# ROLLER CONVEYOR

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## PACKAGE DEFINITION .

First , I only have two piece of information about package first is the wight and it is 15 Kg AND second is there are 15 packages / 1 meter so what I think about I can now get first dimension of package and it is equal (1000/15) = 66.6 mm but in this case there is no space between packages and it is like maybe production line so there is possibility of using sensor maybe to count number of product and it is bad idea to keep no distance so I decide to make this length equal to 50 mm that is make 33.2 mm between each two packages and also I assumed that the rest of dimensions are equal to make it easy to calculate so

$M=\rho*v$

M is the mass of package

P is the density of material

V is the volume equal (L*2A)

So what is the material when I think of package 15 kg is large wight for something in these small dimensions so I assumed that is bulk material and use steel to reach this wight in this small volume and steel density is $\rho$ =7700kg/m^3

And now we can get the last two dimensions equal 200 mm

## ROLLER CALCULATION

First of all I need package to move with high stability and how I will do that by making 2 roller under each package any time in the process and how is that by making

L=(2*D+S)

L = 50 mm # is the dimension of package in moving direction

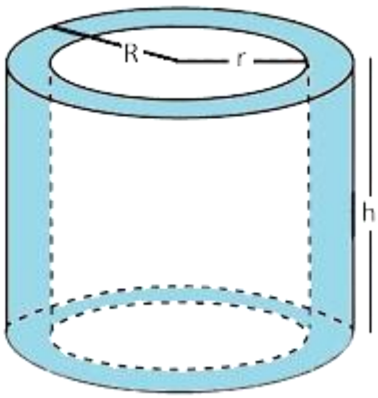
D = 20 mm # is the outer roller diameter

S=10 mm # is the minimum distance between each two roller

By this equation I ensure that at any moment there are two roller under each package

And we can also make 5 mm clearance so the range of maximum distance between each two rollers is 45:55 mm

## Stress analysis




So we use like hollow cylinder but why ?

First I think to make roller solid part so , first it will cause more wight that leads to more stress but why I think of this from the beginning because it will be great to make roller and shaft as one part but the high wight will also cause a high inertia at high rpm so I think again of hollow cylinder and the hard thing is I want to make god and stable  connection between shaft and roller so what is the possibilities

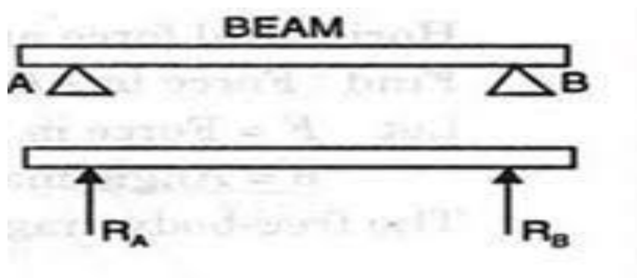
1- Welding but this is very bad for maintenance
2- Screws and nuts but from my experiences it also bad why ? I have great experience in shooting mechanisms so from my tests and developing shooting mechanisms journey I find that at high rpm vibration will loos nuts and screws so it is not stable idea
3- End cap from my research I found how roller manufacture in real life and that is by putting shaft inside roller and use like end cap it is part like hollow cylinder carry shaft and fit inside roller by hydraulic compression process so I use it in my design

So the dimensions of roller is

R=20mm & r = 16 mm & h=220 mm why I put like 20 mm clearance from 200 mm width of package

# how we will study stress on roller ?

We will study it as simple supported beam



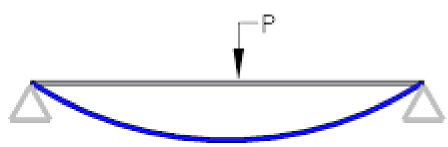

The wight act on beam is half of the  wight of package =75 N

And reaction in each support is radial reaction each one equal to load/2 =75/2=37.75 N

No thrust force only radial load

# this radial load I will use to select bearing

## Expected deformation




How we calculate bending stress

σb=(M*Y/I)

-M is the maximum moment act on beam

-Y is the distance between neutral axis and point we want to study (bending stress is maximum at outer surface and equal zero at neutral axis )

-I is area moment of inertia

1- M = f*r =37.75*125=4687.5 N.mm

2- Y = Do/2 = 10 mm ( outer surface is the worst case )

3-I = (π/64)*((Do^4)-(Di^4)) = 7363 mm^4 σ b = (4687.5*10)/7363 = 6.366 Mpa

## DEFLECTION OF BEAM

We will use double integration method

**1-** $$\frac{d^2y}{dx^2} = \frac{M}{Ei} = \frac{F \cdot r}{Ei}$$

**2-** $$\frac{dy}{dx} = \frac{1}{E \cdot i} \cdot \frac{F}{2} x^2 + \frac{1}{Ei} \cdot C_1$$

**3-** $$y = \frac{1}{Ei} \cdot \frac{Fx^3}{6} + \frac{C_1 x}{Ei} + \frac{1}{Ei} C_2$$

Now we can get deformation or deflection y at any point we just need to get C1 and C2

But how by using boundary condition we know that

1- At X=0 Y=0
2- At X=L Y=0

SO AT X= 0 Y=0

C2 =0

At X=L Y=0

$$C_1 = \frac{F \cdot L^2}{6}$$

Now the final deflection equation is

$$y = \frac{Fx^3}{6 \cdot E \cdot i} + \frac{F \cdot L^2 \cdot x}{6Ei}$$

Now I know cause of load is symmetric the maximum deflection is in the middle at X=L/2

So

$$Y = \frac{1}{E \cdot 1} \cdot \frac{5FL^3}{48}$$

L=250 mm

E=70*10^3 Mpa

I=7363 mm^4

$$y = \frac{(5)(75)(250)}{(48)(70)(1000)(7363)} = 3.789 * 10^{-6} mm$$

Design of shaft

We will deal with shaft the same way we deal with roller as simple supported beam so the dimension of shaft is

Dsh=12 mm

L= 300 mm

# I could increase width of package at first and also make roller and shaft increases but why I choose that ?

Cause in this application the pure stress is bending so I avoid to make over length of package and that leads to short shaft and roller to reduce bending stress and so reduce deformation but just that no the thing is the height of part is 4*length so I need so make sure it is stable so I build my design in way at any moment any package is supported by two rollers under of it

$$\boldsymbol{\sigma_B = \frac{My}{I}}$$

$$\boldsymbol{M = F \cdot L = (37.75)(150) = 5625\ Nmm}$$

$$\boldsymbol{y = \frac{D_0}{2} = 6mm}$$

$$\boldsymbol{I = \frac{\pi}{64} \cdot (12^4) = 1017{,}8\ mm\text{^}4}$$

$$\boldsymbol{\sigma_B = \frac{(5625) \cdot (6)}{(1017{,}8)} = 33{,}15\ Mpa}$$

$$y = \frac{(5)\cdot(75)\cdot(300)}{(48)\cdot(70)\cdot(10)\cdot(1017,8)} = 3,3 * 10^{-5} mm$$

