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DESIGN OPTIMIZATION, ANALYSIS AND REMEDIES OVER FAILURE OF CHARGING BELT CONVEYOR SYSTEM USED IN THE INDUSTRY TO SET THE OPTIMUM RESULTS

Pranav Manikrao Deshmukh[1], Dr.S.P.Trikal[2]

Advanced manufacturing and mechanical system design, SSGMCE Shegaon
Mechanical Engineering, SSGMCE, Shegaon,

Abstract- *The project focuses on choosing the right conveyor belt and suitable components to ensure manufacturing of high-quality belt conveyor. The existing problems of the idlers and belt conveyor are pointed out and proper solutions are given to make them a longer life. This project helps to improve the production by eliminating the various failures and other problem. The aim of the paper is knowledge of damage process which is required for the correct regulation of operation conditions for conveyor belt. The aim is to determine conditions caused this type of damage (height of impact and weight of material impact). The current trend is to provide weight/cost effective products which meet the stringent requirements. The aim of this paper is to study existing conveyor system and optimize the Belt speed,Width,Wrapping angle,troughing angle, Pulley diameter and addition of Snub pulley* **.***The parametric model of belt conveyor where modeled in Solid-work 2014 where different parameter are studied.*

Keyword- *Belt conveyor, Idler, Pulley, Failure, Simulation Software(Solid Works),Ansys software.*

I. INTRODUCTION

This master of engineering project was carried out at a YASH ENTERPRISES, which produces all types soap manufacturing and packaging .Yash enterprises is located in Khamgaon Dist: Buldhana.

The purpose of this project was to provide a comprehensive knowledge of the basic production process theory of designing belt conveyor. The project focuses on choosing the right conveyor belt and suitable components to ensure manufacturing of high-quality belt conveyor. The existing problems of the idlers and belt conveyor are pointed out and proper solutions are given to make them a longer life. This project helps to improve the production by eliminating the various failures and other problem.

The final aim was to create a modified design to achieve large scale production, of idlers which enhances both the efficiency and productivity. In order to help the company to get larger sales market, a plan of designing a belt conveyor was carried out, but further research still is needed to make it come true.

II. ACTUAL DESIGN OF CHARGING BELT CONVEYOR:

A. CONSTRUCTION:-

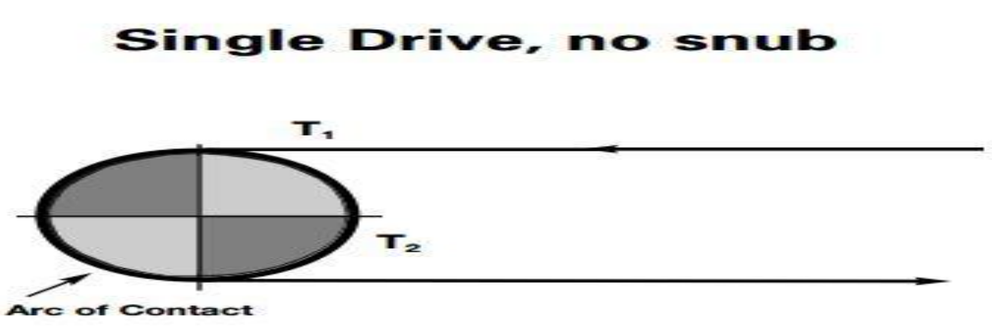

Figure 1. Actual design of charging belt conveyor system

The belt conveyor is an endless belt moving over two end pulleys at fixed positions and used for transporting material horizontally or at an incline up or down. The main components of a belt conveyor are:

1. The ***belt*** that forms the moving and supporting surface on which the conveyed material rides. It is the tractive element. The belt should be selected considering the material to be transported.
2. The ***idlers***, which form the supports for the carrying and return stands of the belt.
3. The ***pulleys*** that support and move the belt and controls its tension.
4. The ***drive*** that imparts power to one or more pulleys to move the belt and its loads.
5. The ***structure*** that supports and maintains the alignments of the idlers and pulleys and support the driving machinery.
6. The trough plate that support the belt for carrying proper amount of material to the feeder.
7. Belt cleaner that keeps the belt free from materials sticking to the belt.

Driving device

Driving device is the power transmitting mechanism of a belt conveyor. It is made up of an electromotor, coupling, reducer and driving pulley and so on. According to different using conditions and working requirements, the drive mode of a belt conveyor can be grouped to single-motor driving, multi-motor driving, single-pulley driving, and double-pulley driving and multi-pulley driving.

