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"Study on screw conveyor using different coating materials"

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Abstract— Screw conveying systems might be used in various types of industries where the goods and products are moved with rotational effect of screw. The primary purpose of the model is to calculate the power, torque and axial force required for the scroll to transport the solid. The model is presented in a non-dimensional form and the procedure for implementing the model is included. The model is compared to test data from an existing publication; there was good agreement between the model and data. Results are presented in the form of graphs to illustrate the influence of key parameters. The 3D model is created in CATIA software and this model is imported for simulation in ANSYS. There are four types of material used SS440, Tin, Zinc and ZrN. Comparative analysis study is done for all the four materials for total deformation directional deformation and equivalent stress.

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Keywords- Conveyor system; Screw conveying, ANSYS, CATIA, SS440, Tin, Zinc, Zrn.

I. INTRODUCTION

Conveyors are defines as a mechanical devices which can transfer material or goods from one plane to another place without any effort allying to it. The construction of the conveyors are mostly based on frame, supporting roller or conveying roller or belt and the driven motor with gearbox as per the rpm of the roller required. The conveyors are also used for conveying the bulk materials which gravel material and other aggregate during the building construction work. In industries it is mainly used to convey the coal, fly ash and the output product to the final destination of the plant. There are various types of conveyor utilize as the area and the type of work such as belt conveyor, roller conveyor, vibratory conveyor, bucket conveyor etc. The all basic types of conveyors are described below:

The basic principle of material along the trough is similar to the sliding motion of a nut along a rotating screw when the nut is not allowed to rotate. The weight of material and the friction of the material against the wall present the load from rotating with the screw.

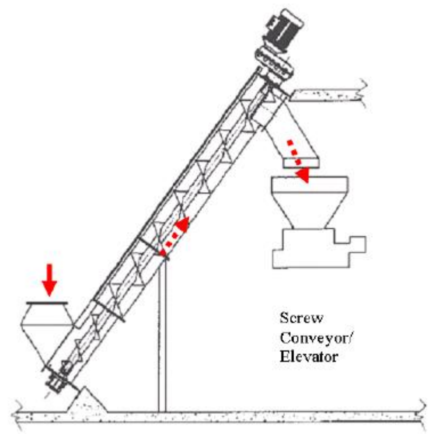

Fig.1-Screw conveyor

A. *Components of screw conveyor*

1) *Screw:*

Based on rotation- Left and Right Hand Screws

A transport screw is either right hand or left hand contingent upon the type of the helix. The hand of the screw is effortlessly dictated by taking a gander toward the finish of the screw. The screw imagined to one side has the flight helix folded over the pipe in a counter-clockwise bearing, or to one side. Same as left hand strings on a jolt. This is subjectively named a LEFT hand screw. The screw envisioned to the privilege has the flight helix folded over the pipe a clockwise way, or on your right side. Same as right hand strings on a jolt. This is named a RIGHT hand screw. A transport screw saw from either end will demonstrate a similar design. In the event that the finish of the transport screw isn't promptly unmistakable, at that point by simply envisioning that the flighting has been cut, with the cut end uncovered, the hand of the screw might be effectively decided.

2) *Mass Flow*

It is the combination of both variable diameter of the centre pipe and the pitch of the flight such that as the pitch increase volume of the material also increase. It is mainly utilizes in screw feeders for uniform flow of bulk material from the silos hoppers etc.

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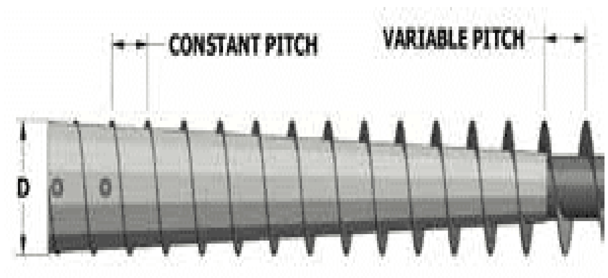

Fig.2 Mass flow screws

3) Tubular Housings

Tubular housing is mainly applicable where the inclination of the conveyor is above 15 degree. It helps to increase the conveying efficiency of the conveyor as it reduces the fall back of the bulk material. Its application can be seen in weather tight condition such that it is capable to hold the pressure developed by the conveyor internally.

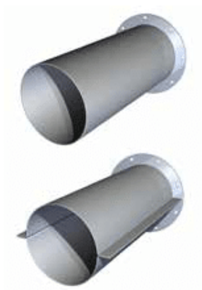

Fig.3 Tubular Housings trough

II. LITRETURE REVIEW

Bepariya Keyur et al 2018 performed investigation on new machine rather than old machine for material handling purpose. The main purpose of the author in the present study is to utilize the land and it space in such a way that it can full fill the all requirement of the manufacturing process in which the material such as soaps biscuits wafers can be transfer from manufacturing area to storage area at higher level with efficient out by using the screw conveyor as a material handling system.

Panchal Prit et al 2017 investigated about the present scenario of the industries and its drainage system such that it is the major problem which cause the pollution and leads to bad impact on biological life and this leads to the enhancement of the global warming. Author also explained the drawbacks of drainage pipe as it sometimes result as loss of human life. To overcome all the related problem author investigated the automated system using screw conveyor which can clean the waste named as “Automatic waste Cleaning System by screw conveyor” and also constructed the prototype of the present suggested system.

Amudha.K 2017 represented the experimental analysis of the screw conveyor and performed a review on the performance of the screw conveyor under various operating conditions. In the investigation the author found that with different flow rates and feed rate there was no change in mass flow of the material. It was also observed the nodule output about 8.6 kg/rotation. In the study screw feeder operation took place for 150meter depth with mass loss of 14% due wash away of finer particles. It was concluded that the design was validated in trials in sea for higher depth about 6000 meter depth.