## Bearing selection

So what I need to insert tables and select suitable bearing

1- Shaft diameter Dsh = 12 mm
2- Rpm revolution/min

$$rp_{m=\frac{60*2}{2*\pi*0.01}=1909.8\, rpm}$$

3- Basic dynamic load

$$C_0 = (F_s)(p_0)$$
$$P_0 = x \circ F_r + y_0 F_a$$

$$p_0 = F_r = 37,75N$$

$$C_0 = (F_s)(p_0) = (1,5)(37,75) = 56,25N$$

**Assunbtion we take**

**First only radial load thrust load = 0 and I assume that x=1**

**Insert koyo table and get informations**

**bearing number = 6800**

$$c_0 = 1,05\ KN$$

$$c = 2,4kN$$

**We now need to check if selection is good or not but first we have to do some assumotions**

1- **Reliability (R) = 90%**
2- **Ks = 2 (moderate chock )**
3- **L10 = 60 million revelation**
4- $\epsilon = 3$ **for ball bearing**

$$p = (x_v)(F_r) + (y)(F_a)$$
$$p = F_r = 37,75N$$

$$C_0 = (2)(37,75)\left(\frac{60}{1}\right)^{0.3} = 0,289\ KN$$

**Bearing that I selected is from koyo**

**Bearing number 6800**

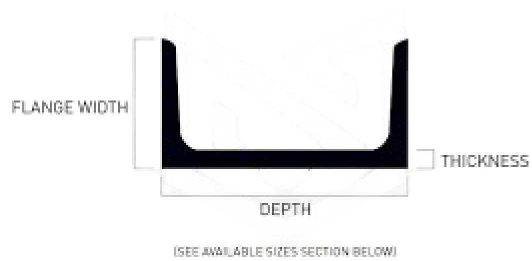
**Do = 21 mm**

**Di = Dsh = 12 mm**

**B= 5 mm**

## Structure analysis

First of all I do use sheet metal as required in task but I do use sheet metal with bended flanges why ? cause effect of flange is really great to stand against bending stress So each leg like C-beam




Depth = 150 mm

Flange width = 50 mm

Thickness = 6 mm

Before I start stress analysis I need to determine where is neutral axis cause the shape is not uniform and it is important to determine its place so we can calculate right area moment of inertia

We can use parallel axis theory

$$A_1 y_1 + A_2 y_2 + A_3 y_3 = (A_1 + A_2 + A_3) \cdot y_n$$

$$(150 \cdot 6) \cdot 47 + (2 \cdot 6 \cdot 44) \cdot 22 = (2 \cdot 6 \cdot 44 + 150 \cdot 6) \cdot y_n$$

$$y_n = 37,75mm$$

## Bending stress

$$\sigma_B = \frac{M \cdot y}{I}$$

$$M = F \cdot r = \frac{(m_T) \cdot (9)}{4}$$

$$F = \frac{(15) \cdot (100)(10)}{4} = 3750 \ \ N$$

I consider 100 package for worst case running conveyor with no space (5000/50) = 100 packages

$$r = \sqrt{1250d^2 + (140)^2} = 2515mm$$

$$m_{m_ix} = (3750) \cdot (2515) = 9431250 \, N.mm$$

$$y_{max} = 37,75mm$$

$$I_{T_0T} = I_1 + I_2 + I_3$$

$$I_1 = i_1 + A_1 \cdot L_1^2$$

$$I_1 = \frac{(150) \cdot (6)^3}{12} + (150)(6) \cdot (9,25)^2 = 79706.250 \, mm^4$$

$$I_2 = I_3 = \frac{(6) \cdot (44)^3}{12} + (44) \cdot (6) \cdot (15.75)^2 = 108080.5 \, mm^4$$

$$I_{T_0T} = I_1 + 2 \cdot I_2 = 79706,25 + 2 \cdot (108080,5)$$
$$= 295867,25mm^4$$

$$\sigma_B = \frac{9.43 \cdot 10^6 \cdot (37,75)}{295867.25} = 1203.33\ Mpa$$

The bending stress is so huge so we have to choise

1- Upgrade dimensions ( thickness )
2- Increase number of legs in sheet metal structure

## Update design conditions

### Update material thickness

*First try*

**Thickness = 8 mm**

$$A_1y_1 + A_2y_2 + A_3y_3 = (A_1 + A_2 + A_3) \cdot y_n$$

$$(150 \cdot 8) \cdot 48 + (2 \cdot 8 \cdot 44) \cdot 22 = (2 \cdot 8 \cdot 44 + 150 \cdot 8) \cdot y_n$$

$$y_n = 38,5mm$$

$$I_1 = \frac{(150) \cdot (8)^3}{12} + (150)(8) \cdot (9,5)^2 = 114700\ mm^4$$

$$I_2 = I_3 = \frac{(8) \cdot (44)^3}{12} + (44) \cdot (8) \cdot (16.5)^2 = 152621.3\ mm^4$$

$$I_{T_0T} = I_1 + 2 \cdot I_2 = 114700 + 2 \cdot (152621.3)$$
$$= 419942.667\ mm^4$$

$$\sigma_B = \frac{9.43 \cdot 10^6 \cdot (38,5)}{419942.667} = 881.436\ Mpa$$

**Still high stress**

*Second try*

**Thickness = 12 mm**

$$A_1y_1 + A_2y_2 + A_3y_3 = (A_1 + A_2 + A_3) \cdot y_n$$

$$(150 \cdot 12) \cdot 50 + (2 \cdot 12 \cdot 44) \cdot 22 = (2 \cdot 12 \cdot 44 + 150 \cdot 12) \cdot y_n$$

$$y_n = 39,8mm$$

$$I_1 = \frac{(150)\cdot(12)^3}{12} + (150)(12)\cdot(16.2)^2 = 493992\ mm^4$$

$$I_2 = I_3 = \frac{(12)\cdot(44)^3}{12} + (44)\cdot(12)\cdot(17.8)^2 = 252475.52\ mm^4$$

$$I_{T_0T} = I_1 + 2\cdot I_2 = 493992 + 2\cdot(252475.52)$$
$$= 998943.04\ mm^4$$

$$\sigma_B = \frac{9.43\cdot 10^6\cdot(39,8)}{998943.04} = 375.8\ Mpa$$

And I apply this material aluminum alloy 7075-T6SN

Has the same density for alluminum alloy 1060 means same light wight and has

Sy=505 Mpa

## increase number of legs in structure

**Use 6 legs instead of 4**

$$F_{leg} = 2500\ N$$

$$M_{m_{ax}} = (2500)\cdot(2515) = 6.2 * 10^6\ Mpa$$

*thickness = 6 mm*

$$\sigma_B = 802\ Mpa$$

*thickness = 8 mm*

$$\sigma_B = 568.410\ Mpa$$

*thickness = 12 mm*

$$\sigma_B = 247.02\ Mpa$$

# MOTOR SELECTION

**1-required torque / roller each 2 roller carry 1 package so load on each roller is 75 N**

$$T_r = (75) \cdot (0,02) \cdot \frac{0.02}{2} = 0.0147\ N.m$$

$$T_{ToT} = (0,0147)(142) = 2.0874\ N.m$$

**Let's assume system efficiency = 85%**

$$T_{motor} = \frac{T_{total}}{\eta_{system}} = 2.45\ N.m$$

$$rpm = \frac{v \cdot 60}{\pi \cdot D} = 1909\ rpm$$

$$p = \frac{2.45 \cdot \omega}{9550} = 0.48579\ kw = 0.65144\ HP$$

SO WE CAN TAKE LIKE FACTOR OF SAFITY AND LOOK FOR MOTOR WITH POWER IN RANGE OF 500:600W AND ANY MOTOR IN THIS RANGE CAN MATCH OUR CLASSIFICATION AND WE CAN EDIT RPM AND RATED TORQUE BY

