Material Optimization of Gravity Roller Conveyor System Using Finite Element Analysis

B. Ravi Kiran[1], Kadiram Venkatesh[2]
[1, 2] Dept of Mechanical Engineering
[1, 2] AVNIET, Hyderabad, TS, India, 501510.

Abstract- *In this project the design and analysis of gravity roller conveyor system is carried out without changing the strength of the material. In order to convey the unit loads, gravity roller conveyor method is the most economical and effective method. These systems does not use any electrical power and works on the gravity because of its unique design. As the conveyor is mounted on the decline angle it requires an initial push of the material movement to a longer distance. The assembly of the Gravity roller conveyor consists of parts like roller, shaft, bearings, c-channel for chassis and supports.*

Keywords- Factor of safety, Structural strength, Material.

I. INTRODUCTION

Gravity roller transport is an intense material taking care of hardware. It offers the chance to support efficiency, lessen item taking care of and harm, and limit work content in an assembling or dissemination office. Transport is for the most part named unit stack transport that is intended to deal with particular uniform units, for example, containers or beds, and process transport that is intended to deal with free item, for example, sand, rock, espresso, treats, and so forth which are nourished to hardware for promote operations or blending. It is very normal for assembling plants to join both process and unit stack transports in its operations.

II. METHODOLOGY

The aim of this project is to redesign existing gravity roller conveyor system by designing the critical parts (Roller, Shaft, Bearing and Frame), to minimize the overall weight of the assembly and to save considerable amount of material. Gravity roller Conveyor has to convey of 50 kg load, 764 mm above ground and inclined at 4 degree.

To Study of the gravity roller conveyor and its design

- To do Geometric modeling of gravity roller conveyor by using UNIGRAPHICS 7.5.
- To generate FEA model using ANSYS APDL
- To carry out static analysis of gravity roller conveyor.
- Modification of critical conveyor parts for weight optimization.
- To carry out analysis of optimized design for same loading condition.
- Comparing the results of both designs

Modeling Part:

The roller conveyor is a part of industry facilities as it has a great helpful position in making of work for material handling. The roller conveyor consists of different parts and all the parts are designed in Unigraphics and assembled by using NX assembly. The following are the parts as shown below.

1) Shaft
2) Roller
3) C section supports
4) Vertical supports
5) Bearing
6) Couplings

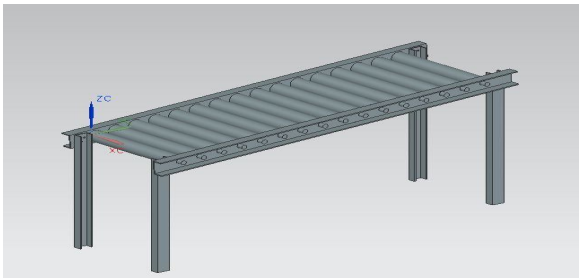


Fig: Isometric view of overall assembly of roller conveyor

III. STATIC ANALYSIS OF ROLLER CONVEYOR WITH MILD STEEL AND POLY CARBON MATERIAL

In order to perform modal analysis of a model Outline and investigation of roller transport for weight enhancement and material sparing (speed) and time differing load that can be approximated as static equal burdens, (for example, static proportionate breeze and seismic loads regularly characterized in many construction standards). Select component and apply material properties. Static examination decides the relocations, stresses, strains, and powers in

structures or segments caused by deposits that don't incite noteworthy idleness and damping impacts

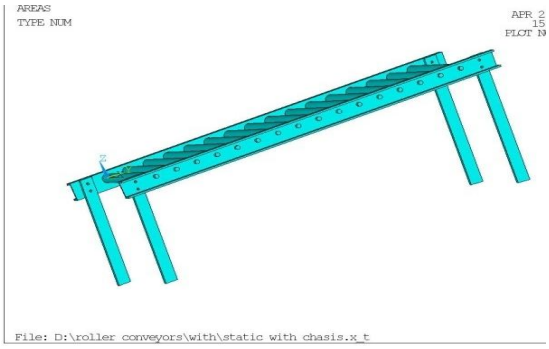


Fig:3d model of roller conveyor

IV. FINITE ELEMENT MODEL

The element is defined by 10 nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The Following Figure shows meshed model of roller-shaft assembly. As shown in below figure

