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Parametric Analysis of Belt Material for Industrial Purpose

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Abstract: Belt conveyor is the transportation of material from one location to another. Belt conveyor is a commonly used equipment of continuous transport; it has a high efficiency and large conveying capacity, it can be achieved at different distances, different materials transportation. An attempt is made in this paper to study the Structural analysis on a belt conveyor system. The modeling of the belt conveyor system is created using Solidworks Parametric Software. Finite element analysis (FEA) is performed to obtain the variation of stress at critical locations of the system using the Solidworks software and applying the boundary conditions to evaluate the total deformation and equivalent (von-misses) stress. Further it can be extended for the different materials and optimization of belt conveyor system.

***Index Terms*– Conveyor belt, Finite Element Analysis (FEA), Creo parametric, Solidworks Software, Structural analysis.**

1. Introduction

A conveyor belt is the carrying medium of a belt conveyor system (often shortened to belt conveyor). A belt conveyor system is one of many types of conveyor systems. A belt conveyor system consists of two or more pulleys (sometimes referred to as drums), with a closed loop of carrying medium—the conveyor belt—that rotates about them. One or both pulleys are powered, moving the belt and the material on the belt forward. The powered pulley is called the drive pulley while the unpowered pulley is called the idler pulley. There are two main industrial classes of belt conveyors; Those in general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport large volumes of resources and agricultural materials, such as grain, salt, coal, ore, sand, overburden and more.

Primitive conveyor belts have been in use since the 19th century. In 1892, Thomas Robins began a series of inventions which led to the development of a conveyor belt used for carrying coal, ores, and other products.[4][5] In 1901, Sandvik invented and started the production of steel conveyor belts. In 1905, Richard Sutcliffe invented the first conveyor belts for use in coal mines which revolutionized the mining industry. In 1913, Henry Ford introduced conveyor-belt assembly lines at Ford Motor Company's Highland Park, Michigan factory.[6] In 1972, the French society REI created in New Caledonia the longest straight-belt conveyor in the world in that moment, at a length of 13.8 km (8.6 miles). Hyacynthe Marcel Bocchetti was the concept designer. The longest conveyor belt is that of the Bou Craa phosphate mine in Western Sahara (1973, 98 km in 11 sections). The longest single-span conveyor belt is at the Boddington bauxite mine in Western Australia (31 km).

In 1957, the B. F. Goodrich Company patented a Möbius strip conveyor belt, which it went on to produce as the "Turnover Conveyor Belt System". Incorporating a half-twist, it had the advantage over conventional belts of a longer life because it could expose all of its surface area to wear and tear. Such Möbius strip belts are no longer manufactured because untwisted modern belts can be made more durable by constructing them from several layers of different materials.[7] In 1970, Intralox, a Louisiana-based company, registered the first patent for all plastic, modular belting.

2. Objective

- An attempt in this paper, the conveyor belt system is modeled by using Solidworks Parametric software, and analysis is done by using Solidworks software to evaluate the total deformation and von-misses stress.
- Utilizing the software Solidworks to analyzing the modification of conveyor belt for better result.

3. Specifications of Conveyor Belt System

Total length of belt = 7000mm
Centre to centre distance = 3500mm
Belt width = 698mm

4. Material Properties Nylon 66 For Conveyor Belt

High strength, high elongation, good resistance to abrasion, fatigue, and impact. While moisture absorption not as high as cotton, it will absorb up to 10% of its own weight in moisture. Consequently, poor dimensional stability. High resistance to mildew. At one time, nylon represented 40% of the raw material input into belt manufacturing. Today, it is something less than 20%.

Table -1: Material Properties

Material Properties	Value	Unit
Density	1180	Kg/m^3
Young's Modulus	1999.5	Mpa
Poisson's ratio	0.39	
Bulk Modulus	3.0295 x 109	Pa
Shear Modulus	7.0924 x 108	Pa
Tensile Yield Strength	527	Mpa
Compressive Yield Strength	527	Mpa
Tensile Ultimate Strength	604	Mpa
Compressive Ultimate Strength	0	Mpa

5. Material Properties ASTM A36 Hot Rolled Steel for 5Structures

A-36 steel bar is one of the most widely used carbon steel bars for construction and manufacturing. A36 bar is a hot rolled steel bar that is weldable, formable and machinable. Intermediate tensile strength carbon steel for use in riveted, bolted or welded construction of bridges and buildings, manufactured parts and equipment.