1- GEARBOX IT MAKE CHANGES IN TORQUE AND Rpm with the same ratio but with inverse relationship
2- Control volt this controller can change volt by change in pulse width
3- Use variable frequency drive


## MOTOR SPECIFICATIONS

1-RATED TORQUE = 0.55 N.m

2-RATED RPM = 1800 RPM

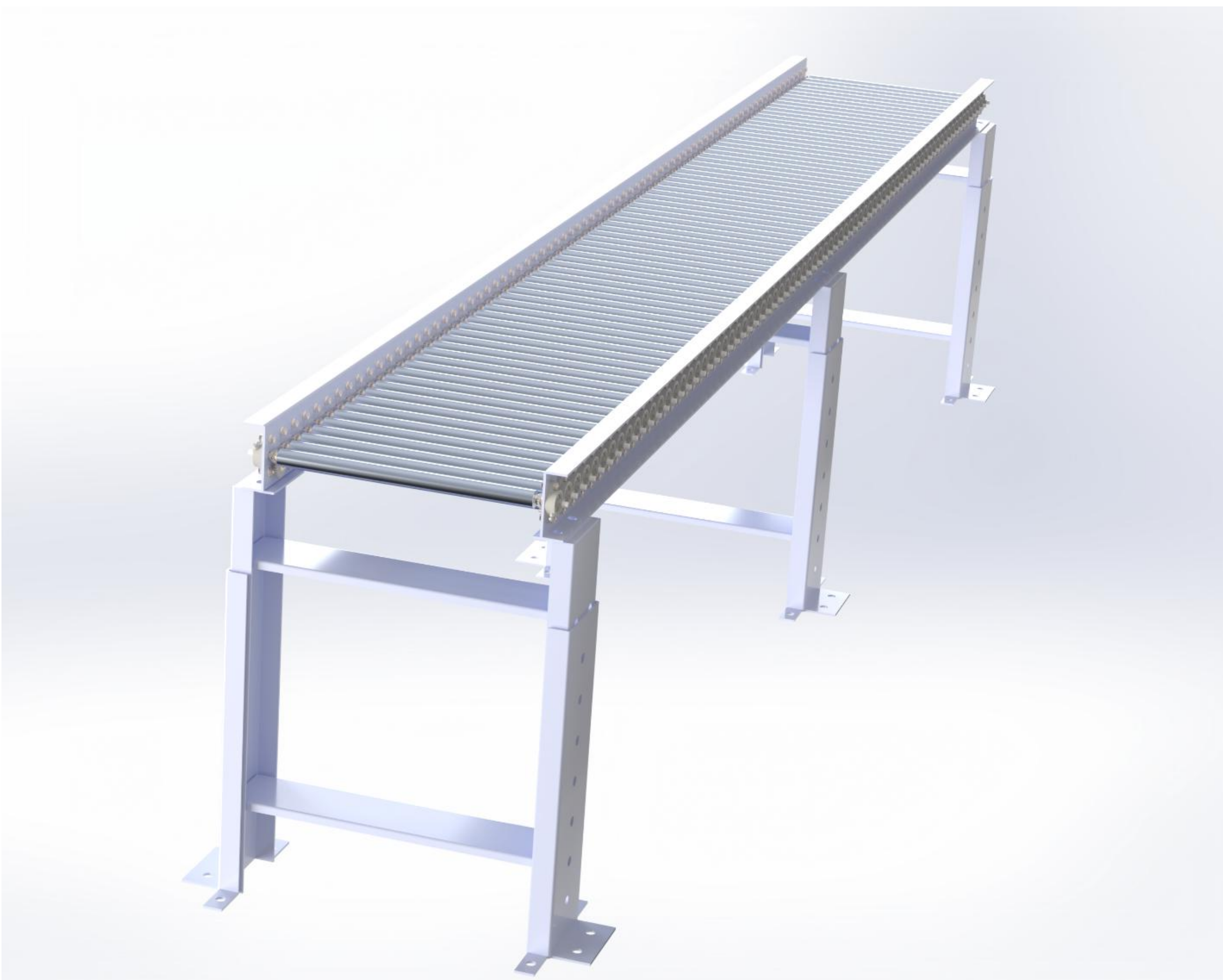
### Motor Selection Justification

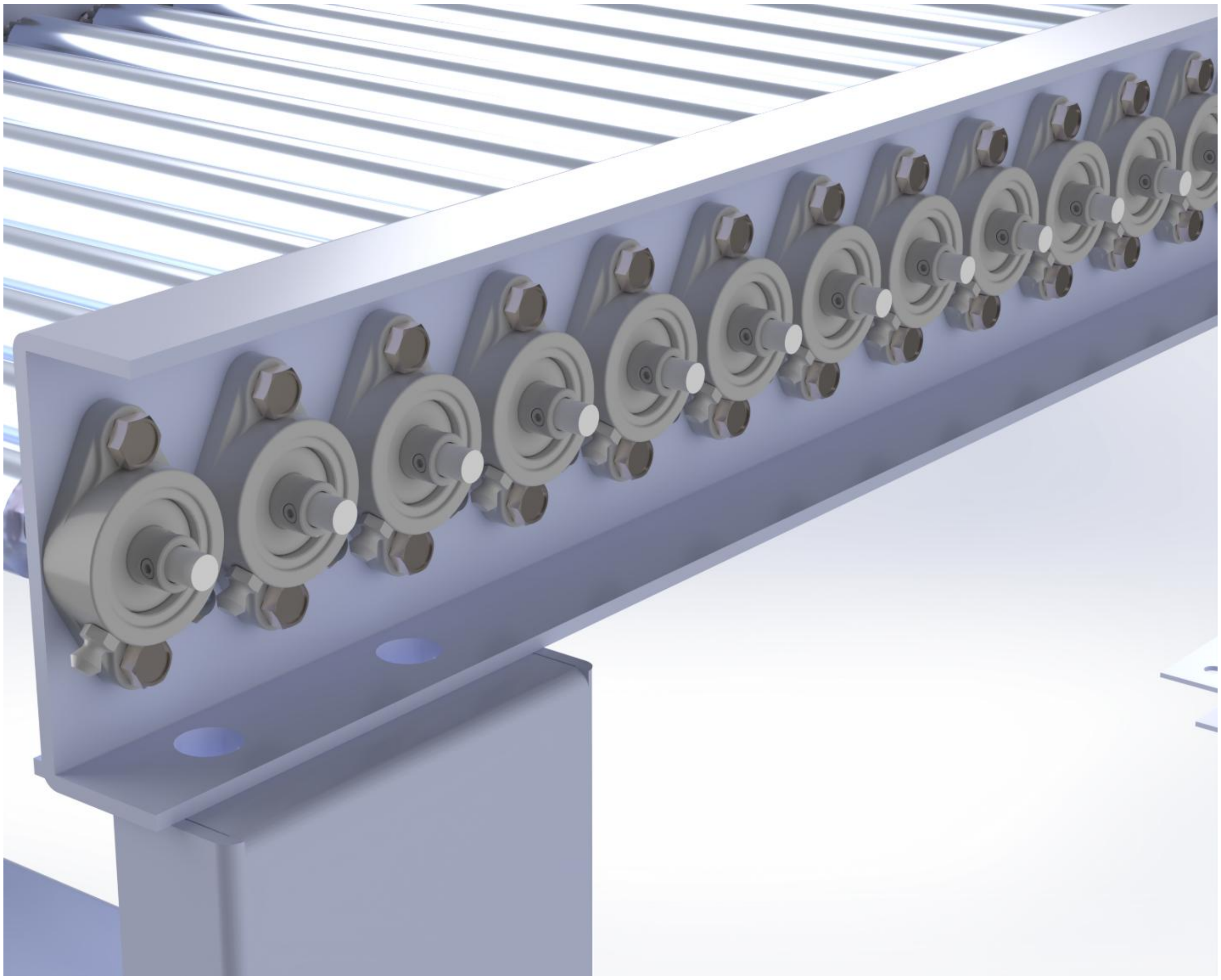
The selected motor (0.55 kW, 1800 RPM, 0.55 N.m) covers the required power of 486 W with a safety margin. The small RPM difference (1909 RPM required vs. 1800 RPM rated) can be adjusted using a variable frequency drive (VFD), ensuring precise speed control

# CAD MODEL STAGES

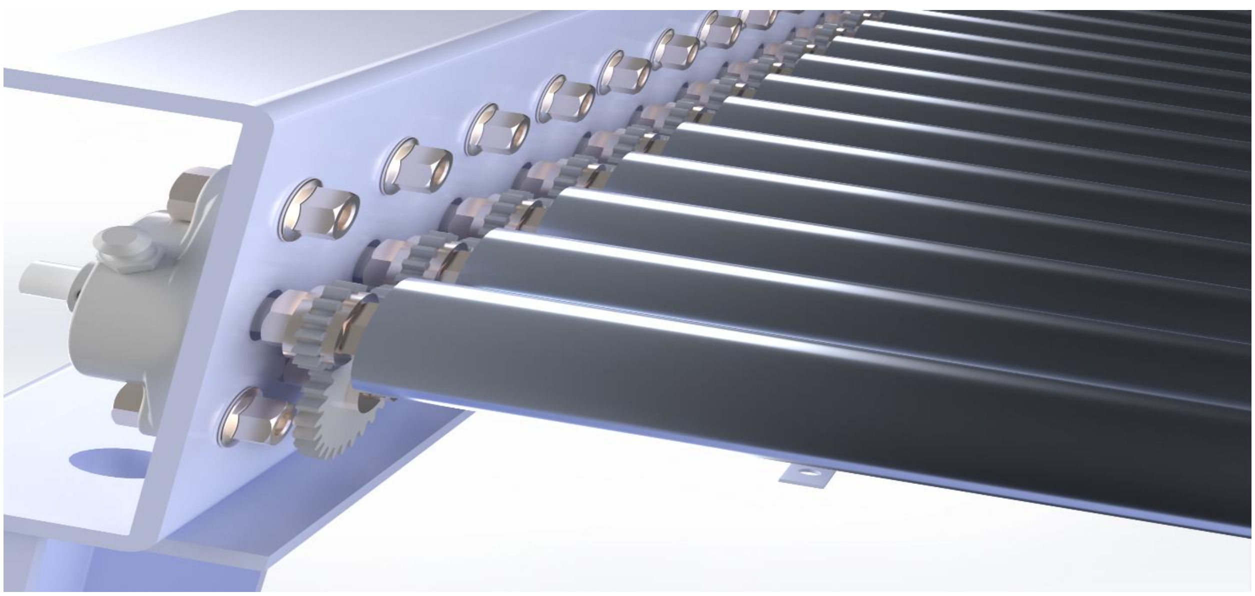
## STAGE-1

I create model in this stage in brain storming stage so I want to visualize my thoughts so I can see it and make updates on it





In this model I decided to use seated gear cause this design is larger than last version and also seated bearing doesn’t need a bearing cover so I use it as prototype also

