Design and Analysis of a Belt Conveyor System

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Abstract: In any sort of manufacturing industry, raw materials, products and by products as well needs to be transported or sometimes shifted from one region to another within the industry. Such impedimenta for the purpose of transportation of raw materials are designed such that they facilitate effortless, economical, smooth and safe loading and unloading with proper design considering the safety and least human indulgence. The belt conveyor system should be designed in such a way that it can be used for glib handling and shifting of materials beyond human adeptness in terms of volume and mass. Here in this project we have discussed, researched out and designed and analysed the design calculations and considerations of the belt conveyor system for coal using 7 simple roller idlers, 5 impact idlers, 12 return idlers along with the frames and channels in terms of size, length , capacity and speed, roller diameter , idler spacing, diameter, location and arrangement of pulley, control mode, 3 node division intended application and made the entire design in Dassault Solidworks 2014 and made the entire assembly in Dassault Solidworks 2014 and Ansys 14.5 and thus designed the Conveyor System with the product to be handled as well as its maximum loading capacity in order to ensure fast, continuous efficient movement of crushed coal assuming that it does not undergo any slip and neglecting halts or fatalities during loading and unloading. Upon the successful cessation of this paper, this has generated design statistics for industrial utility in the build out of a belt conveyor system which is glib, safe and performs with efficacy.

Keywords: Idler, load, force, impact, belt, pulley.

INTRODUCTION

The belt in the conveyor system popularly known as the conveyor belt is the medium for transportation in a belt conveyor system. A belt conveyor system is one of a many types of conveyor systems. There are several materials that can be used for making the conveyor belt that might range from PVC to rubber materials.

The belt consists of two or more layers of material. Generally or in most cases belts have two layers namely an under layer of material for providing linear strength and shape called a carcass and an over layer called the cover. In most cases the carcass material is Polyester, Nylon or cotton. The cover is either Rubber or Plastic. However covers can be made of most exotic materials for unusual applications[1].
There are other major components of a Conveyor belt System:-
- Long continuous belt as discussed before
- Rollers, which carries the belt known as idlers.
  - Impact idler:- present where the impact of the load is done, or where the material falls
  - Normal idlers:- that carries the materials
- Pulleys.
  - Peripheral devices to drop belt

Different types of idlers that are used while a successful design of a conveyor belt system is made are as follows:-
- Normal Idler:- These are the idlers or rollers that are used for transportation of thee material via the belt smoothly.
- Return Idlers:- These are the idlers that are used for returning of the belt to its loading position.
- Special idlers - these are used for certain special purposes.

Different types of pulleys used while designing a conveyor belt system. They are as follows:-
- Snub Pulley
- Take up pulley
- Drive Pulley

Pulley should be large enough to avoid hard bend at point of tension application.

Appropriate ability to grab or hold the material should be there - where risk of slippage turns out to be a function of grab and tension.

Drive should be placed in practical location to minimize the highest tension in the belt - a head pulley location often good on a belt up a slope.

Loading a conveyor belt
1. Chute - may use scalping bars so fines fall on first and provide cushion
2. Transfer Conveyor - wear on short replaceable belt get things up to speed
3. Vibratory feeder

Calculations
        The diameter of the driver and driven pulley is determined by the type and dimension of conveyor belting. The diameter of the pulley must be designed such that it does not place undue stress on the belt. The length of a belt conveyor in meters is the length from the center of pulley parallel to belt line. The length of the belt is dependent the pulley diameters and on the center distances as well [2].

$$V = D * \pi \tag{1}$$

Where: V= Belt speed;
d= diameters of rollers; and
Π=pi

Capacity is the product of speed and belt cross sectional area generally; belt capacity (kg/sec) is given as:

$$B.C. = 3.6 * A * \rho * V \tag{2}$$

Where: A= belt sectional area (m2);
ρ = material density (kg/m3); and
V= belt speed (m/s)

The mass of material m M_m (live load) per meter (kg/m) loaded on a belt conveyor is given as:

$$M_m = C/(3.6 * V) \tag{3}$$

Where: C= Conveyor capacity (355 tonnes/hr.); and
V= belt speed (5 m/s).
M_m =19.72 kg.

Determining the capacity:-

$$C = (C_T * \rho * C_f * V)/(1000) \tag{4}$$

Where: C=Capacity in tonnes/hr of a belt conveyor consisting of 3 equal roll idler; C_T=Capacity of troughed belts for 3 roll equal length idler (175);
ρ =material density in kg/m3 (1500);
C_f=Capacity factor (1.08); and
V=Belt speed in m/s (1.25
From the above equations we get the value of C as 355 tonnes/hr

$$V_L = L_C/W \tag{5}$$

Where: V_L=Volumetric belt load (m3/hr);
L_c=Load capacity of the belt conveyor (tonnes/hr); and
W=Specific Weight of the conveyed material (tonnes/m^3)

Other consideration

Speed of the motor:- 250rpm

Roller diameter
        The roller provide buttress to the belt and facilitates easy as well as free Rotation of the belt conveyor in all direction. The appropriate choice of roller diameter must take into consideration the belt width, the relationship between the maximum belt speed, roller diameter and the relative revolution per minute is given by

$$n = (1000 * v * 60)/(D * pi)$$

Where n=number of revolution per minute.
D=roller diameter
And V=belt speed(m/s)
The belt width is designed as 1200mm

The belt speed is 5 m/s, roller diameter is therefore designed as 400mm (actual diameter is 382mm)

From equation 6
The number of revolution per minute is 250rpm

        Taking the above values and the dimensions provided below, we have designed a conveyor belt system in solid works to check the safety of the conveyor belt system.