Table -2: Material Properties

Material Properties	Value	Unit
Density	7800	Kg/m^3
Young's Modulus	2 x 105	Mpa
Poisson's ratio	0.26	
Bulk Modulus	1.3889 x 1011	Pa
Shear Modulus	7.9365 x 1010	Pa
Tensile Yield Strength	250	Mpa
Compressive Yield Strength	250	Mpa
Tensile Ultimate Strength	400	Mpa
Compressive Ultimate Strength	0	Mpa

6. Modeling of Conveyor Belt System

Solidworks Parametric is the standard in 3D CAD, featuring state of the art productivity tools that promote best practices in design while simultaneously ensuring compliance with industrial and company standards. This 3D CAD software is powerful, easy to use, flexible and fully scalable. It features the industry's broadest range of 3D solid modeling and design capabilities for creating high quality designs in minimum time.

Fig -1: CAD model image of conveyor belt system

7. Analysis of Conveyor Belt System

7.1 Introduction to Finite Element Analysis

The basis of FEA relies on the decomposition of the domain into a finite number of sub-domains (elements) for which the systematic approximate solution is constructed by applying the variation or weighted residual methods. In effect, FEA reduces problem to that of a finite number of unknowns by dividing the domain into elements and by expressing the unknown field variable in terms of the assumed approximating functions within each element. These functions (also called interpolation functions) are defined in terms of the values of the field variables at specific points, referred to as nodes. The finite element method is a numerical procedure that can be used to obtain solutions to a large class of engineering problems involving stress analysis, heat transfer, electro-magnetism, and fluid flow.

7.2 Steps for Solidworks Simulation

7.2.1 Geometry

In Solidworks, simulation module has first step for make 3 D model and insert in that module. As shown in Figure 2 which environment of simulation first step.

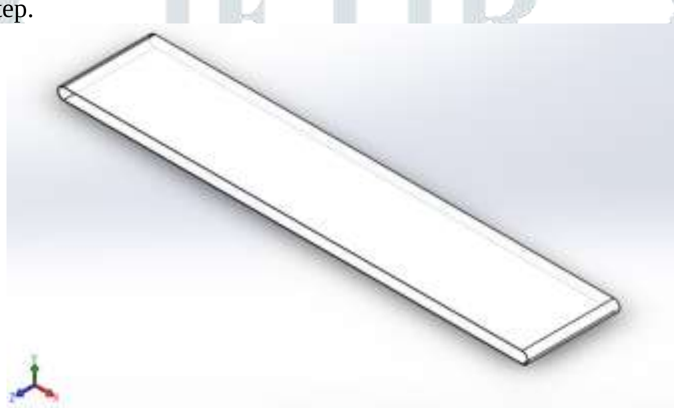

Fig -2: Geometry of Belt

7.2.2 Material Properties

Assign all components have material as per manufacturing process and strength of material which consider in design. As shown Figure 3 which give information regarding material assignment in simulation.

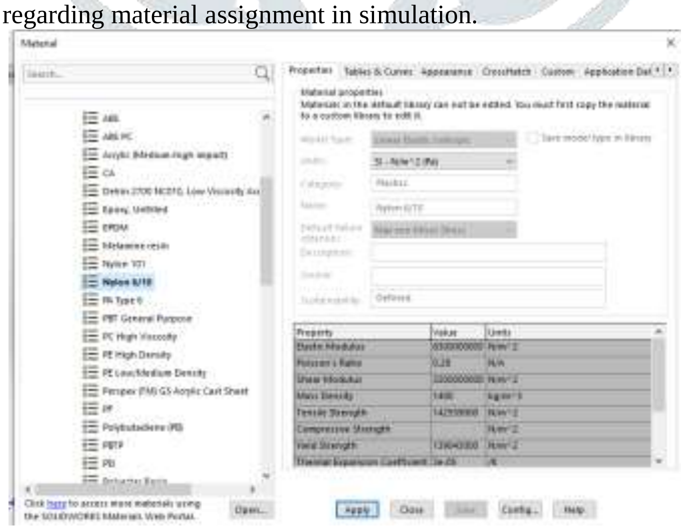

Fig -3: Material applied on Belt Geometry

7.2.3 Boundary Condition

Boundary condition applied for our case is fixed based as vibration pad and load applied 100 KN on top surface belt. As shown in Figure 4 & 5 which give information regarding boundary condition.

