Gearless Transmission via Elbow Rod Mechanism

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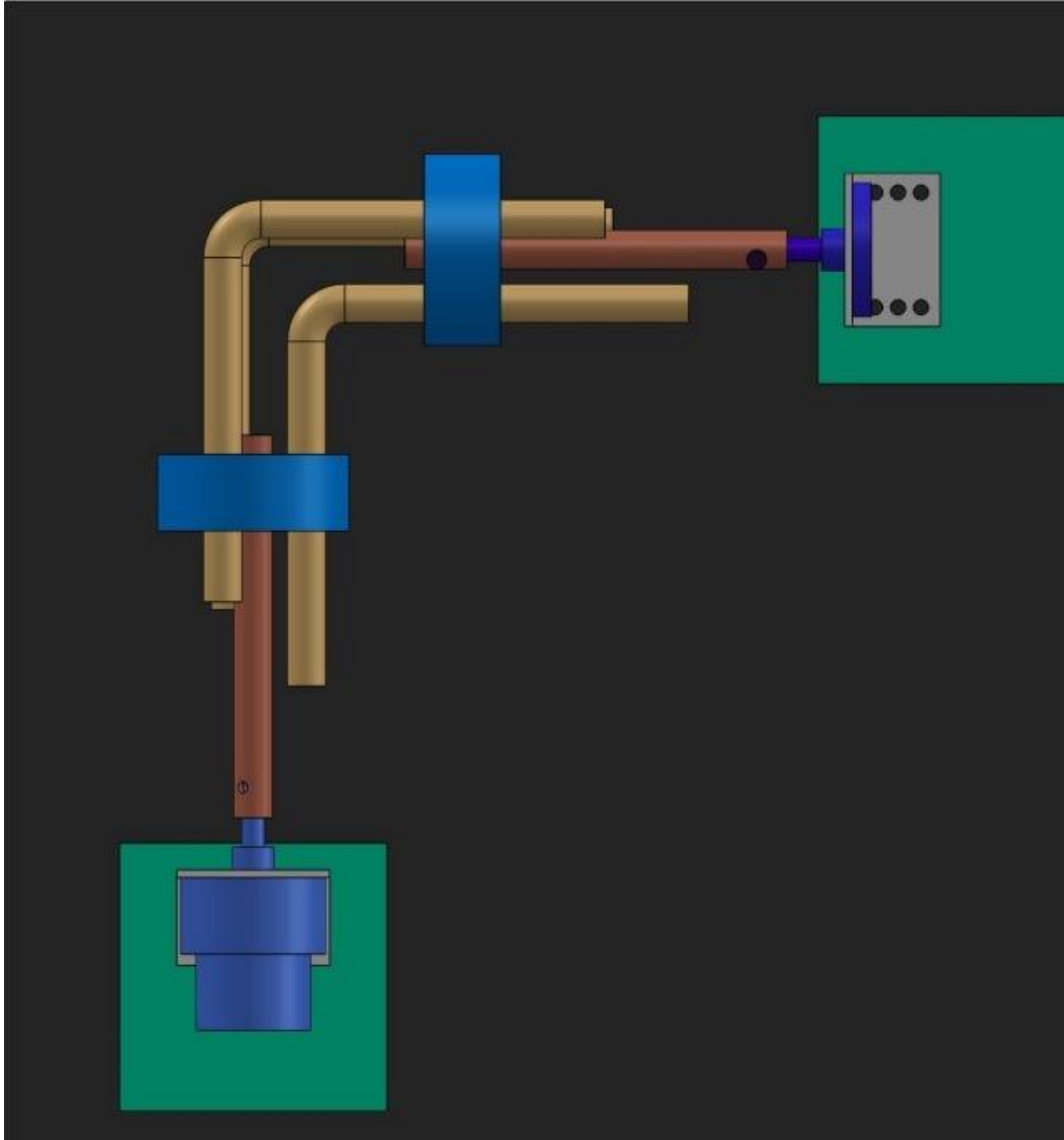

