# OPTIMIZATION OF ROLLER BELT CONVEYOR IN SUGARCANE INDUSTRY

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**Abstract:** Material handling is most important part of the industry and it is consuming a considerable proportion of the total power supply in industry. Material handling system contains various types like Lifts, AGV's, Conveyors, etc. from that conveyors are used mostly in industries for continuous handling. Belt conveyor is used to transport material from one location to another. Belt conveyor is a commonly used equipment of continuous transport it has a high efficiency, large conveying capacity and it can be achieved at different distances, different materials transportation. The task of transportation within the conveyor belt systems can be defined as a process aimed at the transportation of the determined quantity of handled material within a defined period of time between the specified loading and unloading locations. It is significant to reduce the energy consumption or energy cost of material handling sector. This task accordingly depends on the improvement of the energy efficiency of belt conveyors, as these are the main energy consuming components of material handling systems In this project the solution on more weight and power consumption is given. Hence in this project we are going to design the critical parts of roller belt conveyor used in sugarcane industry, i.e., roller, bracket, bearing, and frame of conveyor.

**Keywords**: - Material handling, energy

## I. INTRODUCTION

Material handling is an important part of the industry and consuming a considerable proportion of the total power supply. Material handling system contains various types like Lifts, AGV's, Conveyors, etc. from that conveyors are used mostly in industries for continuous handling. Conveyors are further classified in various types like, belt conveyor, roller conveyor, chain conveyor, screw conveyor, pneumatic conveyor, roller belt conveyor, etc. Belt conveyor is used to transport material from one location to another. Belt conveyor is a commonly used equipment of continuous transport it has a high efficiency, large conveying capacity and it can be achieved at different distances, different materials transportation. Now a day's Belt conveyor system not only used in mining industries but also applied in cement industries, power plant, food industries, production industries etc. So it is essential equipment for in house material transportation today. It has high load carrying capacity, large length of conveying path, simple design, easy maintenance and high reliability of operation. Belt conveyor system is also used various industries such as the material transport in foundry shop like supply and distribution of moulding sand, moulds and removal of waste, coal and mining industry, sugar industry, agricultural industry, bagasse industry, fuel industry etc.

The task of transportation within the conveyor belt systems can be defined as a process aimed at the transportation of the determined quantity of handled material within a defined period of time between the specified loading and unloading locations. To ensure operational reliability of the conveyor system consisting of rollers, roller brackets, bearings, belt lines, in terms of kinematic, dynamic, and energetic conditions is a very challenging task.

The coal loading conveyors can produce noise levels that become an annoyance, especially at night time when the ambient noise levels are low. For these reasons decreasing the noise produced by conveyors is an important topic, and producing an idler roller that lowers the noise emission from the conveyor belt

ISSN: 2231-5063.

assemblies which have significant benefits to both the workers in the factories and the community as a whole.

It is significant to reduce the energy consumption or energy cost of material handling sector. This task accordingly depends on the improvement of the energy efficiency of belt conveyors, as these are the main energy consuming components of material handling systems. Operation is another aspect for energy efficiency of belt conveyors. The operation efficiency in terms of operational cost of belt conveyors is improved by introducing load shifting. Speed control is recommended for energy efficiency of belt conveyor systems, even though it is occasionally challenged. The core of speed control is to keep a constantly high amount of material along the whole belt, which is believed to have high operation efficiency.

The weight of traditional steel idler rollers can also be a problem, particularly for wide belts which can have an individual roller weigh in excess of 20kg. This presents an Occupational Health and Safety risk, as the rollers often need to be maneuvered into hard to reach positions, or places with limited access. The maintenance or replacement of these idler rollers has the potential to injure the worker conducting such maintenance through back and muscle strains. Hence in this project we are going to design the critical parts of roller belt conveyor used in sugarcane industry, i.e., roller, bracket, bearing, and frame of conveyor.

## II. FAILURES IN BELT CONVEYORS

**Belt Failure**:

**i) Belt Slippage:**

When system motor is started then it may cause slip of belt on main drive pulley. It is due to improper tension of belts, long length of belt then requirement, heavy-duty starting, etc.