Olanrewaju T. O. et al 2017 performed experimental analysis on the screw conveyor for grains with inclination of 0°, 30° and 45° respectively. In the experimental analysis he found that for maize the average capacity of the screw conveyor was 407.05, 282.4 and 263.1 kg h-1 in case of gari the capacity of the screw conveyor was 460.0, 365.3, 310.0 kg h-1 and in case of sorghum the average capacity of the screw conveyor was , 450.2, 350.5, 263.0 kg h-1.With al, the output author concluded that screw conveyor with inclination provided 99.95% efficiency in case of handling the granules.

Michael Rackl 2016 investigated the design parameters of the screw conveyor mass flow and driving torque for three grades of wood chips and two blends of wood chips. As a result it was found that one of the chip grade recoded high torque rate ie twice of the another and one get jammed. The result concluded that the blending of the wood chips can reduce the jamming to desirable rate.

Marianna Tomašková 2014 explained the complete working of the screw conveyor and the various design of the system which are utilized across the world for getting the best efficiency in material handling purpose. In the research paper also discussed about the various risks and drawbacks associated with use of screw conveyor for material handling purpose.

Jigar N. Patel 2013 represented the modification of the Auger in order to attain same output with small size and less power consumption. In the investigation author proposed the screw conveyor without shaft for conveying the cement with capacity of 2t/h. As a result it was found that screw conveyor are capable of conveying the material in inclination but its capacity decrease with increase in inclination angle.

III. OBJECTIVE

1. To minimize the deformation in screw conveyor under various operating conditions through analysis of stresses and modify the design of conveyor.

2. To reduce the stress generated in the screw conveyor under the above operated condition in order to increase the production as well as life of the equipment.
3. To increase the life of conveyor blades by surface coating treatment.

IV. METHODOLOGY

A. SOFTWARE USED FOR THE STUDY

1) CATIA V5

In the present study CATIA V5 software is used for CAD modeling .CATIA offer the various stages of the product development which include computer aided design(CAD),computer aided engineering (CAE) computer aided manufacturing (CAM).It also provide the platform for performing various design modules such as wireframe and surface and shape design, mechanical and electrical system design etc.

2) ANSYS

It is the software used for modeling as well as for testing the products durability, temperature distribution in product and the movement of fluid under various boundary conditions. It make possible to analyze the condition of the model under various operating environment and also helped to simulate the effect on model of an object. The basic module of the ANSYS software is FEA, CFD.

B. GOVERNING EQUATIONS

It is simple to use software to analyze the result under various load conditions. The theoretical calculation of the various result under loading conditions can be calculate by using governing equations and the relation between different parameters and formulae.

When working with stability, the loads of screw conveyor include:

Centrifugal force generated by high-speed rotation. Centrifugal load applied in the form of angular velocity. The angular velocity ω is calculated as:

$$\omega = \frac{2\pi \cdot n}{60} = \frac{2 \times 3.14 \times 3000}{60} = 314\,\text{rad/s}$$

Where n is the rotating speed of screw conveyor, in this article, n = 3000 r/min.

Coriolis force. When study on the characteristics of rotary motion, in addition to the centrifugal force, the Coriolis force may arise. According to theoretical mechanics, when the implicated movement is a fixed axis of rotation at constant angular speed, size of Coriolis acceleration is:

$$\alpha_k = 2\omega V_r$$

Where, Vr is the radial velocity of particle relative to drum. Coriolis force is defined as:

$$F_k = 2m\omega V_r$$

Theoretically, the Coriolis force in a centrifuge does exist, but it is always ignored in general engineering problems, because of its weak influence and relatively complex mathematical operation:

Centrifugal hydraulic pressure. When the centrifuge is on working, the liquid and sediment layer will exert considerable pressure to the inner wall of drum under the action of centrifugal force, which is called centrifugal hydraulic pressure. The calculation formula of centrifugal hydraulic is shown as follows:

$$p_c = \rho\omega^2 \int_{r_1}^{R} r\,dr = \frac{1}{2}\rho\omega^2\left(R^2 - r_1^2\right)$$

where pc is the hydraulic pressure, r is the density of material, u is the rotating velocity of drum, R is the radius of drum, r is the inner radius of drum.

C. MATERIAL PROPERTIES

Mild steel is use to design analysis of hydraulic plate due to height strength property.

Table 1 Material properties

Material	Density(Kg/m3)	Young modulus (MPa)	Poisson's ratio
SS440	7800	2x10^5	0.3
TiN	5220	6x10^5	0.25
ZrN	7090	4.2x10^5	0.29
Zinc	7140	1.08x10^05	0.25

D. STEP OF WORKING

1) Collecting information and data related to screw conveyor
2) A fully parametric model of the Screw conveyor is generated using CatiaV5
3) Model obtained in Step 2 is analyzed using ANSYS 15.
4) Manual calculations are done.
5) Finally, we compare the results obtained from ANSYS

E. STEPS OF ANSYS ANALYSIS

The different analysis steps involved in ANSYS are mentioned below.

1) Pre-process

Pre-process include initial stage of the analysis in which first the model of the geometry created with different geometrical parameter. In the study CATIA is used to design the model of the screw conveyor and imported into the workbench of the ANSYS.

Table 2- Geometrical dimensions

Parameter	Value
Cylinder inner radius	152 mm
Scroll pitch	108 mm
Taper angle	Degree
Spiral angle	7.59 Degree
Length of conical section	418 mm
Length of cylindrical section	582 mm
Drum inner radius	225mm

F. Screw conveyor design

In the research analysis screw conveyor is analyzed under various load conditions for deformation and equivalent stress on it under various load conditions. The model is prepared using the CATIA V5R20 software using the base paper dimension data.

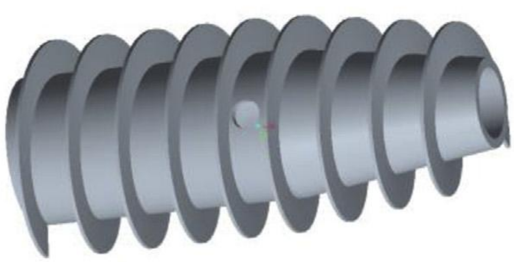

Figure: 3.2 CAD model of screw conveyor

G. Meshing

This is the step before applying the boundary conditions in this step the mesh is generated such that the whole body get divided into nodes and element for accuracy of the result. The meshing helps to analyse the result of the given body under various boundary condition more accurately and precisely. 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.

