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Analysis of Conveyor Belt Materials with Different Carcass Material

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Abstract – Conveying system plays an important role in various industries to convey the material from one end to other end. The purpose of the conveying system is to reduce the human effort and save time with the use of new innovative technology such that it also minimizes the accidents cases in industries. Among all conveying systems, belt conveyor is the most suitable conveying system used by most of the industries across the world, whether it is power industry, chemical industry petroleum industry etc. and many more. The main application of the conveyor belt can be seen in the industries where material have to be conveyed for long distance; in such case it plays a vital role to full fill the requirement. As per the construction, the belt is main part of belt conveyor as it is the only part of the whole system that travels throughout the conveyor carrying the material above it. The construction of the belt mainly consists of the rubber with carcass material inside which provides the strength to the belt. This thesis presented the significance of the carcass material and analytical analysis performed to analyse the stress and deformation on the belt conveyor using various layering materials such as carcass, pineapple fibre and banana fibre. The CAD model is created using CAD software CATIA V5 and the finite element analysis performed on the belt using the software ANSYS 19.

Keywords: Conveyor Belt, Carcass, Pineapple Fibre, Banana Fibre

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INTRODUCTION

Conveyors are mechanical equipment's or assemblies used to move things or bundles with insignificant exertion. They for the most part comprise of frames that support rollers, wheels, or belts and might be motor driven or manual devices. They are utilized to move mass material as well gravels and aggregates. They incorporate belt conveyor that utilization moving belts, bucket and vertical transports that lift material, vibrating material handling system that utilize vibratory movement to move material, and overhead conveyor from which things hang during transport. Different composes incorporate screw transports for moving mass material, chute transports which depend on smooth surfaces and gravity, and drag or tow transports that utilization links to drag questions along. Walking beam conveyor move items to foreordained positions for manufacturing purpose. [1]

The conveying system is a method to transport the material from one point to other point or can say that one location to other location. Its application can be seen in various industries such as automobile industries, power industries, aerospace industries, food processing industries, chemical industries, pharmaceutical industries etc. Many types of material are conveying using conveyor system such as coal, lime nuts, bottles, cartoons as per the utilization in industries. Many factors are responsible for selecting the conveyor for the operation which include the type, size of the conveyor, capacity of the conveyor etc. Conveyors are the best option in industries to reduce the operating cost and increase the production by eliminating the manual power for the same. [2]

LITERATURE REVIEW

S. Rajesh kumar (2017)[3] present paper the author performed the design and analysis of the belt conveyor for finishing house pulper. The main motive of the research is to overcome the human effort and also to reduce the labour cost. The complete research performed on the TN newsprint and paper limited in India. The plant was getting difficulty to produce 1400 mega tonne paper per day due to manual feeding of the damaged paper the complete system was optimized by using the belt conveyor for feeding the

damaged paper to the pulper that it enhanced the production economically.

Abhijit Gaikwad (2017)[4] present research paper explained the difficulties faced by manual operation and feeding in various industries such that it is taken as well as not safe as per the human safety concern, hence the author suggested to use the belt conveyor for feeding purpose in order to reduce the human effort and to increase the speed of feeding in the system. The paper presented the benefits of conveyor belt such that reduced the labour cost as well as increased the material safety.

Salave V. (2017)[5] research represents the design of 360 degree belt conveyor with its all components for material handling in the industry and concluded that various advantages and application:

Advantages:

- Its manufacturing cost is low
- Handling is very easy
- Not much heavy
- Capable of handling all types of material.

Application:

- It can be utilized in unit used for gear manufacturing
- In automobile industry
- National or international airports
- Food processing industries
- Coal mines

Mr. Memane Vijay S (2015)[6] paper focused on the optimizing the weight iof the belt conveyor by optimizing the design of the main basic parts of the belt conveyor using the ANSYS 14.0 software which include the channels, supporting rollers etc. In the complete research Modal and transient analysis was performed on the optimized design and the result concluded that the design was safe as it showed the FOS greater than that of the existing, hence provided the opportunity to further optimization of the weight of the conveyor belt.

