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Development of light weight, high-strength, and Energy-efficient conveyor systems

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ABSTRACT: *A gravity roller conveyor system is widely used in material handling industries for efficient and cost-effective transportation of goods. Unlike powered conveyors, gravity conveyors utilize gravitational force and manual push to move loads, making them ideal for warehouses, manufacturing units, and packaging industries. This study focuses on the design and structural analysis of a gravity roller conveyor system to enhance its load-bearing capacity, durability, and performance. The research involves designing a conveyor system based on material selection, roller diameter, frame structure, and load distribution. Finite Element Analysis (FEA) is performed to evaluate stress distribution, deformation, and safety factors under various load conditions. Additionally, the study examines the effect of roller spacing, conveyor incline, and frictional forces on system efficiency. The findings provide insights into optimal design parameters, material selection, and structural modifications to improve reliability and performance. This research contributes to the development of lightweight, high-strength, and energy-efficient conveyor systems, making material handling more sustainable and cost-effective.*

Keywords: *Optimized design, weight reduction, cost reduction, and material handling.*

I. INTRODUCTION:

A transport framework is bit of mechanical hardware used to transfer the material from one place to another. These are used in transport the material which are having heavy weight and bulky material. Conveyor system allows the quick and efficient transport for a variety of material and having a very popular material in handling and packing industries. There are many types of conveyor system are used in present and used according to needs used in various industries. Conveyors are safely to transport the material from one level to another level and they can reduce the human labour and it is expensive.

Transports are utilized as a part of numerous businesses, incorporate the Automotive, nourishment handling, aviation, compound, packaging and canning pressing. A wide assortment of material can be passed on. Numerous elements are essential in the determination of the conveyor in a few zones the transports are useful to think about the required tasks, for example, transport, material sizes, weights and shapes and where the stacking and emptying the material.

Figure 1

They can be introduced anyplace at a required space are impressively more secure than using lift or mechanism to move the things. Conveyors can move the stacks of different sizes and weights and materials. What's more, numerous have progressed securely highlights to stay away from wounds.

There is a variety of conveyor system available, including the hydraulic, mechanical and automated system. Material handling equipment plays an important role in many industries, such as construction sites and storage units. Gravity conveyors are design without considering the torsional effect on the roller shell. As the application changes the design of the roller may vary in terms of shaft, hub and shell assembly. In most of the research papers, crucial parts of roller conveyors like Roller, chassis and columns and bearings were targeted for weight optimization. By applying basic design concepts carefully according to the loading conditions on each member of system, one can design the system with significant alteration of the components. This issue is taken up for study and execution for developing other options to outline while focusing on weight enhancement for the basic parts like roller in the gathering. Basic investigation of the rollers in transport should offer experiences into the current issue. The FEA approach would be received to take care of the issue while discovering the auxiliary quality of the rollers and tending to the lessening in weight without trading off on the quality of crude material taking care of part parts in the get together.

Gravity roller conveyor needs to pass on 350kg stack, 30 inches over the ground and slanted at 4 degrees.

CLASSIFICATION OF ROLLER SYSTEM:

- Gravity feed Conveyor roller
- Electrical Belt Conveyor roller
- Vibrating roller
- Flexible roller system
- Live Roller Conveyor system

SCOPE OF PRESENT STUDY:

1. Check outline of present transport framework.
2. ANSYS APDL codes or Catia for drawing of existing framework.
3. ANSYS is utilized for direct static, modular, transient and streamlining examination.
4. Optimizations of transport get together for weight lessening.
5. Comparison amongst existing and streamlined outline.

