International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 05 | May 2024 www.irjet.net p-ISSN: 2395-0072

Design, Analysis and Development of Belt Feeder System for Coal Application

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Abstract - *Belt conveyors are one of the most commonly used equipment for transporting bulk materials in various industries. They are versatile, efficient, and reliable, making them suitable for a wide range of applications. Optimizing the current Belt Conveyor System was the goal and purpose of our project. We applied analytical and numerical methods to this. A key factor in reaching the goals was the process used to choose the best material. The dimension constraints for this project, as well as economic considerations, are taken into account in all processes and activities. We attempted to guide our approach in light of India's expanding industrial sector and deliver the best possible solution.*

***Key Words*: Optimizing, Dimension constraints, Economic considerations**

1.INTRODUCTION

Large volumes of coal can be handled effectively by belt conveyors used in coal applications. The type of coal, the amount to be conveyed, the distance to be travelled, and the terrain of the route are some of the variables that affect the conveyor system's design. A belt, pulleys, idlers, and a drive system make up a belt conveyor system. Since it bears the weight and supplies the required traction, the belt is the most important part of the conveyor system. The size and weight of the coal that needs to be transported determine the kind and width of the belt. The belt is supported, guided, and kept in alignment by the pulleys and idlers. The required power is supplied by the drive system.

1.1 Following are some of the key components of a belt feeder conveyor system

- **Frame:** The conveyor belt and other parts are supported by the frame. The frame serves as the foundation for the system's continuous and effective operation, preventing any vibration from entering the system.
- **Conveyor belt:** The part that actually moves the material is the conveyor belt. It is usually constructed of synthetic or rubber material and is intended to endure material deterioration during transportation.
- **Idlers:** Idlers are rollers that support and maintain the smooth motion of the conveyor belt.
- **Drive system:** The conveyor belt is moved by the drive system's power. Pulleys, a gearbox, and a motor are usually its components.

2. LITERATURE SURVEY

Various Types of research studies by different authors are :

Devendra Kumar et al., review belt conveyor modifications for various industries, highlighting the importance of design modifications and safety measures to reduce failures, maintenance costs, and equipment-related accidents. They discuss the latest technologies and methodologies used in these applications, covering coal mines, cement, and food industries [1].

Chudasama Pratik Naresh et al., discuss the optimization of belt conveyor systems for coal applications, focusing on reducing vibrations, increasing fatigue cycles, minimizing weight, and reducing drive shaft deflection. It details the design, analysis, and optimization procedures, including simulations and references to relevant research studies [2].

Sayali Todkar et al., discuss the design procedure of a three-roller type belt conveyor system for heavy duty application in the coal processing industry. The paper provides a detailed study of the design calculations, stresses on pulley due to belt tensions at head side, tail/take up and snub side, and experimentation carried out to verify the selected speed on various load conditions [3].

Ankit Gupta et al., presents a detailed study on the failure analysis of the belt in the conveyor system for coal handling in thermal power plants. The study analyzes the technical characteristics causing deviation in the belt and the operating characteristics of relevant machinery causing deviation. The authors propose various methods to reduce failure due to deviation during use. Overall, this paper provides valuable insights into the factors causing belt failure and proposes practical solutions to improve the life of the belt and reduce rack wear [4].

A.W. Roberts et al., described comprehensive guide on the design and application of feeders for bulk solids handling. The paper reviews the overall requirements for designing gravity flow feeding systems for bulk solids handling with particular emphasis on the feeding operations in association with belt conveying [5].

3. PROBLEM STATEMENT

To develop a belt conveyor system by using suitable material. The newly designed conveyor should have capacity to transport 150 TPH (Tons per hour) of crushed coal and should cost less to manufacture.

4. METHODOLOGY

The first step in the design process for our project is identifying any flaws in the current design so that adjustments may be made. The project's stages are finished in the order shown below.

4.1 Identification of needs

We have to reduce the weight of the shaft assembly and lessen the vibrations in the frame in order to comply with the specifications. To do this, we first look at the current design, then we run calculations to change the shaft and frame design and component analysis to change the material of the shaft and chassis.

4.2 Material Selection

The material selection consists of following steps:

4.2.1 Screening

1. Function: to support material load.
2. Objective: to reduce the weight by increasing the fatigue strength.
3. Variable: Material.
4. Constraint: Length of shaft. Force.