Meshing of screw conveyor model

The mesh created in this work is shown in figure No. The total Node is generated & Total No. of Elements is for screw conveyor model.

Table 3 Nodes & Element

Number of Nodes	Number of Element
44277	34158

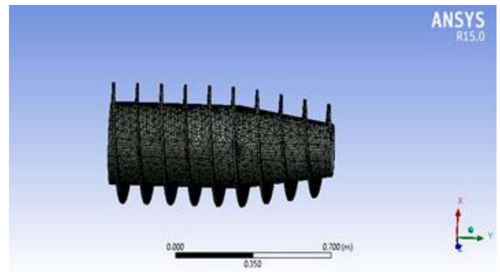

Fig: 3.3 meshing of screw conveyor in ANSYS software

H. Defining material properties

This is the step in which material properties of the base paper applied in ANSYS workbench. So many properties of the material is given in the library of the ANSYS and it is possible to add other material properties also such that add new material option is given in which desired properties of the material can be define as per the requirement for analysis. In the following analysis SS440 TiN, ZrN, Zinc material properties are defined.

I. Boundary condition

In this present case 23568N of centrifugal force 1350000 Pa hydraulic pressure and the combined load of both centrifugal for and hydraulic pressure is applied. The screw conveyor is fixed from both side of the screw conveyor.

1) Fixed support

After applying meshing use fixed support command, the fixed support for the screw conveyor given in figure 3.4

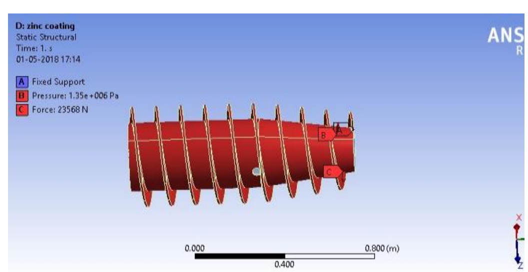

Fig 3.4 fixed support of screw conveyor

2) Force

In the present analysis three load conditions applied for both validating the base paper and during implementation.

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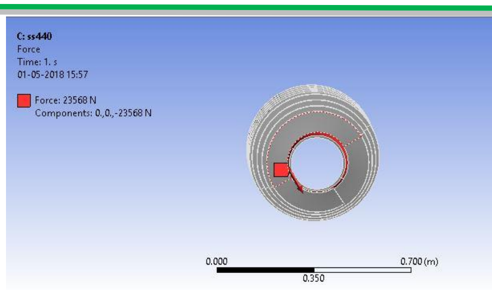

Fig 3.5 Applying centrifugal force

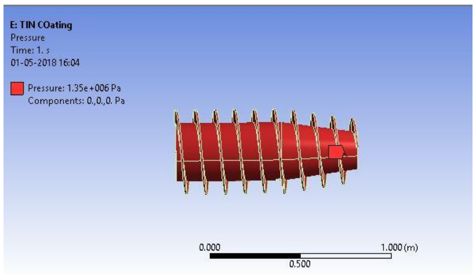

Fig 3.6 Applying hydraulic pressure

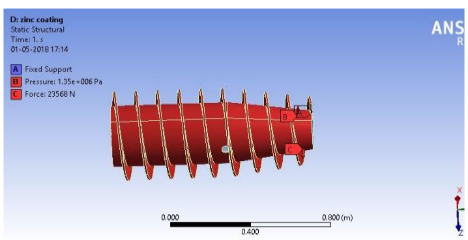

Fig 3.7 Applying combined hydraulic pressure and centrifugal force

In order to investigate the effect on screw conveyor by centrifugal force and hydraulic pressure, the model was calculated at three load situations respectively to get the stress and deformation of conveyor. The loads were centrifugal force, centrifugal hydraulic pressure, and the combination. The equivalent stress and deformation of each load.

