Design and Analysis of Belt Conveyor System of Sugar Industry for Weight Reduction

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Abstract: The aim of this paper is to study existing Belt conveyor system and optimize the critical parts like Roller, L-channels and support, to minimize the overall weight of assembly. Paper also involves geometrical and finite element modeling of existing design and optimized design. Geometrical modeling was done using Catia V5R20 and finite modeling done in ANSYS14.0. Results of Linear static, Modal and Transient analysis of existing design and optimized design are compared to prove design is safe. In this paper we work on the roller design and optimization.

Keyword: Existing roller, Optimized roller

1. INTRODUCTION:

Material handling is an important sector of industry, which is consuming a considerable proportion of the total power supply. For instance, material handling contributes about 10% of the total maximum demand in South Africa. Belt conveyors are being employed to form the most important parts of material handling systems because of their high efficiency of transportation. 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, for they are the main energy consuming components of material handling systems. Consequently, energy efficiency becomes one of the development focuses of the belt conveyor technology. A belt conveyor is a typical energy conversion system from electrical energy to mechanical energy. Its energy efficiency can generally be improved at four levels: performance, operation, equipment, and technology. However, the Majority of the technical literature concerning the energy efficiency of belt conveyors focuses on the operational level And the equipment level. In practice, the improvement of equipment efficiency of belt conveyors is achieved mainly by introducing highly efficient equipment. The idler, belt and drive system are the main targets. In the influences on idlers from design, assembly, lubrication, bearing seals, and maintenance are reviewed. Energy saving idlers is proposed and tested in Energy optimized belts are developed in by improving the structure and rubber compounds of the belts. Energy-efficient motors and variable speed drives (VSDs) are recommended in general, extra investment is needed for the equipment retrofitting or replacement; and the efficiency improvement opportunities are limited to certain equipment. 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 theoretical analysis along with experimental validation on a VSD based conveying system is presented in. Nowadays, the idea of speed control has been adopted by industry and successfully applied to some practical projects. Further investigations on VSDs of belt conveyors are carried out in. The current implementations of speed control however concentrate mostly on lower control loops or an individual belt conveyor. It has not been used to deal with the system constraints and the external constraints, such as time-of-use (TOU) tariff and storage capacities, nor has it been applied to coordinate multiple components of a conveying system. [1]

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries. Many kinds of conveying systems are available, and are used according to the various needs of different industries. There are chain conveyors (floor and overhead) as well. Chain conveyors consist of enclosed tracks, I-Beam, towline, power & free, and hand pushed trolleys. Conveyor systems are used widespread across a range of industries due to the numerous benefits they provide. [4]

Conveyors are able to safely transport materials from one level to another, which when done by human labor would be strenuous and expensive. They can be installed almost anywhere, and are much safer than using a forklift or other machine to move materials. They can move loads of all shapes, sizes and weights. Also, many have advanced safety features that help prevent accidents. Conveyors can be located in areas that cause significant problems with excessive noise production. An example of this is the location of conveyors in some coal export terminals in Australia, which are located across a bay from residential areas. 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 will have significant benefits to both the workers in the factories and the community as a whole. 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 (OH&S) risk, as the rollers often need to be manoeuvred 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. In addition to the potential OH&S problems that may be caused by heavy rollers, the weight can also become an issue when a large number of idlers need to be

replaced. The number of rollers in a conveyor is often in the hundreds, however, can go up to thousands depending on the length of the conveyor. Because the steel idler rollers are heavy, only one roller may be carried at a time due to their weight. If the conveyor is elevated, and only accessible via a walkway, such a task could require many trips to be made to in order to replace the idlers. A light weight idler would make it possible to carry two idlers at a time, thus greatly reducing the workload. A detailed search of the available literature was conducted to determine any known causes for excessive noise production from conveyors. The search showed a limited amount of information existed dealing with noise production of roller conveyors, which are typically found in packaging and sorting warehouses. However, in the case of belt conveyors, the work in the area of noise production was sparse. The material found for roller conveyors was often relevant to belt conveyors, and this information was used in conjunction with previous studies conducted by Tyton Conveyors to determine the main sources of noise in belt conveyors. [4]
Failure to include transient response to elasticity can result in inaccurate prediction of:
• Maximum belt stresses
• Maximum forces on pulleys
•Minimum belt stresses and material spillage
• Take-up force requirements
• Take-up travel and speed requirements
• Drive slip
• Breakaway torque
• Holdback torque
• Load sharing between multiple drives
• Material stability on an incline
It is, therefore, important a mathematical model of the belt conveyor that takes belt elasticity into account during stopping and starting be considered in these critical, long applications. [3]