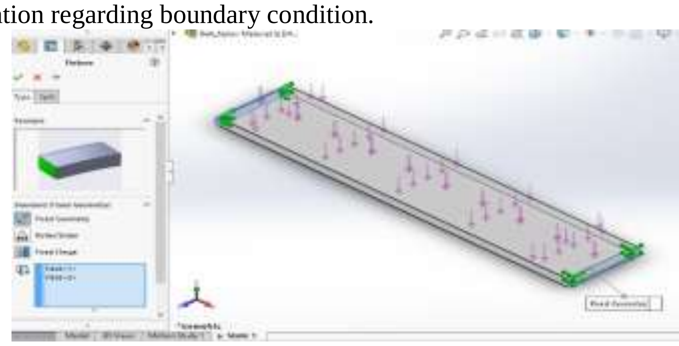

Fig -4: Fixed Constraint applied at both end of belt

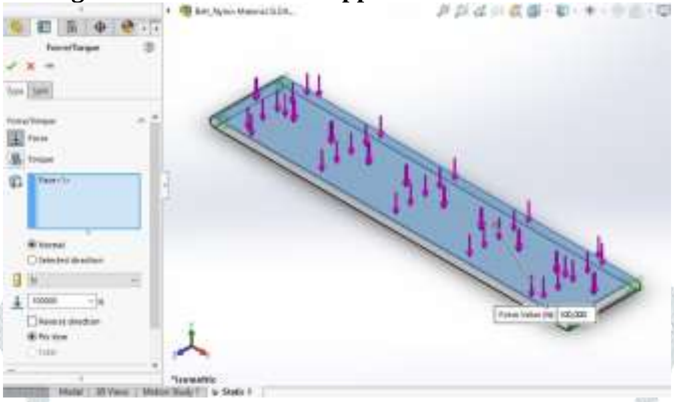

Fig -5: Force applied at top face of belt

7.2.4 Result

In post process of Finite Elements Analysis which gives result of Von mises stress and Deformation as per given boundary and compared with material properties that safe as per taken factor of safety. As shown Figure 6 and 7 which indicated Von mises Stress and Deformation respectively for Nylon Material.

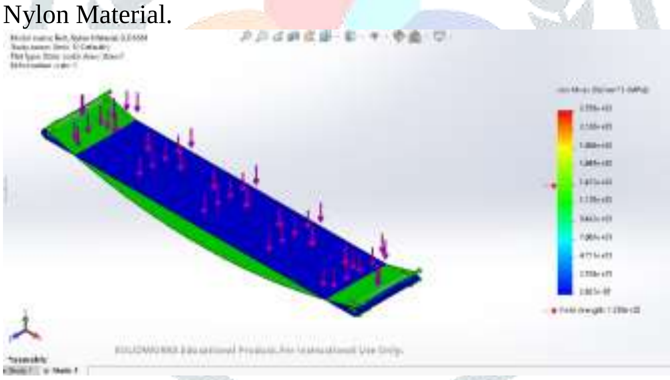

Fig -6: Von Mises Stress in Static Analysis (Nylon Material)

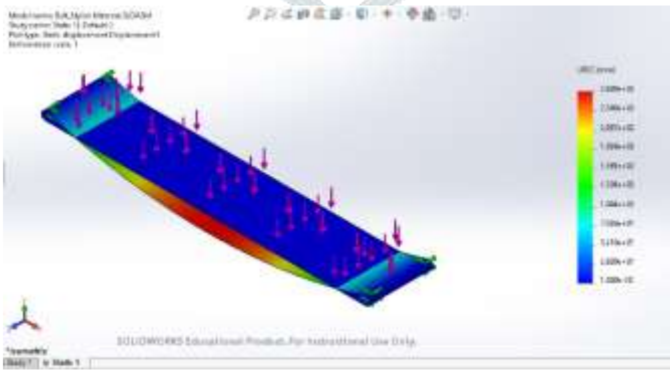

Fig -7: Deformation in Static Analysis (Nylon Material)

As shown Figure 8 and 9 which indicated Von mises Stress and Deformation respectively for ASTM A36 Hot Rolled Steel.