J. Case – 1:- Result for Applying Hydraulic pressure

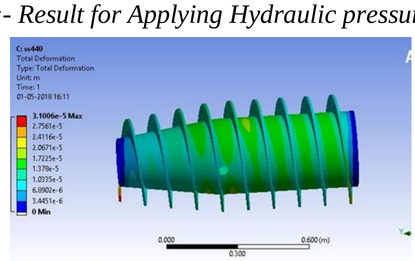

Fig. 3.8.Total Deformation of SS440 in applying hydraulic pressure

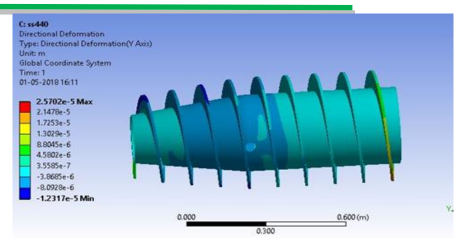

Fig. 3.9.Directional deformation of SS440 in applying hydraulic pressure

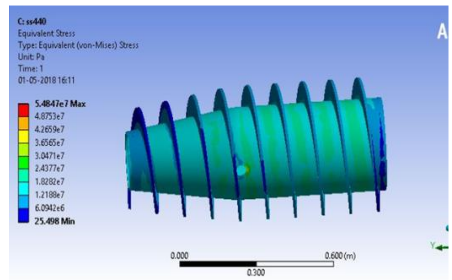

Fig. 3.10.Equivalent stress of SS440 in applying hydraulic pressure

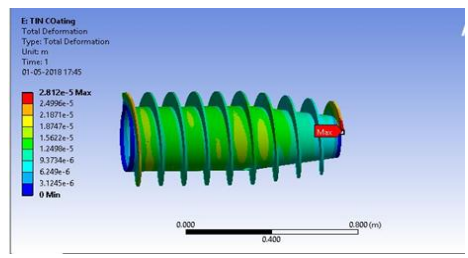

Fig. 3.11.Total Deformation of TIN in applying hydraulic pressure

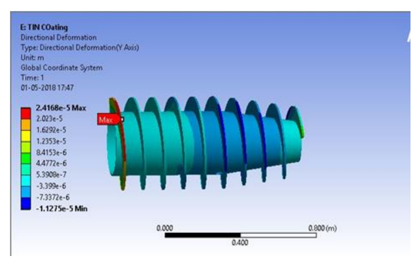

Fig. 3.12.Directional Deformation of TIN in applying hydraulic pressure

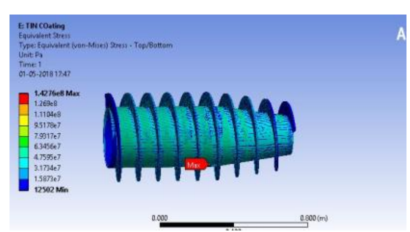

Fig. 3.13.Equivalent stress of TIN in applying hydraulic pressure

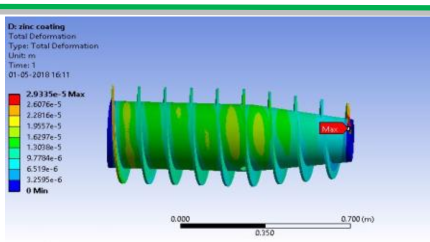

Fig. 3.14.Total Deformation of ZINC in applying hydraulic pressure

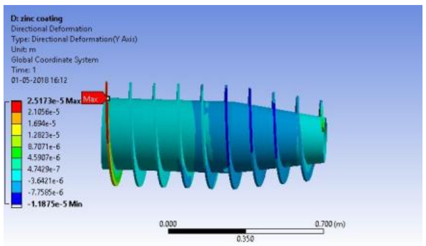

Fig.3.15.DirectionalDeformation of ZINCin applying hydraulic pressure

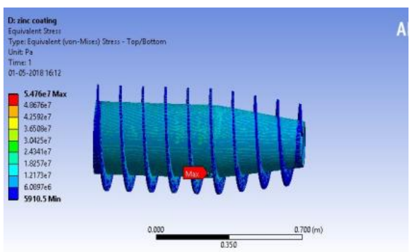

Fig. 3.16.Equivalent stress of ZINC in applying hydraulic pressure

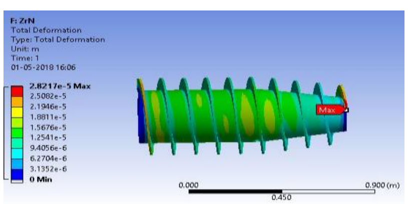

Fig. 3.17.Total Deformation of ZrN in applying hydraulic pressure

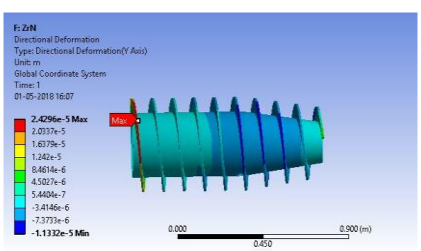

Fig. 3.18.Directional deformation of ZrN in applying hydraulic pressure

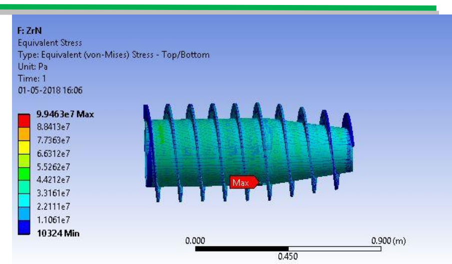

Fig. 3.19. Equivalent Stress of ZrN in applying hydraulic pressure

K. Case –2 :- Result for Applying Centrifugal Force

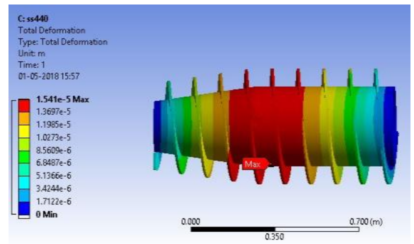

Fig.3.20 Total Deformation of SS440 **for** Applying Centrifugal Force