From the tables provided above we got the dimensions of the normal idler and the impact idler
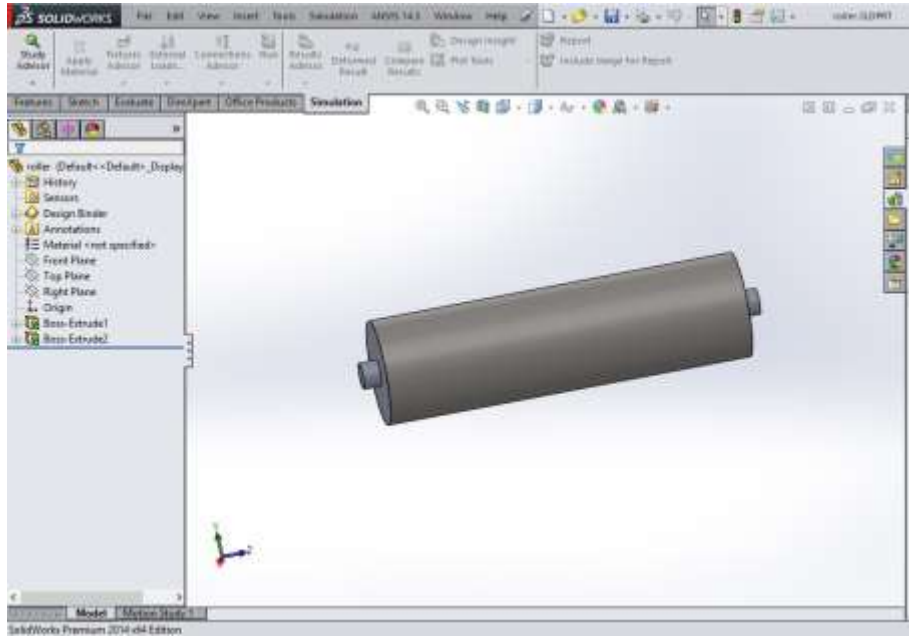
DESIGN STEPS IN SOLIDWORKS
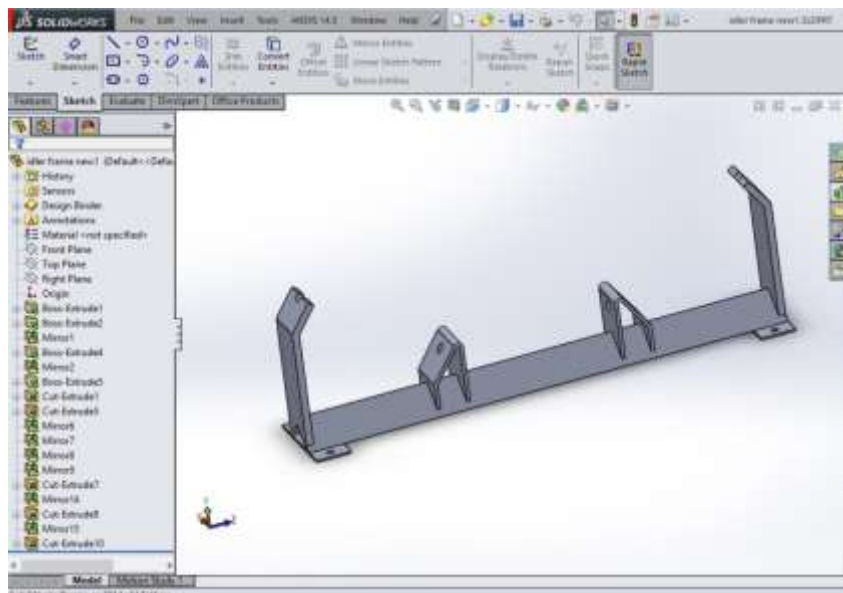
IDLER FRAME

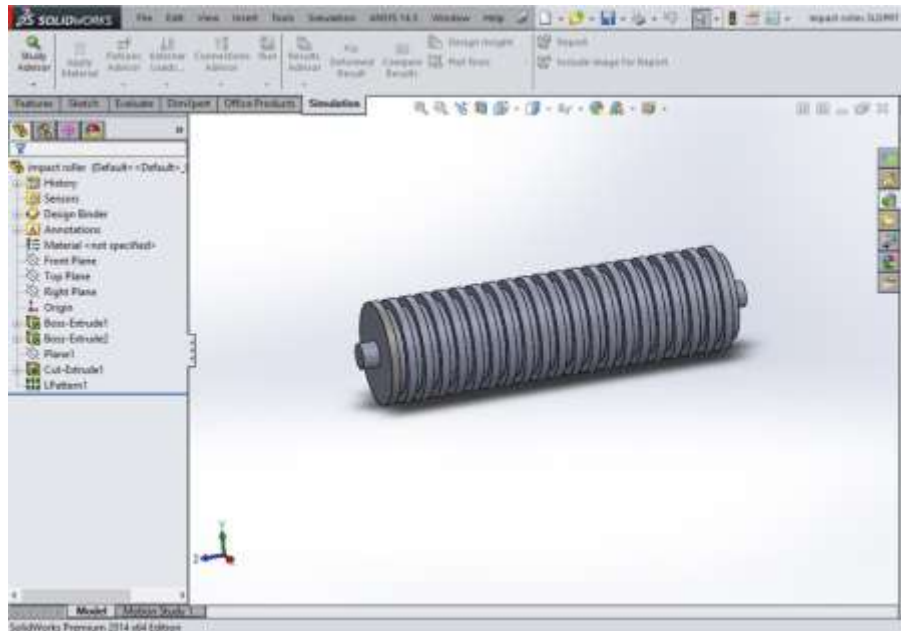The above image is the image of an idler frame that is designed in Solidworks 2014. The idler frame is used for holding the idler or roller that is used holding and for movement of the conveyer belt. The idler frame is attached to the base channel of the entire conveyer system.

IDLERS

The above part designed in Solidworks is of a normal idler or roller that is used for carrying the conveyer belt loaded with the material. This idler is attached to the idler frame and thus the entire assembly is made.

IMPACT IDLERS

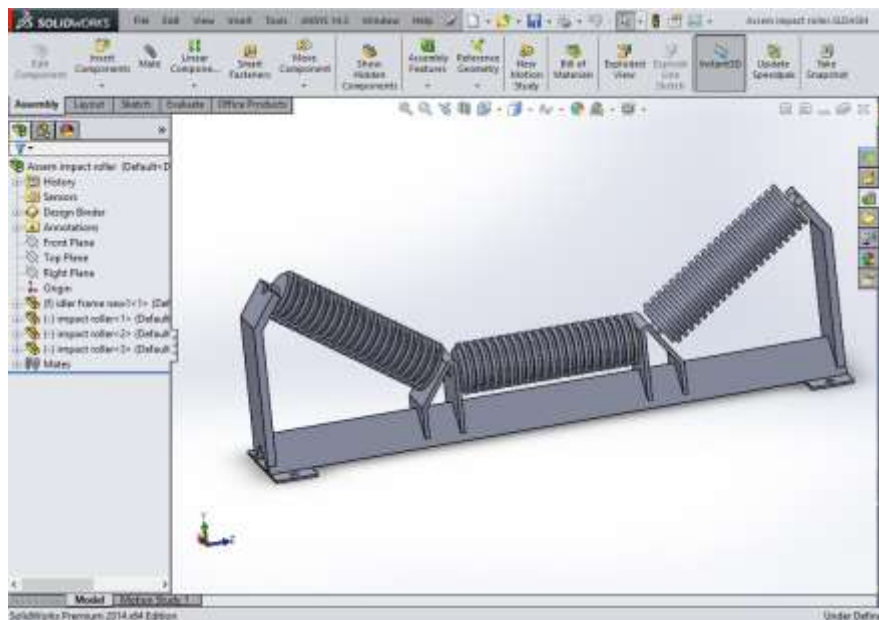The above image is that of an impact idler. It is made groove shaped so that it can absorb shock as the grooves has more surface area and provides cushion for the impact of the coal or any material that falling on it from the coal hopping machine.
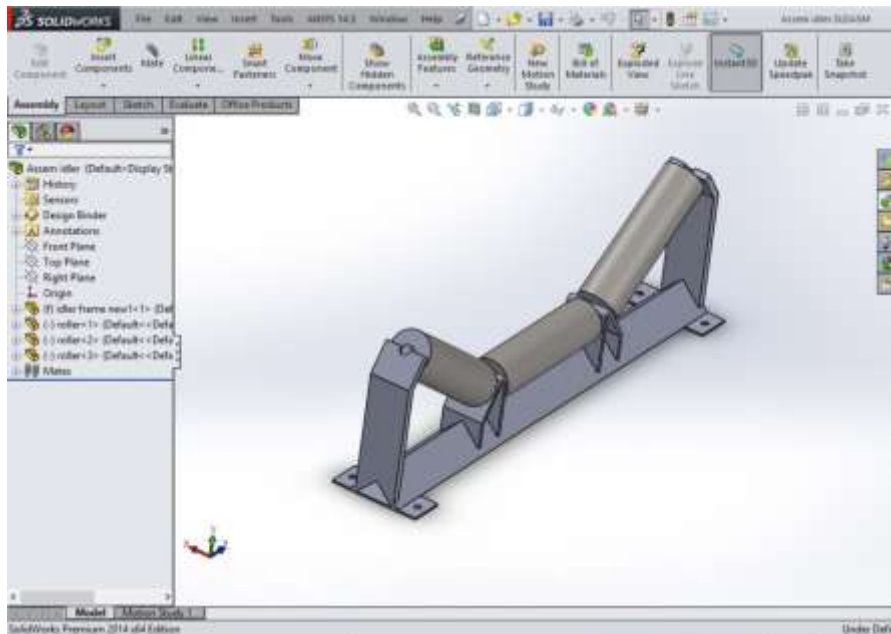
NORMAL IDLER FRAME ASSEMBLY