Return pulley

A return pulley has three categories: 180^0. The return pulley's diameter is related to driving pulley's diameter and the wrap angle that the belt has on the return pulley. Return pulley is a welded-steel plate construction with an antifriction bearing.

Troughing plate:-

Troughing plate are used to support the belt during conveying the material into the feeder.Troughing platee having 550 mm distance from the sdjacent plate for the proper belt alignment.The plate having the trough angle is 45^0.

B. DESIGN CALCULATION:-

Design calculation of belt conveyor

Table 1 Specification of Belt-Conveyor System

Parameter	**Dimension**
Height of conveyor, H	3042mm
Total belt length L_b	18040mm
Centre to centre distance L	9000mm
Belt width W	550mm
Belt speed V	0.2m/sec
Capacity C	3ton/hr

Motor RPM N	1500rpm
Temperature required T	10-20^{0}c
Motor -	3-phase induction motor

Density of Belt Materials

The density of various belt materials are given in the following table.

Table 2 Density of Belt Materials

Material	Density(Kg/m^3)
Leather	1000
Convass	1220
Rubber	1140
Balata	1110
Single woven belt	1170
Double woven belt	1250

C. DESIGN PROCEDURE FOR BELT CONVEYOR SYSTEM:

1) Belt capacity [c] :-

C=3.6×Load cross-section area perpendicular to belt× Belt speed ×Material density =3000 kg/hr

2) Belt power

POWER=$\frac{Fc(L+tf)(c+3.6QS)}{367} \pm \frac{CH}{367}$ KW

For horizontal and elevating conveyor,

Fc=0.020 Tf=45m

From table 3, Q=33 S=0.2m/sec

POWER=$\frac{0.020(9+45)(3000+3.6\times33\times0.2)}{367} \pm \frac{3000\times3.042}{367}$ KW=33.76KW

3)Belt Tension:-

Effective tension(T_e) =Total empty friction+ Load Friction+ load slope friction

a)Return side friction=Fe×Q×L×0.4×(9.81×10^{-3}) KN

For horizontal and elevating conveyor, Fe=0.020

Return side friction= 0.020×33×9×0.4×(9.81×10^{-3}) KN=0.0233KN

Total empty friction=Fe×(L+tf)×Q×(9.81×10^{-3}) KN

Total empty friction= 0.020×(9+45)×33×(9.81×10^{-3}) KN=0.3496KN

Carrying side empty friction=total empty friction-return side friction =0.3263KN

b)Load friction=F_l(L+tf)$\frac{C}{3.6\times S}\times(9.81\times10^{-3})$ KN

For horizontal and elevating conveyor, F_l=0.025

Load friction=0.025(9+45)$\frac{3000}{3.6\times0.2}\times(9.81\times10^{-3})$ KN =55.181KN

c)Load slope tension=$\frac{CH}{3.6S}\times(9.81\times10^{-3})$ KN =$\frac{3000\times3.042}{3.6\times0.2}\times(9.81\times10^{-3})$ KN =124.24KN

d)Belt slope tension=B×H×(9.81×10^{-3}) KN=0.55×9×9.81×10^{-3} =0.486KN

Effective Tension,

Te=0.3496+55.181+124.34=179.8706 KN

Power is also calculated from Effective Tension,

Power=Te×S KW=179.8706×0.2=35.97 KW

4)Motor selection:-

At present,all the motors are of 1500rpm.

By referring the databook,the selected motor is of 37KW/1500rpm(nominal power).
The shaft diameter of motor is 60mm.

5)Belt Width:-

Belt Width=$\frac{T1}{Belt\ Strength\left(\frac{N}{mm}\right)}=\frac{179.8706\times10^{3}}{300}$=599.569mm

The belt strength of canvas belt is 300N/mm and the belt having properties like high tensile strength,corrosion resistance,wear and tear resistance.

6)Design of shaft:-

Drive pulley shaft design:-

T_e=179.8706KN

$T_1=T_e[\frac{\varepsilon}{e^{\mu\theta}-1}+1]=179.8706[\frac{1.66}{e^{0.35\times\pi}-1}+1]$=328.95KN