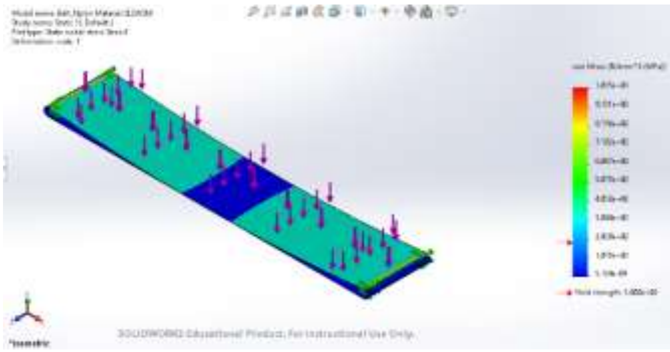

Fig -8: Von Mises Stress in Static Analysis (ASTM A36 Hot Rolled Steel Material)

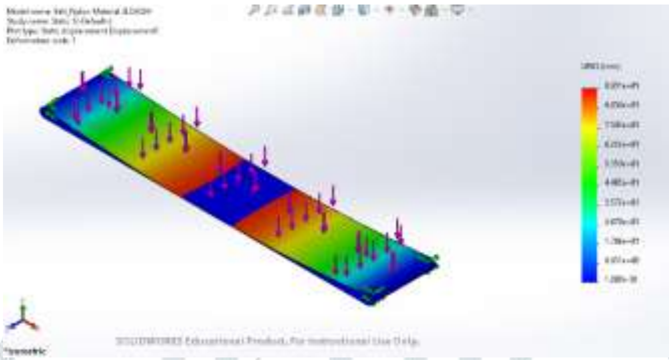

Fig -9: Deformation in Static Analysis (ASTM A36 Hot Rolled Steel Material)

Table -3: Result

Material -1	**NYLON 66**	
Von mises Stress	235	NMPa
Deformation	260.9	mm
Material-2	**ASTM A36 HOT ROLLED STEEL**	
Von mises Stress	1015	NMPa
Deformation	89.31	mm

7. Modal Analysis of Conveyor Belt System

7.1 Dynamic Analysis of Ratchet and Pawl Mechanism

An approximation for the component deformation was introduced by means of a weighted sum of constant shape functions. When dealing with the task of deriving these functions the finite element method can be very effective. Here, a well-known and widely used concept known as component mode synthesis (CMS) can be used. One of the most common approaches (Craig and Brampton 1968) is based on the idea of using normal mode analysis techniques to calculate eigenvectors for use as shape functions, or shape vectors, respectively. While employing eigenvectors for approximation was already very widespread, Craig and Bampton among others (Hurty 1965) enhanced the method by considering additional types of vectors. In the following, Craig and Bampton's method is dealt with in more detail since it is also implemented in MSC.ADAMS/Flex. Here, the following types of vectors or modes are utilized:

1. Fixed boundary normal modes
2. Static correction modes

Fixed boundary normal modes are eigenvectors that result from a finite element normal mode analysis. They relate to the boundary condition implying that all nodes of the finite element model are fixed at which forces and joints that is applied within the multi body system. In the following sections, these nodes are referred to as interface nodes. Static correction modes are deformation vectors that result from static load cases with which loads are applied to interface points. Typically, a unit load is applied to every nodal coordinate, whereas all other interface nodes are fixed. This leads to six static correction modes for each interface node. Figure 5.1 illustrates some mode shapes for a one-dimensional bar. The shapes (a) and (b) are fixed-boundary normal modes, shapes (c) and (d) are static correction modes resulting from a unit displacement (c) and a unit rotation (d), respectively. The use of static correction modes ensures a good approximation of the deformation when forces and moments are applied to interface points. The fixed boundary normal modes are important as soon as high frequency excitation is expected, i.e., if the loading may not be considered "quasi-static". Note: In the following, the flexible component is always assumed to be represented by a finite element model.

