

## Design of belt convey our system with case study of application in sugarcane factory

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### Abstract

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. 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, conveyors, AGV's

### 1. 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 <sup>[1]</sup>.

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 assemblies which have significant benefits to both the workers in the factories and the community as a whole <sup>[9]</sup>.

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.

### 2. Literature Review

Mr. Amol Kharage *et al.* <sup>[2]</sup>: The main objective of this paper was to analysis the gravity Roller Conveyor, the detail study of existing gravity roller and optimizing its parts by using

composite material, so weight reduction of system is achieved. A finite element model was generated of existing system by using Pro-E software. In this paper only roller is optimized by using composite material.

**Tabello Mathaba and Xiaohua Xia** <sup>[3]</sup>: The aim of this paper was to propose a generic energy model based on belt resistance for long belt conveyor. Here they have used two parameter power equation and also partial differential equation through the belt for calculating the variability of the material mass per unit length on the belt in order to give a more accurate representation of the transported bulk material throughout the belt. Here they have achieved with the error of less than 4 % the power consumption calculation of newly proposed simpler model are consistent with those of known non-linear model.

**Shirong Zhang, Xiaohua Xia** <sup>[4]</sup>: The aim of this paper focuses on the saving energy of the belt conveyor system through improvement of the operation efficiency, thus optimization is employed here. We begin with the energy model of belt conveyors which is the base of optimization. The existing energy models are reviewed and then an analytic model, lumping all the parameters into four coefficients, was proposed. The four coefficients of the new model can be derived from the design parameters or be estimated through field experiments. The latter guarantees an improved accuracy of the model, consequently, the practicability of the energy optimization of belt conveyors. Off-line parameter estimation, based on least square (LSQ), and on-line parameter estimation, based on recursive least square (RLSQ), proposed to the identification of this energy model respectively. Off-line parameter estimation is applicable for the belt conveyors without permanent instruments for electrical power of motor, for belt speed and for feed rate. On the other hand, if a belt conveyor is equipped with permanent instruments, on-line parameter estimate is adopted to update the coefficients of the energy model automatically. Simulation results are presented to show the applicability of the proposed off-line and on-line parameter estimation of the energy model.

**Miroslav Bajda and Robert Krol** <sup>[5]</sup>: The aim of this paper was to reduce the energy consumption of belt conveyor by reducing the resistance of conveyor. The various resistances are belt rolling conveyor, sliding resistance of conveyor, bending resistance, idlers turning resistance, flexure resistance of bulk materials. The biggest savings of energy is expected in belts and idlers selection, and in some cases in unconventional solutions of the route. The test rig was used to test various resistances of the idlers and belt. By decreasing this resistance 34 % energy conservation was achieved. The belt conveyor used in mining was took in study.

**Yogesh Padwal and Satish Rajmane** <sup>[6]</sup>: The aim of this paper was to convert the material handling from fork lift to belt conveyor of 30 m distance. The optimization in some parts like roller and frame was done in this paper. To develop the FEA model for engineering problem, solving requirements like static, dynamic, and nonlinear behavior; MSC/PATRAN software is used. The analysis was carried out by using MSC/NASTRAN software.

**Pranav Deshmukh et al.** <sup>[7]</sup>: The aim of this paper focuses on choosing the right belt conveyor and suitable components in the system. It was a sponsored project carried out in Yash Enterprises, Khamgaon, Buldhana. The problems of various components in the system was carried out and the proper solution was given to make larger life of components. The final

aim was to create a modified design to achieve larger scale production of idler which enhance the efficiency and productivity. The remedies on various problems was given in this paper.

**Rohini Sangolkar et al.** <sup>[8]</sup>: In this paper the study of structural analysis was done. The modelling is done by using Creo Software and the FEA is performed to obtain variation of stress at critical location of system using the ANSYS software and applying the boundary conditions to evaluate the total deformation, equivalent stress and shear stress. ASTM A-36 hot rolled steel bar and nylon 66 materials was studied for rollers in system and belt respectively.