4.2.2 Property chart

With the help of Function and Objectives we considered the ASHBY Standard property Chart, Young's Modulus vs Density Chart.
Plotting the guidelines: Young's Modulus- 100 to 250 GPa, Density - 7 to 8 Mg/m3

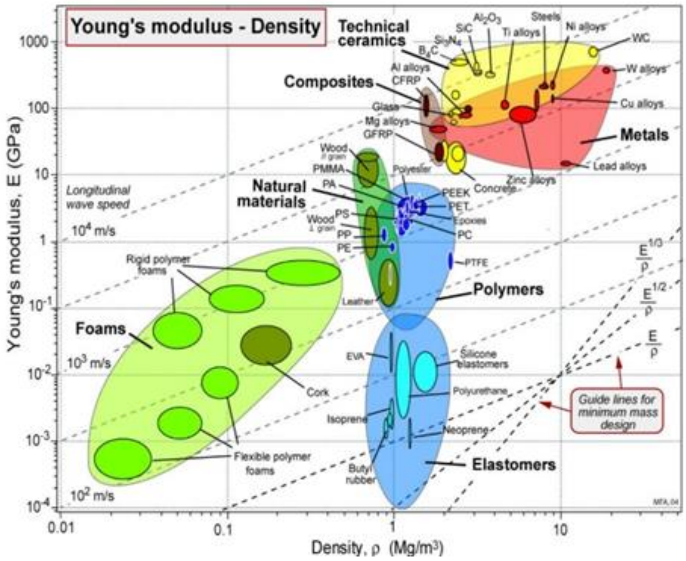

Fig -1: ASHBY Standard property Chart, Young's Modulus vs Density Chart

Table -1: Potential candidates for frame

Sr.no.	Materials	Cost inr/kg
1	Carbon steel, AISI 1040	50-70
2	Carbon steel, AISI 1137	50-70
3	Carbon steel, AISI 1141	50-70
4	Low alloy steel, AISI 5140	50-70

4.2.3 Final material selection

After selecting the candidate materials, we calculate the performance index of each material by digital logic method and the material with highest performance index is selected.
Here, Carbon steel, **AISI 1141** with performance index **99.65** is selected for the frame.
Similarly, Stainless steel, austenitic, **AISI 202** with performance index **97.31** is selected for the roller.

5. DESIGN CALCULATIONS

We start by figuring out how big the belt conveyor has to be. Next, we calculate the overall forces acting on the different components of the drag chain conveyor as well as the tensions acting on the tight and slack sides of the belt conveyor. We calculate the actual capacity of the conveyor and finally the motor power required to run our system is ascertained.

5.1 Capacity calculation

The conveyor capacity should satisfy the load carrying capacity with minimal amount of energy usage. The conveyor motor's power must overcome the difference between the tight and slack side tensions.

Input Data

C = Conveyor length factor

F = Conveyor coefficient friction factor as per the following data

(i) 0.02 for easy condition for conveying

(ii) 0.024 for less easy condition for conveying

(iii) 0.03 for different condition for conveying

Lh =Length in meter horizontal length (28m)

H = Conveyor lift i.e. (head pulley level + tail pulley level)

Hm = Conveyor material lift (in mm) (20mm)

Mm = Material mass (kg/m)

Mt = Belt mass (kg/m) of belt length

Mc = Carrying idler rotating mass of conveyor (kg/m) (21.78 kg/set)

Mi = Return idler rotating mass of conveyor (kg/m)

Uoc = 0.4

Ce = 0.4 for 30 degree through idler

0.434 for 35 degree through idler

0.5 for 45 degree through idler

o = Conveyor average inclination

i.e o = tan^-1 (H/Lh)

LITc = Conveyor length which has tilted side rollers (If Conveyor length for tilt side roller is not mentioned take LITc = Lh)

Omega Wc = 2 Degree

Dynamic u2 = 0.5 (Friction, roller and shaft)

I = Material ; m^3/sec

Y = bulk density kg/m^3

v = belt speed m/sec

b1 = 0.666 x belt width

g = gravity 9.81

Lsk = 3 meter

Mm = design capacity/(3.6 x V)