$T_2=T_1-T_e$=149.079KN

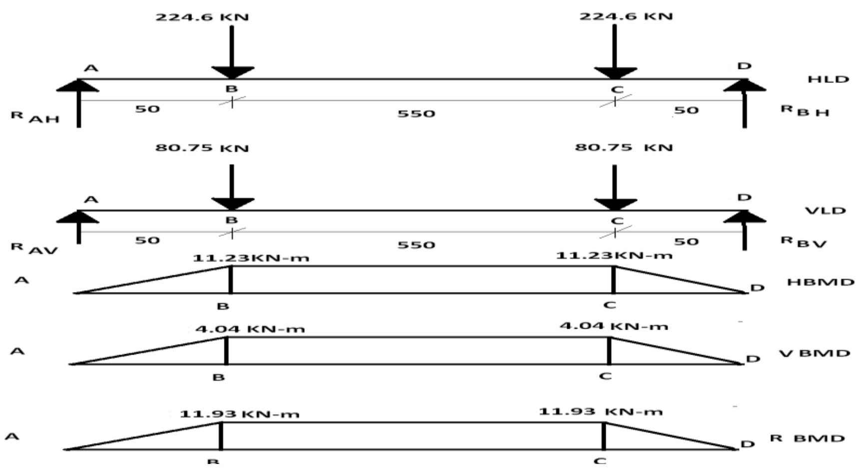

Fig2: Load and Moment Diagram

Allowable bending stress $6_b=\frac{32}{\pi\times d^3}\times M_{eq}$

$$d=\sqrt[3]{\frac{32\times21.24\times10^{3}}{65\times10^{6}\times\pi}}=0.1493m=149.3mm$$

The required diameter of the shaft pulley is 149.3mm

D.Simulation of Charging belt conveyor system:-

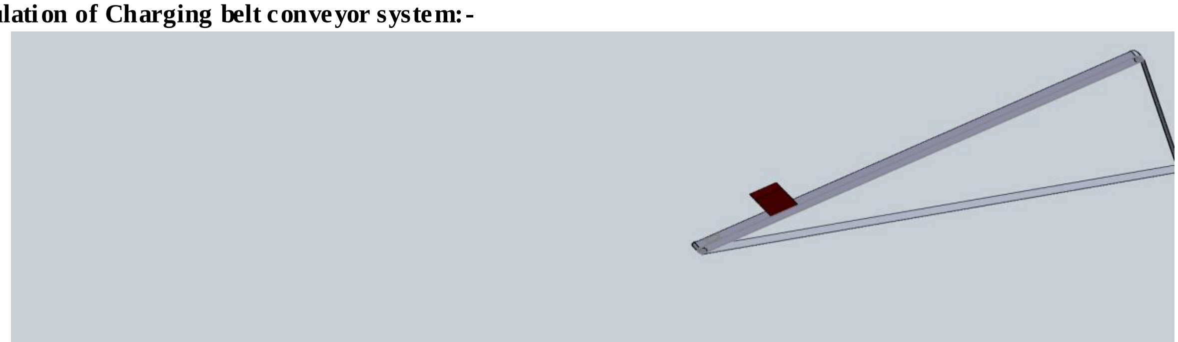

Figure 3-Simulation of Actual charging belt conveyor system

E.Analysis of actual charging belt conveyor system:

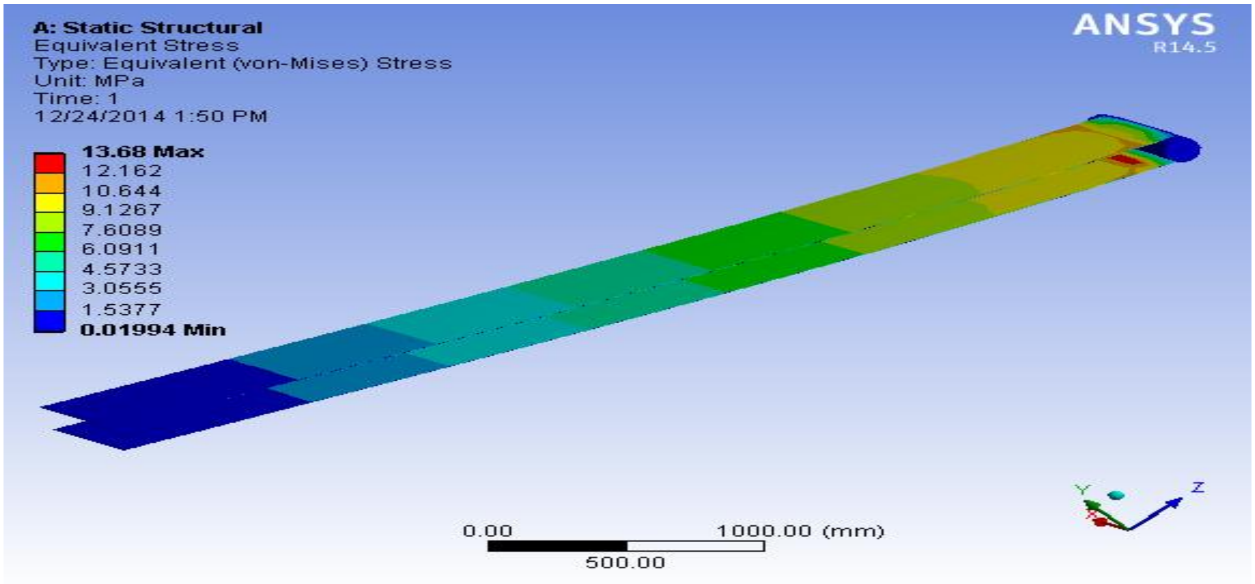

Figure 4- Analysis of actual charging belt conveyor system

F. From Actual Design of Charging Belt Conveyor System, The following problem or failure should be occur-

1) Belt slips when conveyor is started.
2) Belt slips while running.
3) The belt is stalling or jerking.
4) Excessive top cover wear over entire top surface or in load carrying area.
5) The covers are hardening and/or cracking.
6) Transverse breaks in belt at the edge.
7) Belt runs fine when it's empty but wont track right when it's loaded.

III. MODIFIED DESIGN OF THE CHARGING BELT CONVEYOR SYSTEM

1) By adding snub roller and Idlers for increasing the wrap angle between belt and pulley.

A.CONSTRUCTION:-

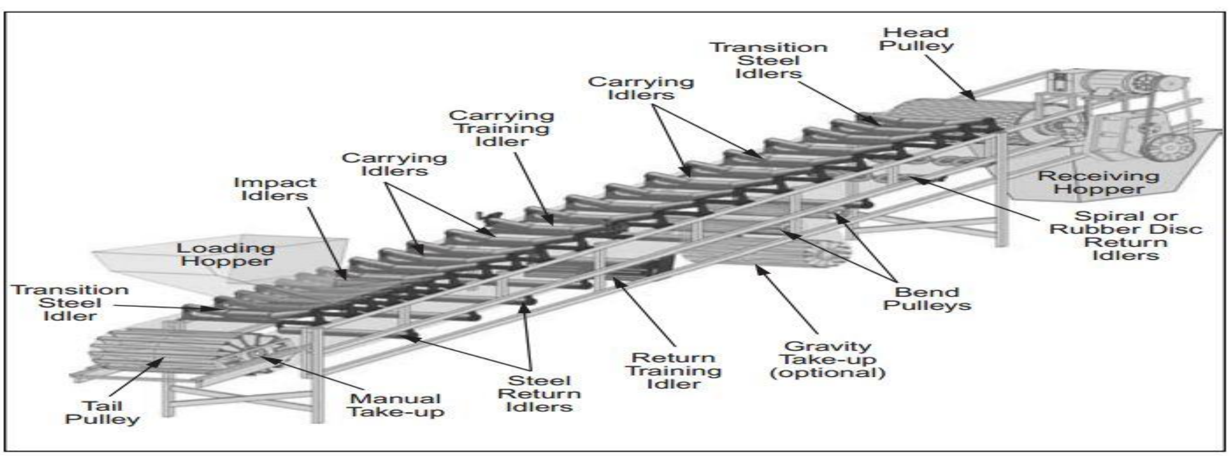

Figure 5:Modified design of charging belt conveyor system

SNUB ROLLER:-

Snub pulley is added to the bottom side of the conveyor for increasing the belt wrap between pulley and belt. Increases the slack side tension. Traction between belt and pulley increases.

B. IDLER FUNCTIONS

Idler is the supporting device for belt and cargo of a belt conveyor. Idlers move as the belt moves so as to reduce the running resistance of the conveyor. Idlers' qualities depend on the usage of the belt conveyor, particularly the life span of the belt. However, the maintenance costs of idlers have become the major part of the conveyor's operating costs. Hence, idlers need to have reasonable structure, durability in use, small ratio of steering resistance, reliability, and dust or coal dust cannot get in bearing, due to which the conveyor has a small running resistance, saves energy and prolongs the service life.

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Figure 6- Idlers used on a belt conveyor to support the belt on the carrying and return strands

THE FOLLOWING TYPE OF IDLERS ARE USED IN BELT CONVEYOR SYSTEM:

IMPACT IDLER:

Rubber-cushioned impact idlers are one solution for absorbing impact in the belt's loading zone. These idlers use rollers composed of resilient rubber disks to cushion the force of loading. Impact idlers typically have the same load rating as standard idlers, because they utilize the same shafts and bearings. The rubber covers absorb some of the energy to provide the benefit of shock absorption.