## 2.1 Findings from Literature Review

From all above papers, it is found that they have used the conveyor system and worked on energy conservation of conveyor and weight reduction of single component in system. In my project work I mainly concentrate on the weight reduction technique on all critical components of conveyor system using Modelling and analysis software.

## 2.2 Scope

The present scenario of factory is high weight belt conveyor that causes various issues for workers like back and muscles strain at time of maintenance due to heavy weight of system and technical issues like difficulty in maintenance of critical components. The detail study of current belt conveyor system with its design and specifications and finding suitable method for optimization of current design, and later wards results of redesign compile as modelling will be done using CATIA software and analysis of components will done using ANSYS software. Results of Linear static, Model and Transient analysis of existing design and optimized design are compared to prove design is safe. Optimization leads to give an appropriate optimum design for carrying the same load while saving the material of system, weight reduction and power conservation of the system.

## 3. Problem Definition

The current design for belt conveyor is heavy weight that includes the critical parts like roller, roller shaft, supporting brackets, L channel base frame which directly affects on excess use of material with increase in costs, so that power consumption and also the maintenance is more due to heavy weight system. To overcome these problem redesign of existing system and analysis with optimization will be done.

## 4. Design and Calculations

### 4.1 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

**Table 1:** List of components in factory

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

### 4.2 Specifications on existing conveyor

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

**Table 2:** Specifications of components of belt conveyor in factory

Sr. No.	Name Of Element	Specifications
1	Roller	Outer Diameter, $D_1 = 76$ Mm Inner Diameter, $D_2 = 66$ Mm Length Of Roller, $L = 680$ Mm
2	Roller Shaft	Diameter Of Shaft, $D = 12$ Mm
3	Support Bracket	Thickness, $T = 10$ Mm Height = 112 Mm
4	Base Frame	L Channel Frame $35 \times 35$ Thickness Of L Channel = 5 Mm

### 4.3 Calculations on existing conveyor

Material - MS

For given material we have to select standard properties of that material, such as

$$E = 2.10 \times 10^5 \text{ Mpa}$$

$$S_{yt} = 590 \text{ Mpa}$$

$$\rho = 7860 \text{ kg/m}^3$$

Considering uniformly distributed load & FOS as 3

We have to calculate actual FOS for optimised roller.

$$\text{Allowable Stress } (\sigma_{all}) = S_{yt} / F_s$$

$$= 590/3$$

$$= 196.67 \text{ Mpa.}$$

Maximum Stress Calculation for given condition

$$W = 50 \text{ kg}$$

$$D_1 = \text{Outer diameter of roller} = 76 \text{ mm}$$

$$D_2 = \text{Inner diameter of roller} = 66 \text{ mm}$$

$$L = \text{Length of roller} = 680 \text{ mm.}$$

$$y = \text{Distance from neutral axis} = 76/2$$

$$= 38 \text{ mm}$$

Considering Uniformly Distributed load

$$\begin{aligned} \text{Maximum moment } (M_{max}) &= W \times L^2 / 8 \\ &= (50 \times 9.81 \times 0.682) / 8 \\ &= 28.35 \text{ N-m.} \end{aligned}$$

$$\begin{aligned} \text{Moment of Inertia } (I) &= \pi (D_1^4 - D_2^4) / 64 \\ &= \pi (0.076^4 - 0.066^4) / 64 \\ &= 7.0624 \times 10^{-7} \text{ m}^4. \end{aligned}$$

Maximum Bending Stress

$$\begin{aligned} (\sigma_b) &= M_{max} \times Y / I \\ &= 28.35 \times 0.038 / (7.0624 \times 10^{-7}) \\ \sigma_b &= 1.525 \text{ Mpa.} \end{aligned}$$

Checking Factor of Safety for design.

$$FOS = (\sigma_{all}) / (\sigma_b)$$

$$= 196.67 / 1.525$$

$$FOS = 128.96$$

As calculated factor of safety (FOS) is greater than assume factor of safety,

So selected material can be considered as a safe.