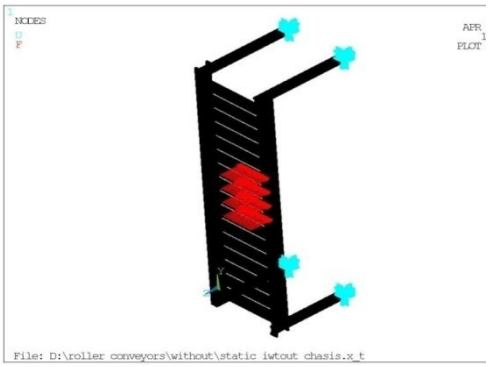
V. MATERIAL PROPERTIES

The analysis was carried out by considering the material of roller conveyor as mild steel. The material properties are given below.

Material: Mild steel
Young's modulus of elasticity: $2.1x10^5$MPa
Poisson's ratio: 0.3
Density: 7850 Kg/m^3
Yield strength: 26

VI. BOUNDARY CONDITIONS

Load of 50 kg (490 N) is applied on four rollers in the negative direction of Z. And displacements were applied at the bottom end of frame as shown in Figure below.



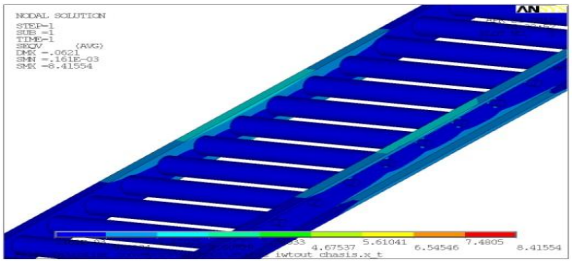
VII. TOTAL WEIGHT OF OPTIMIZED GRAVITY ROLLER CONVEYOR

(POLYCARBONATE ROLLER)

Sr.No.	Name of Component	Weight (Kg)
1	C- Channel for Chassis	40.30
2	Rollers (Polycarbonate)	15.55
3	Shafts	20.7156
4	Bearing	4.11
5	C- Channel for Supports	19.932
	Total weight of assembly	*100.61*

VIII. PROPERTIES OF ROLLER:

Material – Mild Steel,
Young's modulus of elasticity (E) = $2.10x10^5$ MPa,
Density (ρ) =7850 Kg/m^3,
Yield stress = 260 MPa
D1=outer diameter of roller=70mm=0.07m,
D2=inner diameter of roller=50mm=0.05m,
W=width of roller=500mm=0.5m,
y = distance of outer fiber from neutral axis =35mm =0.035m



Factor of safety for mild steel

Factory of Safety [FS] = Actual Breaking Strength (lb)
Normal Working Load (lb)

= 260/8.4

= 30.95

IX. MAXIMUM STRESS CALCULATION FOR GIVEN CONDITION

Allowable stress = yield strength / f.s = 70/1.5= 46.66 MPa

As stress is independent of material, maximum bending stress is same as mild steel roller As maximum bending stress << allowable stress i.e.(1.077<<46.66), the roller is safe for given loading condition

X. MAXIMUM DEFLECTION

$(y_{max}) = 5 \times W \times L^3 / 384EI$
$= (5 \times 122.5 \times 9.81 \times .5^3) / (384 \times 2.75 \times 10^9 \times 8.7179 \times 10^{-7})y_{max}$
= 0.58 mm.
As compared to length 500 mm, deflection of 0.58 mm is very negligible. Hence, selected roller can be considered as safe.