The above image is of a normal idler frame assembly. The assembly is done in Solidworks assembly and this frame with the roller is used for the movement of the material through the conveyer.

IMPACT IDLER ASSEMBLY

The above assembly is that of an impact idler with the idler frame. This entire assembly is attached to the base channel. On these impact idlers the impact or the live load of coal from the coal hopping machine falls and is carried away.
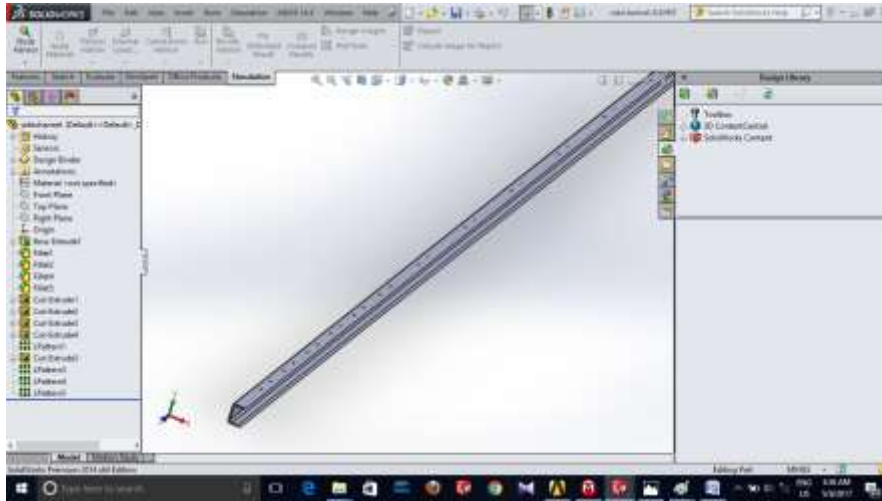
SIDE CHANNEL

The above image is that of a side channel with the threading for the screws to hold the idler frame. This side channel is supported by the base channel, on which it stands.
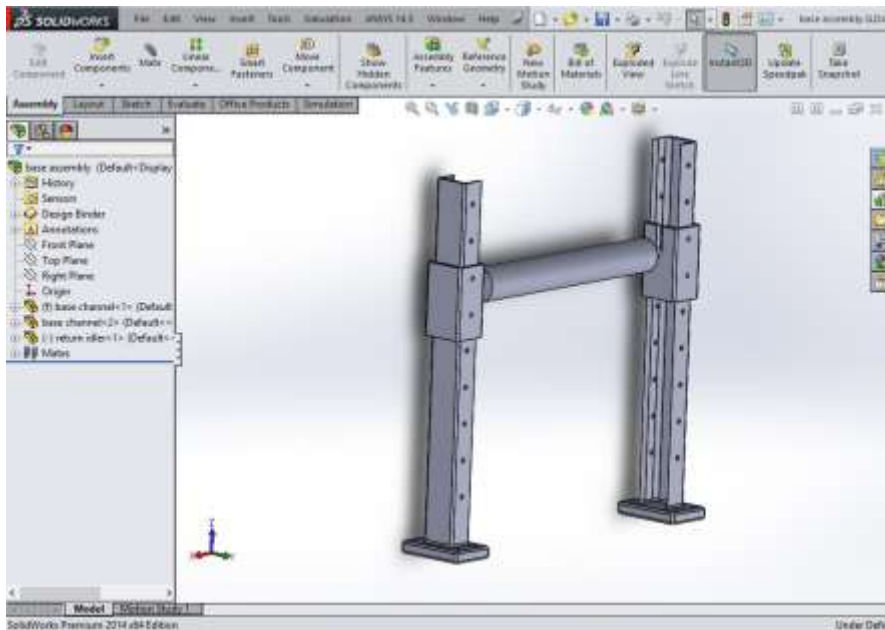
BASE CHANNEL ASSEMBLY WITH RETURN IDLER

The above image is that of a return idler with the base channel that is used for holding the sliding arrangement of the return idler as well as the side channel. The return idler is used for carrying the conveyer belt whole it is returning.
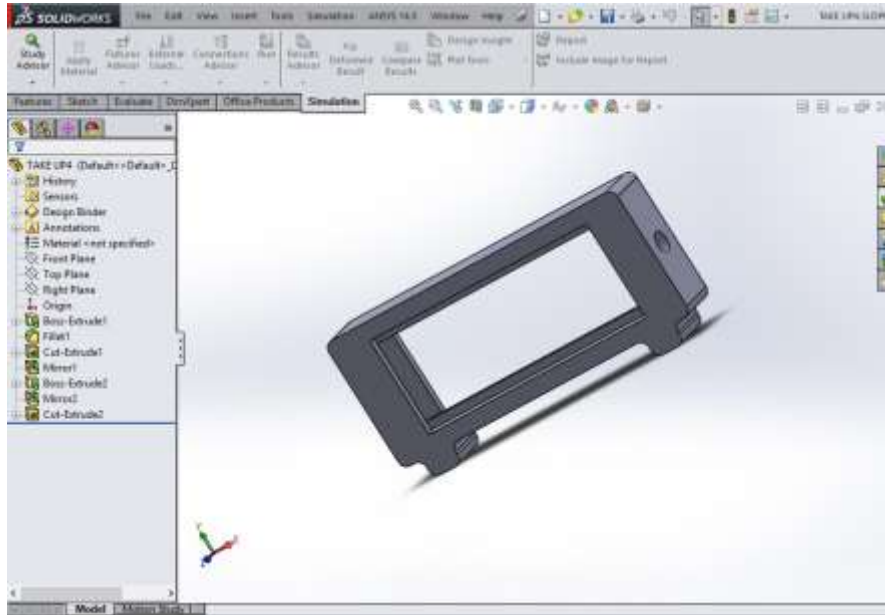
SLIDING FRAME FOR PAKE UP PULLEY

