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Study on Design & Analysis of Shaft for Roller Conveyor with Different Materials

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A B S T R A C T

In this report we studied existing conveyor system and optimized critical parts of roller conveyor system like Roller, C-channels for chassis and support, to minimize the overall weight of assembly and material & cost saving. Paper contains geometrical modeling and finite element modeling of existing design and optimized design. Geometrical modeling is done using hyper mesh and optistruct software. Result shows safe design of optimized design. Optimization gives optimum design for same loading condition with huge amount of weight reduction. Using optimized procedure and using practical available structure precise weight reduction is achieved. The aim of this project is to study existing conveyor system and new weight optimize roller conveyor system (like wt. of roller, shaft etc.) The current trend is to provide weight/cost effective products which can give less effort to user.It is designed for ease for assembly, manufacturing safely convey part and reduce cost.

Keywords: Weight & Cost reduction, alloying element, Optimised Technique, Material handling system

1. INTRODUCTION

A conveyor system is a type of mechanical handling equipment that transports materials from one place to another. Conveyors are particularly useful in applications where large or bulky products must be transported. Conveying systems come in a variety of shapes and sizes, and they're employed to meet the needs of numerous sectors. There are also chain conveyors (both floor and overhead). Enclosed tracks, I-Beam, towline, power & free, and hand-pushed trolleys are all examples of chain conveyors. Because of the multiple advantages that conveyor systems provide, they are widely used across a variety of industries.

There is wide variety of conveyor system available, including the hydraulic, mechanical and automated system. Material handling equipment plays an important role in many industries, such as construction sites and storage units. Gravity conveyors are design without considering the torsional effect on the roller shell. As the application changes the design of the roller may vary in terms of shaft, hub and shell assembly. In most of the research papers, crucial parts of roller conveyors like Roller, chassis and columns and bearings were targeted for weight optimization. By applying basic design concepts carefully according to the loading conditions on each member of system, one can design the system with significant alteration of the components. This issue is taken up for study and execution for developing other options to outline while focusing on weight enhancement for the basic parts like roller in the gathering. Basic investigation of the rollers in transport should offer experiences into the current issue. The FEA approach would be received to take care of the issue while discovering the auxiliary quality of the rollers and tending to the lessening in weight without trading off on the quality of crude material taking care of part parts in the get togethe.

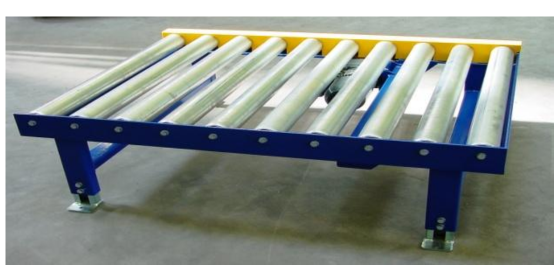

Fig1.1 Roller conveyor

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1.1. ***Problem Statement***

The conveyor drives by the high torque gearbox to avoid the load on input side motor which drives the shaft, due to the load of gear box and tension from the belt side there are two types of load developed on the drive shaft.

1. Angular load 2. Axial load

So, there is a problem of crack in shaft and wear as the operating time increased of the machine day by day. So, need such a design of shaft which needs to avoid the life problem of the shaft and improve its efficiency.

1.2. Objective of the Project

1. To reduce roller manufacturing cost & time consuming for assembly.
2. Study roller conveyor system and its design using CATIA.
3. To simulate model using HYPERMESH and OPTISTRUCT software.
4. To study conveyor parts for weight optimization.
5. To study a fixture system and its design.
6. To study the selection of sensors.