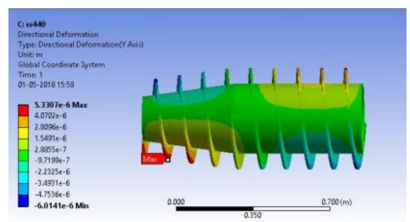

Fig.3.21 Directional deformation for Applying Centrifugal Force

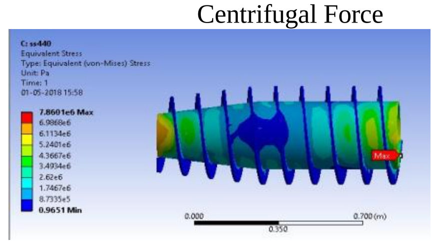

Fig. 3.22 Equivalent stress for Applying Centrifugal Force

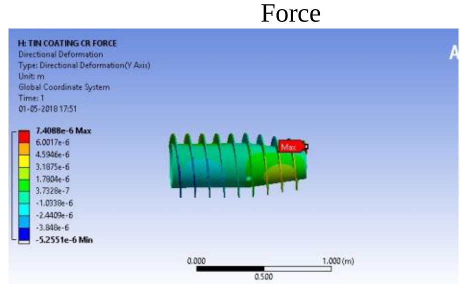

Fig.3.23 Total Deformation of TIN for Applying Centrifugal Force

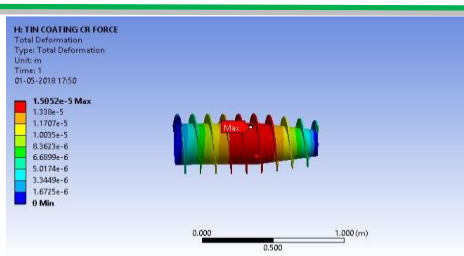

Fig. 3.24 Directional deformation for Applying Centrifugal Force

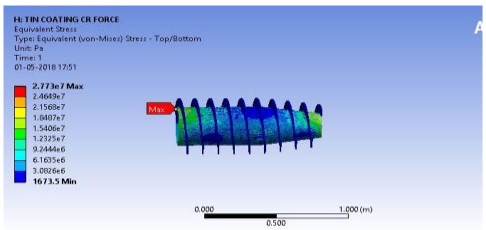

Fig. 3.25 Equivalent stress for Applying Centrifugal Force

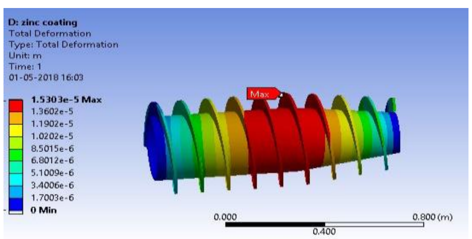

Fig. 3.26 Total Deformation of Zinc for Applying Centrifugal Force

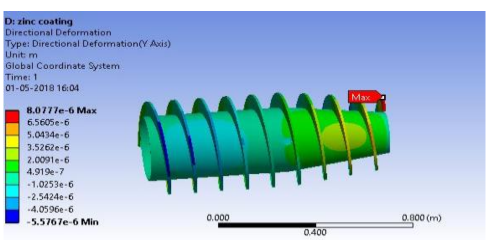

Fig. 3.27 Directional deformation for Applying Centrifugal Force

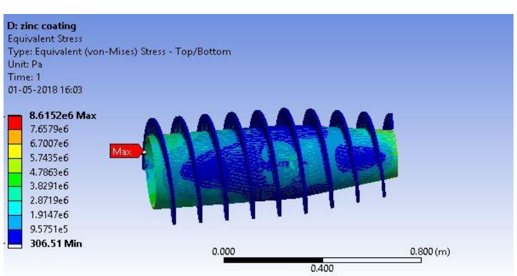

Fig.3.28 Equivalent stress for Applying Centrifugal Force

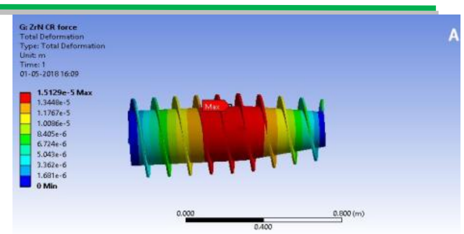

Fig. 3.29 Total Deformation of ZrN for Applying Centrifugal Force

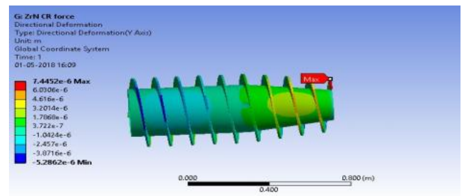

Fig. 3.30 Directional deformation Of ZrN for Applying Centrifugal Force

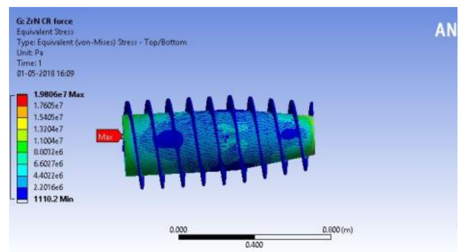

Fig. 3.31 Equivalent stress of ZrN for Applying Centrifugal Force

L. Case – 3:- Result for Applying Combine Loading

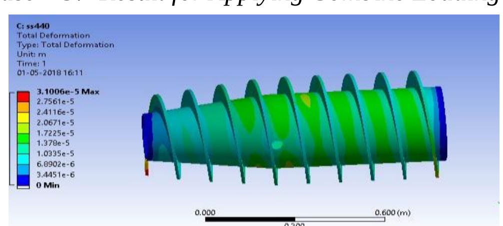

Fig. 3.32 Total Deformation of SS440 for applying combine loading

M. Case – 3:- Result for Applying Combine Loading

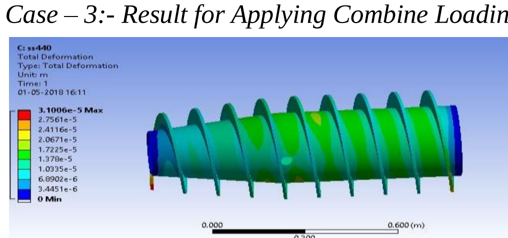

Fig. 3.32 Total Deformation of SS440 for applying combine loading

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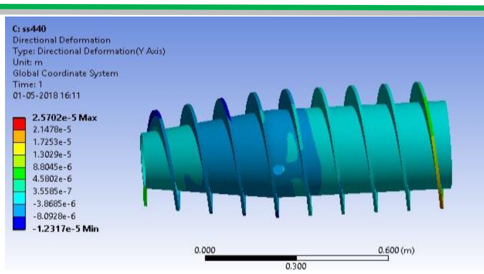