Cross sectional area of the belt = 0.0678 m^2

Total cross sectional area on = 0.0678 x 0.91
= 0.55528 m^2

Maximum possible capacity for 1000mm belt

i.e. cross sectional area x 3.2 x 3600 x (1000/1000)
= 60.769 > 60 mtph

Available cross sectional area = 0.111 x area reduction factor x belt filling factor
= 0.111 x 0.91 x 0.9
= 0.090909 m^2

Capacity of conveyor

Capacity at 1mps = cross sec area x (1.0 x 3600) x (width – 1000)
=0.090909 x 1.0 x 3600 x (1000/1000)
= 327.27 mtph

5.2 Speed required for 600 mtph

=1.0 m/s x (600/327.27)
=1.833 (theoretical)
= 1.924 (5% increased)
=1.924 m/s

Thus the design speed is less than the allowable speed i.e. 3.65 mps

Hence it is safe for working condition.

5.3 Power calculation

Power calculation for drive shaft
= P x V/1000
= (15026.383 x 2.023)/1000
= 30.3983 KW

Power at motor shaft
= Power at drive pulley shaft / Drive efficiency
= 30.3983 / 0.9
= 33.775 KW
= 40 KW

6. MODELLING AND ANALYSIS

The whole representation of the system or product utilizing both graphical and non-graphical data is referred to as modeling. Geometric modeling is another word for it. In a computer database, it produces a mathematical description of the product or system's geometry and nongeometry in addition to a graphical representation of it. Through modeling, a designer can create a graphical depiction of an object on a computer screen.

6.1 Modelling Parts and Assembling

We created a 3D model of the components using SOLIDWORKS design software, providing an accurate view of each part. Modifying the project's features during the design phase is easier and reduces the risk of post-completion losses. The base frame, shaft, drive mechanism, belt, and roller were modeled according to specific requirements and calculations. Once the components were completed, we assembled the belt conveyor.

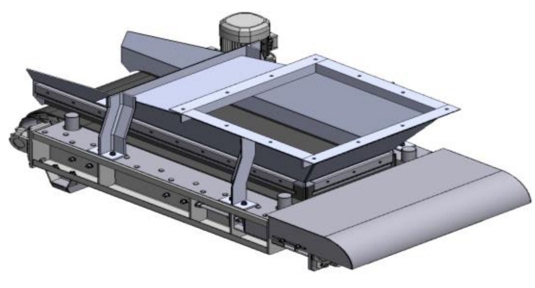

Fig -2: Conveyor Assembly

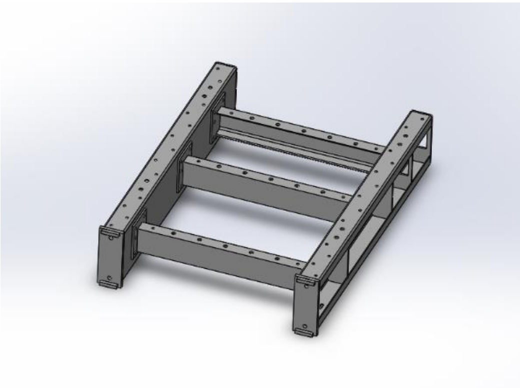

Fig -3: Chassis Assembly

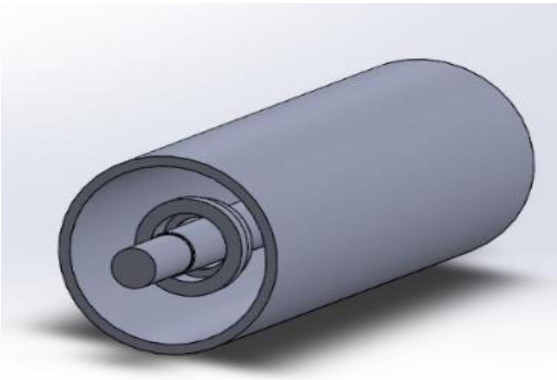

Fig -4: Drive Shaft Assembly

6.2 Analysis

After the completion of the 3D CAD model, we analysed the part of the product that they should meet to the basic parameter's which will validate the product configuration which are stress distribution, deformation, factor of safety. Most of the power and torque is been transmitted by the roller shaft so, both static and dynamic analysis is done on it. Along with that we analysed the static load carrying capacity of the base frame. Drive shafts need to be strong enough to bear the pressure without gaining weight since they are prone to stresses and torsion. If they do, more material will be consumed, increasing the cost, and more power will be needed due to the increased inertia.