The above image is of the sliding frame for the take up pulley also called the tail pulley arrangement. The take up pulley arrangement so that there is no slag of the conveyer belt in the entire arrangement.
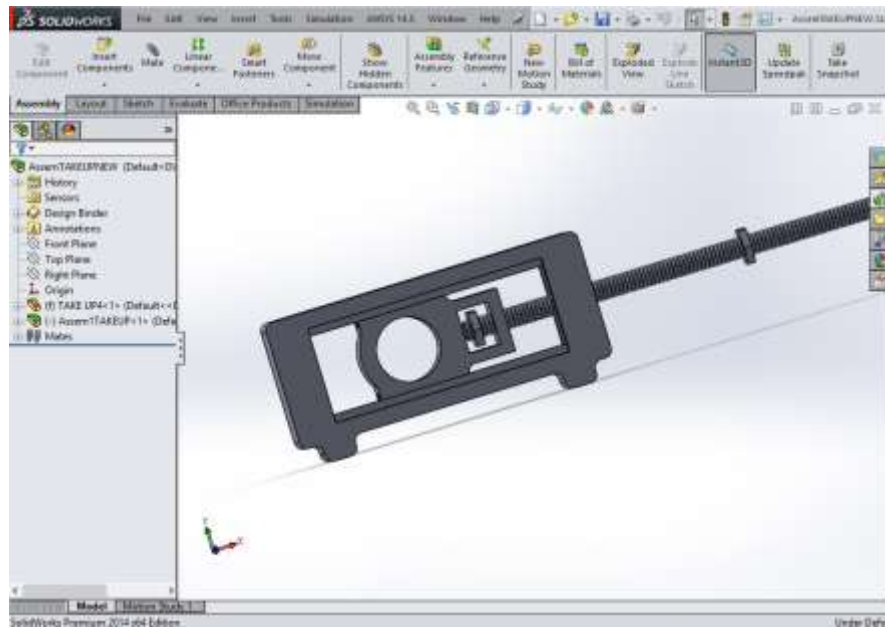
ASSEMBL OF SLIDING ARRANGEMENT IN TAKE UP PULLEY

The above arrangement is that of the assembly of the entire assembly of the sliding mechanism in take up pulley arrangement. The take up pulley arrangement is made so that there is no slag of the conveyer belt in the entire arrangement.
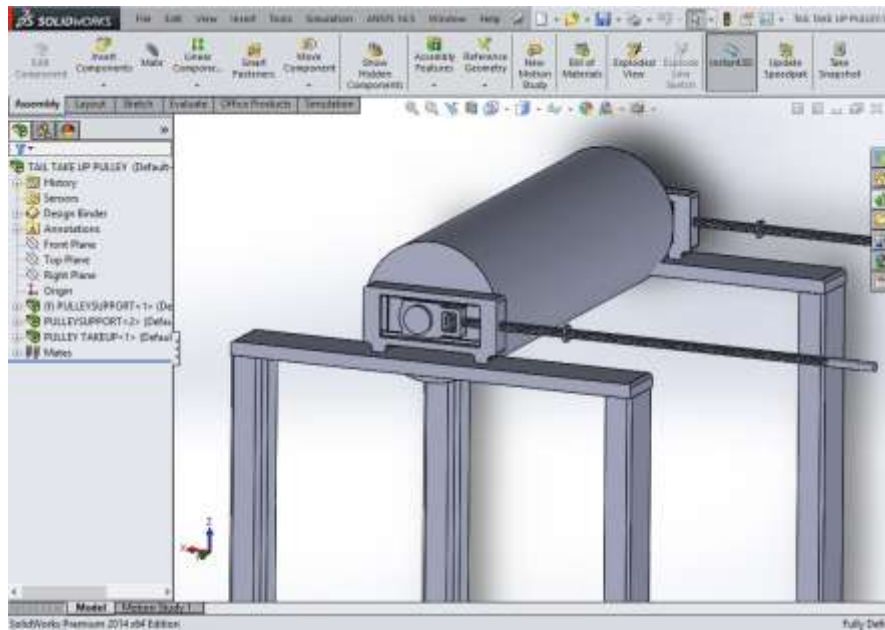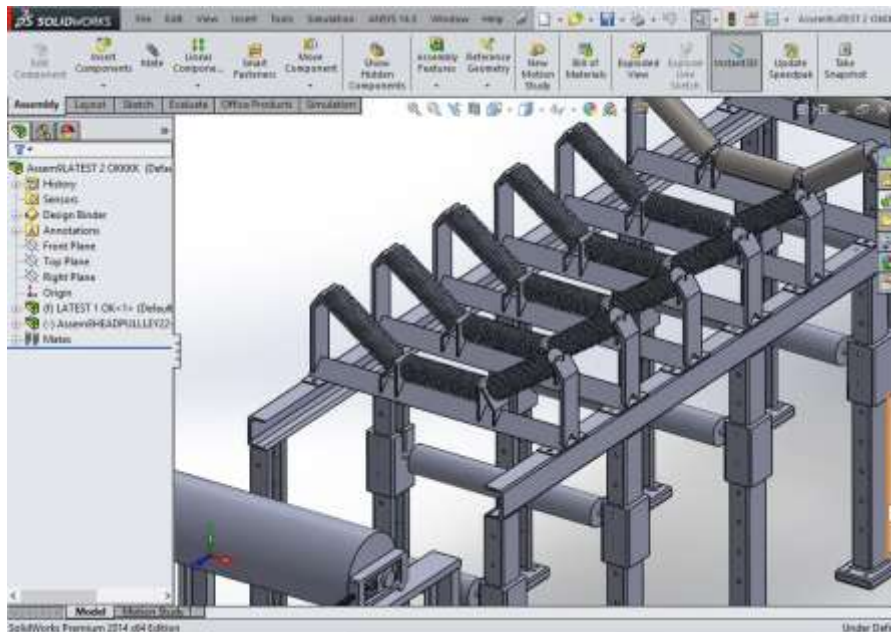
TAKE UP PULLEY ARRANGEMENT