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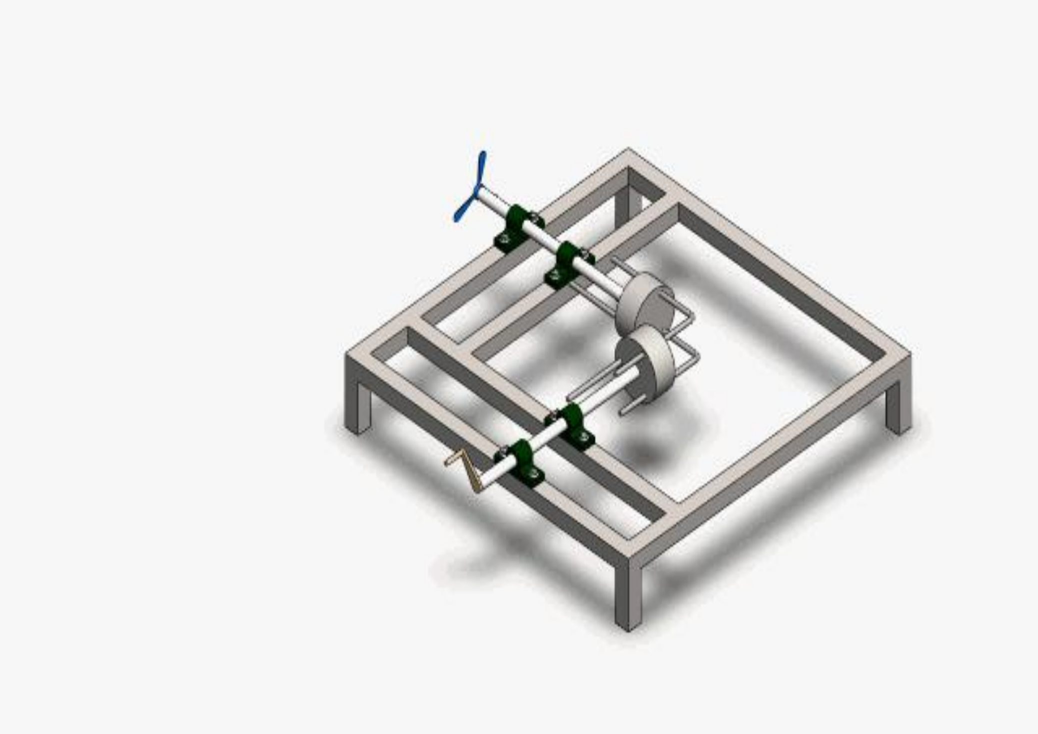
What is Gearless Transmission?

A gearless transmission is mechanism for transmitting rotational velocity from an input connected to the bent links in-turn to the output. Rotation of the input shaft results in a processional motion of the axis of the bent link. The rotary and reciprocating motion of bent link transmits the rotation to 90 degress without any gear system to an output shaft.