2. Literature Review

Pravin A. Mane published paper on Design, Manufacture and Analysis of Belt Conveyor System used for Cooling of Mould. This Paper worked on design and analysis of belt conveyor system.their actual work shows that the major components and its parameters like belt capacity, belt width, and effective belt tension, power, and motor speed, diameter of shaft, idler spacing and diameter of pulley were designed successfully by using standard practice such as CEMA standard, Fenner Dunlop handbooks, available theories and software. The belt comp software was used to get the appropriate profile of pulley arrangement. Different alternatives of pulley arrangements are tried by altering the horizontal and vertical distance between two consecutive pulleys. For each alternative the designed parameters like belt width, belt tension etc. are calculated by using CEMA standard and Dunlop handbook and those results are verified by using belt comp software. From the belt comp software the effective belt tension and power observed was 50.0551 KN and 5.8 KW etc. and from theoretical results the effective belt width and power was found to be 47.908 KN and 7.5 KW. So the results got from belt comp software found to be good agreement with the theoretical results. The components like different types of pulleys namely drive pulley, tail pulley, pressure pulley, snub pulley and hold down pulley etc., carrying and return idlers, frame structures, and columns were manufactured successfully with the required dimensions and also from motor speed, power required, diameter of pulley, diameter of shaft the horizontal foot mounted PBL type geared motor and foot mounted Elecon type gear box was procured from manufacturer’s organization.

Mrs. Ashvini S. More studied on A Review on Materials for Belt Conveyor Roller Shaft. Their paper shows that different type of material can be used for making roller conveyor shaft. Design and fabricate the efficient shaft for conveyor system which can sustain at variable load and variable speed to minimize the breakage and wear of the shaft. Also they concluded following points:

1. When MS Bright material is used the stresses are more as compare to EN24 material.
2. When EN24 material used less wear and reduced shaft breakage
3. By using EN24 material achieve more strength and life of same size shaft.

Harshavardhan A. Kadam1, Nilesh S. Hyalij, Design and Analysis of Belt Conveyor Roller Shaft, for the continuous transportation of material a belt conveyor are used in the transport of Coal and mineral powder it gives high efficiency and environmental protection. The purpose of this article is to examine the existing Belt Conveyor System and analyse the Roller Shaft at higher motor specifications in order to prevent belt conveyor Roller Shaft failure at greater belt conveyor inclination. The paper also includes a Geometrical Model and Finite Element Model of a Roller Shaft at different inclinations. CREO parametric and ANSYS 14.1 would be used for geometrical modelling and finite element modelling.. Result of Linear static model and Transient Analysis of existing design and Analysed design at higher inclination with Design Failure Mode and Effective Analysis (DFMEA) are compared to prove which design is safe. In this Paper they work on Design of Roller Shaft and improve the life of Roller Shaft.

Aniket Jagtap et.al identifies the correct choice of roller diameter must take into consideration for the proper belt width. The relationship between the maximum belt speed, roller diameter and the relative revolution per minute. The angle of surcharge, which directly influences the cross sectional area of material in the belt and thus the volume being transported, is one of the most essential parameters in determining carrying capacity.

W L Bowen and colleagues investigated the unique functional properties that the use of hollow rolling parts in a radial type cylindrical roller bearing produces. The ability to consistently and properly preload these hollow rollers between the inner and outer races, together with the necessary but standard degree of bearing component precision, allows for excellent shaft run-out control. This makes the bearing ideal for high-precision applications.The roller preloading also eliminates the need for roller guidance from a retainer which, combined with the lighter rollers, generally means higher speed capabilities.

3. Design consideration for Roller shaft

The following procedures are used to design shafts:

Design Based On Strength:

The type of the load acting on the shaft determines the stress at any point on the shaft.

Design based on Strength:

With this method, the shaft is designed so that the tension at any point on the shaft does not exceed the material yield stress. Shaft deflection and shaft twist, on the other hand, are not taken into account.

Design based on Stiffness:

In this situation, the basic design concept is based on the shaft's permitted deflection and twist.

Basic stress equations:

Bending stress

$$\sigma_b = 32M/(\pi d^{(3)}(1-k^4))$$

Where,
M: Bending moment at the point of interest
d: Outer diameter of the shaft
K: Ratio of inner to outer diameters of the shaft
(k = 0 for a solid shaft because inner diameter is zero)

Axial Stress:

$$\sigma_a = 4aF/(\pi d\_(0\ )^2\ (1-k^2))$$

Where,
F: Axial force (tensile or compressive)
α: Column-action factor (= 1.0 for tensile load)
The term α has been introduced in the equation. This is known as column action factor. What is a column action factor? This arises due the phenomenon of buckling of long slender members which are acted upon by axial compressive loads.
Combined Bending and Axial stress:
Both bending and axial stresses are normal stresses; hence the net normal stress is given by,

$$\sigma x = [32m/\pi do^3(1-k^4) \pm 4aF/\pi do^2(1-k^4)$$

Design of the shaft mostly uses maximum shear stress theory. It states that a machine member fails when the maximum shear stress at a point exceeds the maximum allowable shear stress for the shaft material. Therefore,

$$\tau_{max} = \tau allowable = \sqrt{([(\sigma x/2)^2] + \tau xy^2\ )}$$

Therefore, the shaft diameter can be calculated in terms of external loads and material properties.