The above arrangement is the assembly of the take up pulley arrangement. The take up pulley arrangement ensures that there is no slag in the arrangement. A base frame is separately made so that it can hold the pulley and the sliding arrangement.
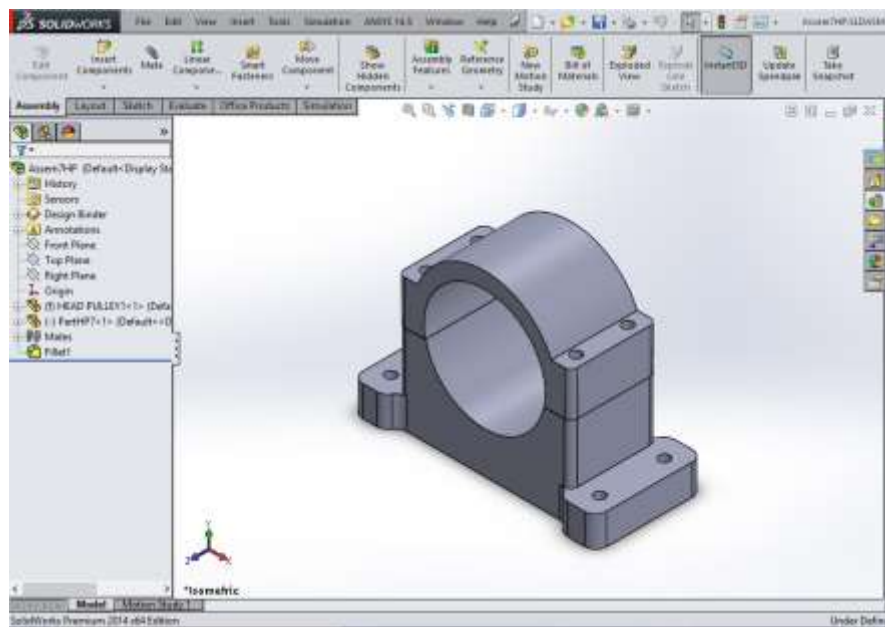
THE CONVEYER BELT SYSTEM

Thus the entire assembly is made in SOLIDWORKS 2014 of the parts that are discussed above. The above design is safe according to the calculation [3].
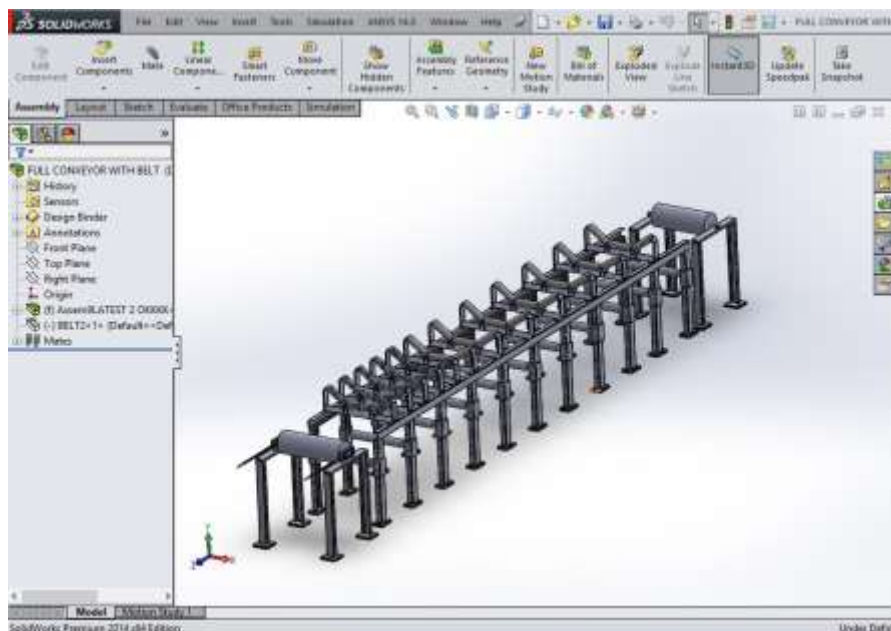
The design that is made in solidworks is based on the calculations that are made in the previous page.

Simulation of Assembly idler

Date: Monday, April 24, 2017
Designer: ujjayansujitdesigns
Study name:Static 1
Analysis type:Static

Table of Contents

Assumptions

The assumption that is taken is that we have put the belt load as well, however we have neglected the cushion which the belt provides to the coal and the force that is provided is a three face force.

Model Information
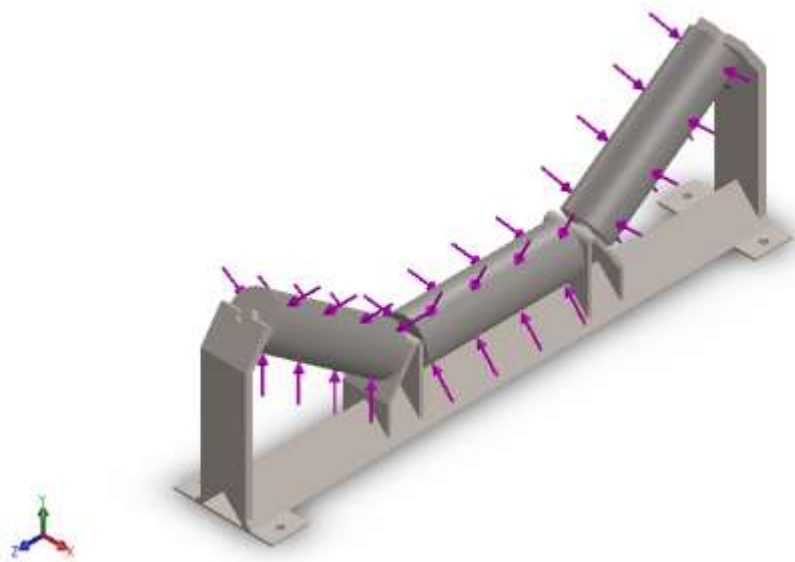
Model name: Assem idler
Current Configuration: Default

Solid Bodies

<L_MdInf_SldBd_Nm/>	Treated As	Volumetric Properties	Document Path/Date Modified
Cut-Extrude10	Solid Body	Mass:50.5566 kg Volume:0.00656579 m^3 Density:7700 kg/m^3 Weight:495.454 N	C:\Users\user\Desktop\conve yor cazz project\idler frame new1.SLDPRT Apr 20 03:45:54 2017
Boss-Extrude2	Solid Body	Mass:36.7934 kg Volume:0.00477836 m^3 Density:7700 kg/m^3 Weight:360.575 N	C:\Users\user\Desktop\conve yor cazz project\roller.SLDPRT Apr 19 04:53:19 2017
Boss-Extrude2	Solid Body	Mass:36.7934 kg Volume:0.00477836 m^3 Density:7700 kg/m^3 Weight:360.575 N	C:\Users\user\Desktop\conve yor cazz project\roller.SLDPRT Apr 19 04:53:19 2017

