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# Design and Optimisation of Conveyor Belt System in Zuari Agro Chemical Industry

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***Abstract:-*** **Conveyor belt systems have wide application in industrial and domestic fields. In industry, material in various forms are transported on these belts. This eliminates the problem of manual transportation of goods which would lead to a large volume of labour and increased time consumption. Currently the conveyor belt system at ZACL uses a conventional design of the chute which leads to various problems such as overheating of the chute surface, alteration of material composition in the bag, choking of the chute, removal of print on the bags etc. Our research work is designed to overcome all the above mentioned issues pertaining to the current means of operation at ZACL and serve as a platform for further development.**

***Keywords:--*** **Conveyor Belt System, Pipe Chute , Pulley, Cooling Tower.**

## I. INTRODUCTION

Zuari Agro Chemicals Ltd (ZACL) is one of the leading conglomerates in India. It is a single-window agricultural solution provider, which uses natural gas as the core raw material to produce ammonia which in turn is used to produce fertilizers viz. urea and Nitrogen Phosphorous Potassium (NPK). Zuari enables agricultural self-sufficiency and economic independence by providing fertilisers that are both affordable and effective. Zuari's operations are spread across five key marketing areas. The company has a manufacturing facility at Goa, with four plants, dedicated to manufacturing urea, Di ammino Phosphate (DAP) and Nitrogen Phosphorous Potassium (NPK) based fertilizers. The company is also a significant importer of fertilizer and farm nutrients. The company produces high quality complex fertilizers of various grades along with seeds, pesticides, micro nutrients and specialty fertilizers.

The conveyor belt system is 1.4km long. During regular operation, due to impact of bags on the belt, the belt tends to go off-centre. This causes the bags to come in contact with the guide rollers and support bars on either side of the belt. As a result, the bags tear and a lot of loss is incurred. At the entry of the chute, many-a-time, a number of bags arrive simultaneously. This causes blockage and the bags tend to pile up, obstructing the movement of the next set of bags. As a result, a lot of time is lost and the problem has to be sorted out manually. Due to the constant contact between the bags and the chute material, friction is produced, which gives rise to a lot of heat. Heating of the chute indirectly leads to choking which results in bottlenecks. Error in count occurs when bags from the conveyor belt are loaded into the wagons.

## II. PROBLEM DEFINITIONS AND SOLUTION PROPOSED TO ZACL

### *2.1 Off-centering of belt and tearing of bags*

During operation, the conveyor belts get off centered and tearing of bags occur. The conveyor belt system is 1.4km long. During regular operation, due to impact of bags on the belt, the belt tends to go off-centre. This causes the bags to come in contact with the guide rollers and support bars on either side of the belt. As a result, the bags tear and a lot of loss is incurred.

***Suggested solutions***

- Use of piston actuators to keep the bag on the conveyor belt system which would be operated using compressed air and programmed automatically using a PLC.
- Crowning of Head and Tail pulleys.
- Use of self alignment pulleys to keep the belt in line.

***Optimal Solution :*** Use of self alignment pulleys

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*Fig 2.1 Self alignment pulleys*

Self alignment pulleys are used to re-align the belt once it gets off-centered. It uses the principle of rotating rollers. By using this method, there are very little chances of the belt getting off-centered.

***2.2 Choking of chute***

Due to current design of the chute, choking occurs. At the entry of the chute, many-a-time, a number of bags arrive simultaneously. This causes blockage and the bags tend to pile up, obstructing the movement of the next set of bags. As a result, a lot of time is lost and the problem has to be sorted out manually.

***Suggested solutions***

• Use of roller or pipe chute in place of conventional chute.

***Optimal Solution*** : Use of pipe chute

*Fig. 2.2 Pipe chute*

Use of pipe chutes reduces the contact area between bags and chute material. This in turn reduces the heat produced between the two.

***2.3 Overheating of chute***

Due to the constant contact between the bags and the chute material, friction is produced, which gives rise to a lot of heat. Heating of the chute leads to heating of the bags passing through it.

***Suggested solutions***

- Use of water sprinkling system on the underside of the chute in order to reduce heat produced due to sliding of bags.
- Use of automated cooling system using PLC and temperature sensor

***Optimal Solution*** : Use of automated cooling system using PLC and temperature sensor

***2.4 Counting error***

Error in count when bags are loaded into the wagons.