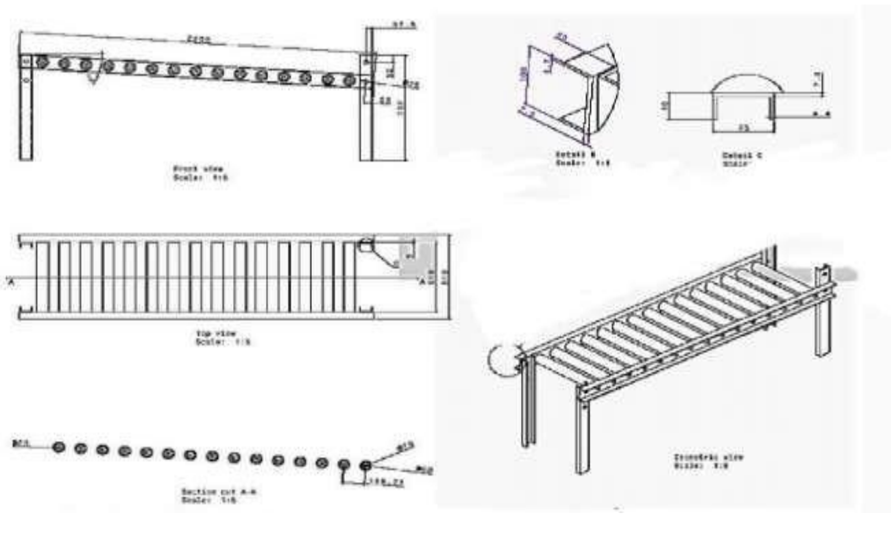


Figure 2 Gravity conveyor roller assembly

II. DESIGN AND EXISTING ASSEMBLY OF CONVEYOR ROLLER:

The explanation behind the transport is to empower present gravity roller transport by arranging the significant parts such as Roller, Shafts, Bearings and Frames, to force the general weight of the social gathering and save the wide evaluate of materials.

Gravity feed roller Conveyor needs to pass on 3500 N stack, 21 inches over the ground and inclined at 4 degrees.

Table 1

S.no	Components	Material	Qty
1	C-shaped channels for chassis	ISMC 100	2
2	Cylindrical Rollers	Mild steel	18
3	Bearings	Std	36
4	C-shaped Channels for stand	ISMC 75	4
5	Cylindrical Shaft	Mild steel	18

Table 2 Total weighting of existing transport get together:

S .no	Name of the components	Weight (kg)
1	C-shaped Channels for chassis	80.72
2	Cylindrical Rollers	172.59
3	Cylindrical Shafts	49.78
4	Bearings	8.978
5	C-shaped Channel for supports	39.77
	Total weight of assembly	351.89kg

GEOMETRIC MODELLING:

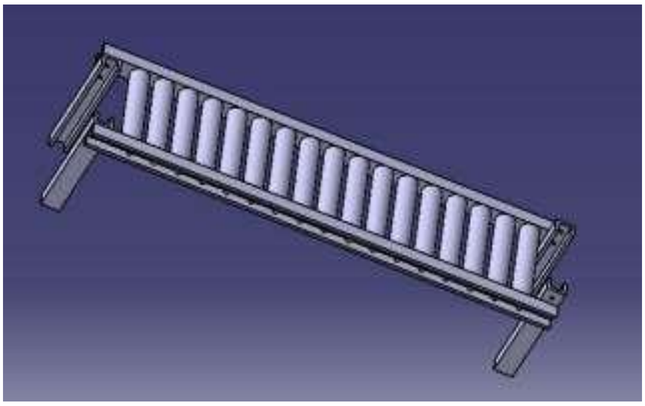


Figure 3 Geometrical modelling done with the help of CATIA V5R17

STATIC STRUCTURAL EXAMINATION:

A static examination finds the effect of persevering stacking condition on the structure while slighting dormancy and damping impacts, for instance, those caused by time fluctuating weights. A static examination, in any case, entwine ardent torpidity stack, for instance, gravityand rotation.

Plan and examination of roller transport for weight change and material saving and time moving weight that can be approximated as static proportionate weights, (for instance, static equivalent breeze and seismic loads from time to time portrayed in various change measures).

BASIC LOAD CONDITION:

Load is following up on any four rollers thus by considering 3500 N stack following up on four rollers most extreme avoidance, greatest pressure esteems are checked for existing plan.