2. OBJECTIVE:
1. Check design of existing conveyor system.
2. ANSYS APDL codes applied for linear static, modal, transient and optimization analysis.
3. Simulations for linear static Analysis.
4. Simulations for Modal Analysis.
5. Optimization of conveyor assembly for weight reduction.
6. Comparison between existing and optimized design.

3. PRINCIPLE OF WORKING:

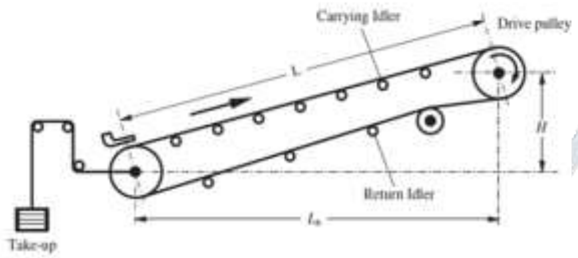

Fig.3.1.Principle working of belt conveyor

Failure most of cases happen in roller of conveyor which is made up of steel.

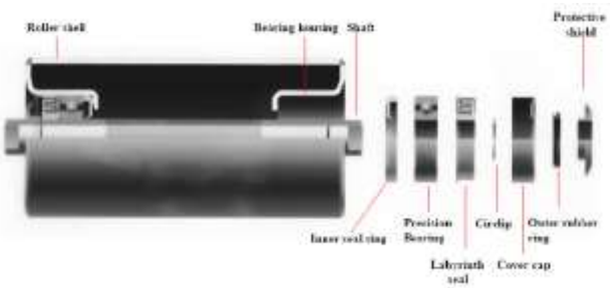

Fig.3.2.Parts of roller

Loading on the roller

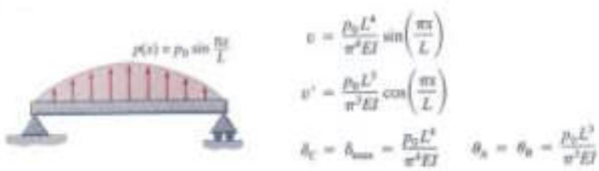

Fig.3.3.Application of load on roller

4. DESIGN OF ROLLER:

4.1 Material – MS

E = 2.10*105 Mpa, ρ= 7860 Kg/m3, Syt = 590 Mpa
Considering uniformly distributed load & FOS = 2
Allowable Stress (σall) = Syt / Fs =590/2=295 Mpa

4.2 Maximum Stress Calculation for given condition

W= 1000/2= 500kg (Load act on 2 rollers at a time)
D1= Outer diameter of roller = 61 mm
D2 = Inner diameter of roller = 51 mm
w = Width of roller = 730 mm
y = Distance from neutral axis = 0.061/2 = 0.0305
Considering uniformly distributed load**,**
Maximum Moment (Mmax) = $W*L^2/8$
= $(500*9.81*0.73^2)/8$
Mmax = 326.73 Nm
Moment of Inertia (I) =$\Pi (D_1^4 – D_2^4)/64$
= $\Pi (0.061^4 – 0.051^4)/64$
I = 3.476*10-7 m4
Maximum bending stress σb = Mmax * y/ I
= 326.73 * 0.0305/ 3.476*10-7
σb = 28.66 Mpa

4.3 Checking Factor of Safety for design-

Fs = σall / σb
= 295/28.66
Fs =10.29
As Calculated Fs is greater than assumed Fs, Selected Material can be considered as safe.