Suggested solutions:

- Use of load cell for counting of the bags depending upon the weight of the bag (50kg).
- Use of an automatic counting device with infrared sensor

***Optimal Solution*** : Use of an automatic counting device with infrared sensor

***2.4 Solution Selected By Zacl*** :

Pipe chutes with automated cooling system for the conveyor belt system

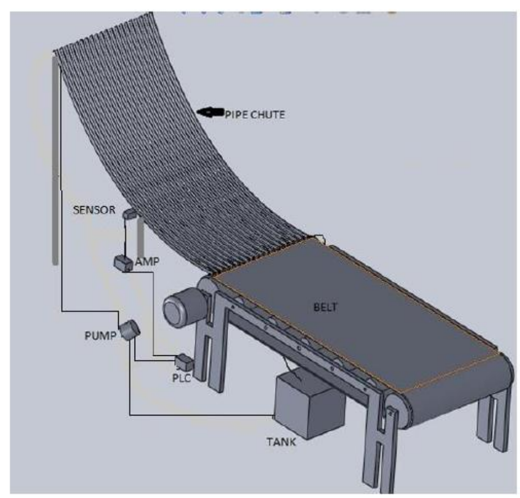


*Fig. 2.3 Final setup*

In the setup shown above when the pipe chute heats up to a particular temperature the sensor senses that

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temperature and sends a signal to the PLC, programmed for a upper and lower threshold using ladder programming. The sensor signal is amplified using a amplifier and a signal is sent to PLC which starts the pump in turn using a relay which is mounted on a circuit board. The pump then pumps water from the tank to the chute which is made up of hollow pipes and used for sliding of bags. Once the sufficient temperature of the chute is attained i.e. the lower threshold, the relay breaks the circuit and the pumping of water is stopped to the chute. The water which is used for cooling of the pipes is sent to the cooling tower (evaporative cooling tower), which exchanges the heat between the water entering the cooling tower and ambient air entering through the fins, which helps to draw ambient air into the cooling tower. This transfer of heat between two mediums lowers the water temperature as it reaches the bottom of the tower.

## III. COMPONENTS REQUIRED FOR THE FINAL SETUP

1). Conveyor belt
2). Pipe chute
3). Head and tail pulley
4). Guide rollers
5). Sensor
6). Pump
7). Cooling tower

***1). Conveyor belt***

A belt conveyor system consists of two or more pulleys (sometimes referred to as drums), with an endless loop of carrying medium. The conveyor belt that rotates about them, one or both o the pulleys are powered, moving the belt and the material on the belt forward. The powered pulley is called the drive pulley while the unpowered pulley is called the idler pulley.

There are two main industrial classes of belt conveyors; Those in general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport large volumes of resources and agricultural materials, such as grain, salt, coal and sand.

***2). Pipe chute***

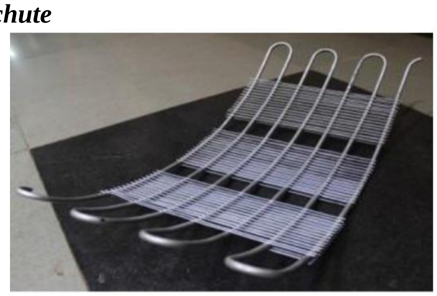

***Fig. 3.1 Pipe chute***

Pipe chute is a special type of chute which uses pipes which serve as the surface on which material is transported, as opposed to the conventional design of the chute in which a plate is used. Pipe chutes have a discontinues surface which reduces contact between the chute material and the bags. This causes less friction to be developed and hence less heat is produced. Pipe chutes are more versatile than conventional chutes as the can be oriented in more ways. There is no separate drainage system required for the water which is used for cooling and the same water can be re-used. Hence there is no wastage of water. Pipe chutes can be cleaned with pressurized air which will clear the slurry.

***3). Head and tail pulley***

Head Pulley is the pulley at the discharge end of a conveyor belt; may be either an idler or a drive pulley. Usually it has a larger diameter than other pulleys in the system and is often lagged to increase traction and pulley life. It is the pulley which provides driving force for the belt to rotate. They are manufactured from thick wall pipes or tubings, then machined on the lathe to form the crown and ensure minimum run out in operation. They run more concentric than pulleys made by the expansion method. This ensures better belt tracking and less vibration transferred to the bearings.