Deepak Gupta (2015)[7] present research performed to analyse the handling capacity of the belt conveyor with sample weight of 17 kg on two roller conveyor with centre distance of 500 mm. The belt was designed with full automated system for better movement and unloading. The result of the system concluded that the proposed system was much flexible, low cost with high safety.

Amol B.Kharage (2015)[8] research focused on optimizing the weight of the gravity roller conveyor by optimizing the design of the component of the conveyor system which include structural frame and the roller without effecting the strength of the existing conveyor system. The complete analysis was performed on CAD model which was developed using the CAD software (PRO-e).In the analysis the C channel material replaced with the carbon fibre and observed the results in modal and transient analysis. The results showed better results with safe design.

Rohini N. Sangolkar (2015)[9] present research structural analysis was performed on the conveyor belt using ANSYS software the model was created using the software called Creo. In the FEA total deformation, equivalent stress and stress was analysed .The result concluded that the maximum deformation was induced at the tail end surface of the conveyor belt with value 0.6403mm.FEA result showed that the design of the was safe with higher factor of safety. It was observed that the equivalent stress value was much less as compared to the yield stress of the material hence the design was safe.

S.Ojha (2015)[10] failure of coal plant conveyor analysed deeply to investigate root cause for the failure. The main motive of the study was to analyse each and every cause of the conveyor failure such the it can be eliminate in next design of the conveyor to avoid the failure hence can increase the life of the conveyor, increase the productivity and it will also help to reduce the maintenance cost of the conveyor.

ShubhamD.Vaidya (2015)[11] study performed on the conveyor system with 3 roll idler in order to reduce the spillage of material and fatalities. With the analysis it was observed that the belt specification of PN 450 with double weave standard runner belt was capable of conveying the crushed wood in biomass plant. It was also analysed with the crushed limestone and performed well with good loading movement, high unloading efficiency hence it was safe, flexible with low maintenance cost to conveying the material.

Ghazi Abu Taher (2014)[12] paper showed the investigation on combined bucket and belt conveyor system to perform a complex task. For the analysis complete automated prototype model was proposed and analysed its performance. The performance of the prototype showed that the system of capable of filling the right amount of material to large no of packets and given proper stoppage between two process of packaging. It was also concluded that to operate that system it was required skilled person as compared to completely manual system.

DESIGN CALCULATION

These equations are hypothetical calculation and outline that can model and simulate the framework into different programming software for approval. The theoretical computations depend on

conventional machine design utilizing an arrangement of conditions. This gives the fundamental thought of the design of the item.

Design steps of belt conveying system:

1) Capacity of conveying belt [C] :-

$$C = 3.6 \times \text{Load cross} - \text{section area perpendicular to belt} \times \text{Belt speed} \times \text{Material density}$$
$$= 3000 \text{ kg/hr.}$$

2) Power required by belt

$$\text{POWER} = \frac{Fc\,L + tf\,(c + 3.6QS)}{367} \pm \frac{CH}{367}\ KW$$

For horizontal and inclined conveyor,

$$Fc = 0.020,\ Tf = 45_{m}$$

$$Q = 33, S = 0.2m/sec$$

$$\text{POWER} = \frac{0.020(9 + 45)\,(3000 + 3.6 \times 33 \times 0.2)}{367} \pm \frac{3000 \times 3.042}{367}\ KW$$

$$Power = 33.76KW$$

Belt Tension:-

$$\text{Effective tension}(Te) = \text{Total empty friction} + \text{Load Friction} + \text{Load slope friction}$$

a)

$$\text{Return side friction} = Fe \times Q \times L \times 0.4 \times (9.81 \times 10 - 3)\ KN$$

$$\text{For horizontal and elevating conveyor}, Fe = 0.020$$

$$\text{Return side friction} = 0.020 \times 33 \times 9 \times 0.4 \times (9.81 \times$$