Boss-Extrude2	**Solid Body**	**Mass:36.7934 kg** **Volume:0.00477836 m^3** **Density:7700 kg/m^3** **Weight:360.575 N**	**C:\Users\user\Desktop\conve yor cazz project\roller.SLDPRT Apr 19 04:53:19 2017**
<L_MdInf_ShlBd_Nm/>	**<L_MdIn_ShlBd_F r/>**	**<L_MdInf_ShlBd_VolPro p/>**	**<L_MdIn_ShlBd_DtMd/>**
<L_MdInf_CpBd_Nm/>	**<L_MdInf_CompBd_Props/>**		
<L_MdInf_BmBd_Nm/>	**<L_MdIn_BmBd_F r/>**	**<L_MdInf_BmBd_VolPro p/>**	**<L_MdIn_BmBd_DtMd/>**

Study Properties

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SolidWorks Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	On
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SolidWorks document (C:\Users\user\Desktop\conveyor cazz project)

Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

Material Properties

Model Reference	Properties	Components
	Name: **Alloy Steel**	**SolidBody 1(Cut-**
	Model type: **Linear Elastic Isotropic**	**Extrude10)(idler**
	Default failure criterion: **Max von Mises Stress**	**frame new1-1),**
	Yield strength: **6.20422e+008 N/m^2**	**SolidBody 1(Boss-**
	Tensile strength: **7.23826e+008 N/m^2**	**Extrude2)(roller-**
	Elastic modulus: **2.1e+011 N/m^2**	**1),**
	Poisson's ratio: **0.28**	**SolidBody 1(Boss-**
	Mass density: **7700 kg/m^3**	**Extrude2)(roller-**
	Shear modulus: **7.9e+010 N/m^2**	**2),**
	Thermal expansion **1.3e-005 /Kelvin** coefficient:	**SolidBody 1(Boss-Extrude2)(roller-3)**

Curve Data:N/A

Loads and Fixtures

Load name	Load Image	Load Details
Force-1		Entities: **3 face(s)**
		Type: **Apply normal force**
		Value: **6.4 N**

Connector Definitions

No Data

Contact Information

Contact	Contact Image	Contact Properties
Global Contact		Type: **Bonded**
		Components: **1 component(s)**
		Options: **Compatible mesh**

Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	0.0275493 m
Tolerance	0.00137747 m
Mesh Quality	High
Remesh failed parts with incompatible mesh	Off

Mesh Information - Details

Total Nodes	21887
Total Elements	11981
Maximum Aspect Ratio	39.075
% of elements with Aspect Ratio < 3	89.2
% of elements with Aspect Ratio > 10	0.367
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:06
Computer name:	WI

Model name: Assem idler
Study name: Static 1(-Default-)
Mesh type: Solid mesh
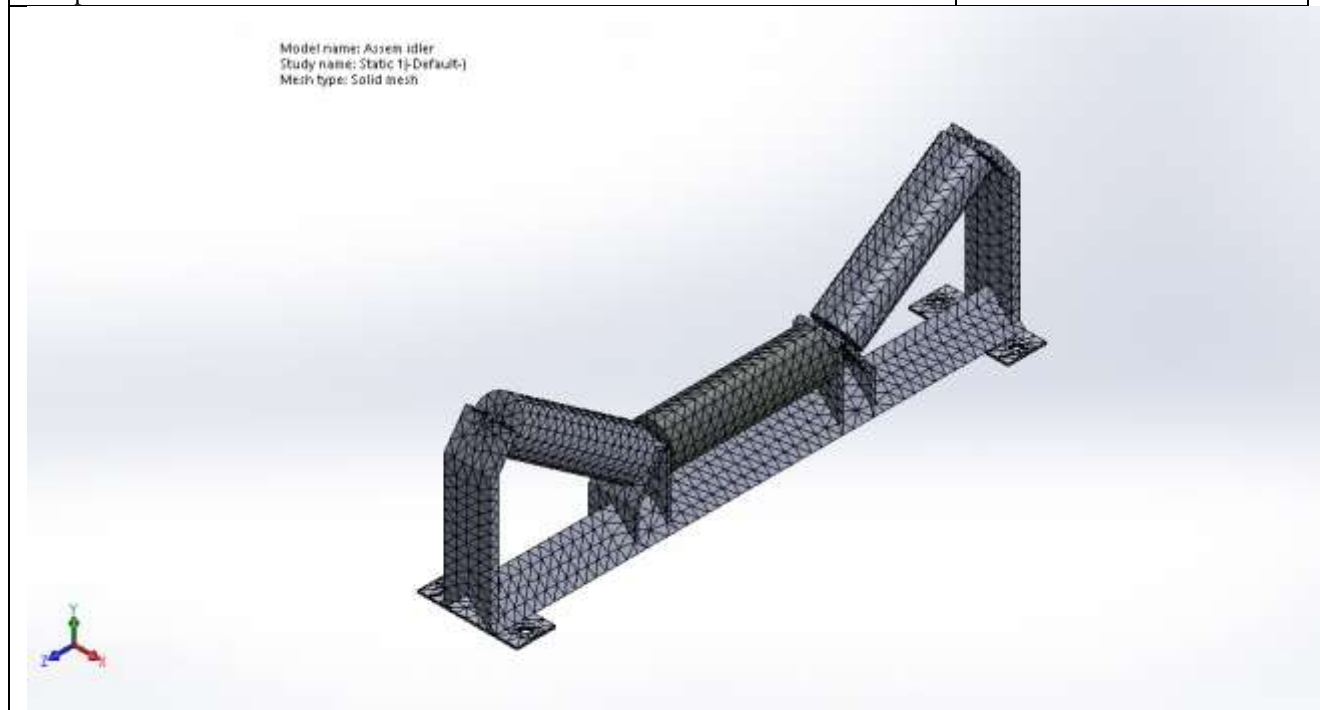
Sensor Details
No Data

Resultant Forces					
Reaction Forces					
Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	0	0	0	1e-033
Reaction Moments					
Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	0