Sr. No.	Component	Material	Qty.
1	C-Channels for Chassis	ISMC 100	2
2	Rollers	Mild Steel	15
3	Bearing	Std.	30
4	C-Channels for Support	ISMC 75	4
5	Shaft	Mild Steel	15

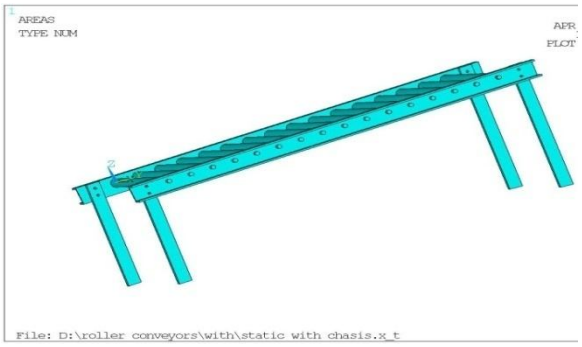
XI. STATICANALYSISFOR POLYCARBONATE

In order to reduce the weight of the gravity roller, the mater of the gravity roller is changed from mild steel to polycarbonate. The material properties of poly carbonate are shown below.

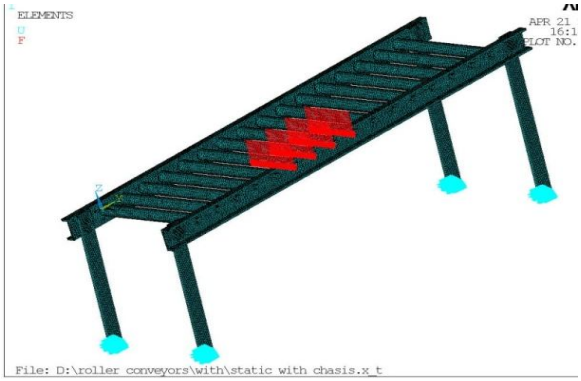
XII. MATERIAL PROPERTIES

Material: Polycarbonate
Young's modulus of elasticity: $2.75x10^3$Mpa
Poisson's ratio: 0.38
Density: 1100 Kg/m^3
Yield strength: 70MPa

CAD Model, Meshing, loads and boundary conditions are same except material properties that change are as given below.



Method	Before optimization		After optimization	
	Mild steel roller		Polycarbonate roller	
	Stress(MPa)	Deflection(mm)	Stress(MPa)	Deflection(mm)
Analytical	1.077	0.00763	1.077	0.58
FEA	8.4	0.06	6.8	4.9



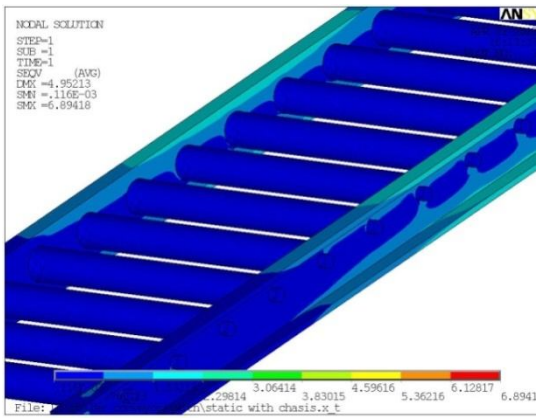


Fig: VonMises stress plot

Factory of Safety [FS] = Actual Breaking Strength (lb)/ Normal Working Load (lb)

= 70/6.8

= 10.29

RESULTS AND DISCUSSIONS

Design and analysis of gravity roller conveyor was done with mild steel and poly carbonate material. The analysis results were documented in the previous chapters. The Comparison between analytical and finite
element analysis results were tabulated

XIII. EFFECT OF OPTIMIZED DESIGN OF GRAVITY ROLLER CONVEYOR

From the above table of weight comparison, it can be seen that there is a great change in weight of optimized design as compared to before optimized design. (95.42 kg weight reduction for conveyor containing polycarbonate rollers

XIV. CONCLUSIONS

T Design calculation of gravity roller conveyor shows the factor of safety is very high in roller component and therefore this is utilized as a scope for weight reduction in this component. Mild steel material is replaced by polycarbonate material for roller for weight optimization of gravity roller conveyor. Though value of deflection is more in case of optimized design, it is within allowable limit and maximum stress induced is also within allowable limit. Therefore the design of the optimized conveyor is safe. There is 95.42 kg of weight reduction due to use of polycarbonate roller in gravity roller conveyor. The gravity roller conveyor is designed on the basis of static loading. The stresses induced in the roller and deflections are validated by FEA using ANSYS software for static case.

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