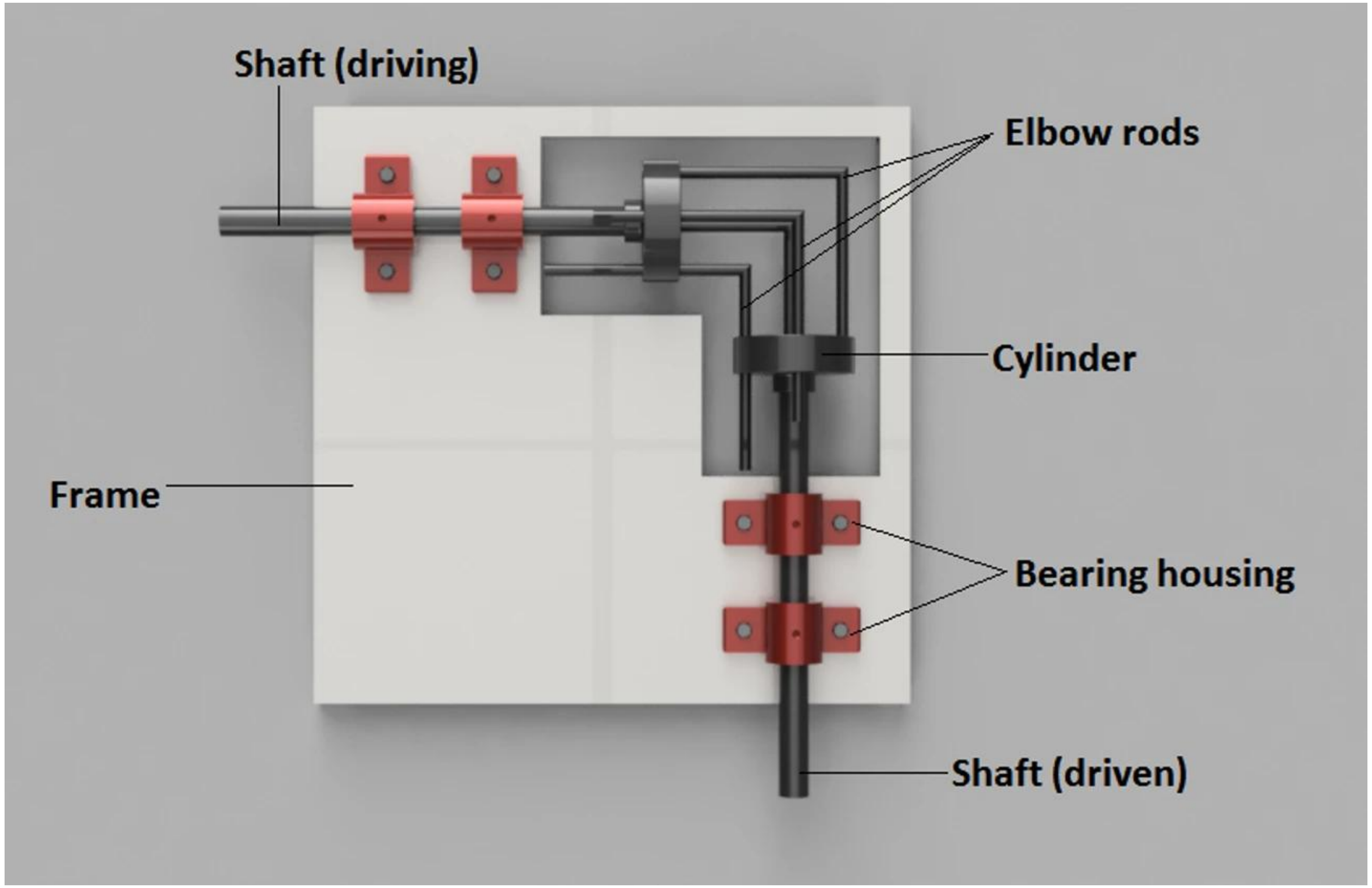
Need of Gearless Transmission?

- Reduces complexity and cost compared to gear-based systems.
- Requires minimal maintenance due to fewer moving parts.
- Enables smooth power transmission at angles (e.g., 90°).
- Lightweight and space-efficient, ideal for compact systems.
- Efficient for low-torque applications.
- Noise reduction due by eliminating gear meshing.

Differences between Geared and Gearless?

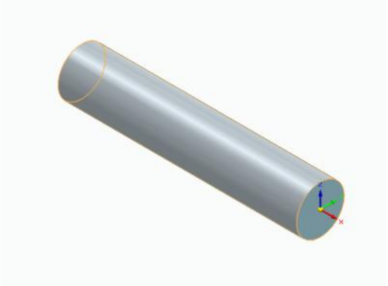
Aspect	Geared Transmission	Gearless Transmission
Manufacturing Complexity	High; involves forming, machining, heat treatment, finishing	Low; simpler fabrication using basic machining and welding
Precision Requirements	Very high; essential for tooth profile accuracy	Moderate; precise positioning of rods is critical
Common Causes of Failure	Wear, misalignment, overloading, lubrication issues	Rod wear, misalignment, fatigue failures
Maintenance Needs	High; requires regular lubrication and inspection	Low; fewer moving parts reduce maintenance
Torque Transmission	Used in high torque transmission , different speed at any angle is not possible	Used in low torques transmission, Different speed at any angle is possible.

Components


Shaft (driving)
Elbow rods
Cylinder
Frame
Bearing housing
Shaft (driven)

Design and Analysis

Shaft



Power (P):

$$P = 3 \times 1hp = \frac{3}{4} \times 746 = 559.5W \tag{1}$$

Given:

$$N = 300 \text{ rpm}, \quad \rho = 786 \times 10^{-8} \text{ kg/mm}^3 \text{ (mild steel)} \tag{2}$$

Torque:

$$T_{max} = \frac{P \times 60,000 \times 1.25}{2\pi N} \approx 22261.797 \text{ N-mm} \tag{3}$$