**ii) Improper deviation of belt:**

The lateral force generation on any side of belt may cause belt deviation, this is resulting due to following reasons:-

1. One side Loading of material on conveyor, and not in the middle of conveyor.
2. Improper installation of roller and roller axis with belt center.
3. Position of unloading roller is improper
4. Due to improper belt tension.
5. Wrong adjustment of Tail rollers, guide rollers can cause belt deviation

When the material is loaded improperly on any one side of belt, then the other side will be load free. This causes the pressure on loaded side rollers, and may damage the load bearing components like supporting bracket, ball bearings etc. Thus proper adjustment of above causes can make a system with good deviation in belt.

**Failure causes in rollers:**

i) The roller is main component of roller conveyor system. The positive or negative working of roller may affect working of conveyor system in same way. According to the actual work of conveyor, roller in the conveyor system can be classified four kinds according their working carrying roller, impact roller, return roller. According to the loads, it can be divided two kinds, no-load roller and bearing roller.

ii) Carrying rollers are used to support the conveyor belt and are installed on the groove shape frame, impact rollers are used as carrying rollers instead of normal steel rollers at a loading point. Return rollers are used when the straight tracking of the belt may be compromised by the type of conveyed material, especially when this material is sticky and thereby adheres easily to the belt surface. In this case, material is also deposited on the return rollers that support the belt, adding an irregular addition of scale to the roller itself.

**Failure causes in drive unit:**

i) The drive unit consists of electric motor, damping coupling, two stage gearbox and coupling that connect output shaft with pulley. A crucial object in this subsystem is gearbox. According to Matuszewski in a considered lignite open coal handling system even 14 % of gear boxes may be replaced each year due to unexpected failures.

ii) These failures are related to the geared wheel wear or damages (broken tooth) and bearing (mainly over limit backlash due to environmental impact, also typical failures like outer/inner race, rolling element).

ISSN: 2231-5063.

## III. CASE STUDY ON ROLLER BELT CONVEYOUR IN SUGARCANE INDUSTRY

**IV.** IN SUGARCANE FACTORY ROLLER BELT CONVEYOR SYSTEM IS USED MOSTLY FOR CARRYING SUGAR BAGS FROM PACKAGING TO GOWDOWN. THE ROLLER BELT CONVEYOR SYSTEM IS MOST RELIABLE SYSTEM IN FACTORY. THE POWER CONSUMPTION OF THIS CONVEYOR IS IMPORTANT. ADVANTAGES AND DISADVANTAGE OF THIS CONVEYOR SYSTEM ARE:

Advantages
- Robust in design
- Long life

Disadvantages
- Consumes more power.
- Heavy in weight
- Fatigue to worker while maintenance

Due to heavy design and high weight of system many problems like power consumption and heavy weight increses. So to overcome this problems optimization of system is a solution. This optimization can be carries out by using following cases.

After study of existing system, design of that system for optimization will be started. The critical load bearing components like roller, bracket and L channel Frame will be designed by iterative method. Optimization of system will be according to one of the following cases:
- Case I - Changing dimensions of system and keeping material same as it is.
- Case II - Keeping same dimensions and changing material of components,
- Case III - Changing both material as well as dimensions of component.

**This are some important steps:**

**Data collection of Roller belt conveyor in sugarcane factory.**

The specification and related data collection on existing roller belt conveyor in sugarcane factory is collected. The important data like material, quantity of components, measurements, etc. of components like roller, bracket, frame, etc. will be collected. The system consist of following components

| Sr. no. | Name of Component | Material | Quantity |
|---|---|---|---|
| 1 | Roller | MS | 18 |
| 2 | Roller Shaft | MS | 18 |
| 3 | Support bracket | MS | 36 |
| 4 | Bearings | STD | 36 |
| 5 | Base Frame | C 10 | 1 |

**Table no. 1**

**Specifications on existing conveyor**

The following are specifications of components of existing belt conveyor for calculations

| Sr. No. | Name Of Element | Specifications |
|---|---|---|
| 1 | Roller | Outer diameter, $D_1$ = 76 mm<br>Inner diameter, $D_2$ = 66 mm<br>Length of roller, L = 680 mm |
| 2 | Roller Shaft | Diameter of shaft, d = 12 mm |
| 3 | Support bracket | Thickness, t = 10 mm<br>Height = 112 mm |
| 4 | Base Frame | L channel Frame<br>35 × 35<br>Thickness of L channel = 5 mm |

**Table no. 2**

**Calculations on existing conveyor**

Calculation on existing system consist of its critical parts on which load is more, will be designed. This critical parts are roller, support bracket, base frame.