| **Beams** | | | |
| No Data | | | |

| **Study Results** | | | |

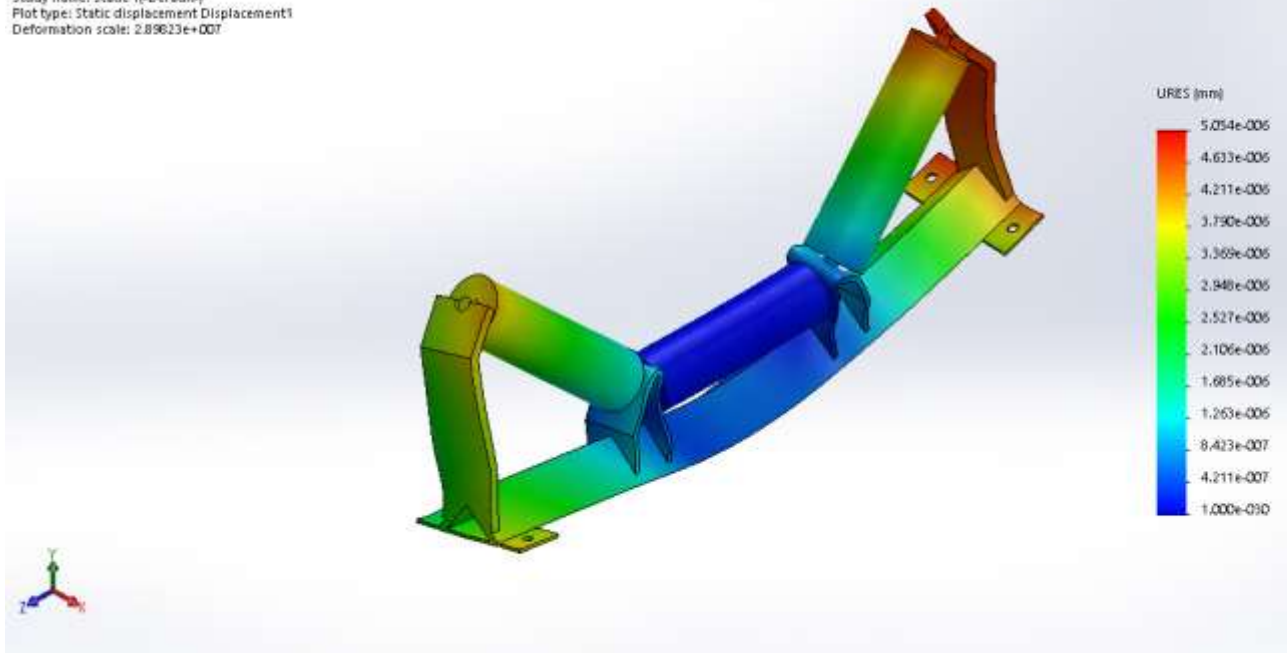| Name	Type	Min	Max
Stress1	VON: von Mises Stress	2.55811 N/m^2 Node: 9700	10447 N/m^2 Node: 10138

Model name: Assem idler
Study name: Static 1(-Default-)
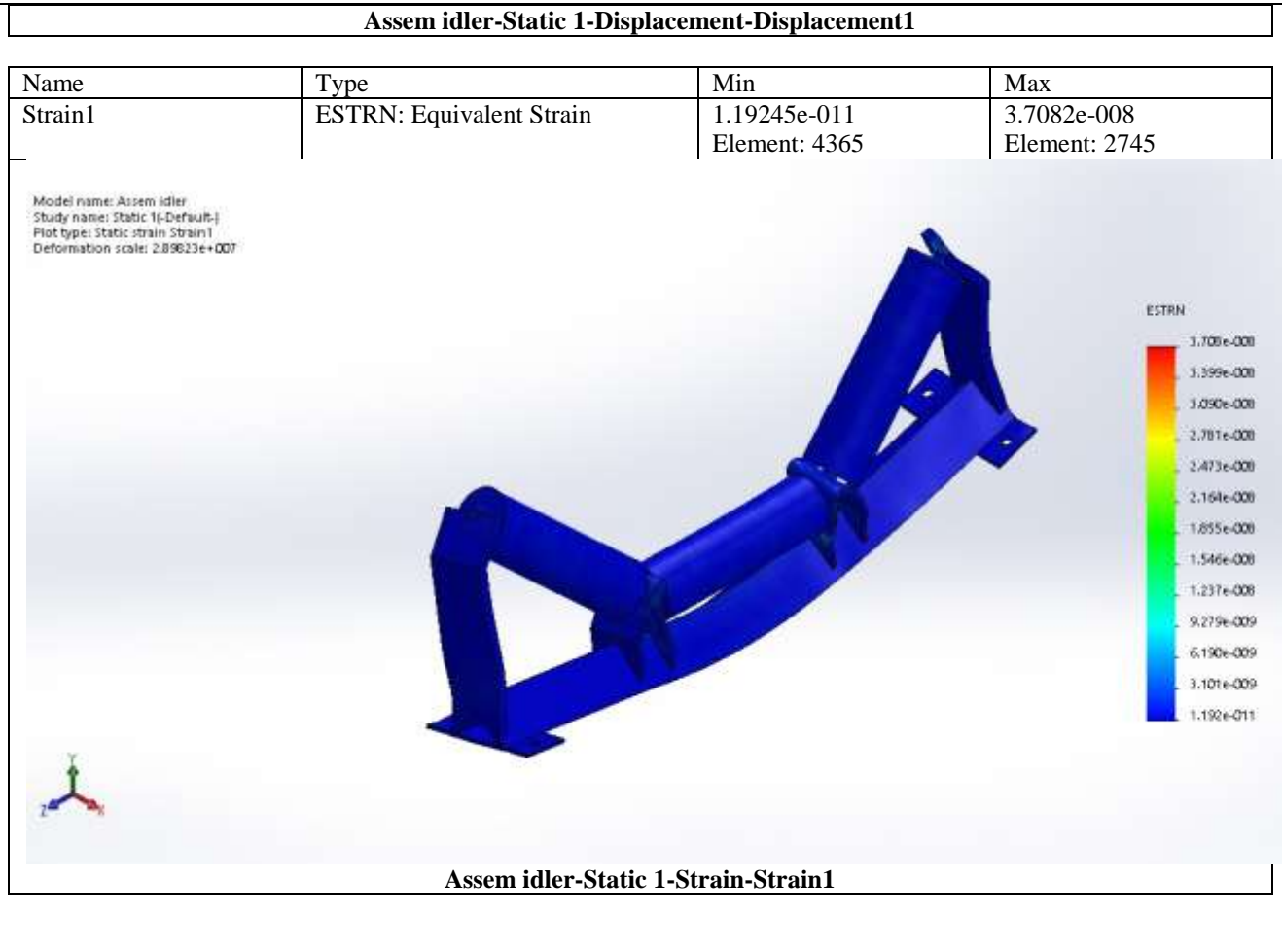Plot type: Static nodal stress Stress1
Deformation scale: 2.89823e+007

Assem idler-Static 1-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 10775	5.05368e-006 mm Node: 347

Model name: Assem idler
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 2.89823e+007

URES (mm)

5.054e-006
4.633e-006
4.211e-006
3.790e-006
3.369e-006
2.948e-006
2.527e-006
2.106e-006
1.685e-006
1.263e-006
8.423e-007
4.211e-007
1.000e-030

Assem idler-Static 1-Displacement-Displacement1			
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.19245e-011 Element: 4365	3.7082e-008 Element: 2745

Model name: Assem idler
Study name: Static 1(-Default-)
Plot type: Static strain Strain1
Deformation scale: 2.89823e+007

ESTRN
3.708e-008
3.399e-008
3.090e-008
2.781e-008
2.473e-008
2.164e-008
1.855e-008
1.546e-008
1.237e-008
9.279e-009
6.190e-009
3.101e-009
1.192e-011

Assem idler-Static 1-Strain-Strain1

Conclusion of the simulation

Thus we arrive at the conclusion that the calculation and the assumption that we have taken makes the model a safer design and hence can be collective said that it leads to a design which can be used in the industry without any failure.