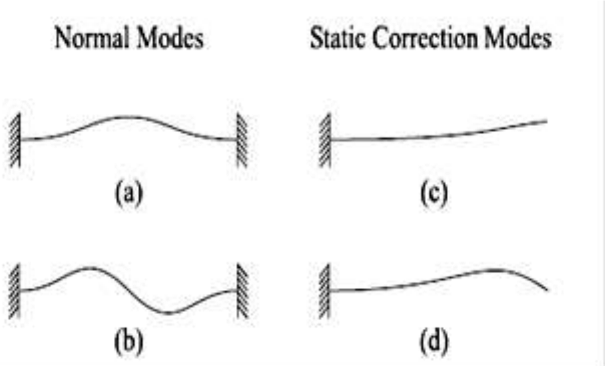

Fig -10: Mode shapes of one-dimensional bar

7.2. Benefits of Modal Analysis

- Allows the design to avoid resonant vibrations or to vibrate at a specified frequency (speaker box, for example).
- Gives engineers an idea of how the design will respond to different types of dynamic loads.
- Helps in calculating solution controls (time steps, etc.) for other dynamic analyses.

7.3 Steps of Dynamic Analysis of belt

Model Analysis

7.3.1 Geometry

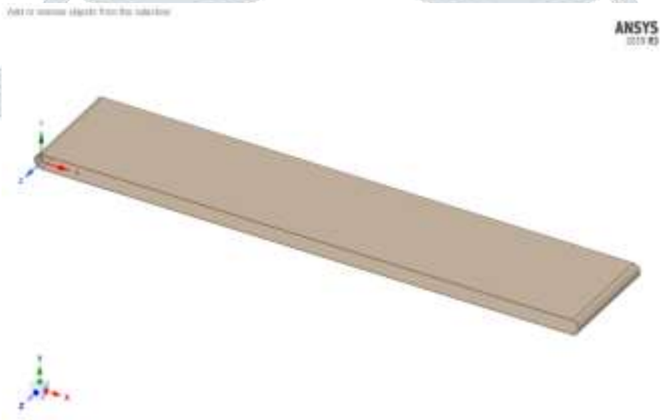

Fig -11: Geometry of structure of belt using dynamic analysis

7.3.2 To Find Natural Frequency at Connection Region

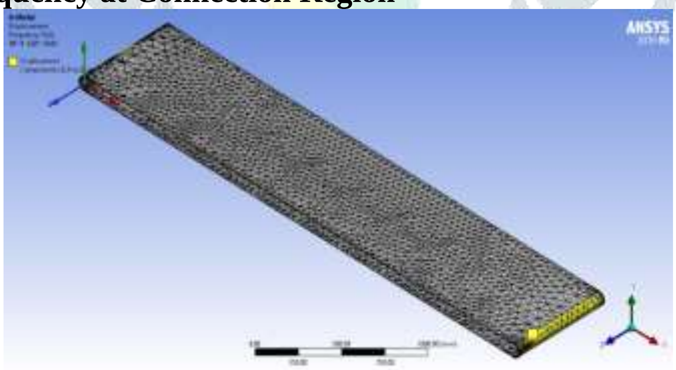

Fig -12: Connection between parts

7.3.3 Meshing
Solid mesh (Beam mesh) which is programme generated.
Fine Meshing is apply
No. of Nodes: - 47304
No. of Elements: - 22332