**2D and 3D modelling and analysis**

Modelling of the existing belt conveyor system will be by using CATIA software and after proper modelling the analysis of system will be done using ANSYS software.

**Design of system for optimization**

After study of existing system, design of that system for optimization will be started. The critical load bearing components like roller, bracket and L channel Frame will be designed by iterative method. Optimization of system will be according to one of the following cases:

1. Changing dimensions of system and keeping material same as it is.
2. Keeping same dimensions and changing material of components,
3. Changing both material as well as dimensions of component.

**Modelling and analysis of optimized design**

**Tests and comparison between existing and new design**

Experimental tests of roller for calculation of deformation and stresses in it will be carried out on universal test machine. Our college provide us universal testing machine. After experimentation of this rollers; the comparison between results of existing and optimized design will be done.

**Validation of results for new**

Best design will be finalize and submitted to factory.

## V. CASE I: CHANGING DIMENSIONS OF SYSTEM AND KEEPING MATERIAL SAME AS IT IS.

Calculations of critical parts like roller, support bracket, base frame is carried out.
Here we didn't changed the material of component, we are just changing the geometry.

**Design of roller**

Material - MS
For given material we have to select standard properties of that material, such as
$E= 2.10\times10^5$ Mpa
Syt= 590 Mpa
ρ= 7860 kg/m3
Considering uniformly distributed load & FOS as 3
We have to calculate actual FOS for optimised roller.
Allowable Stress (σall) = Syt / Fs
= 590/3
= 196.67 Mpa.
Maximum Stress Calculation for given condition
W= 50 kg
D1= Outer diameter of roller = 76 mm
D2= Inner diameter of roller = 66 mm
L= Length of roller = 680 mm.
y = Distance from neutral axis = 76/2
= 38 mm

Considering Uniformly Distributed load
Maximum moment ($M_{max}$) = $W\times L^2 /8$
$= (50\times9.81\times 0.68^2) / 8$
= 28.35 N-m.
Moment of Inertia (I) = $\pi (D1^4 - D2^4) / 64$
$= \pi (0.076^4 – 0.066^4) / 64$
$= 7.0624\times10^{-7} m^4$.
Maximum Bending Stress
(σb) = Mmax x Y / I
$= 28.035 \times 0.038 / (7.0624\times10^{-7})$
σb = 1.525 Mpa.
Checking Factor of Safety for design.
FOS= (σall) / (σb)
= 196.67 / 1.525
FOS= 128.96
As calculated factor of safety (FOS) is greater than assume factor of safety,
So selected material can be considered as a safe.

ISSN: 2231-5063.

Maximum deformation

$(Y_{max})$= 5 x W x $L^3$/48 x E x I

= (5 x 50 x 9.81 x $0.68^3$) / (48 x $2.10\times10^5$ x $7.0624\times10^{-7}$)

$(Y_{max})$ = 0.0134 mm.

Comparison with length 680 mm deformation obtained 0.0134 mm is very negligible. Hence selected material can be considered as safe for the same material.

Weight of Rollers = Cross section area x width x mass density x numbers of rollers

= $\pi$ /4 ($D1^2$ - $D2^2$) x w x ρ x 18

= $\pi$ /4($0.076^2$ – $0.066^2$) x 0.680 x 7860 x 18

= 108 Kg.

**Same alike above, 9 iterations was carried out and best design was selected.**

| **Iteration no** | **OD** | I.D (mm) | Mmax (Mpa) | Deformation (mm) | F.O.S | Weight of roller(Kg) | Reduction in weight of roller(Kg) |
|---|---|---|---|---|---|---|---|
| 1 | 76 | 66 | 28.35 | 0.01354 | 129.38 | 108 | - |
| 2 | 70 | 60 | 28.35 | 0.0176 | 108 | 98 | 10 |
| **3** | **80** | **75** | **28.35** | **0.02009** | **79.30** | **59** | **49** |
| 4 | 76 | 71 | 28.35 | 0.02450 | 71.25 | 56 | 52 |
| 5 | 60 | 50 | 28.35 | 0.02901 | 76.22 | 83.11 | 24.89 |
| 6 | 60 | 55 | 28.35 | 0.05141 | 43.03 | 43 | 65 |
| 7 | 57 | 47 | 28.35 | 0.03439 | 67.81 | 79 | 29 |
| 8 | 70 | 65 | 28.35 | 0.03166 | 59.96 | 51 | 57 |
| 9 | 65 | 60 | 28.35 | 0.03984 | 51.34 | 47 | 61 |
| 10 | 75 | 70 | 28.35 | 0.02553 | 69.35 | 95.88 | 12 |

