Chute was blocked by dummy material after block chute detector was activated, belt did not start up when chute was blocked while running, the belt had to stop
- The Assize bin level interlocks was removed from the sequence.

4.2.4 Export Coal Conveyor (2000 tpa)

There were no interlock changes to this belt. The only interlock adjustment was on the belt throwing on to it and the system in relation to the set up in question.

4.3 Operations Risk Assessment

Risk assessments need to cover the operation, health, and safety of people. Operations will cover areas not to damage the existing equipment and avoid contaminating the original process by this additional or new improvements.

5. Previously used Methods of Transferring Material

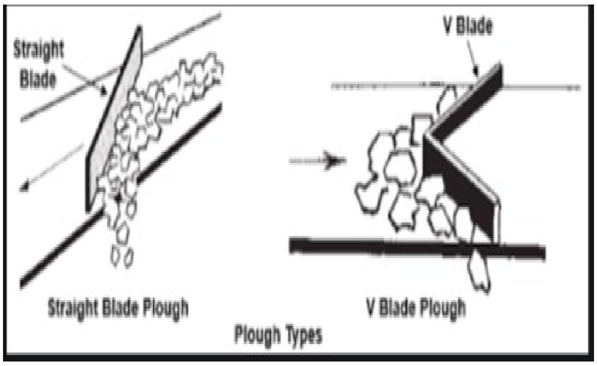
The previous methods of transferring materials from a belt in an upper elevation to a belt in a lower elevation was done with a traditional transfer tower with some bifurcating chutes. The running upper-level conveyor was modified completely to include a new tail end and head on the section. A conveyor would be cut, and an idle pulley installed for the current drive. Install a new drive for the other section. Level changes to allow the flow from the conveyor that a new drive is installed to be higher than the conveyor that an idle pulley is installed on the lower position. The chute transferring materials from the feed line to the idle puller new belt would be bifurcating chute with a flopper to flip and discharge to any feed either being the idle pulley one or the one we are discharging material to (new required line).

Due to the time span this traditional method takes to design and install, the supplier would arrange supplement supply or face penalties to the customer due to no feed for the time span of the execution. The traditional method cost is unreasonably high as is too much work. The cost would be about 4 times the Tilting Device Plough one, this is excluding penalties or cost to supply using alternative supplier to avoid cutting of feed. Using alternative supplier comes with risk of quality as one cannot be sure if the alternative supplier will maintain the quality and material characteristic contracted to as required by the customer.

A temporary infrastructure needs to be in place to tie in the alternative supplier in line. This could either be done at the customer or original supplier' site. That temporary installation is to be taken off and discarded on completion, although there could be some of the items that can be sold as second hand, but their selling price compared to the price they bought it new is massive. Recovering this temporary supply arrangement is just close to impossible. This high cost and effort are discouraging new improvements or expansion. Higher demands can also not be realized by this new idea as they just never implemented which limits the demand and expansion. Popular previously used Plough Scaping methods are shown in Figure 7 and 8. Figure 9, 10 and 11 shows previously used Scrapers without Plough. Carrybacks are to be minimised at discharge points to save substantial costs of reducing potential damage to belts and idlers and avoiding clean-up costs (Msaimh, 1992)

Figure 7: Straight Plough in Open/Non-Scraping (MARS, n.d.)

Figure 81: Straight Plough in Closed/Scraping (MARS, n.d.)



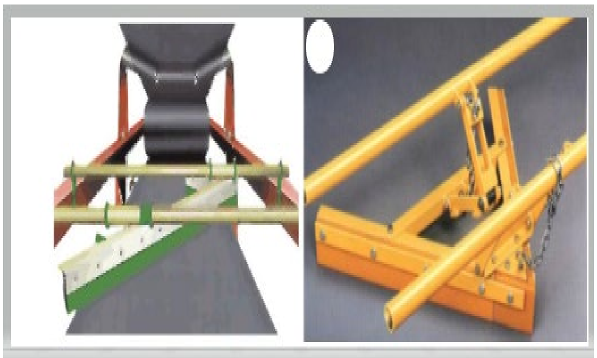


Figure 9: Straight and V Blade Plough (Shah, 2018)

Figure 10: Straight Blade Plough (Hrabovsky, et al., 2019)

Figure 11: Chained V Blade Plough (Tru-Trac, 2021)

6. Results and Discussion

The use of Tilting Device and Plough Scraper worked very well for the intended purpose. The design tool less time to develop, fabricate and install on site. The cost of the system was also very less compared to the normal traditional transfer tower set ups used in many set ups. This operation is nicely shown in Figure 1,2 and 3 during operation.

7. Conclusion

The operation of the Plough Scraper and Tilting Device on the Conveyor is very simple and straight forward. Once the system starts no other activities are expected except monitoring. Once the system stops no activities are required except inspection to ensure all is in good order. No additional employees were added with this system. The operation is the simplest with only 4 buttons being Plough Scrapper up and down and Tilting Device up and down. Everything else is automated and interlocked to kick in when required.

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Biographies

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