Even impact idlers are subject to impact damage, suffering damaged bearings and rollers from "too large" lumps or unusual impacts. Idlers with worn or seized bearings cause the belt to run erratically, allowing mistaking and spillage over the size of the belt. Idlers damaged from severe impact or seized due to fugitive material increase the conveyor's power consumption significantly. In many cases, it becomes more effective to absorb impact.

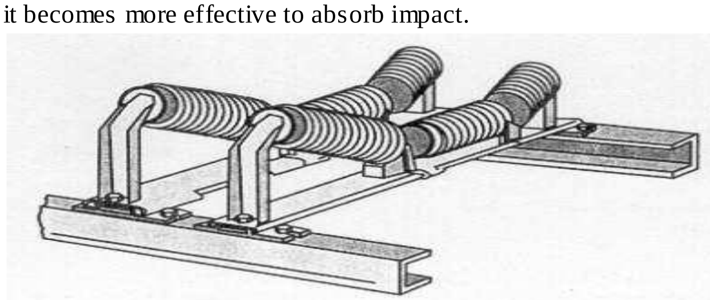


Figure 6- Impact Idler

CARRYING IDLERS:

Carrying idlers provide support for the belt while it carries the material. They are available in flat or troughed designs. The flat design usually consists of a single horizontal roll for use on flat belts, such as belt feeders.

The troughed idler usually consists of three rolls-one horizontal roll in the center with inclined rolls on either size. The angle of the inclined rollers from horizontal is called the trough angle. Typically, all three rolls are same length, although there are sets that incorporate a longer center roll and shorter inclined rollers called "picking idlers". This design supplies a larger flat area to carry material while allowing inspection.

TRAINING IDLER:

There are a number of designs for training idlers that work to keep the belt running in the center of the conveyor structure. Typically, these idlers are self-aligning: they react to any mistracking of the belt to move into a position that will attempt to steer the belt back into the center. They are available for both carrying side and return side application.

Belt-training idlers should never be installed under the carrying side of the belt in the load zone, as they sit higher than the adjacent regular carrying idlers and raise the belt as they swivel.

TRANSITION: These idlers ease the belt from a troughed configuration to the flat pulley surface. Reducing stress in the outer belt edges.

RETURN IDLER:

Return idlers provide support for the belt on its way back to the loading zone after unloading cargo. These idlers normally consist of a single horizontal roll hung from the undesirable of the conveyor stringers-return idlers, incorporating two smaller rolls, are sometimes installed to improve belt tracking.

IDLER SPACING:

The spacing between the rolling components has a dramatic effect on the idler support and shaping missions. Idlers placed too far apart will not properly support the belt nor enable it to maintain the desired profile. Placing idlers too close together will improve belt support and profile, but will increase conveyor construction costs and may lead to an increase in the conveyor's power consumption.

Normally, idlers are placed close enough to support a fully loaded belt so it will not sag excessively between them. If the belt is allowed too much sag, the load shifts as it is carried up and over each idlers and down into the valley between. This shifting of the load increases belt wear and power consumption. The sag also encourages material spillage.

The spacing of return idlers is determined by belt weight, because no other load is supported by these idlers and sag related spillage is not a problem on this side of the conveyor. Typical return idler spacing is3 meters.

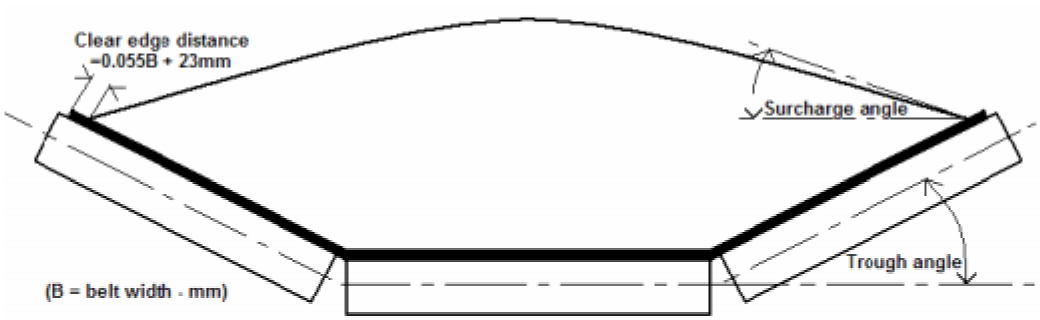
Driving device

Driving device is the power transmitting mechanism of a belt conveyor. It is made up of an electromotor, coupling, reducer and driving pulley and so on. According to different using conditions and working requirements, the drive mode of a belt conveyor can be grouped to single-motor driving, multi-motor driving, single-pulley driving, and double-pulley driving and multi-pulley driving.