6.2.1 Analysis of Frame

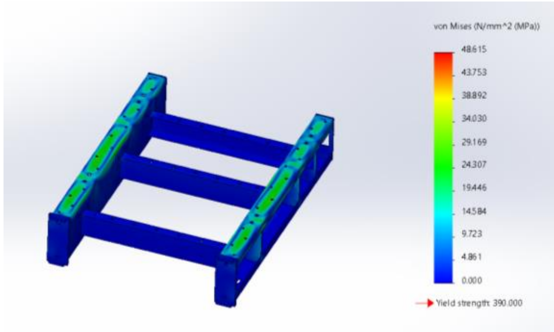

Fig -5: Stress Analysis

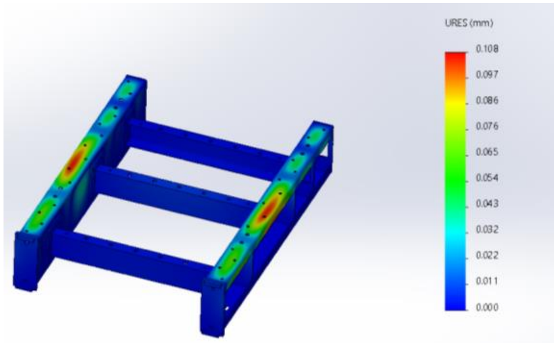

Fig -6: Static Displacement Analysis

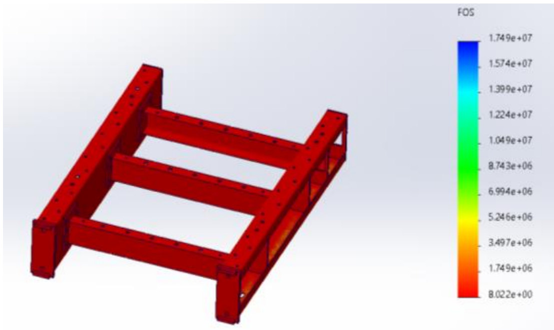

Fig -7: Factor of Safety Analysis

Table -2: Result for Analysis of Frame

Sr. No.	Parameter	Result
1.	Yield Stress	390Mpa
2.	Static Displacement	0.108mm
3.	Factor of safety	8

6.2.2 Analysis of Roller

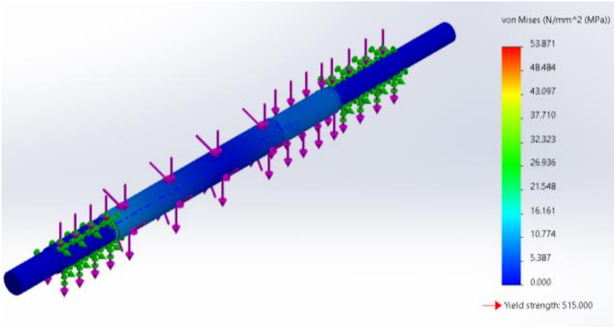

Fig -8: Torsional Stress Analysis

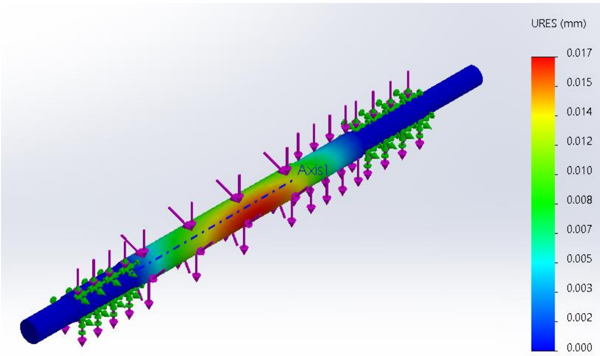

Fig -9: Torsional Displacement Analysis

Table -3: Result for Analysis of Roller

Sr. No.	Parameter	Result
1	Torsional Stress	515Mpa
2	Static displacement	0.017mm

7. RESULTS AND DISCUSSION

a) The capacity of coal at the outlet is increased due to design modifications
b) Due to optimum material selection, the overall cost of manufacturing the conveyor has been reduced.

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