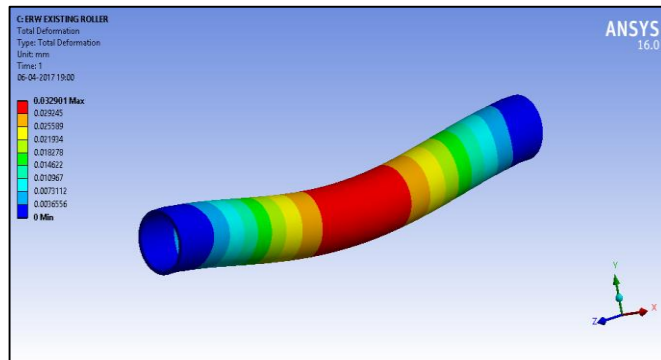
Maximum deformation

$$\begin{aligned} (Y_{max}) &= 5 \times W \times L^3 / 384 \times E \times I \\ &= (5 \times 50 \times 9.81 \times 0.68^3) / (384 \times 2.10 \times 10^5 \times 7.0624 \times 10^{-7}) \\ (Y_{max}) &= 0.0134 \text{ mm.} \end{aligned}$$

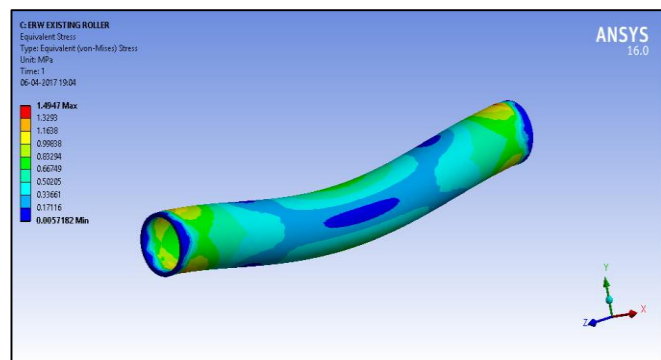
Comparison with length 680 mm deformation obtained 0.0134 mm is very negligible. Hence selected material can be considered as safe for the same material.

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

$$\begin{aligned} &= \pi / 4 (D_1^2 - D_2^2) \times w \times \rho \times 18 \\ &= \pi / 4 (0.076^2 - 0.066^2) \times 0.680 \times 7860 \times 18 \\ &= 108 \text{ Kg.} \end{aligned}$$



**Fig 1:** Total deformation of existing roller.



**Fig 2:** Equivalent Stress of existing roller

### 4.3 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.

$$D_1 = \text{Outer diameter of roller} = 76 \text{ mm}$$

$$D_2 = \text{Inner diameter of roller} = 72.5 \text{ mm}$$

$$L = \text{Length of roller} = 680 \text{ mm.}$$

$$y = \text{Distance from neutral axis} = 76/2$$

$$= 38 \text{ mm}$$

Considering Uniformly Distributed load

$$\begin{aligned} \text{Maximum moment } (M_{max}) &= W \times L^2 / 8 \\ &= (50 \times 9.81 \times 0.68^2) / 8 \\ &= 28.35 \text{ N-m.} \end{aligned}$$

$$\begin{aligned} \text{Moment of Inertia } (I) &= \pi (D_1^4 - D_2^4) / 64 \\ &= \pi (0.076^4 - 0.0725^4) / 64 \\ &= 2.81 \times 10^{-7} \text{ m}^4. \end{aligned}$$

Maximum Bending Stress

$$\begin{aligned} (\sigma_b) &= M_{max} \times Y / I \\ &= 28.35 \times 0.038 / (2.81 \times 10^{-7}) \\ \sigma_b &= 3.8 \text{ Mpa.} \end{aligned}$$

Checking Factor of Safety for design.

$$FOS = (\sigma_{all}) / (\sigma_b)$$

$$= 196.67 / 3.8$$

$$FOS = 51.30$$

As calculated factor of safety (FOS) is greater than assume factor of safety,

So selected material can be considered as a safe.