Return pulley

A return pulley has three categories: 180^0. The return pulley's diameter is related to driving pulley's diameter and the wrap angle that the belt has on the return pulley. Return pulley is a welded-steel plate construction with an antifriction bearing.

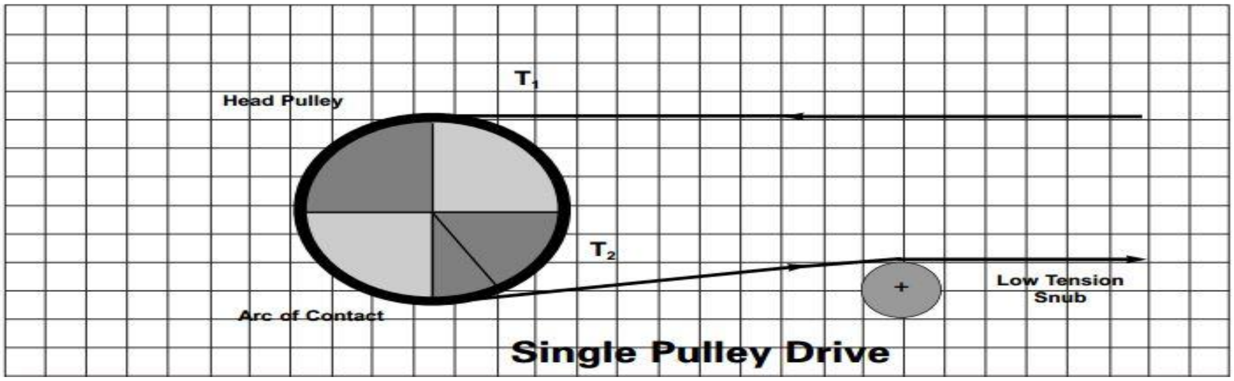
Trough Angle:-



The inclination of the side rollers of a transom (from 20° to 45°) defines the angle of the troughing. Troughing sets at 40° / 45° are used in special cases, where because of this onerous position the belts must be able to adapt to such an accentuated trough.

C. DESIGN CALCULATION OF CHARGING BELT CONVEYOR SYSTEM

1.BY ADDING SNUB ROLLER



From the actual design, we are taking the effective tension of the belt.

Effective Tension, T_e=179.8706KN

Diameter of the snub pulley=70mm

Distance between centre of the snub roller and drive pulley=400mm

T_1=Carrying side belt tension

$T_1=T_e[\frac{\varepsilon}{e^{\mu\theta}-1}+1]$

$T_1=179.8706[\frac{1.36}{e^{0.35\times3.316}-1}+1]$=291.48KN

$T_2=T_1-T_e$=291.48-179.8706=111.609KN

Allowable bending stress $\sigma_b=\frac{32}{\pi\times d^3}\times M_{eq}$

$$d=\sqrt[3]{\frac{32\times18.815\times10^3}{65\times10^6\times\pi}}=0.143m=143mm$$