Fig. 3.33 Directional deformation of SS440 for applying combine loading

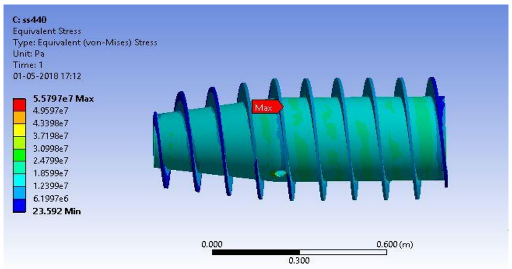

Fig. 3.34 Equivalent stress for SS440 for applying combine loading

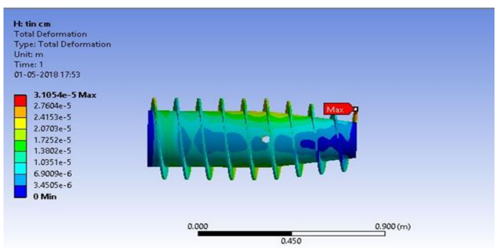

Fig. 3.35 Total Deformation for TIN for applying combine loading

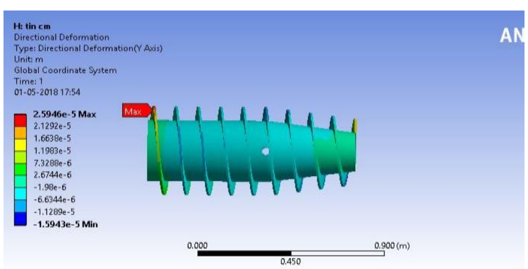

Fig. 3.36 Directional deformation for TIN for applying combine loading

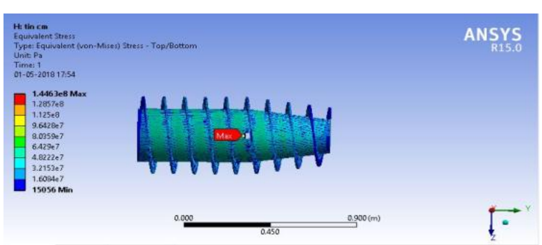

Fig. 3.37 Equivalent stress for TIN for applying combine loading

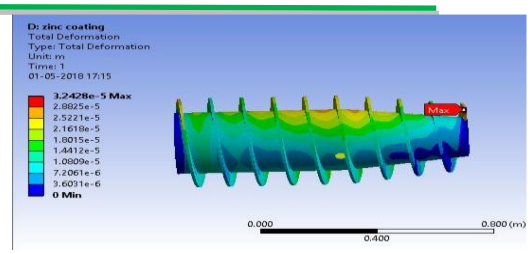

Fig.3.38 Total Deformation for ZINC for applying combine loading

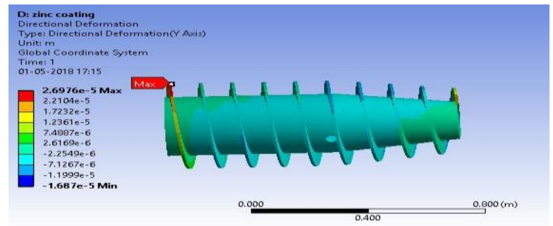

Fig. 3.39 Directional deformation for ZINC for applying combine loading

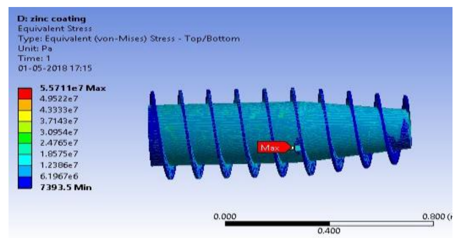

Fig. 3.40 Equivalent stress for ZINC for applying combine loading

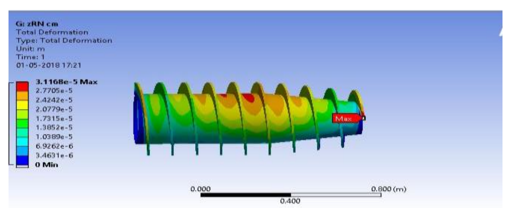

Fig. 3.41 Total Deformation for ZrN for applying combine loading

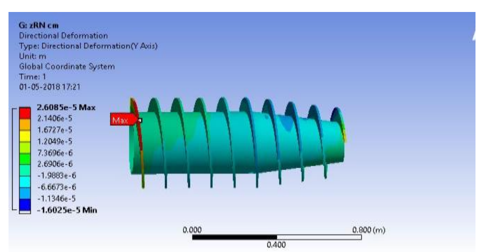

Fig. 3.42 Directional deformation forZrN for applying combine loading

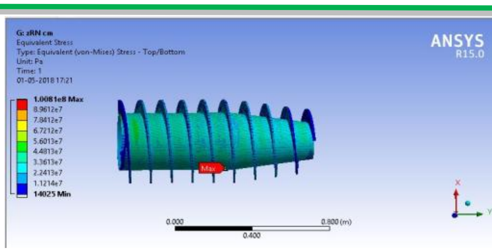

Fig. 3.43 Equivalent stress for ZrN for applying combine loading

V. RESULT

The above material analysis is giving valuable results. All the solutions after loading the screw conveyor are analyzed for material SS440,TIN,ZrN,Zinc.The result of the screw conveyor is categorized under three loading conditions ie Hydraulic pressure, centrifugal force and combined force for three results ie. Total deformation, directional deformation, equivalent stress

Case : 1 Hydraulic pressure result

1. Comparison Deformation

Table 4.comparison of deformation for applying hydraulic pressure

Material	**Deformation (m)**
SS440	$3.1006x10^{-5}$
TIN	$2.812x10^{-5}$
Zinc	$2.9335x\ 10^{-5}$
ZrN	$2.8217x\ 10^{-5}$

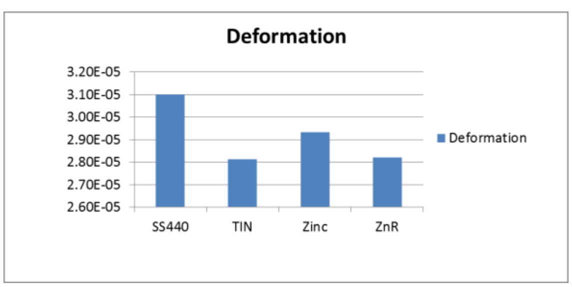

Figure 4.1. Result comparison in deformation for applying hydraulic pressure

From the above graph it is concluded that the screw conveyor under given hydraulic pressure for material TIN giving good result for total deformation of $2.812x10^{-5}$ meter as compared to other materials selected for analysis and SS440 of $3.1006x\ 10^{-5}$ given worst result with highest deformation for same loading condition.