3.1. Material For roller shaft

The material selection of a shaft depends on following factors;

1. Operating time of a conveyor
2. Machining process on a shaft
3. Load on a shaft

Axial, transverse, and torsional loading conditions are the most common loading conditions for shafts. The wear stage of a shaft is continuously dependent on the tension of a belt or the varied load applied under three loading conditions.

Material for Shaft

We have taken Four materials in our projects are as follows:
1. Mild Steel
The M S bright material is a normal grade of mild steel having easy for the machining and can sustain at a higher load.
2. Alloy Steel
Finding high suitability for forging industries, grill fencing and engineering component. Available in both Metric and Imperial options
3. EN 24
It's having efficient mechanical properties than mild steel and another material like, hardness, tensile strength and availability in the industrial sector.
4. Iron material
Because of availability in large quantity

3.2. *Types of Roller Conveyor*

1. Gravity Conveyor systems

2. Powered Belt Conveyor systems
3. Pneumatic conveyor systems
4. Vibrating conveyor systems
5. Flexible conveyor systems
6. Vertical conveyor systems and spiral conveyors
7. Live Roller Conveyor systems

Table 3.1 component of Roller Conveyor

Sr.No	Component	Material	Qty
1.	C-Channels for Chassis	ISMC 100	2
2.	Rollers	Mild Steel	15
3.	Bearing	Std	30
4.	C-Channels for Stand	ISMC 75	4
5.	Shaft	SS	15

4. Methodology

4.1. Experimental Set-up:

Fig.4.1 Universal Testing Machine

The following procedure is done for testing deformation.

1. 1. The equipment is operated by hydraulic load transmission from the test specimen to a separate load indicator. The techniqu e is suitable because it eliminates the need for load transmission via levers and knife edges, which are prone to wear and damage due to shock during test piece breakage. A hydrodynamically lubricated ram applies the load.

2. The pressure from the main cylinder is transferred to the cylinder of the pendulum dynamometer system, which is housed in the control panel. The dynamometer's cylinder also has a self-lubricating construction. The absolute load applied to the test specimen is represented by the pendulum's deflection. In the event of a rapid shattering of the specimen, the pendulum's return movement is efficiently damped to absorb energy.

3. A test method, which is generally published by a standards organisation, describes how to set up and use the equipment. This covers sample preparation, fixturing, gauge length (the length being studied or observed), analysis, and so on.

4. The testing specimen is positioned between the grips of the machine, and if necessary, an extensometer can automatically record the gauge length change during the test. The machine can record the displacement between its cross heads on which the specimen is held if an extensometer is not used.

5. As soon as the machine is turned on, it starts applying an increasing load to the specimen. The load and extension or compression of the specimen are recorded by the control system and its related software during the testing.

6. Check that all of the switches, including the main switches, are turned on, and that the release valve and the control valve on the control unit are closed. The spacing between the upper crosshead and the middle crosshead reduces or increases when the middle crosshead of the loading unit is moved up and down by mechanical motors, allowing us to vary the gap between the crossheads according to the length of the specimen.

7. Now that the control valve is open, look at the changes on the load and displacement dials/displays. The figure for load will rise for a while and then level off, but the value for displacement will continue to rise. The dead weight of the lower crosshead is used to calculate this load value. With the help of the tare switch, set the load reading to zero. Turn off the machine. Open the release valve after closing the control valve. Note the hydraulic oil backflow and the slow lowering of the crosshead.

8. The load valve will decrease for a short period before becoming negative, and the displacement values will continue to fall. This is referred to as improper adjustment. Between the middle and lower crosshead, place the timber specimen. Make sure there's a modest space between the crosshead and the specimen. Close the release valve and progressively open the control valve after selecting a suitable range on the load dial gauge.