With the modified design,

The required diameter of the shaft pulley is 143mm

D. Simulation of modified design of charging belt conveyor system:-

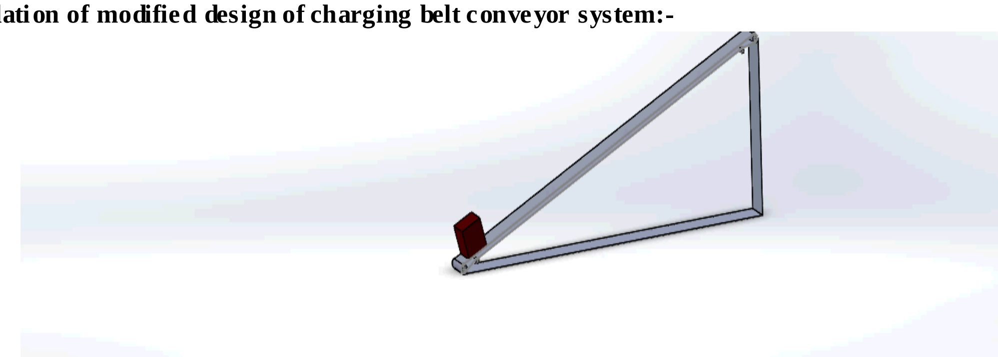
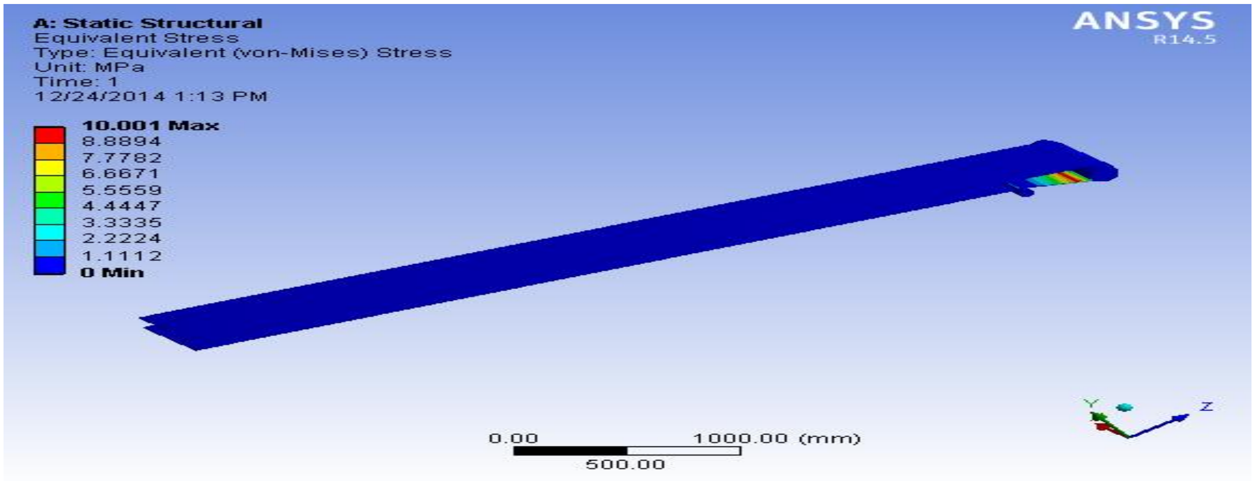


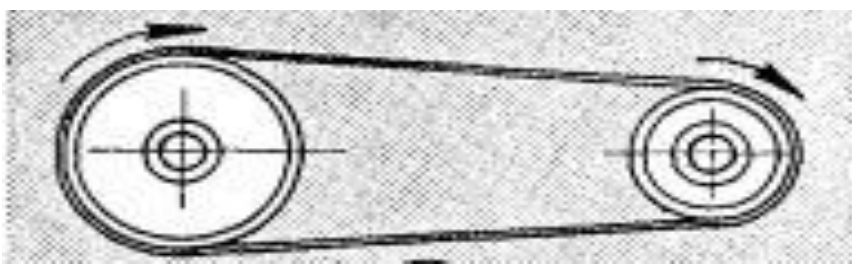
Figure 7:-Simulation of modified design of charging belt conveyor system.

E.Analysis of modified charging belt conveyor system:



IV. OPTIONAL DESIGN:-

A)BY INCREASING THE DIAMETER OF THE DRIVE PULLEY AND REDUCING THE DIAMETER OF THE TAIL PULLEY.ANGLE OF WRAP INCREASES.



Angle of wrap $Ø=200^0$

$\Theta=\frac{\pi}{180}\times 200=3.491$ rad

$T_1=T_e[\frac{\mathcal{E}}{e^{\mu\Theta}-1}+1]$

$T_1=179.8706[\frac{1.36}{e^{0.35\times 3.491}-1}+1]=282.076KN$

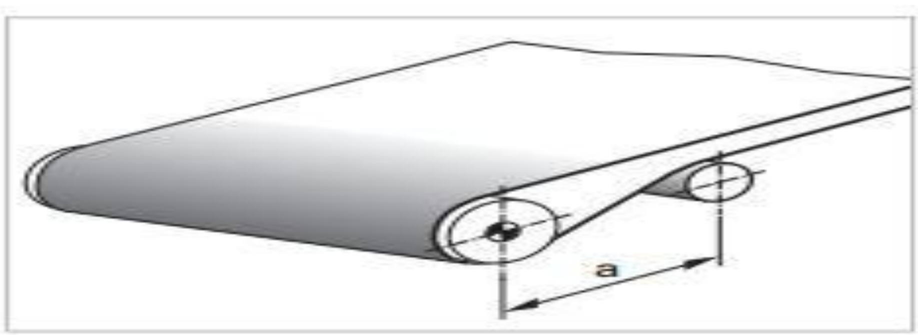
$T_2=T_1-T_e=282.076-179.8706=102.205KN$

Allowable bending stress $\sigma_b=\frac{32}{\pi\times d^3}\times M_{eq}$

$d=\sqrt[3]{\frac{32\times 18.139\times 10^3}{65\times 10^6\times\pi}}=0.142m=142mm$

With the modified design,
The required diameter of the shaft pulley is 142mm.