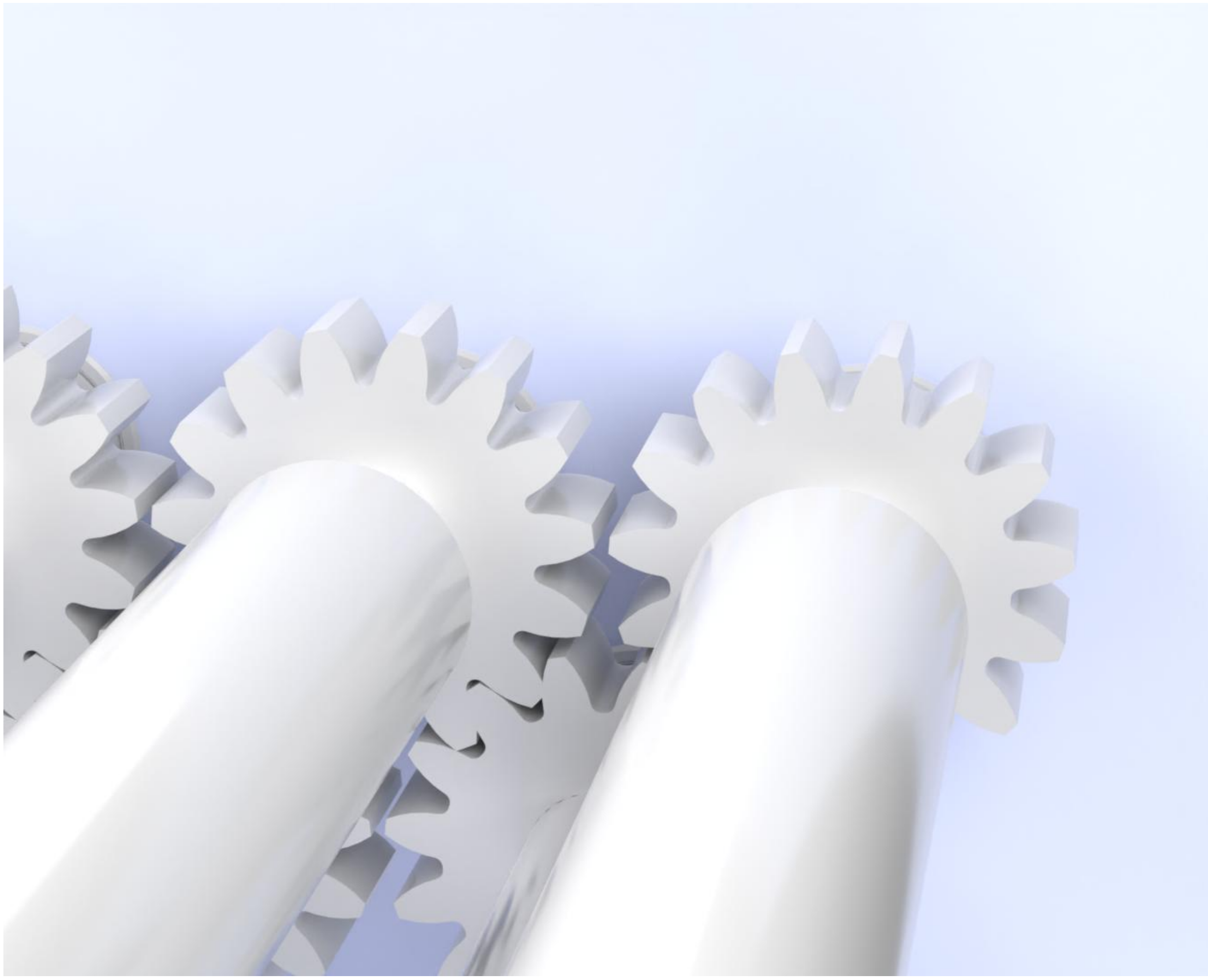


Power transemition I use gear why cause gears has a higher efficiency and it is long term power transimition neel low maintenance so I use a gear on each roller shafts and between each two roller I use idlear bearing and that’s to redirect the rotation of second roller in the same direction of moving

## STAGE-2(Final cad model )

This model I do my calculation on and I want to add some features but I have limited time to study and make calculation on it but I will cover it as separate feature we can add in next stage

I use the same structure for last one and the same holder of roller with updated dimensions and I also use regular gear I selected from koyo tables and use more suitable gear with module 2 and outer diameter of 34 mm and pitch diameter 30