Maximum Shear Stress:

$$\tau_{s,max} = 40 \text{ N/mm}^2 \tag{4}$$

Shaft Diameter:

$$D_{shaft} = \left(\frac{16T_s}{\pi\tau_s}\right)^{\frac{1}{3}} \times 1.4 = 20 \text{ mm} \tag{5}$$

Shear Stress in Shaft:

$$\tau_{shaft} = \frac{16T}{\pi D^3} = 14.17 \text{ N/mm}^2 \tag{6}$$

Moment Due to Self-weight:

$$M_{shaft,self-wt} = \frac{W_{shaft} L_{shaft}^2}{8} = 3027.96 \text{ N-mm} \tag{7}$$

Moment Due to Hub:

$$M_{shaft,hub} = \frac{F_{hub} L_{shaft}}{4} = 172.59 \text{ N-mm} \tag{8}$$

Bending Stress in Shaft:

$$\sigma_{b,shaft} = \frac{32(M_{shaft,self-wt} + M_{shaft,hub})}{\pi(D_{shaft})^3} = 4.075 \text{ N/mm}^2 \tag{9}$$

Von Mises Stress:

$$\sigma_{eq} = \sqrt{\sigma_b^2 + 3\tau^2} = 24.66 \text{ N/mm}^2 < 60 \text{ N/mm}^2 \text{ (tensile permissible)} \tag{10}$$

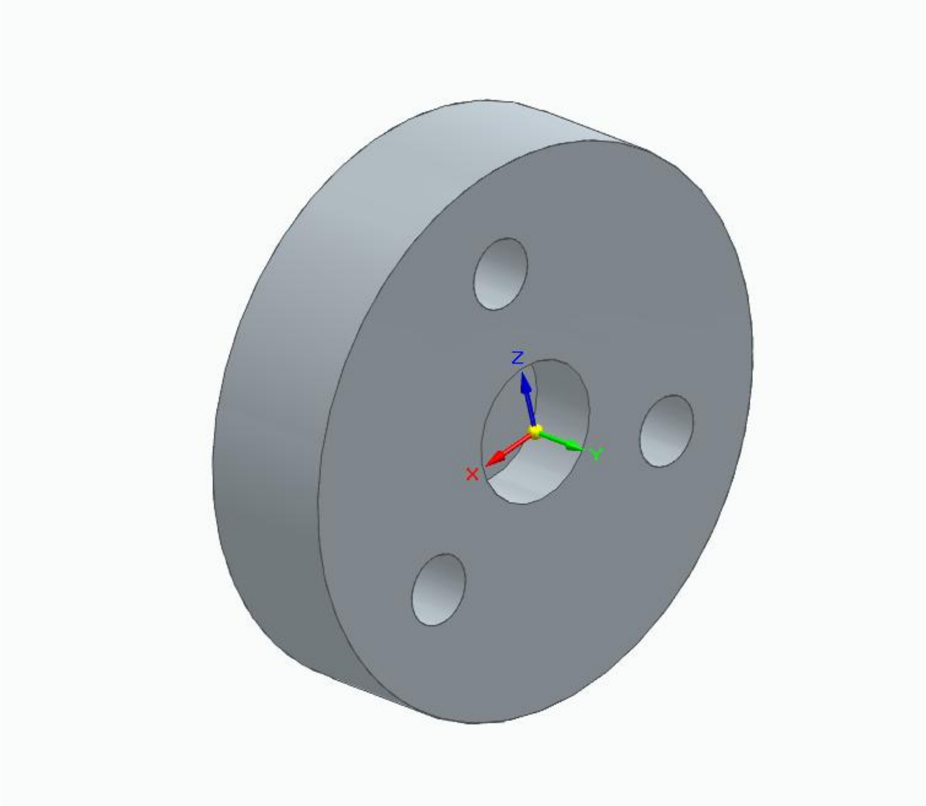
Hub

Given:

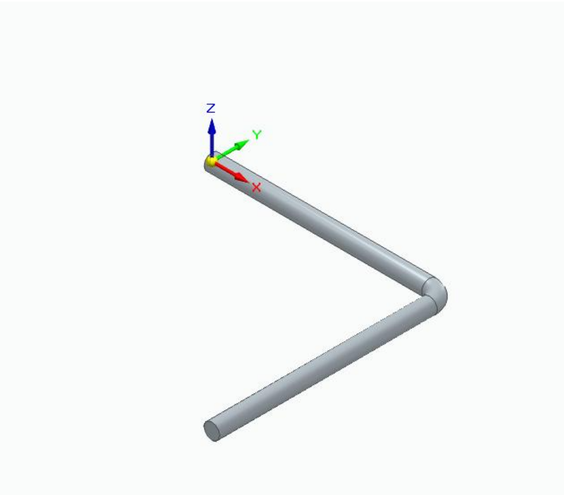
$$D_o = 80 \text{ mm}, \quad D_i = 20 \text{ mm} \tag{11}$$

Shear Stress at Hub:

$$\tau_{Hub} = \frac{16 T_{max} D_o}{\pi(D_o^4 - D_i^4)} = 0.22 \text{ N/mm}^2 \tag{12}$$



Elbow Rod



Torque in Rod:

$$T_{rod} = \frac{T_{max}}{3} = 7420.5 \text{ N-mm} \tag{13}$$

Diameter of Rod:

$$D_{elbow} = \frac{16T_{rod}}{\pi\tau_{s,max}} = 10mm \tag{14}$$

Shear Stress in Rod:

$$\tau_{rod} = \frac{16T_{rod}}{\pi D_{elbow}^3} = 37.492 \text{ N/mm}^2 \tag{15}$$

Moment at Elbow:

$$M_{elbow} = W_{rod} \times \frac{L_{rod}}{2} = 17.032 \text{ N-mm} \tag{16}$$

Bending Stress at Elbow:

$$\sigma_{b,elbow,self-wt} = \frac{32M_{elbow}}{\pi D_{elbow}^3} = 0.1735 \text{ N/mm}^2 \tag{17}$$

Force in Rod:

$$F_{rod} = \frac{T_{rod}}{r} = 296.82 \text{ N} \tag{18}$$

Moment Due to Rod Force:

$$M_{hub,txn} = F_{rod}L_{rod} = 2226.79 \text{ N-mm} \tag{19}$$

Bending Stress at Hub:

$$\sigma_{b,Hub-txn} = \frac{32M_{hub,txn}}{\pi D_{elbow}^3} = 226.75 \text{ N/mm}^2 \tag{20}$$

Total Bending Stress:

$$\sigma_{b,total} = \sigma_{b,elbow,self-wt} + \sigma_{b,Hub-txn} = 226.93 \text{ N/mm}^2 \tag{21}$$

Von Mises Stress at Hub:

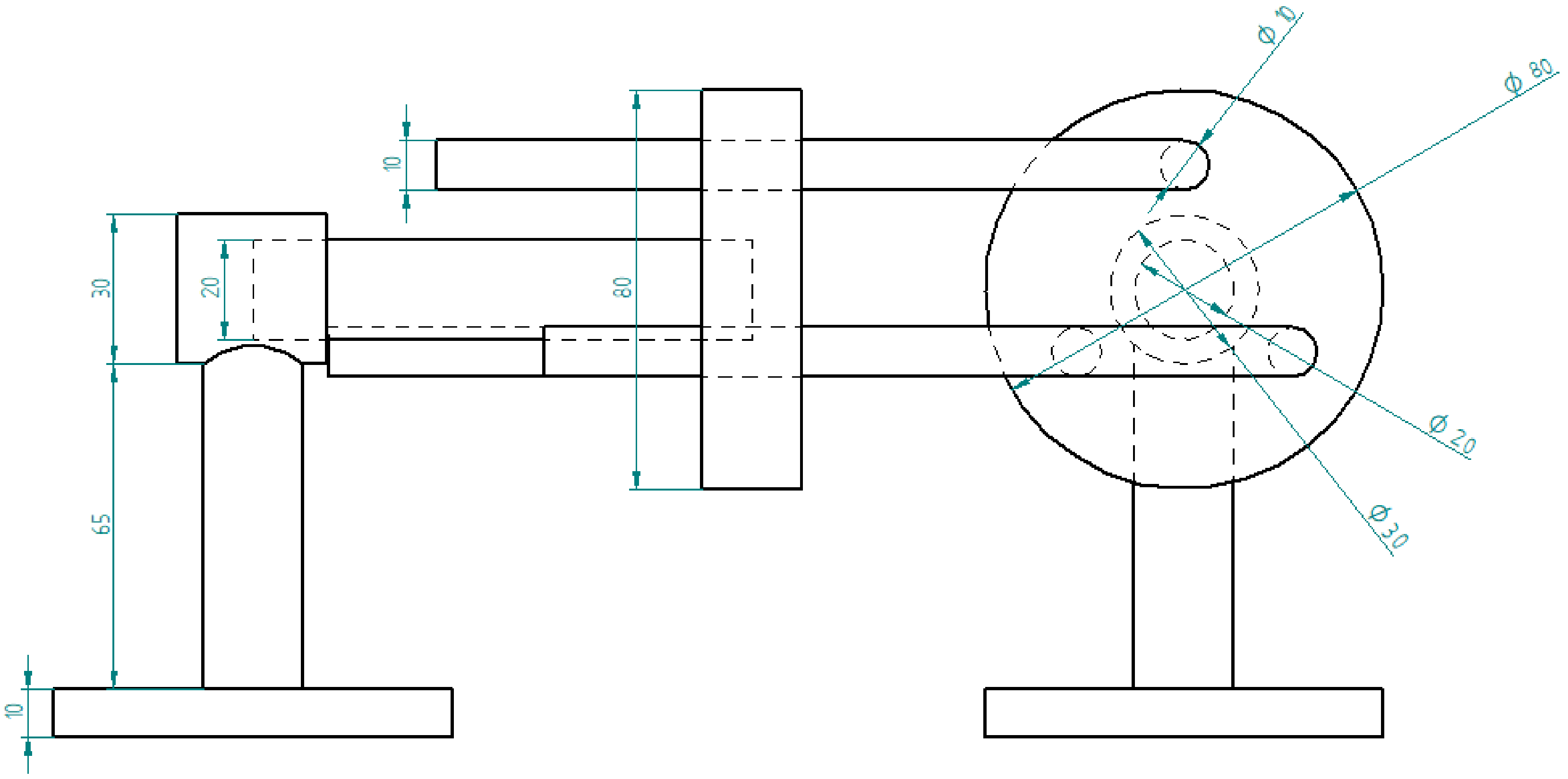
$$\sigma_{eq} = \sqrt{\sigma_{b,total}^2 + 3\tau_{rod}^2} = 236.18 \text{ N/mm}^2 < 380 \text{ N/mm}^2 \tag{22}$$