RESULTS FOR STSTIC INVESTIGATION:

- Weight of the model is 351.81 kgs.
- Maximum preoccupation plot.

- Maximum pressure plot Load of 3500 N is connected on 3 rollers which situated at the focal point of the transport framework. We get the greatest redirection and most extreme pressure.

Figure 4 Total Deformation

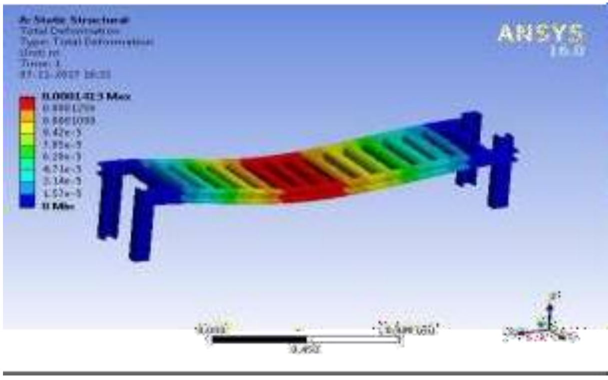
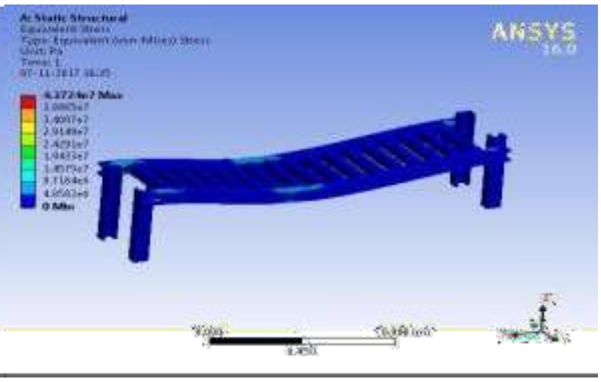


Figure 5 Equivalent Stress



MODAL ANALYSIS:

The deliberate examination is done to discover general rehash and model shapes.

- As the stacking will be the vertical way (gravity) the model shape which will displaydevelopment vertical way was vital.

There are diverse kinds of basic mode shapes happen in the transport framework. Wechose the transverse mode shape which require for the examination reason.

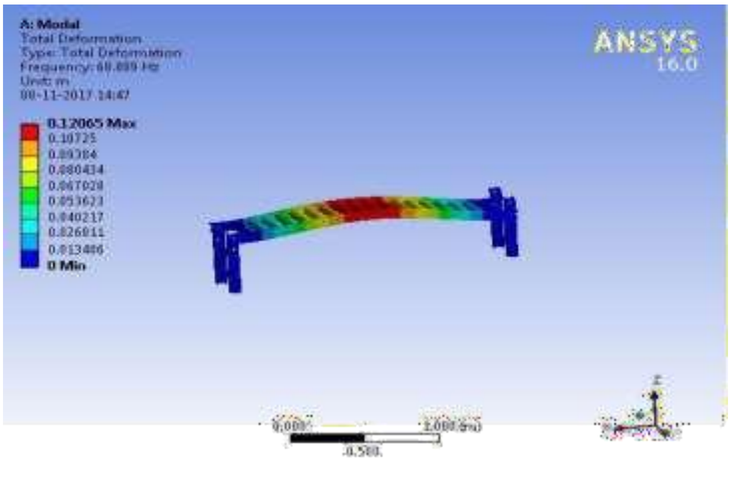


Figure 6

RESULTS FROM MODEL ANALYSIS:

- From the outcomes plainly, mode shape in fig will have most extreme movement vertical way. So common recurrence ought to be more prominent than the excitation recurrence.
- Natural recurrence is 68.889 Hz

NEED FOR OPTIMISATION:

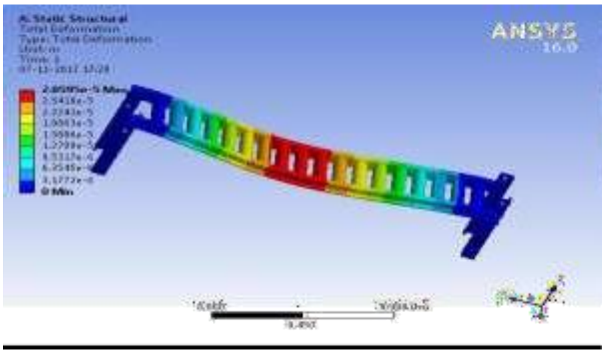
As factor of security the C-Channels and Rollers are high there is level of weight reducing inthis part.

OPTIMIZED DESIGN ON THE BASIC OF FOLLOWING CRITERIA:

- Selecting accessible parts which are like enhanced plan.
- Select ISJC 100 and ISJC 75 C-channels for edge and sponsorships independently
- Roller Outer estimation is 80 mm and roller thickness 5 mm.

Table 3 Total Weight of Transport Gathering (ANALYSED DESIGN)

S .no	Name of the component	Weight (kg)
1	C-shaped Channels for chassis	53.24
2	Cylindrical Rollers	106.21
3	Cylindrical Shafts	49.78
4	Bearings	8.978
5	C-shaped Channel for supports	26.62
	Total weight of assembly	244.82kg



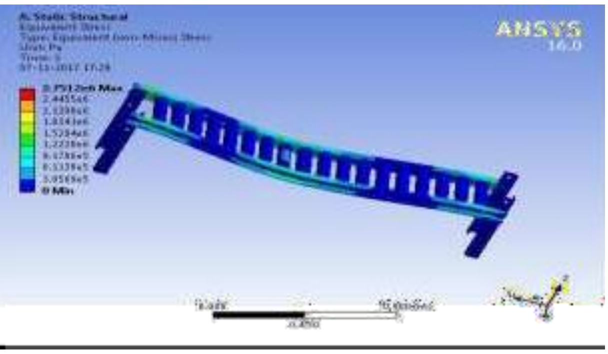


Figure 7 Total Deformation

Figure 8 Equivalent Stress

MODAL ANALYSIS:

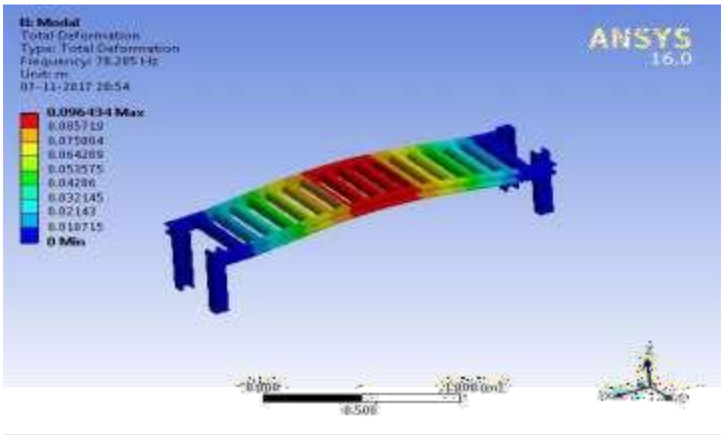


Figure 9

CALCULATION:

Shaft: Outer Diameter = 50 mmLength = 500 mm

Roller:

Outer Diameter = 80 mmInner Diameter = 50 mmLength = 400 mm

C - Channel Chassis: Length = 2000 mm

C- Channel for Support:Length = 500 mm

L = 350/4 = 87.5 KgsD_1 = 80 mm

D_2 = 50 mm

Width (length) = 400 mm = 0.4m Maximum Moment: $M_{max} = w*l/8$

= (87.5*9.81*0.4)/8

M_{max} = 53.64 Nm

Moment of Inertia: = $\pi(D_1^4-D_2^4)/64$

= $\pi(0.08^4-0.05^4)/64$

= $1.7029x10^{-6}m^4$

Maximum bending stress: Zb = (M_{max} * y)/I

= 1.10y mpa

Maximum deflection:

Y = $(5*w*L^3)/(384EI)$

= $(5*87.5*9.81*0.5^3)/(384*2.10x10^{11}*1.7029x10^{-6})$

= 7830

Weight of Roller (mild steel): = Cross section area x width x max density x no. of rollers

= $(\pi(d_1^2 - d_2^2)$ x0.4x7830x18)/4

= $(\pi(0.08^2-0.05^2)$ x0.4x7830x18)/4

= 172.59 kgs.

Weight of shaft: (mild steel): = Cross section area x width x mass density x no. of shafts

= πr^2x0.5x7830x18

= π x0.15^2x0.5x7830x18

= 49.78 kgs.

Total weight of Bearing: = 36x0.2494x8.978 kgs.Weight of C-frame: (Structure area)

Cross section area = 2bh+(lxb)

= 2x0.06x (0.015+0.01) x0.015

= $2.55x10^{-3}m^2$

= Cross segment territory x Length of casing x Mass thickness

= $2.55x10^{-3}$x2x7830

= 39.933 / per frame

= 2x39.33

= 79.86 kgs.

Weight of Channel: Cross section area x length x Mass density x No. of Channel

= $2.53x10^{-3}$x0.5x7830x4

= 39.93 kgs.

C- frame: Cross segment territory x Length of casing x Mass thicknessCross section area

= 2Bh+(l*b)

= 2x60x10+(50x10)

= 2x0.06x0.01+0.05x0.010

= $1.7x10^{-3}m^2$

= $1.7x10^{-3}$x2x7830

= 26.62/per lane

= 2x26.62

= 53.24 kgs.

Weight of channel: = Cross section area x Length x Mass density x No. of channel

= $1.7x10^{-3}$x0.5x7830x4

= 26.62 kgs.

Inclination angle: β = 4.

Assembly	Weight
C- Chassis	80.70 kg
Rollers	172.59 kg
Shaft	49.78 kg
Bearing	8.978 kg
C- Channel Support	39.77 kg
Total	351.81 kg

Optimization of weight of assembly:Outer Diameter = 70 mm
Inner Diameter = 50 mmLength = 400 mm

Weight of roller = $((0.07^2-0.06^2)\pi$ x0.4x7830x18)/4
= 106.21 kgs

After Assembly	After Optimization
C- Chassis	53.24 kg
Roller	106.21 kg
Shaft	49.78 kg
Bearing	8.978 kg
C Channel Support	26.62 kg
Total	244.82 kg

III. RESULTS AND DISCUSSIONS:

S.no	Name of the component	Weight optimiseddesign(kg)	Weight of the existingdesign(kg)
1	C-channels for chains	53.24	80.72
2	Rollers	106.21	172.59
3	Shafts	49.78	49.78
4	Bearings	8.978	8.978
5	C-channels for support	26.62	39.77
	Total weight	244.82	351.81

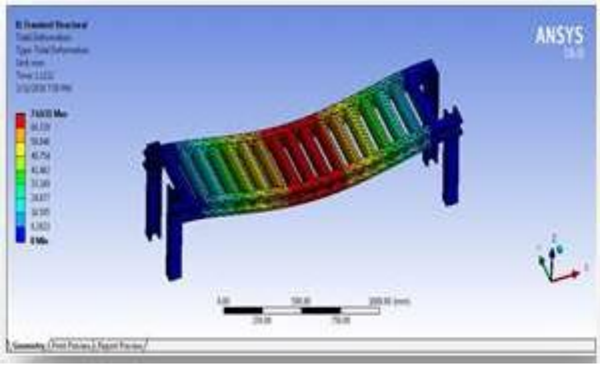
OBSERVATION FROM RESULTS – EFFECT OF OPTIMIZED DESIGN COMPARED WITH EXISTING PLAN:

- From above chart we can find the great change in weight of optimized design and existing design. (107 Kg. weight reduction)
- Here we can observe changes in 3 main components, i.e. C-channels for Chassis, C- Channels for Supports and Rollers due to optimization.