**So the best design was selected with OD = 80 mm and ID = 75mm**

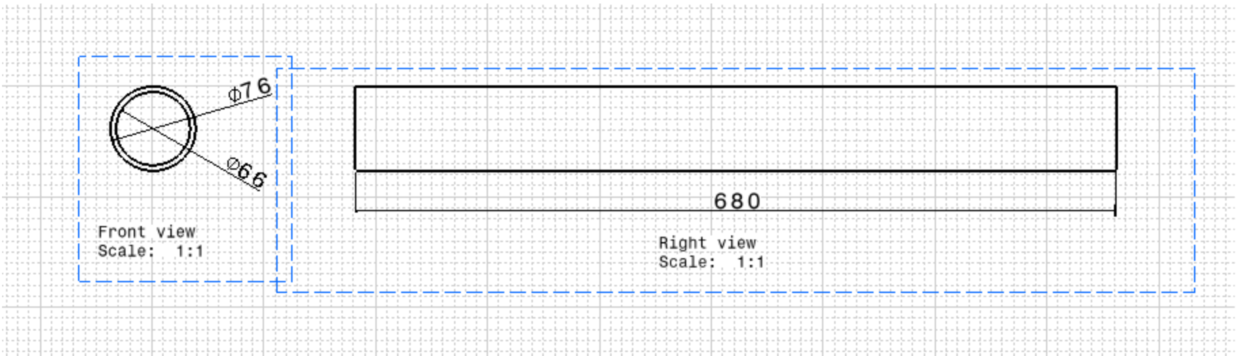


Fig. Drafting view of existing roller

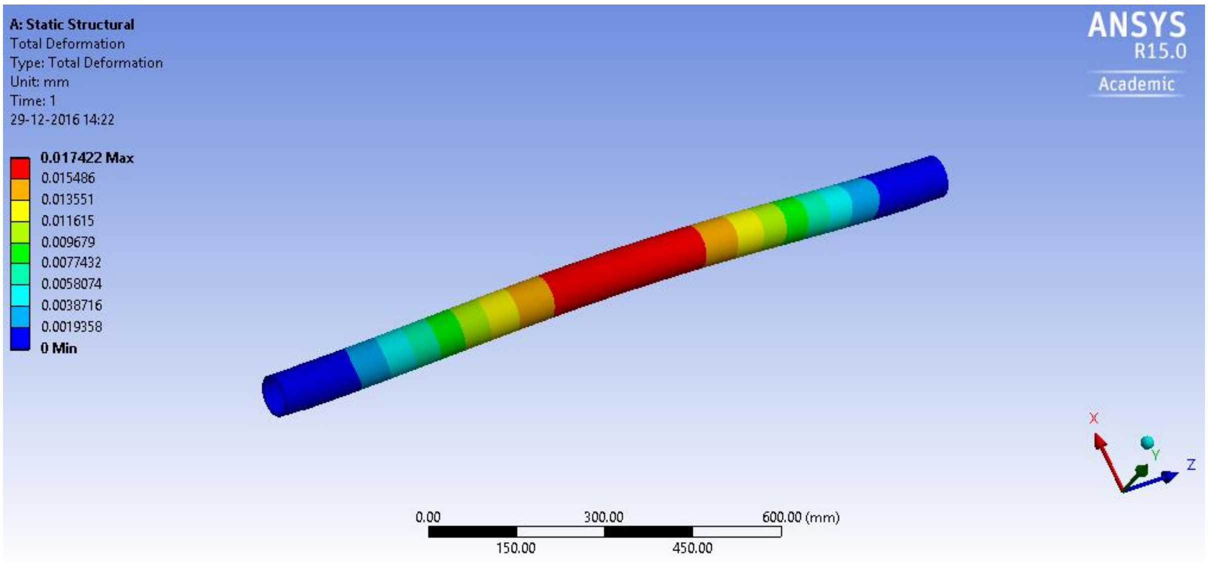


Fig. Stress analysis of existing roller

**Design of supporting bracket**
Material - MS
For given material we have to select standard properties of that material, such as
E= 2.10×105 Mpa
Syt= 590 Mpa
ρ = 7860 kg/m3
Considering uniformly distributed load & FOS as 2
We have to calculate actual FOS for existing roller.
Allowable Stress (σall) = Syt / Fs
= 590/2
= 295 Mpa.
Maximum Stress Calculation for given condition, we are selecting the maximum load conditions on roller i.e one bag of sugar having weight 50 kg and support bracket used to fix the roller on both sides, therefore 50 Kg will be distributed as 25 Kg on each support bracket ,
W= 25 kg
h = Depth of Section.
t = Thickness of Section.
L = 112 mm. h= 82 mm
t =10 mm.
y = Distance from neutral axis = 5 mm.
Ixx= $2.73\times10^{-6}$ $mm^4$
Considering simply supported beam with load act at centre
Maximum moment (Mmax) = W x L /4
= (25×9.81)× 0.112/4
= 6.867 MPa

Maximum Bending Stress (σb) = Mmax ×Y/ I
= 6.867 x 0.005 / (2.73 × 10-6)
σb = 12.57 Mpa.
Checking Factor of Safety for design.
FOS= (σall) / (σb)
= 295 / 12.57
FOS= 23.46
As calculated factor of safety (FOS) is greater than assume factor of safety, hence selected material can be considered as a safe.
Maximum deformation ($Y_{max}$) = W x $L^3$/48 x E x I