Maximum deformation

$$(Y_{max}) = 5 \times W \times L^3 / 384 \times E \times I$$

$$= (5 \times 50 \times 9.81 \times 0.68^3) / (384 \times 2.10 \times 10^5 \times 2.81 \times 10^{-7})$$

$$(Y_{max}) = 0.0340 \text{ mm.}$$

Comparison with length 680 mm deformation obtained 0.0340 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

$$= \pi / 4 (D1^2 - D2^2) \times w \times \rho \times 18$$

$$= \pi / 4 (0.076^2 - 0.0725^2) \times 0.680 \times 7860 \times 18$$

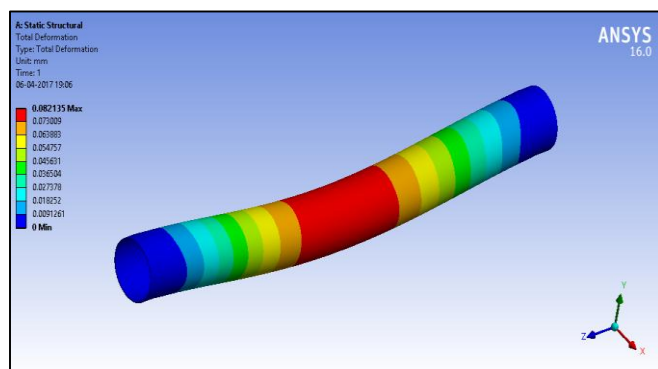
$$= 39.3 \text{ Kg.}$$

Same iterations on various dimensions was carried on is tabulated below.

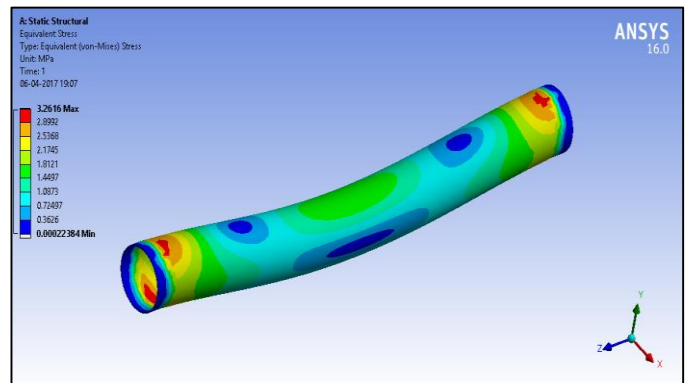
**Table 3:** Iterations carried out for roller according to case 1

Sr. No.	OD (Mm)	ID (Mm)	M Max	$\sigma_b$ (Mpa)	FOS	Deformation (Mm)	Actual Weight (Kg)	Weight Per Roller (Kg)	Weight Reduction (Kg)
1	0.0635	0.06	28.35	5.5	35.38	0.0602	32.7	1.8	75
2	0.0635	0.0595	28.35	4.9	39.77	0.0525	37.2	2.1	71
3	0.0635	0.059	28.35	4.4	44.35	0.0471	41.7	2.3	66
4	0.0635	0.058	28.35	3.7	52.88	0.0395	50.5	2.8	58
5	0.0635	0.057	28.35	3.2	60.96	0.0342	59.2	3.3	49
6	0.076	0.0725	28.35	3.8	51.30	0.0347	39.3	2.2	69
7	0.076	0.072	28.35	3.3	58.05	0.0308	44.7	2.5	63
8	0.076	0.0715	28.35	3.0	64.63	0.0273	50.2	2.8	58
9	0.076	0.0705	28.35	2.5	77.59	0.0227	60.9	3.4	47
10	0.076	0.0695	28.35	2.1	89.82	0.0194	71.5	4.0	37
11	0.089	0.085	28.35	2.4	80.60	0.0185	52.6	2.9	55
12	0.089	0.0845	28.35	2.1	89.95	0.0166	59.0	3.3	49
13	0.089	0.0835	28.35	1.8	108.0	0.0138	71.7	4.0	36
14	0.089	0.0825	28.35	1.5	125.4	0.0119	84.2	4.7	24
15	0.070	0.060	28.35	1.8	108	0.0176	98	5.4	10
16	0.080	0.075	28.35	2.4	79.30	0.02009	59	3.2	49
17	0.076	0.071	28.35	2.7	71.25	0.02450	56	3.1	52
18	0.060	0.050	28.35	2.5	76.22	0.02901	83.11	4.6	24.89
19	0.060	0.055	28.35	4.5	43.03	0.05141	43	2.3	65
20	0.057	0.047	28.35	2.9	67.81	0.03439	79	4.3	29
21	0.070	0.065	28.35	3.2	59.96	0.03166	51	2.8	57
22	0.065	0.060	28.35	3.8	51.34	0.03984	47	2.6	61
23	0.075	0.070	28.35	2.8	69.35	0.02553	95.88	5.3	12