COMPARING MILD STEEL WITH ALUMINIUM:

The existed design is optimized in respect of weight by replacing the existed low carbon mild steel material with Aluminium because strength to weight ratio is high for aluminium so that without sacrificing the required strength there is a huge reduction in weight of the critical parts and assembly.

STATIC STRUCTURAL ANALYSIS:



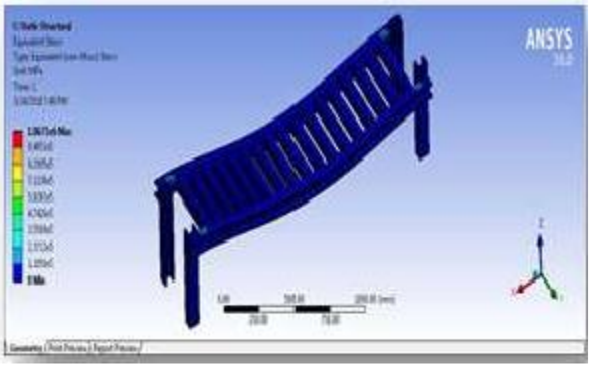
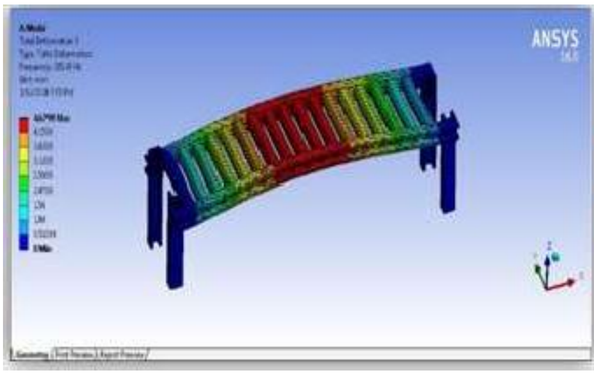
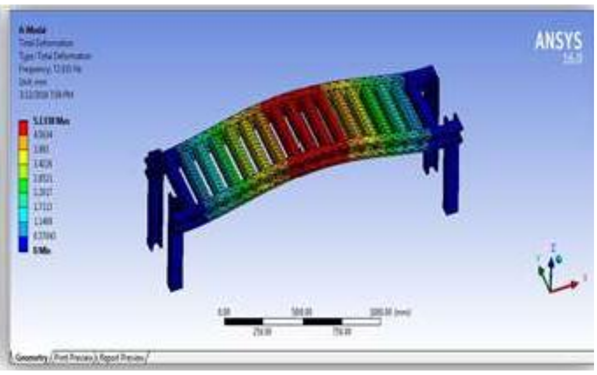


Figure 10 Total deformation **Figure 11** equivalent stress (von-misses):

DYNAMIC ANALYSIS:





OBSERVATION FROM CHANGE IN METAL:

- Total weight of aluminium system is 208kg.
- Natural frequency is having maximum motion in vertical direction.
- Natural frequency is 72.033HZ
- Factor of safety is 2.89

IV. CONCLUSION:

- Existing course of action computation shows the factor of security is extraordinarily more critical than require and there is a development for weight diminishment.
- The Critical parameter which diminishes the expansiveness of C shaped channels, rollers external partition across finished and roller thickness.
- Though estimation of redirection, push is progressively if there ought to emerge an event of Optimized diagram, yet it is permissible.
- 106.89 Kg. weight lessening accomplished by enhanced plan than existing outline.
- From the analysis we conclude that aluminium is more suitable for our application conveyor rollers compared to low carbon mild steel alloy.

Mild steel metal Cost is low compared to aluminium.

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