5. RESULT FROM ANSYS 14.0 FOR OLD ROLLER

Deformation in old roller

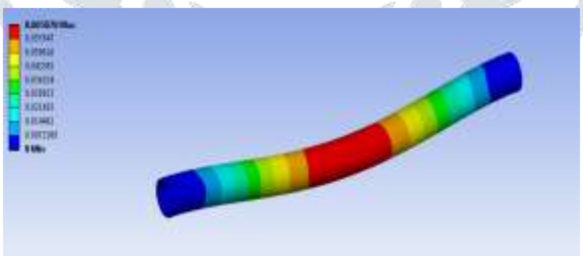

Fig.5.1.Deformation in old roller

Stress on old roller

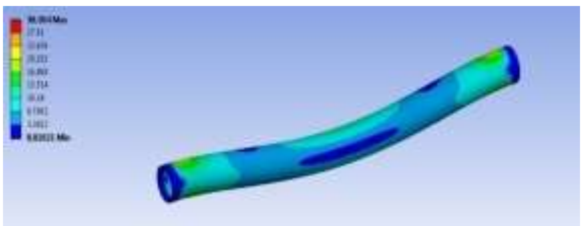

Fig.5.2.Stress on old roller

6. OPTIMIZATION DESIGN OF ROLLER:

6.1 Material – MS

E = 2.10*105 Mpa, ρ= 7860 Kg/m3, Syt = 590 Mpa
Considering uniformly distributed load & FOS = 2

Allowable Stress (σall) = Syt / Fs =590/2=295 Mpa

6.2 Maximum Stress Calculation for given condition

W= 1000/2= 500kg (Load act on 2 rollers at a time)
D1= Outer diameter of roller = 61 mm
D2 = Inner diameter of roller = 56 mm
w = Width of roller = 730 mm
y = Distance from neutral axis = 0.061/2 = 0.0305
Considering uniformly distributed load**,**
Maximum Moment (Mmax) = $W*L^2/8$
= (500*9.81*0.732)/8
Mmax = 326.73 Nm
Moment of Inertia (I) = $\Pi (D_1^4 - D_2^4)/64$
= $\Pi (0.061^4 - 0.056^4)/64$
I = 1.969*10-7 m4
Maximum bending stress σb = Mmax * y/ I
= 326.73 * 0.0305/ 1.969*10-7
σb = 50.60 Mpa

6.3 Checking Factor of Safety for design-

Fs = σall / σb
= 295/50.60
Fs =5.83
As Calculated Fs is greater than assumed Fs, Selected Material can be considered as safe.

7. RESULT FROM ANSYS 14.0 FOR NEW ROLLER

Deformation in new roller

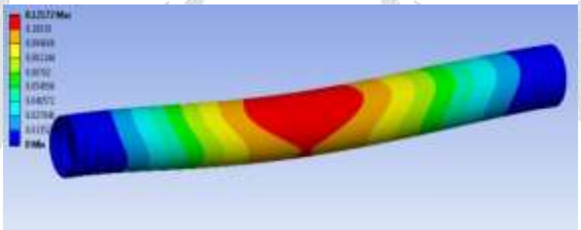

Fig.7.1. Deformation in new roller

Stress on new roller

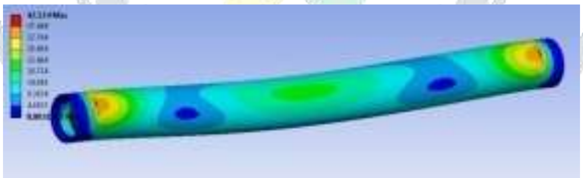

Fig.7.2. Stress on new roller

8. RESULT:

Comparing existing and new design of roller we get following results

Sr No	PARAMETER	OLD	NEW
1	Deformation	0.073mm	0.17mm
2	Stress	39MPa	51MPa

9. CONCLUSIONS

• Existing design calculation shows the factor of safety is very greater than requirement and there is a scope for weight reduction.
• Critical parameter which reduces the weight are roller outer diameter and roller thickness.

10. FUTURE SCOPE:

1. Fatigue analysis for life calculation. Fatigue analysis can be done by obtaining the SN curve. ANSYS predicts the number of cycles of different regions.
2. Buckling analysis. Buckling analysis of support channels can be done to find maximum load.
3. Non-linear analysis. Material non-linearity can be considered to find more accurate results.

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