2. Comparison Directional Deformation

Table 5. Comparison of directional deformation for hydraulic pressure

Material	Directional Deformation
SS440	$2.5702x10^{-5}$
TIN	$2.4168x10^{-5}$
Zinc	$2.5173x10^{-5}$
ZrN	$2.4296x10^{-5}$

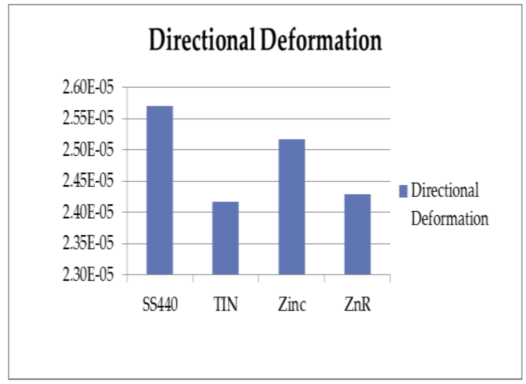

Figure 4.2. Comparison of directional deformation for hydraulic pressure

From the above graph it is concluded that the screw conveyor under given hydraulic pressure for material TIN giving good result for directional deformation of $2.4168x10^{-5}$meter as compared to other materials selected for analysis and SS440 of $2.5702x10^{-5}$ given worst result with highest directional deformation for same loading condition.

1. Comparison Equivalent stress

Table 6. Comparison of equivalent stress for hydraulic pressure

Material	Equivalent stress (Pa)
SS440	$5.487x10^{7}$
TIN	$4.8898\ x10^{7}$
Zinc	$5.476\ x10^{7}$
ZrN	$4.9463\ x10^{7}$

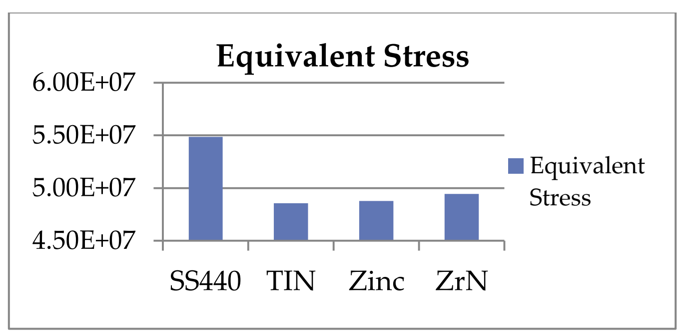

Figure 4.3. Comparison of equivalent stress for hydraulic pressure

From the above graph it is concluded that the screw conveyor under given hydraulic pressure for material TIN giving good result for equivalent stress of $4.8898\ x10^{7}$Pa as compared to other materials selected for analysis and SS440 of $5.487\ x10^{7}$ Pa given worst result with highest equivalent stress for same loading condition.

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Case : 2 Centrifugal Force result

1. **Comparison Deformation**

Table 7. Comparison of deformation for Centrifugal Force

Material	Deformation (m)
SS440	$1.541\ x10^{-5}$
TIN	$1.5052\ x10^{-5}$
Zinc	$1.5303\ x10^{-5}$
ZrN	$1.5129\ x10^{-5}$

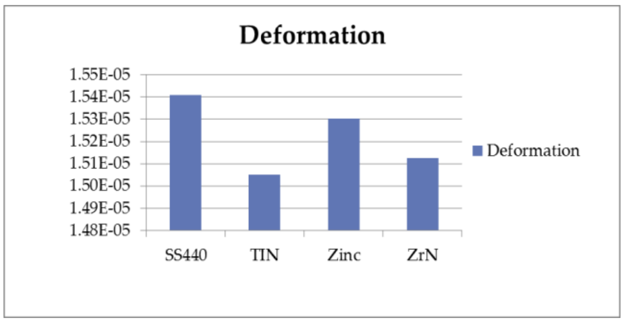

Figure 4.4. Comparison of deformation for Centrifugal Force

From the above graph it is concluded that the screw conveyor under given centrifugal force of 23568 N for material TIN giving good result for total deformation of $1.5052\ x10^{-5}$ meter as compared to other materials selected for analysis and SS440 of $1.541\ x10^{-5}$ meter given worst result with highest total deformation for same loading condition.

1. **Comparison Directional Deformation**

Table 8. Comparison of directional deformation for Centrifugal Force

Material	Directional Deformation (m)
SS440	$5.3307\ x10^{-6}$
TIN	$7.4088\ x10^{-6}$
Zinc	$8.0777\ x10^{-6}$
ZrN	$7.4452\ x10^{-6}$

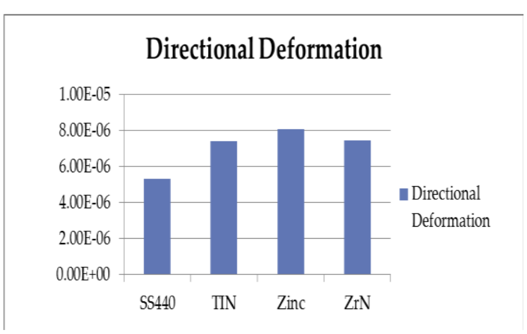

Figure 4.5 Comparison of directional deformation for Centrifugal Force

From the above graph it is concluded that the screw conveyor under given centrifugal force of 23568 N for material SS440 giving good result for total deformation of $5.3307\ x10^{-6}$ meter as compared to other materials selected for analysis and Zinc of $8.0777\ x10^{-6}$meter given worst result with highest total deformation for same loading condition.

2. **Comparison Equivalent Stress**

Table 9. Comparison of equivalent stress for Centrifugal Force

Material	Equivalent Stress (Pa)
SS440	$7.8601\ x10^{6}$e6
TIN	$2.773\ x10^{6}$
Zinc	$8.6152\ x10^{6}$
ZrN	$1.986\ x10^{6}$

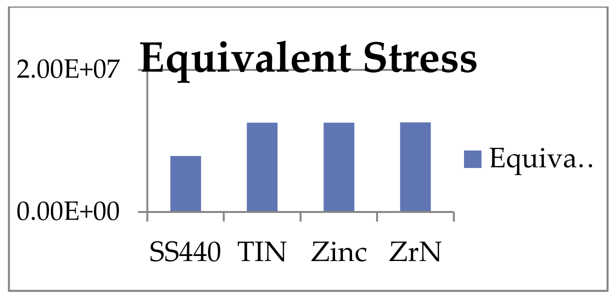

Figure 4.6. Comparison of equivalent stress for Centrifugal Force

For the centrifugal force of 23568 N on screw conveyor of four different materials SS440 given best result with $7.8601\ x10^{6}$ Pa while TIN given worst result with highest stress of $2.773\ x10^{7}$Pa.