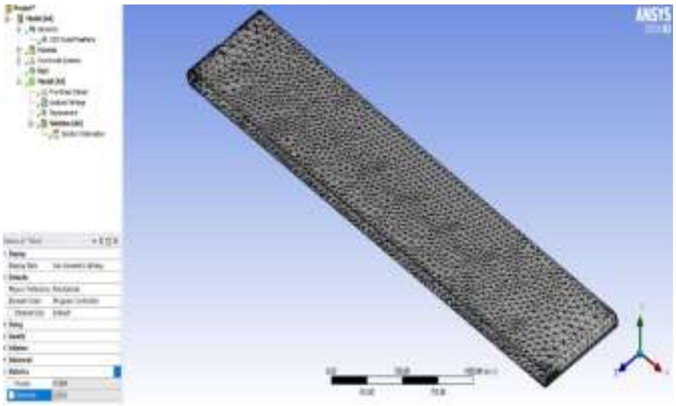

Fig -13: Mesh Model of belt

7.3.4 Apply Fixed Support

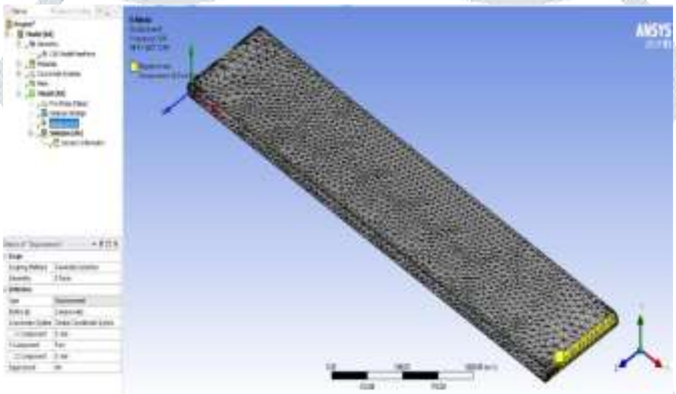

Fig -14: Application of Fixed Support

7.3.5 Results of Analysis

Mode – 1

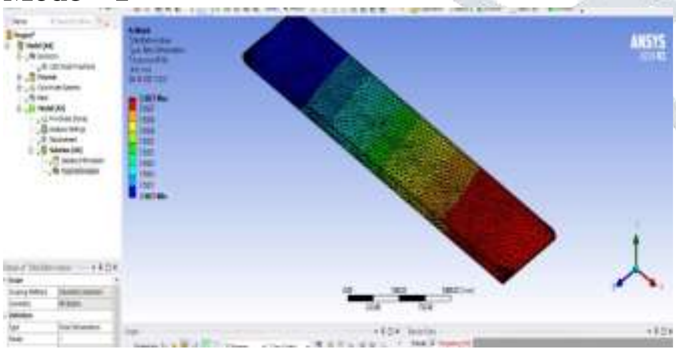

Fig -15: Total deformation of mode 1

Mode-2

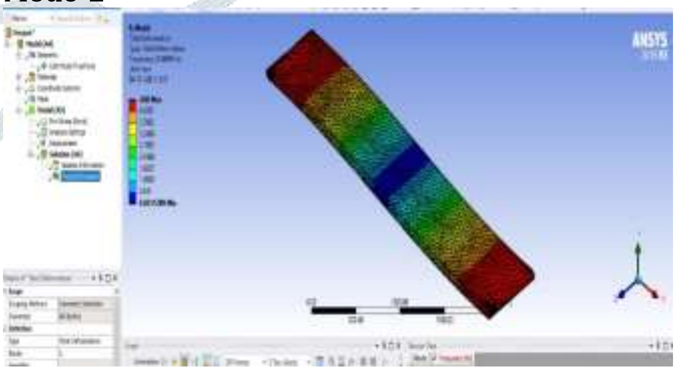

Fig -16: Total deformation of mode 2

Mode-3

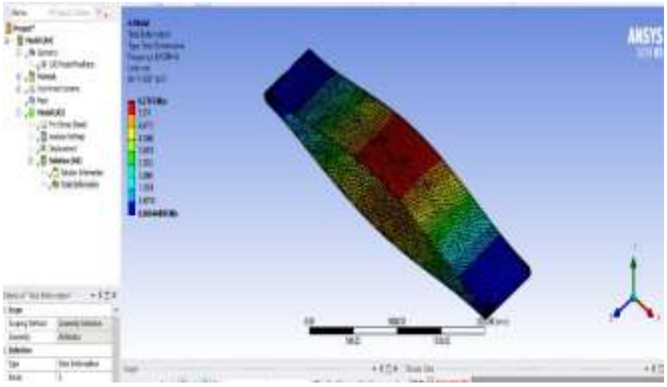

Fig -17: Total deformation of mode 3

Mode-4

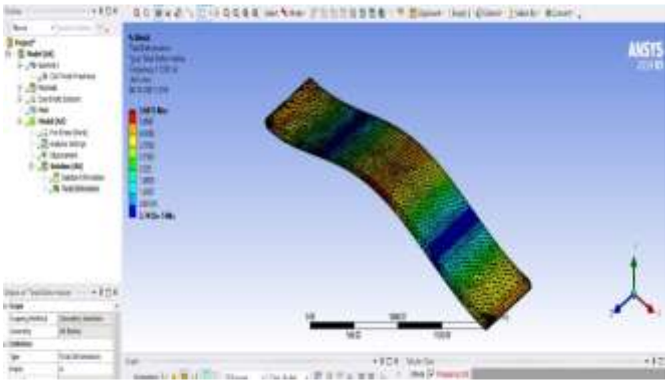

Fig -18: Total deformation of mode 4

Mode-5

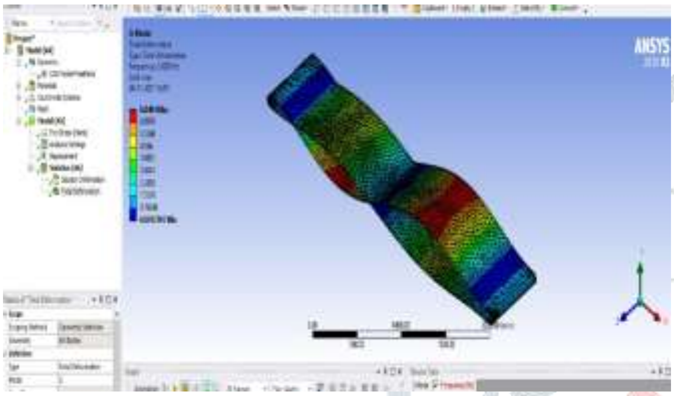

Fig -19: Total deformation of mode 5

Mode-6

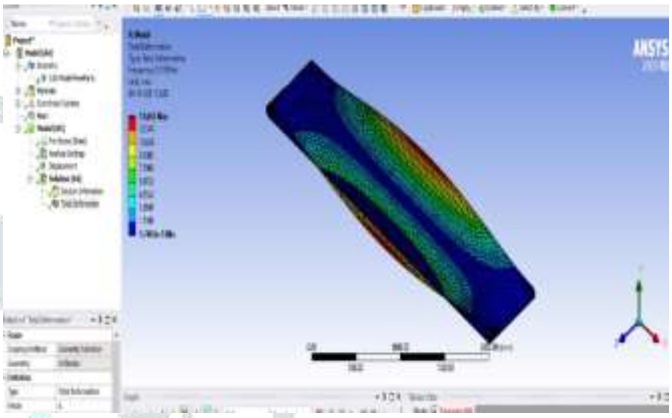

Fig -20: Total deformation of mode 6

7.4 Results of Modal Analysis of belt

Table -4: Modal Analysis Result of belt

Total Deformation of belt		
Mode	**Frequency (Hz)**	**Deformation Scale**
1	0	3.5027
2	0.36876	4.86
3	0.91094	6.2707
4	1.5313	5.6813
5	2.5805	6.8484
6	3.1378	13.662

8. Conclusion

CAD model of the belt conveyor system is generated in Solidworks Parametric, and this model is imported to Solidworks Simulation for processing work. An amount of force 100 KN is applied along the upper belt surface and base structure is fixed.

Following are the conclusions from the results obtained:

- The maximum deformation induced in belt conveyor system is 260.9mm near the tail pulley side belt surface.
- From the FEA output the maximum design strength is 235MPa from the material property the ultimate tensile strength of the material is 527MPa, then the factor of safety becomes within that safety limit.
- The value of equivalent (von-misses) stress that comes out from the analysis is far less than material yield stress, so our design is safe.

By using ANSYS 2019 R3 software found total deformation with respect to different mode 1 to 6. Maximum frequency and deformation were at mode 6 which were 3.1387 Hz and 13.662 mm respectively. In these reflected capabilities of CAD tools like Solidworks and ANSYS which give solve any kindly technical problem.

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