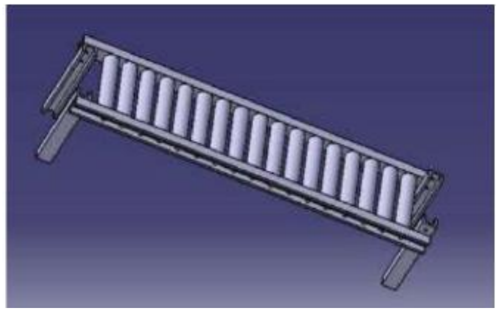

Fig 4.2 Geometrical Modelling of Roller conveyor done with CATIA

5. Result & Discussion

We have designed shaft on the basis of their material & applications, our aim to carry objects over the conveyor so, the conveyor shaft must be design by taking consideration of following points,

1. Belt width
2. Load on shaft
3. Bearing arrangement
4. Gear box fitting arrangement
5. Encoder assembly arrangement

Table5.1 obtained Result

Load (Kg)	**Displacement(mm0**	**Stress (Mpa)**
200	0.09	0.39
250	0.11	0.45
300	0.15	0.52

6. Analysis of Design

ANSYS R-18.1 is a general purpose finite element analysis tool with a group of engineering simulation programs capable of modeling structures under different loading conditions. It can solve problems of relatively simple structural analysis to the most complicated linear to nonlinear analyses.The required inputs for the ANSYS finite element analysis consists of model geometry, material properties and loading. Following plot is obtained with the help of ANSYS Software.

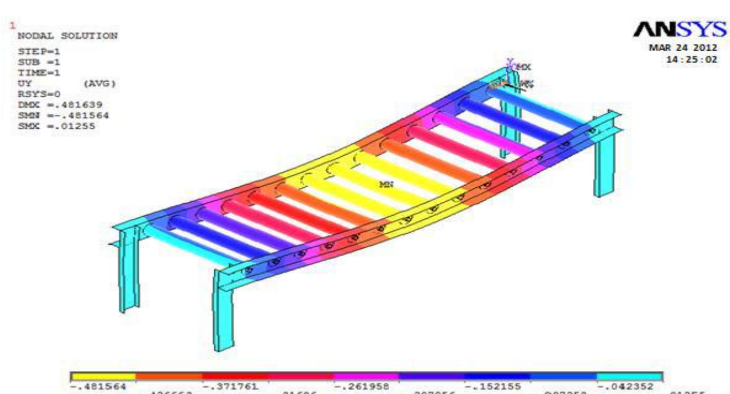

Fig 6.1 Deflection Plot

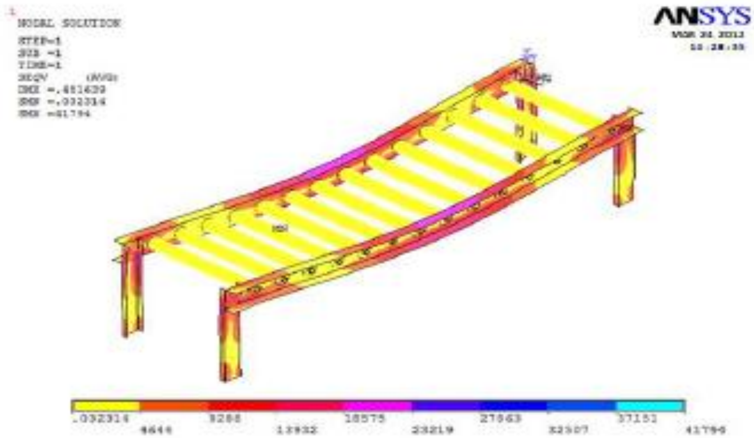

Fig 6.2 Stress Plot

Steps used in finite element analysis are as follows:

1. Geometry generation
2. Connections examination
3. Mesh generation
4. Application of support
5. Application of forces
6. Solution for results-
    - Total deformation.
    - Equivalent Von-Mises stress

7. Conclusion

The following conclusions can be made from the obtained data;

1. When Mild steel material is used the stresses are much more as compare to EN24 & iron material.
2. When EN24 material used less wear and reduced shaft breakage
3. By using EN24 material achieve more strength and life of same size shaft.
4. Also we have seen the stresses developed in iron material are much more than reamaining material.

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