***Fig. 3.2 Head pulley***

Tail Pulley is pulley at the tail of the belt conveyor opposite the normal discharge end which is an idler pulley. It helps to keep the belt in tension and is also known as take up pulley.

***4). Guide rollers***

The conveyor belt tends to drift laterally, in such cases vertical rollers are utilised with cantilevered spindles, these are known as Guide Rollers . Guide rollers take up the forces which are induced on the belt surface thus preventing the damage to the belt edge. Motion of guide rollers takes place simultaneously as the belt rotates.

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*Fig. 3.3 Guide rollers*

***5). Sensor***

The sensor needed in the cooling system is a temperature sensor. LM35 is the most commonly used temperature sensor The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the centigrade temperature.

*Fig 3.4 LM35 temperature sensor*

***7). Cooling tower***

Cooling tower is a heat rejection device which rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. In ZACL, the cooling tower used is induced draught cross flow cooling tower . Air flows through the fills horizontally and water falls down vertically. Cross flow cooling tower are filled by splash type fillings, which are suitable for the application where water has higher suspended particles. Non compatibility of film type fills is a drawback of cross flow type cooling towers.

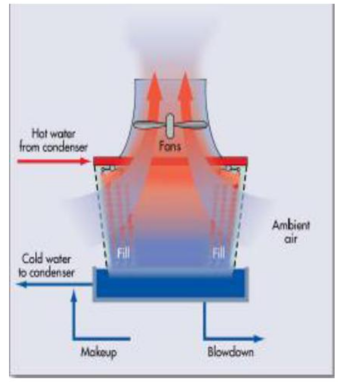


*Fig 3.5 Induced draught cross flow cooling tower*

## IV. DESIGN CALCULATIONS

***A. Design calculations for chute angle.***

***Coulomb's Law Of Friction***: The law states that for two dry solid surfaces sliding against each other, the magnitude of the kinetic friction exerted through the surface is independent of the magnitude of the velocity (i.e., the speed) of the slipping of the surfaces against each other.

In ZACL

Chute angle (θ) = 40°

Chute material: Austenite stainless steel 304

Coefficient of friction= 0.58

Driving force = mgSin(θ)

= 50*9.81*Sin40 = 315.28N

Frictional force (µf) = 0:58*50*9.81=284:49N

Since mgSin(θ) > frictional force(µf )

We need to optimise the frictional angle

Trial 1:

Taking chute angle as (θ) = 36°

Now,

mgSin(θ)=50*9.81*Sin36° = 288.31N

Trial 2:

Taking chute angle as (θ) = 37°

Now, mgSin(θ) = 50*9.81*Sin37° =295.2N

Comparing Trial 1 and Trial 2, we conclude that (θ) = 37° is the optimum chute angle as the frictional force is slighlty less than mgSin(θ) = 295.2N. An optimized curved chute design controls the flow of bags, placing it onto the receiving belt where the bags forward velocity approximates the belt's speed, minimizing abrasive degradation, and where the material's design impact pressure is below the belt cover's critical damage threshold.

1) The need for thicker belt top cover
2) Impact damage on steel cords
3) Rip and punture damage
4)Spillage and its related damage at the transfer statio

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***B. Cooling tower calculations***

Effectiveness =Range/ Range+Approach
Range = (T2–T1)
(T2–T1): Difference between cooling tank water inlet and outlet temperature.
Approach = difference between the cooling tower water outlet and cold water temperature and ambient wet bulb temperature. (Approach is better indication of cooling tank performance).
Range :
R = T1-T2 = 40.55-32 = 8:55°C
Approach :
A = T2-TWBT = 40.05-30 = 10:55°C
Effectiveness (ε) = R
(R+A)
= 8.55
(8.55+10.55)
= 0:4476 = 44.76%

## V. CONCLUSION

- The aim of our project was to design and Optimise the conveyor belt system at Zuari Agro Chemicals Ltd.(ZACL). After an extensive study of the system, the following conclusions were drawn:
- The chute angle was optimised from 40° to 37° which reduces the impact forces on the belt surface.
- Introduction of cooling tank reduces water temperature from 60°C to 54°C.
- Due to reduced friction between the bag and the chute, the print of the bags remain intact.
- Composition of the material in the bags remain un-altered. This is because the heat produced due to friction is comparatively low and there is no direct contact between the coolant and the bag.
- Manual labour was reduced significantly.

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