CONCLUSION

We have come to the conclusion that the design that is done for each component for the belt conveyor system is safe and can be successfully implemented in the industry without any failure. The material description is provided in the report and the material can be used of the quality provided so ensure that there is no failure in the system. The system will work as designed if the calculations are met and the design done in a way provided in the manuscript.

Future scope

Currently we are working in making software which can be used to determine the safe and failure limit of the conveyor belt system just by providing the material used. The impact load will be constant which is as used is the industry. This would help a lot of industry where longer they have to calculate and make the entire design in paper and pen.

Total Deformation and analysis
Subject: CONVEYOR BELT SYSTEM DESIGN AND ANALYSIS
Date Saturday, April 29, 2017
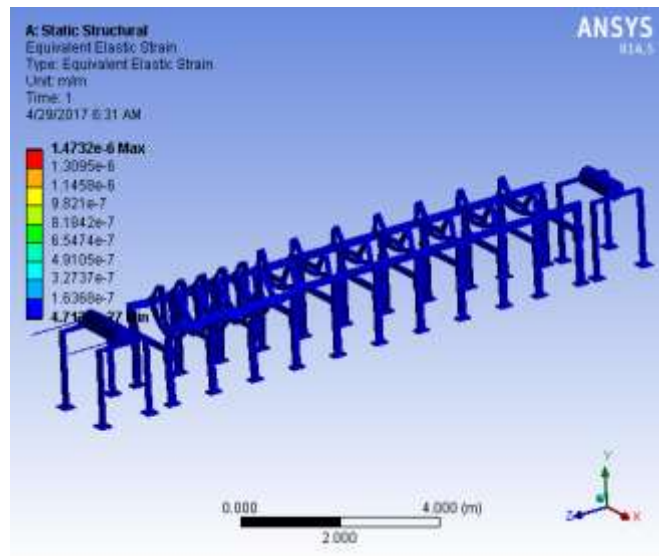Comments:
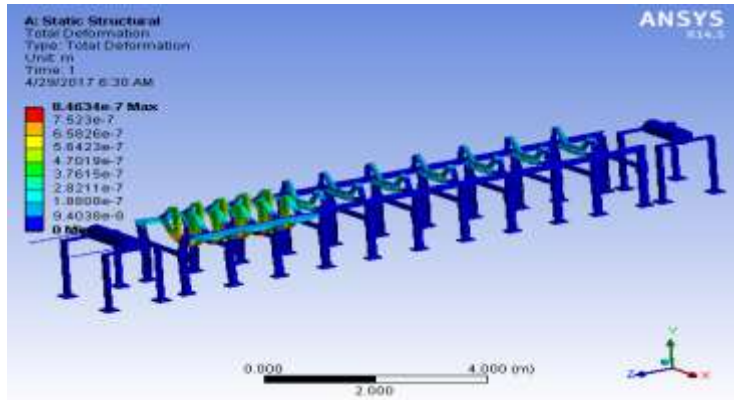
Equivalent Stress
Subject: CONVEYOR BELT SYSTEM DESIGN
AND ANALYSIS

Date   Saturday, April 29, 2017
Comments:
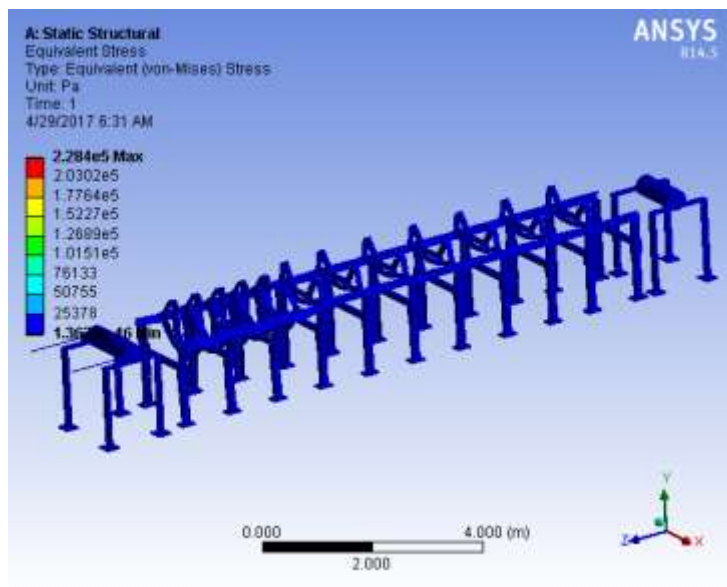
Equivalent Elastic Strain
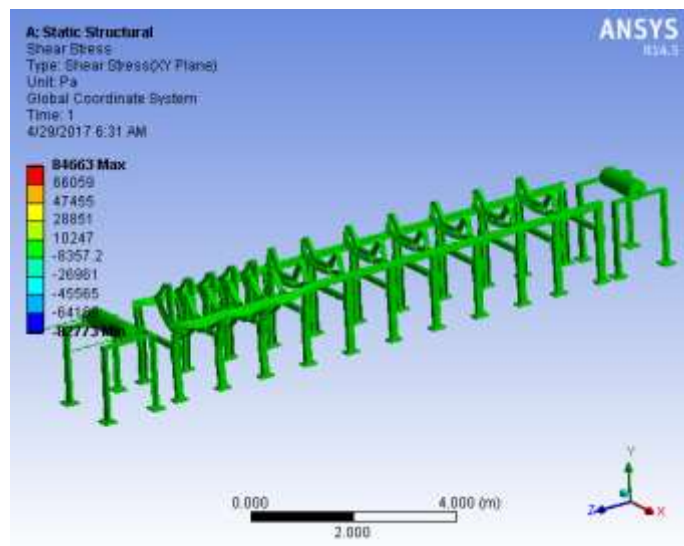Subject: CONVEYOR BELT SYSTEM DESIGN
AND ANALYSIS

Date   Saturday, April 29, 2017
Comments:

Shear Stress

Subject: CONVEYOR BELT SYSTEM DESIGN AND ANALYSIS

Date Saturday, April 29, 2017

Comments:

Acknowledgement

REFERENCES

1. Ogedengbe, T. I. (2010). Lecture Note on Applied Techniques of Production Management. pp. 16-20.
2. Daniyan, I. A., Adeodu, A. O., & Dada, O. M. (2014). Design of a Material Handling Equipment: Belt Conveyor System for Crushed Limestone Using 3 roll Idlers. *Design of a Material Handling Equipment: Belt Conveyor System for Crushed Limestone Using 3 roll Idlers*, *1*(1), 1-7.
3. Gupta, D., Dave, D., Gupta, D., & Dave, D. Study and performance of Belt Conveyor system with different type parameter. *International Journal*, *2*, 29-31.