$$\text{Total empty friction} = Fe \times (L + tf) \times Q \times (9.81 \times 10$$

$$\text{Total empty friction} = 0.020 \times (9 + 45) \times 33 \times (9.81$$

Carrying side empty friction=total empty friction-return side friction =0.3263KN

Effective Tension,

$$Te = 0.3496 + 55.181 + 124.34 = 179.8706\ KN$$

The power is calculated for this effective tension of belt

$$\text{Power} = Te \times S\ KW = 179.8706 \times 0.2 = 35.97\ KW$$

$$\text{Angle of wrap} \emptyset = 2100 = 3.6652\ rad \pi r^2$$

$$T_1 = T_e\left[\frac{\varepsilon}{e^{\mu\theta} - 1} + 1\right]$$
$$T_1 = 179.8706\left[\frac{1.36}{e^{0.35 \times 3.6652} - 1} + 1\right] = 273.711KN$$
$$T_2 = T_1 - T_e = 273.711 - 179.8706 = 93.84KN$$

Motor selection:-

The 1500rpm motors is used in present study

According to design data book in 37KW/1500rpm motor, the shaft diameter of this type of motor is minimum 60mm.

Belt Width:-

$$\text{Belt Width} = \frac{T_1}{\text{Belt Strength}\ \left(\frac{N}{mm}\right)} = \frac{179.8706 \times 10^3}{300} = 599.569mm$$

The canvas material belt strength is 300N/mm and canvas material shown high tensile strength, wear and tear resistance and also corrosion resistance.

METHODOLOGY

Material Property

This is the progression in which material properties of the base paper is applied in ANSYS workbench. A significant number of properties of the material is given in the library of the ANSYS which is shown in table 1 and it is conceivable to include other material properties additionally with the end goal that include new material choice in which wanted properties of the material can be characterized according to the requirement for analysis.

Table 1: Material Properties of Different Material

Material	Density (Kg/m3)	Young modulus (MPa)	Poisson's ratio
Mild steel (Roller material)	7860	2.1x10^5	0.334
Canvas (belt material)	1220	7.9x10^9	0.071
Carcass (middle layer)	1100	9000	0.3
Pineapple fiber (middle layer)	1500	68000	0.243
Banana fiber (middle layer)	1400	30000	0.2

Meshing

This is the progression before applying the boundary conditions in which the mesh is generated with the whole body in such a way that the complete body gets separated into nodes and element for accuracy of the outcome. It is practically observed that the fine mesh take much time due to large number of nodes and elements as compared to the coarse mesh.

The number of nodes 2566 and number of element 266 in conveyor system is shown in fig.1.

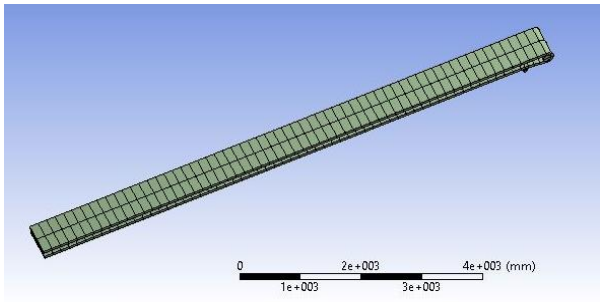

Fig. 1:Meshing of conveyor system

Applying Force

Tight side force is T_1 = 273.211KN is applying in one side of belt is shown in fig. 2.

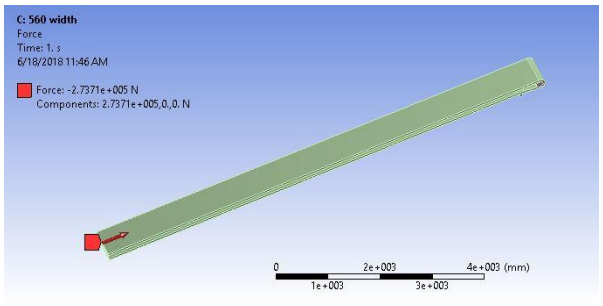

Fig. 2:Apply force in tight side

And slack side force is T_2= 93.81KN is applying in another side of belt is shown in fig. 3.