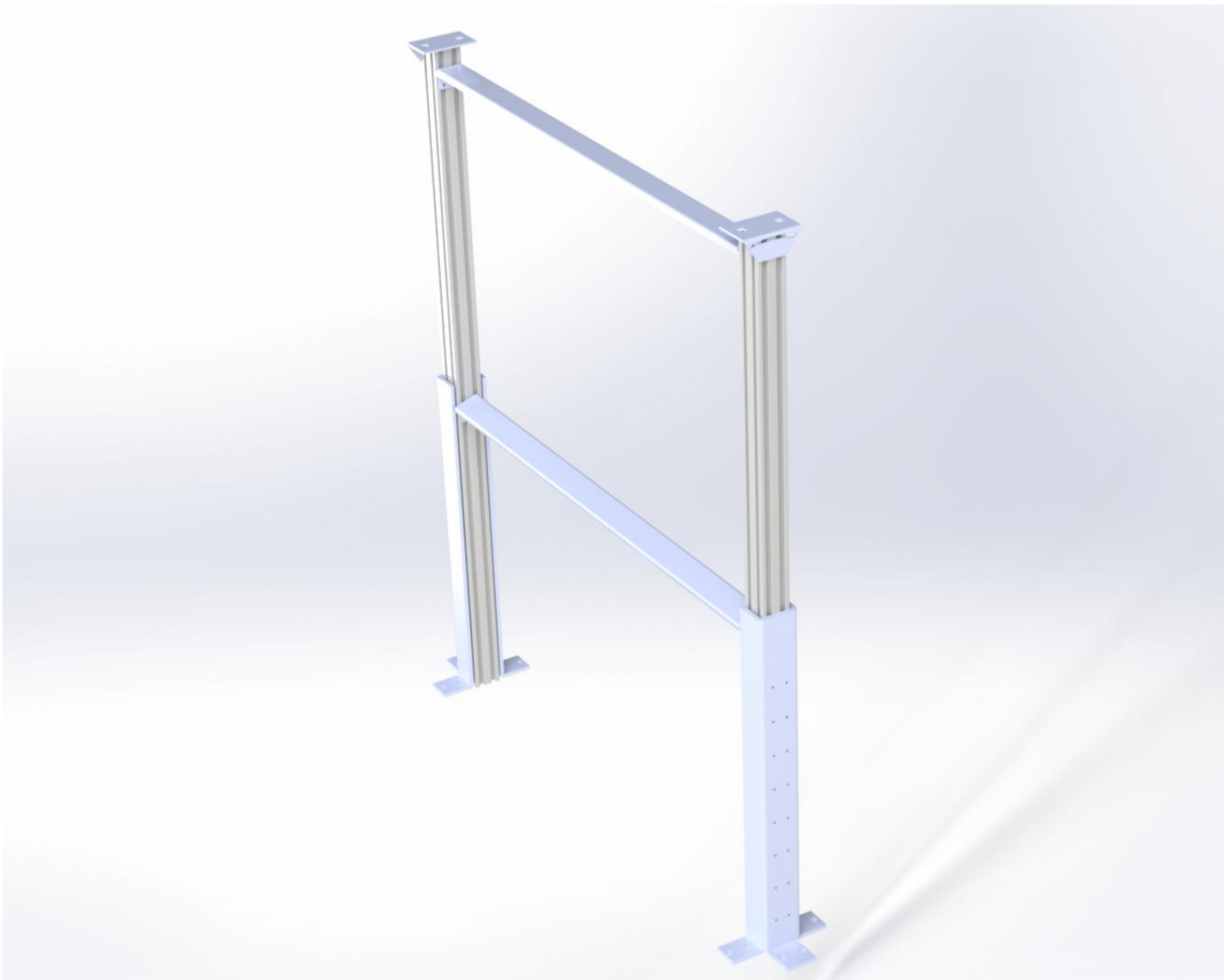


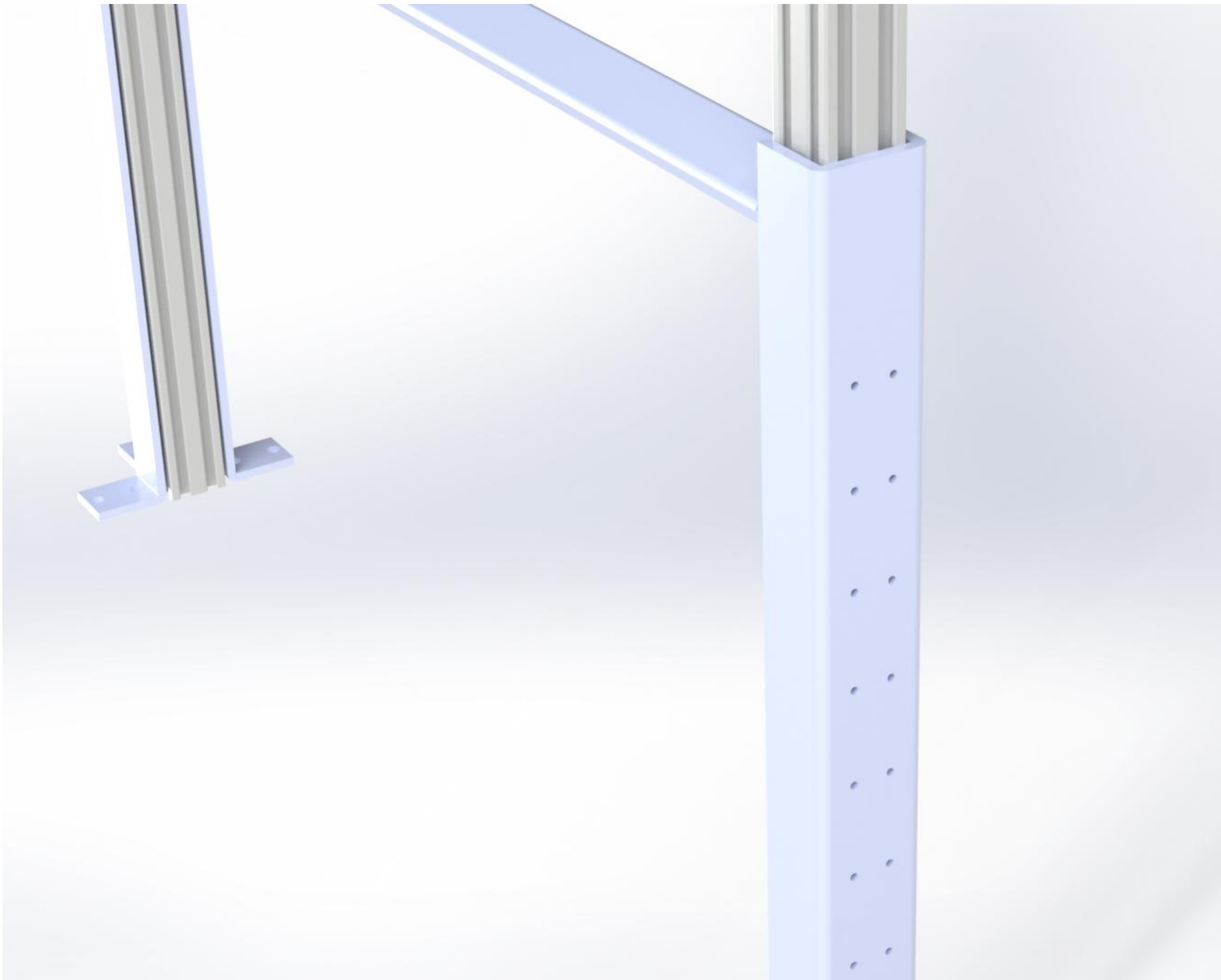
This pic shows meshing of gears between each two rollers

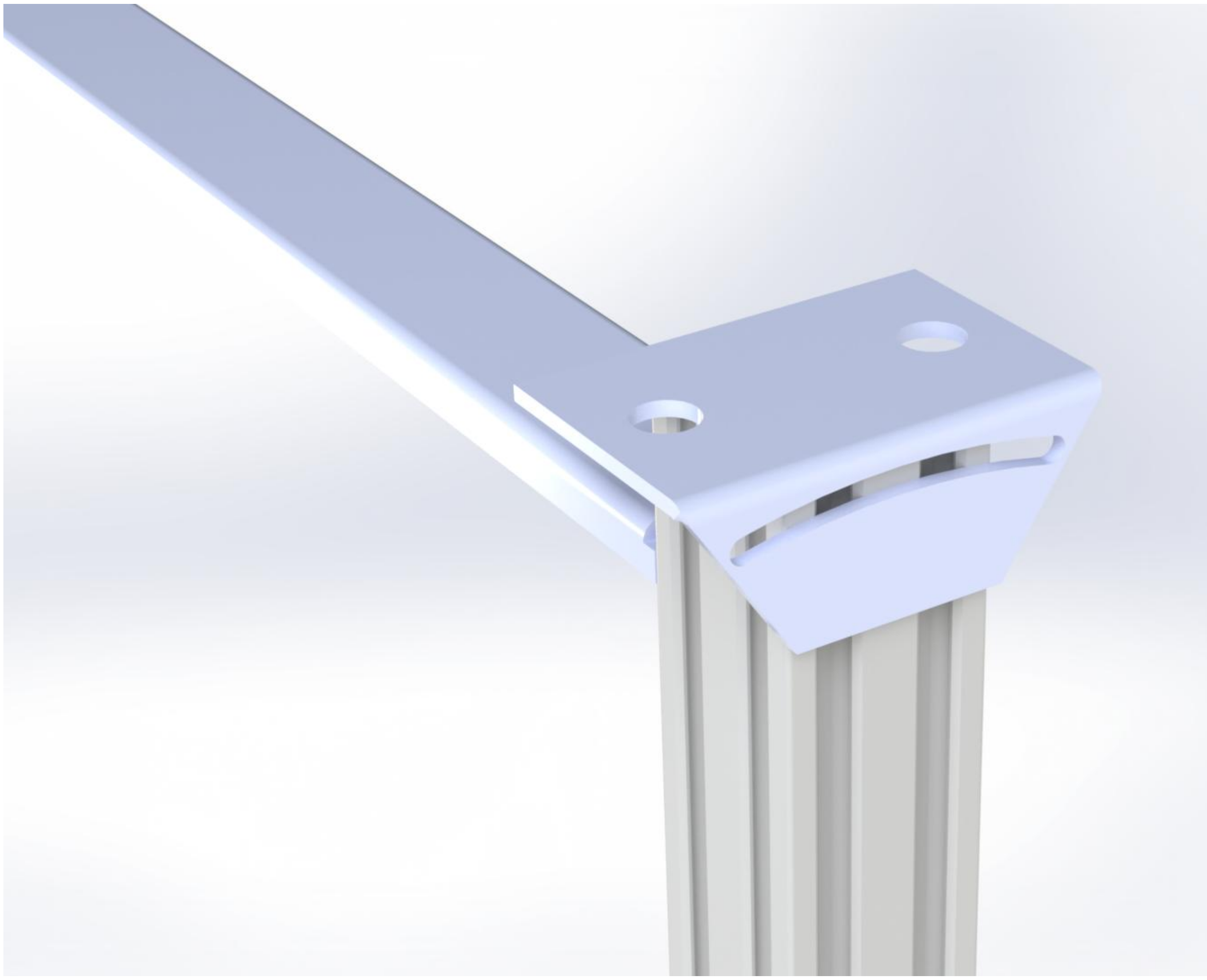
## Next Features

I do some updated in structure that carry roller conveyor

1- Add sheet metal part that allow the roller conveyor to change its angle
2- Add V-SLOT to make change in Hight more easy and has no limit like in first version I use screws for that but the limit in this is the step between each screw like I can not take 0.5 of this step