Case : 3 Combine Loading result

1. **Comparison Deformation**

Table 10. Comparison of deformation for Combine Loading

Material	Deformation (m)
SS440	$3.4368\ x10^{-5}$
TIN	$3.1054\ x10^{-5}$
Zinc	$3.2428\ x10^{-5}$
ZrN	$3.1168\ x10^{-5}$

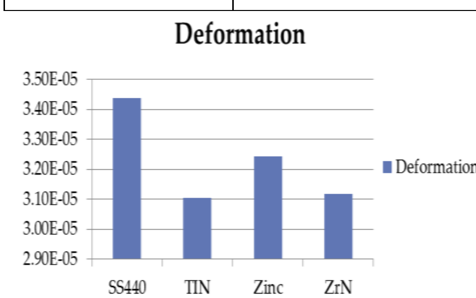

Figure 4.7. Result comparison in deformation for combine loading

For the combined loading of centrifugal force of 23568 N and hydraulic pressure of $1.35\ x10^{6}$ Pa on screw conveyor of four different materials TIN given best result with 3.1054 x10^{-5} meter while SS440 given worst result with highest total deformation of 3.4368 x10^{-5} meter.

1. **Comparison Directional Deformation**

Table 11. Comparison of Directional deformation for Combine Loading

Material	Directional Deformation (m)
SS440	2.7375 x10^{-5}
TIN	2.5946 x10^{-5}
Zinc	2.6976 x10^{-5}
ZrN	2.6085 x10^{-5}

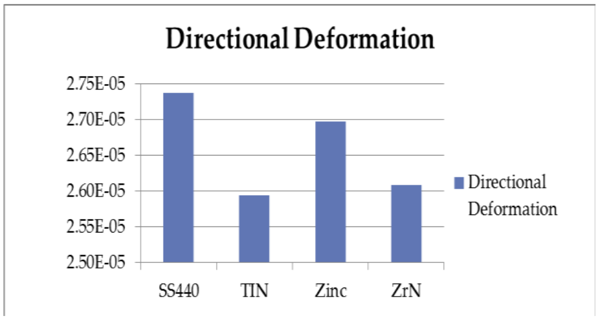

Figure 4.8. Comparison of Directional deformation for Combine Loading

For the combined loading of centrifugal force of 23568 N and hydraulic pressure of 1.35 x10^{6} Pa on screw conveyor of four different materials TIN given best result with 2.5946 x10^{-5}meter while SS440 given worst result with highest total deformation of 2.7375 x10^{-5} meter.

2. **Comparison Equivalent stress**

Table 12. Comparison of equivalent stress for Combine Loading

Material	Equivalent Stress (Pa)
SS440	5.5797 x10^{7}
TIN	1.4463 x10^{8}
Zinc	5.5711 x10^{7}
ZrN	1.0081 x10^{8}

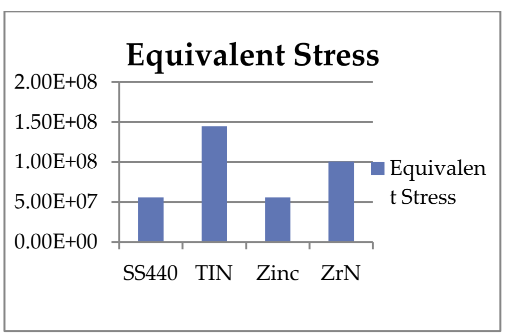

Figure 4.9. Comparison of equivalent stress for Combine Loading

For the combined loading of centrifugal force of 23568 N and hydraulic pressure of 1.35 x10^{6} Pa on screw conveyor of four different materials SS440 given best result with 5.5797 x 10^{7} Pa while TIN given worst result with highest equivalent stress of 1.4463 x10^{8} Pa

VI. COUNCLUSION

In the following analysis screw conveyor is analysed for three different types of loading for four different materials ie TIN, SS440, ZrN and Zinc. During the static structural analysis in ANSYS various results are evaluated.

In three loading condition hydraulic pressure, centrifugal force and combined loading of both centrifugal force and hydraulic pressure is applied. As a result it is concluded that during the hydraulic pressure of 1.35x 10^{6} Pa the total deflection for TIN is less as compared to the other materials ie 2.812x 10^{-5} meter and the SS440 material get higher deflection of 3.1006x 10^{5} meter, the same condition also followed in directional deformation and equivalent stress.

For centrifugal force of 23568N the total deformation for TIN is less ie 1.5052 x 10^{-5} and for SS440 material it obtained higher value of 5.487x 10^{7} but in case of directional deformation SS440 provided better result of 5.330x 10^{-6} meter and ZINC given worst result of 8.0777x10^{-6} and for equivalent stress for material SS440 given better result of 7.8601x10^{6} Pa and TIN given worst result of 2.773x10^{7} Pa.

In combined loading condition for total deformation TIN given better result of 3.1024x10^{-5} meter and SS440 given worst result with higher deformation of 3.486x10^{-5} meter and for directional deformation TIN given better result of 2.5946x10^{-5} meter and SS440 given higher deformation of 2.7375x10^{-5} while in case of Equivalent SS440 performed better with lower stress of 5.5759x 10^{-7} Pa and TIN performed with higher stress of 1.4463x10^{8} Pa.

From the overall results it is concluded that in most of the cases TIN performed better as compared to the other materials and due to which the life of the equipment can be enhanced which can reduce the production loss as well as the maintenance cost for the equipment .

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