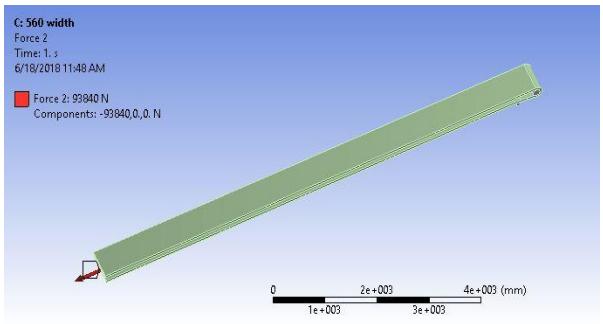

Fig. 3:Apply force slack side

Carcass material in belt

Carcass of a belt keeps up the belt pressure and providers structural strength; it does the majority of the work in supporting and pulling the load. Carcass comprises of different rubber piles that employ elasticity, and impregnated texture fortified with friction and skim coatsis shown in fig. 4. The textures most usually made up of nylon, polyester and cotton and so on.

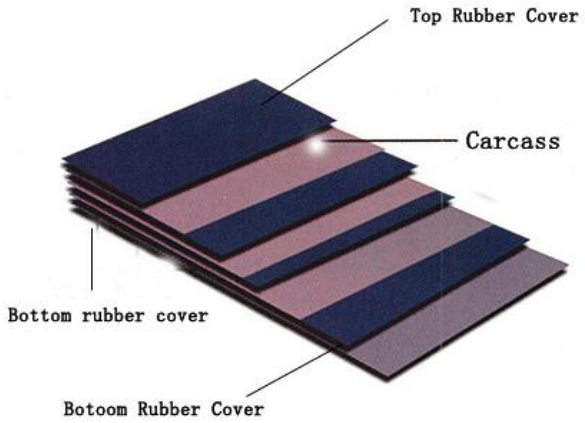

Fig. 4:Carcass materials in belt

RESULT

The analysis results are found in different material used in this study. The deformation of canvas material is 25.84mm and stress is 10.887 MPa but when apply carcass material layer in centre of belt the deformation is found 11.09mm and stress is 34.551MPa.

Further the study carcass material is replaced in banana fiber and pineapple fiber, the deformation in banana fiber carcass material belt is 9.74 mm and stress is 33.7981 MPa, and deformation of pineapple fiber carcass material belt is 8.41 mm and deformation is 68.438MPa is shown in table 2. The graph comparisons of total deformation and stress are shown in fig. 5 and fig.6 respectively.