## Stress analysis

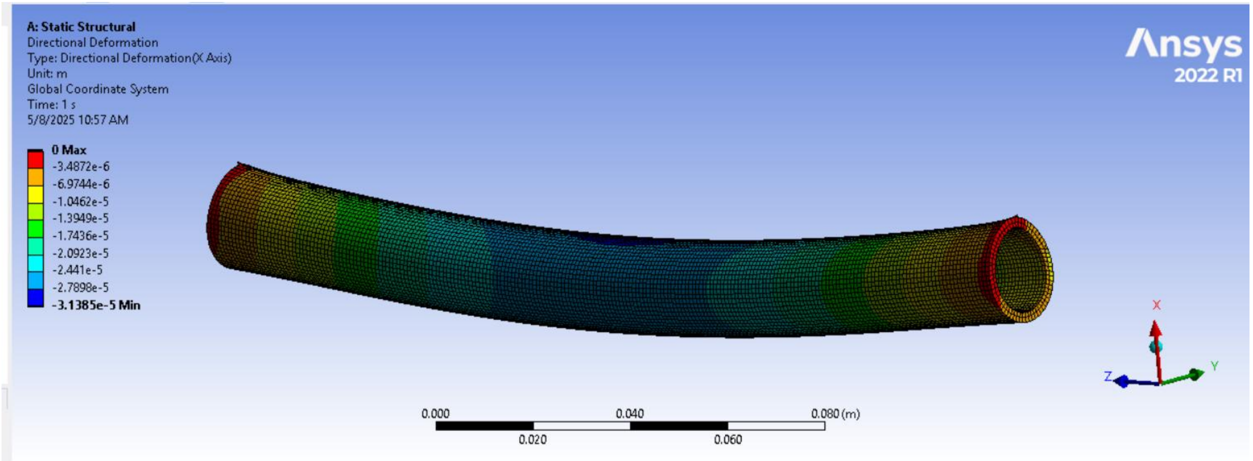
### Roller & shaft case study

### This two cases are similar so I will show you the preprocessing stage and then the results

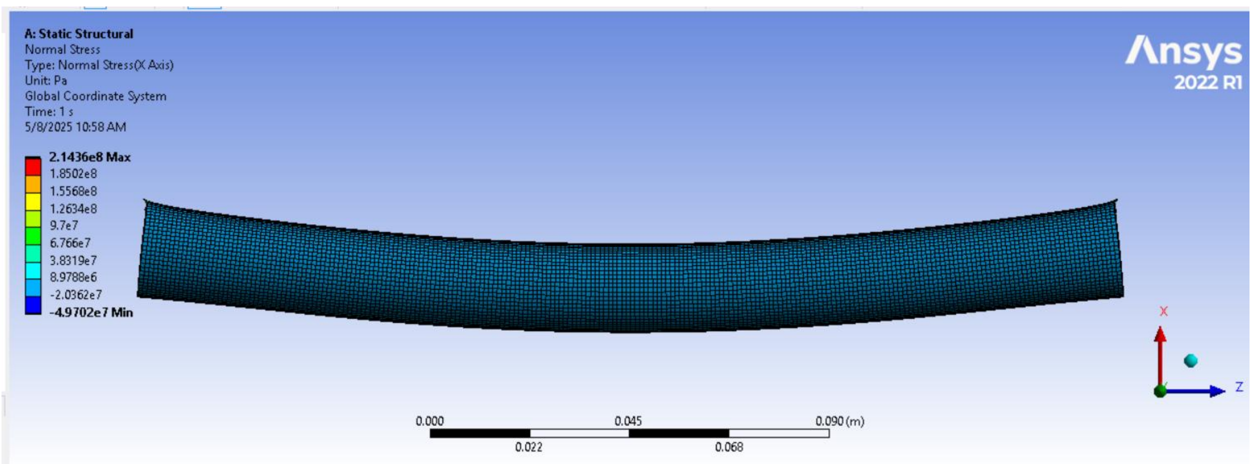
1- I apply remote displacement at the fixation point so this point allowed only to rotate in one direction only
2- I apply load in the center or roller or shaft