= (25 x 9.81x $0.112^3$) / (48 x $2.10\times10^5$ x 2.73 × $10^{-6}$)

ISSN: 2231-5063.

$(Y_{max}) = 0.0125$ mm.

Weight of Support Bracket = Cross section area x length x mass density x numbers of bracket

$= 1.12\times10^{-3} \times0.112\times7860\times36$

$= 35.49$ kg.

**Same alike above, 2 iterations was carried out and best design was selected.**

| **Iteration no** | **L** | H | t | Y | Deformation | F.O.S | Weight of roller(Kg) | Reduction in weight of roller(Kg) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.112 | 0.82 | 0.010 | 0.005 | 0.0125 | 23.46 | 35.49 | - |
| 2 | 0.112 | 0.82 | 0.006 | 0.003 | 0.0125 | 23.46 | 21.29 | 14.19 |
| **3** | **0.1** | **0.8** | **0.006** | **0.003** | **0.0123** | **31.61** | **8.48** | **27** |

**So the best design was selected with L = 100 mm, h = 80mm and t= 6 mm.**

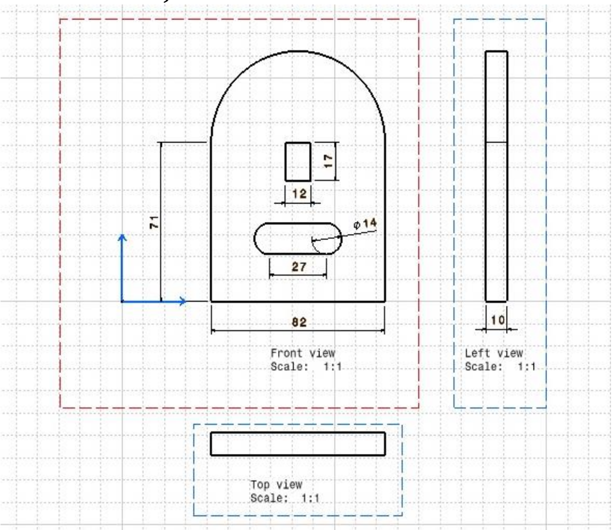


Fig. Drafting view of existing supporting bracket

## VI. CONCLUSION:

The following points was concluded in this project:-

- Existing design calculations shows the factor of safety is very greater than requirement and there is a scope for weight reduction.
- Critical parameters which reduce the weight are roller, support bracket.
- Though value of deformation, stress is more in case of optimized design, but its allowable.
- 40% of weight reduction achieved by optimized design than existing design.
- 39.69 kg. weight reduction achieved by optimize design than existing design

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