Comparison result

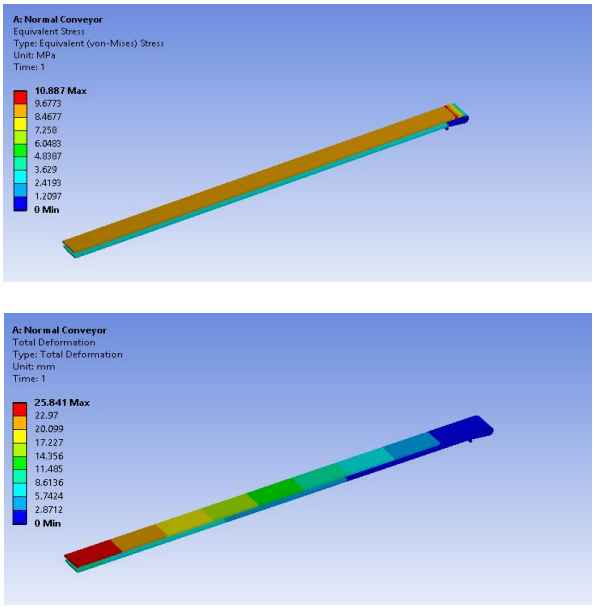

Fig. 5:Simple belt stressand deformation

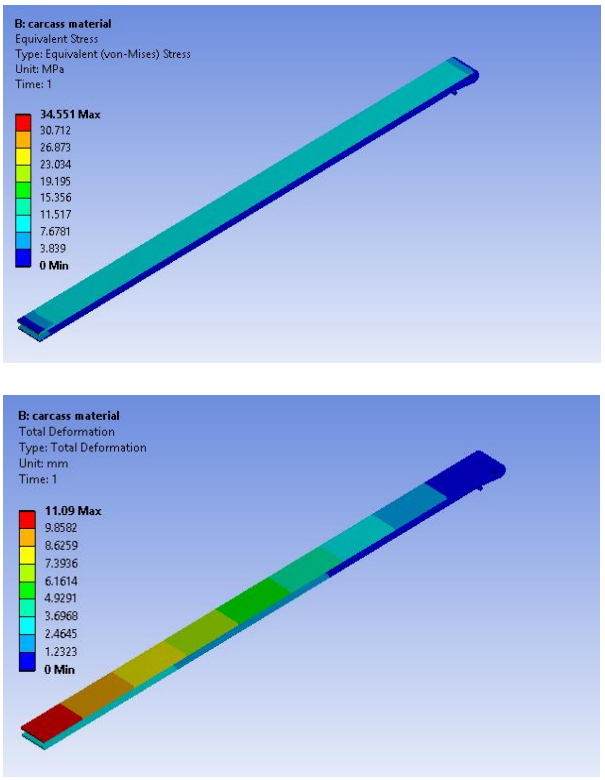

Fig. 6: Carcass material belt stressand deformation

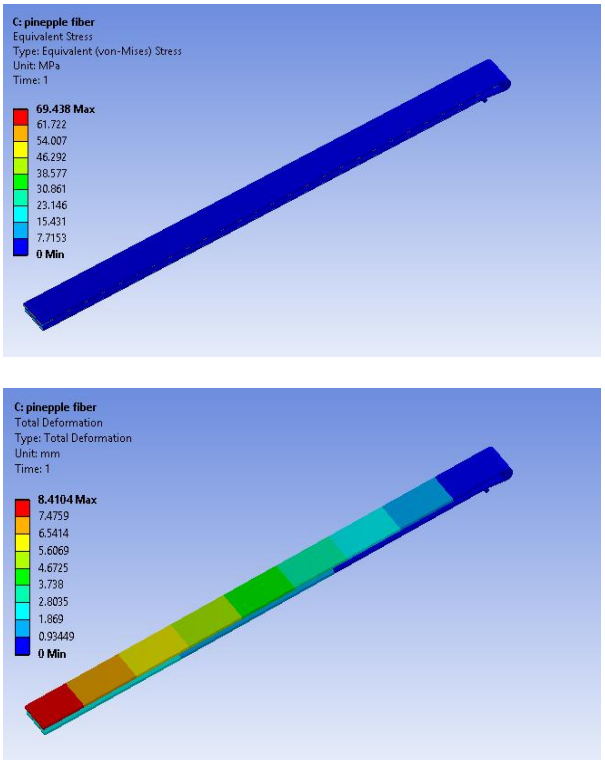

Fig. 7: Pinepple fiber material belt stressand deformation

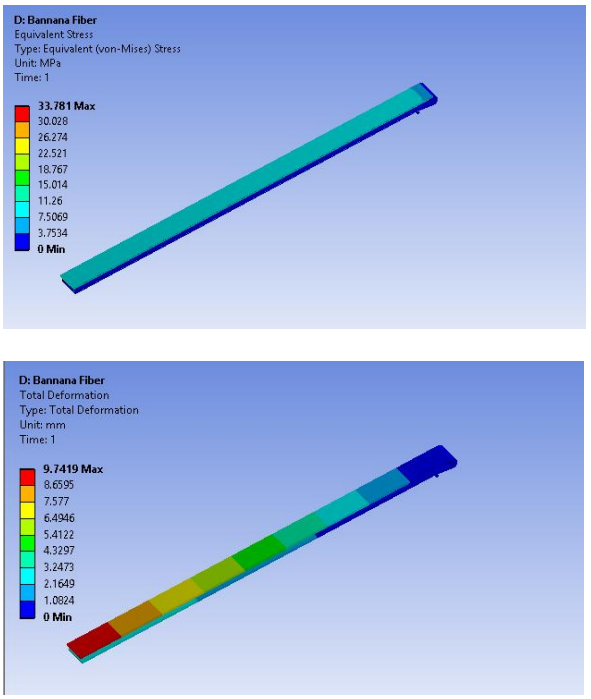

Fig. 8: Bannana Fiber material belt stressand deformation

Table 2: Deformation and stress of conveyor belt

Number of case	Total Deformation (mm)	Equivalent stress (MPa)
Case-1	25.84	10.887
Case-2	11.09	34.551
Case-3	9.74	33.781
Case-4	8.41	68.438

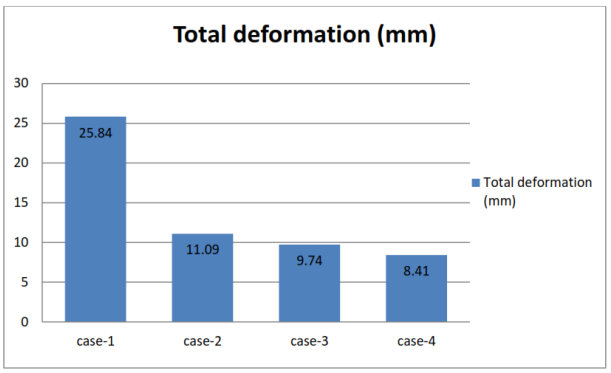

Fig. 9:Total Deformation Graph

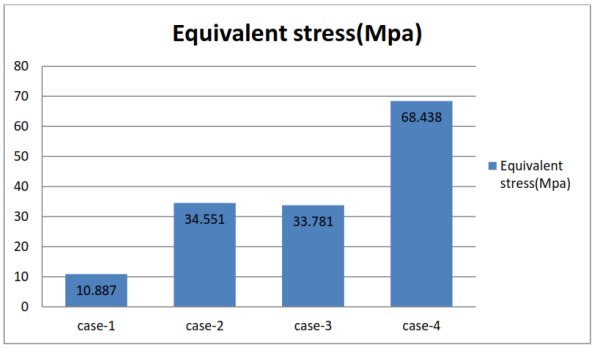

Fig. 10: Equivalent Stress Graph

CONCLUSION

During the design process of belt conveyors or the similar structures, the main concern is not only to keep the system safe in terms of strength. The design must fulfill the minimum safety conditions as well as it should be light in weight and cheap. Therefore, to be able to reach the optimum design, system should be modified and revised numerous times.

The result shows that the presence of carcass material in conveyor belt is very effective; the deformation of carcass material belt conveyor is less compared to simple conveyor belt. There are four cases shown in which the first is simple belt conveyor, second is simple carcass material, third is banana fiber carcass material and fourth is pineapple fiber material. The minimum deformations are found in pineapple fiber and banana fiber and given materials' maximum stress is under yield limit hence the new proposed material is safe for manufacturing. Calculating the system with analytical approaches leads to long time in calculation and values so obtained are often. In belt conveyor, the design process and related studies which require repetitive calculations, the designers can save time by using finite element method. Constructor can change the model in computer environment and get the results of the new design via finite element method without wasting time. Also, this is the most practical and reliable way to reach the optimum design in terms of deformation, stress, and availability of material.

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