*roller results*

## 1-directional deformation

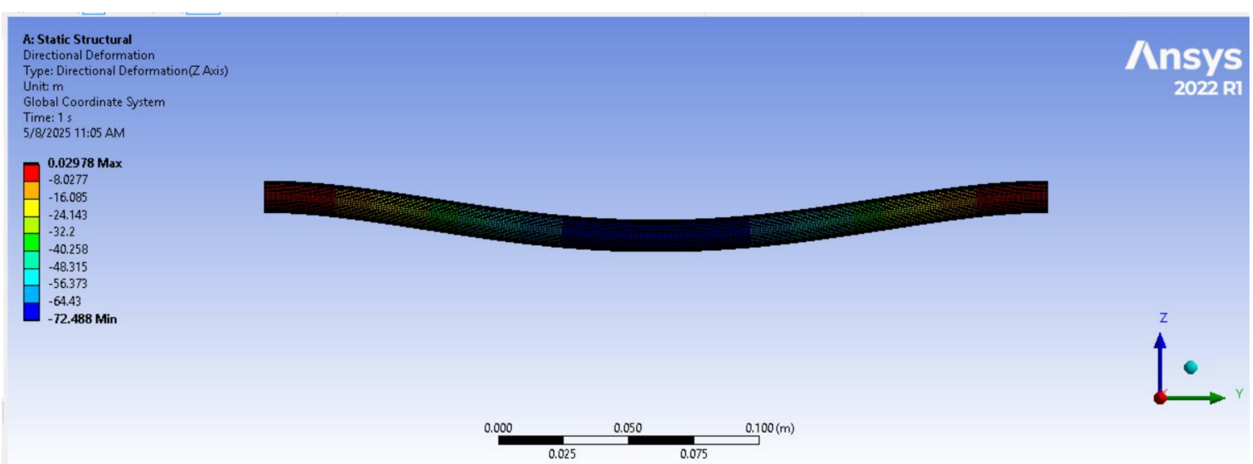



## 2-Normal stress

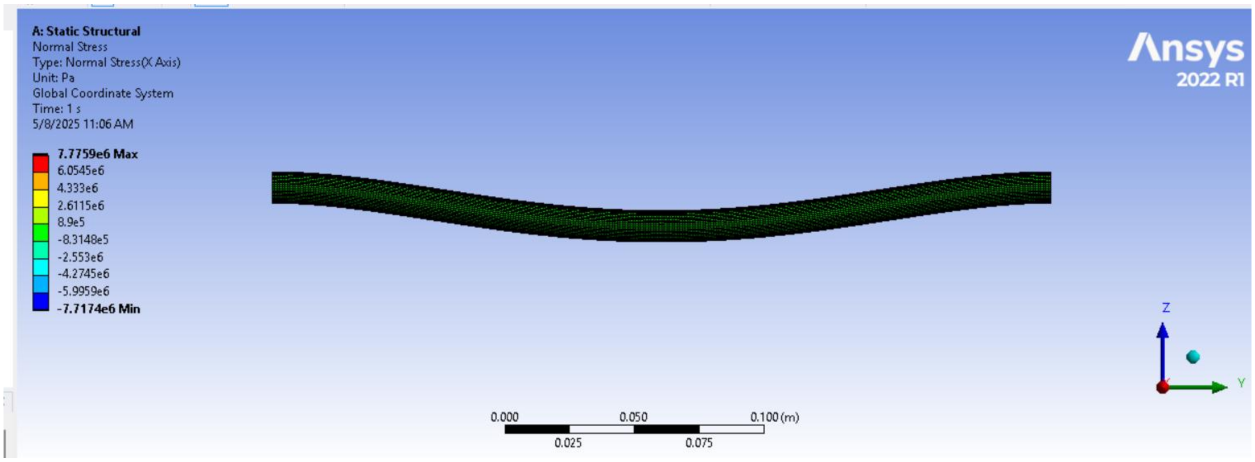



*Shaft results*

## 1-Directional deformation



### 2-Normal stress



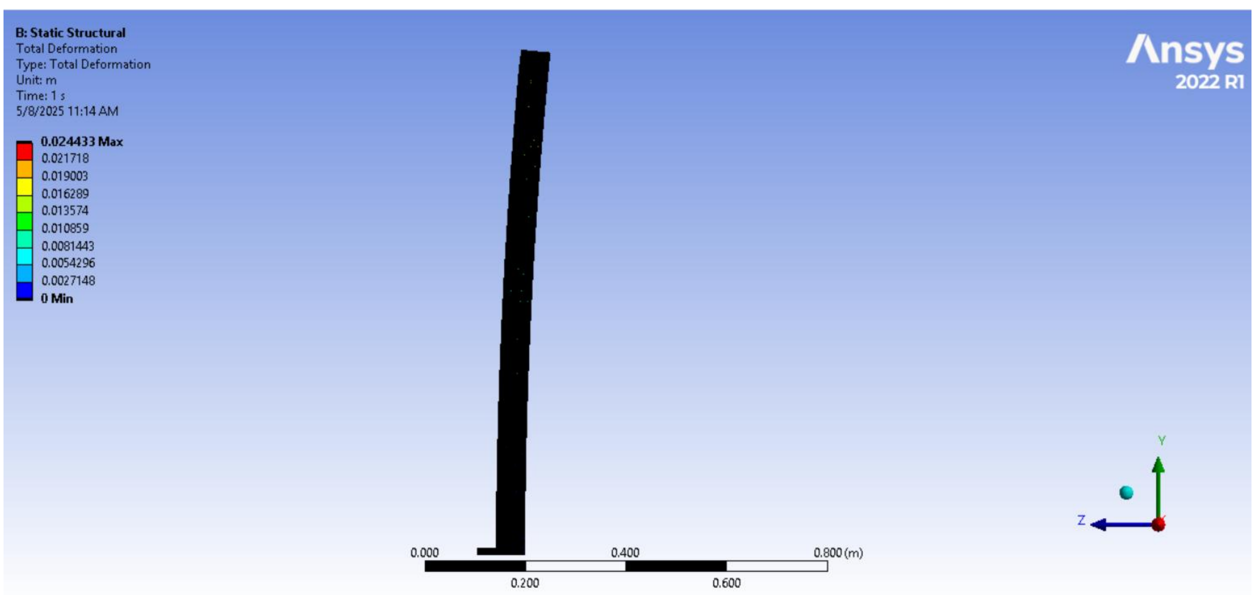

## Structure analysis

## Preprocessing

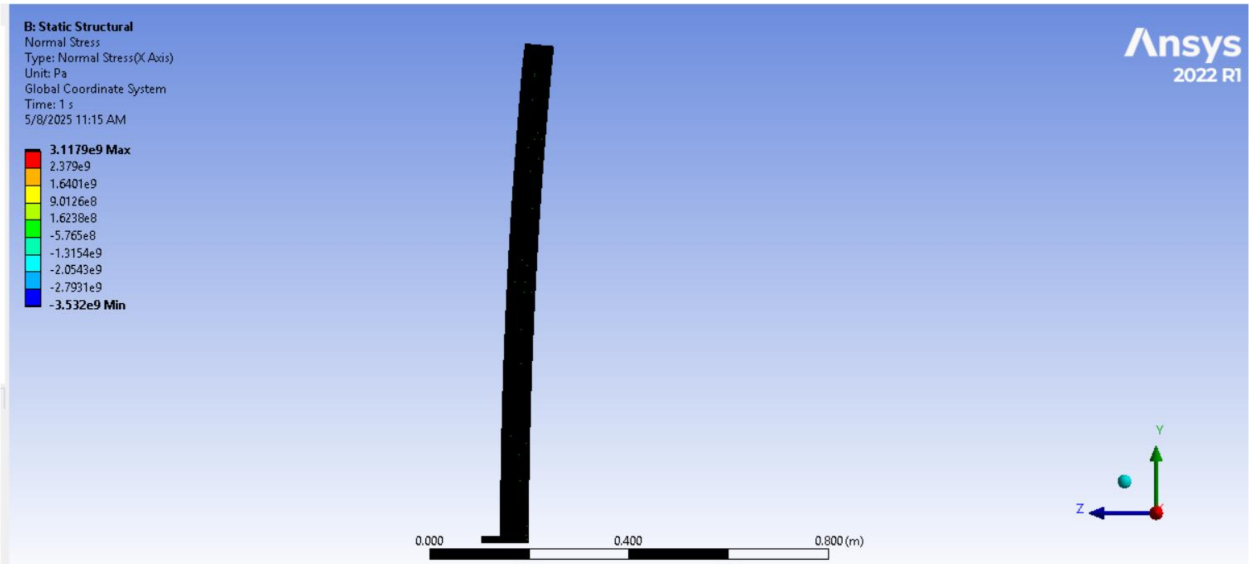
1- Fixed support in ground
2- Apply force
3- Apply moment

### Results

#### *Deformation*



*Normal stress*




## Comment

There is a discrepancy between the analytical calculations ( bending stress of 6.366 MPa for the roller) and the ANSYS simulation results. This could be due to factors such as differences in boundary conditions, mesh refinement, or load application between the analytical model and the software. I am currently investigating these factors by reviewing the ANSYS setup, including mesh quality and constraint definitions, to identify the root cause. Further analysis, such as refining the mesh or adjusting boundary conditions, will help align the results. I welcome feedback on potential causes and suggestions for improving the simulation accuracy.

# Conclusion and Feedback Request

This is my work on the roller conveyor design. I would have liked to have more time to finalize the design with additional modifications, such as incorporating the proposed next features and refining the stress analysis. I'm eager to receive your feedback and discuss this project further to enhance its outcome."