By studying all above iterations design with 76 mm outer and 72.5 mm inner diameter is selected as best solution. The deformation and stress analysis is shown below.



**Fig 8.3:** total deformation of optimized roller



**Fig 8.4:** Equivalent stress of optimized roller

**5. Results**

So After calculations the results of existing and optimized system is as follow

**Table 4:** Comparison of Results of Optimized Roller Design Calculations with Andy's Results

Dimensions	Design Calculations Results		Ansys Results	
	Deformation	Stress	Deformation	Stress
OD= 76 Mm ID= 72.5 Mm	0.0347 Mm	3.8 Mpa	0.0821 Mm	3.26 Mpa

**Table 5:** Comparison of Existing and Optimized System

Sr. No.	Component	Weight of Existing System	Weight of Optimized system	Weight reduction
1	Roller	108 Kg	39.3 Kg	68.7 Kg
2	Supporting Bracket	25.98 Kg	10.39 Kg	15.59 Kg
3	Shaft	11.69 Kg	11.69 Kg	-
4	Base Frame	51 Kg	51 Kg	-
5	L channel frame	77 Kg	77 Kg	-
TOTAL WEIGHT		273.67 Kg	189.38 Kg	84 Kg

## 6. Conclusion

Design calculations, analysis model of existing system and optimized system are compared on deformation and stress basis. The weight reduction achieved on roller does not affect the load carrying capacity of system. 84 Kg weight reduction is achieved by optimize design than existing design.

## 7. References

1. Pawar Jyotsna, DD Date, Pratik Satav Design And Optimization Of Roller In Belt Conveyor System For Weight Reduction International Journal of Mechanical And Production Engineering.
2. Mr. Amol B.Kharage, Prof. Balaji Nelge, Prof. Dhumal Ketan Analysis And Optimization Of Gravity Roller Conveyor Using Ansys International Journal Of Engineering Sciences Research Technology.
3. Tebello Mathaba, Xiaohua Xia A Parametric Energy Model for Energy Management of Long Belt Conveyors.
4. Shirong Zhang, Xiaohua Xia. Modeling and energy efficiency optimization of belt conveyors. 'Journal homepage: [www.elsevier.com/locate/apenergy](http://www.elsevier.com/locate/apenergy), 2011.
5. Miroslav Bajdaa, Robert Krol, "Experimental Tests of Selected Constituents of Movement Resistance of the Belt Conveyors Used in the Underground Mining. World Multidisciplinary Earth Sciences Symposium, WMESS, 2015.
6. Yogesh Tanajirao Padwal, Mr. Satish M. Rajmane, Swapnil S. Kulkarni, Design and Analysis of a Roller Conveyor for Weight Optimization & Material Saving. International Journal of Advanced Engineering Research and Studies. 2013, 138-140. E-ISSN2249-8974.
7. Pranav Manikrao Deshmukh, Dr. SP. Trikal Design Optimization, Analysis And Remedies Over Failure Of Charging Belt Conveyor System Used In The Industry To Set The Optimum Results" International Journal of Advance Engineering and Research Development. 2015, 2(3).
8. Rohini N. Sangolkar, Vidhyadhar P. Kshirsagar "Modeling And Analysis Of Industrial Belt Conveyor System Using Creo Parametric And Ansys Software" International Journal of Technical Research and Applications. 2015; 3(4):178-181. E-ISSN: 2320-8163.