B. BY INCREASING THE DIAMETER OF THE DRIVE PULLEY AND ADDING A SNUB ROLLER.



With these changes, angle of wrap increases.
Angle of wrap $Ø=210^0=3.6652$ rad

$T_1=T_e[\frac{\Sigma}{e^{\mu\theta}-1}+1]$

$T_1=179.8706[\frac{1.36}{e^{0.35\times3.6652}-1}+1]=273.711KN$

$T_2=T_1-T_e=273.711-179.8706=93.84KN$

Allowable bending stress $б_b=\frac{32}{\pi\times d^3}\times M_{eq}$

$$d=\sqrt[3]{\frac{32\times17.475\times10^3}{65\times10^6\times\pi}}=0.1399m=139.9mm$$

With the modified design,
The required diameter of the shaft pulley is 139.9mm.

V. REMEDIES OVER THE FAILURE AND PROBLEM WHILE CHARGING BELT CONVEYOR OPERATION

1) Belt slips when conveyor is started.

-A) Insufficient traction between belt and drive pulley. Make sure drive pulley is free of built up.
-Increase belt wrap on drive pulley.
-Increase belt tension.
-B) One or more of the system pulleys are below the acceptable diameter. Replace pulleys with diameters acceptable to belt requirements.

2) Belt slips while running.

-A) Insufficient traction between belt and drive pulley. Make sure drive pulley is free of built up.
-Increase belt wrap on drive pulley.
-Increase belt tension.
-B) Material build-up on the pulley face or conveyor structure .Clean system, improves material containment, install cleaners, install material ploughs and scrapers.
-C) Replace pulleys with diameters acceptable to the belt requirements.

3) The belt is stalling or jerking.

-A) An improper slack side tension problem exists. Adjust the take up position. Lag the drive pulley or replace the current pulley lagging. Add a snub pulley behind the drive pulley to increase the wrap of the belt on the drive pulley.

4) Excessive top cover wear over entire top surface or in load carrying area.

-A) The top cover quality is not adequate for the system/material being conveyed. Upgrade to a heavier top cover. Upgrade to a better cover compound.
-B) Off centre loading or improper loading of the belt.
-C)Install Idlers with too much distance in between the idlers causing excessive material movement as the load travels up and over the Idlers. Decrease the distance between idlers, increase tension if the belt is under tensioned.

5) The covers are hardening and/or cracking.

-A) Heat or chemical damage to the belt. Make sure to use the correct belt carcass and compounds for the application.
-B) It is a natural tendency for rubber to get harder as it edges. This is due to the drying out of the plasticizers in the compound. AS belts age, and the rubber dries out, the cover wear will be accelerated. This is similar to what is commonly referred to as dry rot in tires.

6) Transverse breaks in belt at the edge.

-A)The belt edges are folding over on the system or folding up on the structure.Re-track belt, centre load point,cheak the belt as it comes into and through the load point, check to make sure the belt isn't coming into contact with the conveyor structure.
-B) Install troughing idlers and inadequate transition distance from the pulley to the troughing idlers.

7) Belt runs fine when it's empty but wont track right when it's loaded.

-A) The belt is not making good contact with the convex surface.
-B) Replace convex surface with idlers for proper belt contact.
-C) Off centre loading or improper loading of the belt.

VI.RESULT :

BENEFITS OVER OLD:-

- Increase belt wrap on drive pulley.
- Sufficient traction between belt and drive pulley.
- Sufficient belt tension.

- Clean system, proper material containment, proper scraping of the system.
- Proper slack side tension.
- Proper loading of the belt.
- The belt making good contact with the convex surface.
- Proper belt contact.

VII. CONCLUSION

This project provides a comprehensive knowledge of the basic production process theory of designing belt conveyor. The project focuses on choosing the right conveyor belt and suitable components to ensure manufacturing of high-quality belt conveyor. The existing problems of the idlers and belt conveyor are pointed out and proper solutions are given to make them a longer life. This project helps to improve the production by eliminating the various failures and other problem.

The final aim was to create a modified design to achieve large scale production, of idlers which enhances both the efficiency and productivity. In order to help the company to get larger sales market, a plan of designing a belt conveyor was carried out, but further research still is needed to make it come true.

The calculated shaft diameter is 149.3 mm and analysis and simulation of actual design of charging belt conveyor system. The problem occur during working of conveyor system should be determined.

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