Dimensions

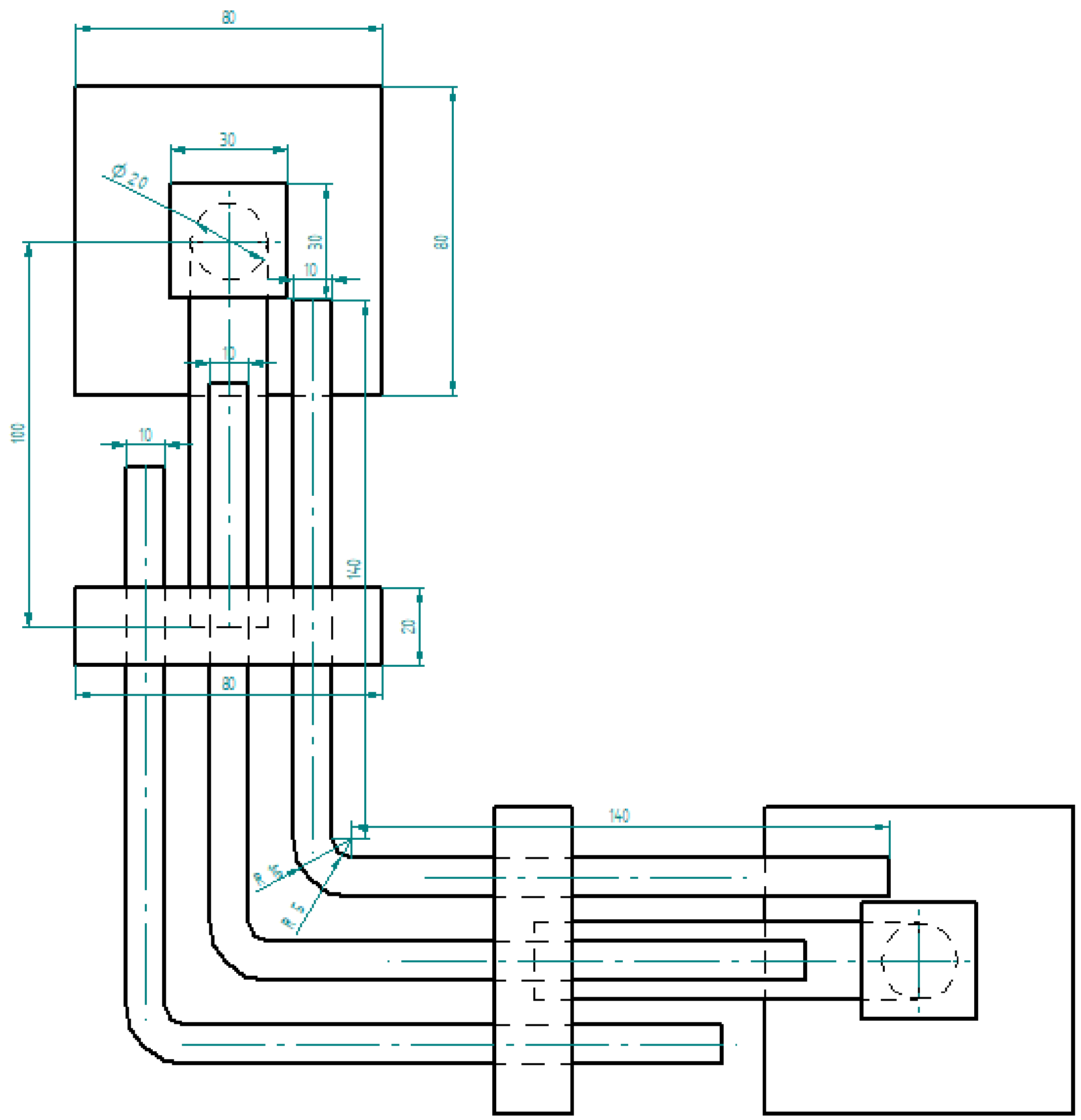
Part	Dimension
Cylindrical Hub	D=80mm, t=20mm, three holes radially at 25 mm distance of d=10 mm, center 20mm hole
Elbow link	D = 10mm, l = 150mm on each side
Shaft	D=20mm, l=100mm
Bearing	D = 20mm inner, outer 30mm, t = 30mm
Base rectangular section	L = 80mm, b=80mm
Pole on the base	D =20mm, h=80mm

CAD and FEM Analysis

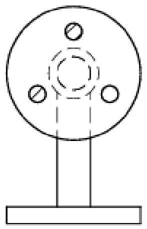
Dimensions



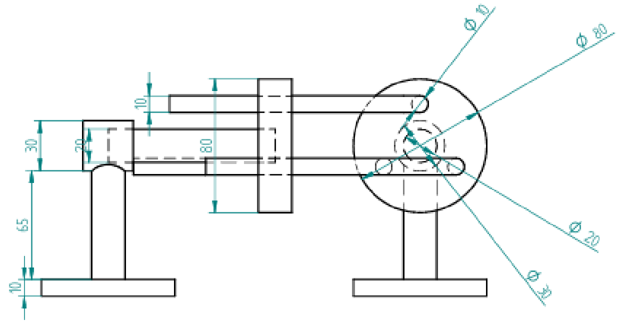
Dimensions

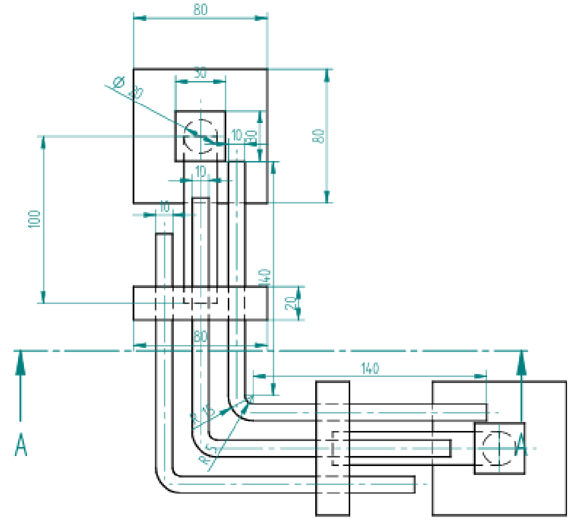


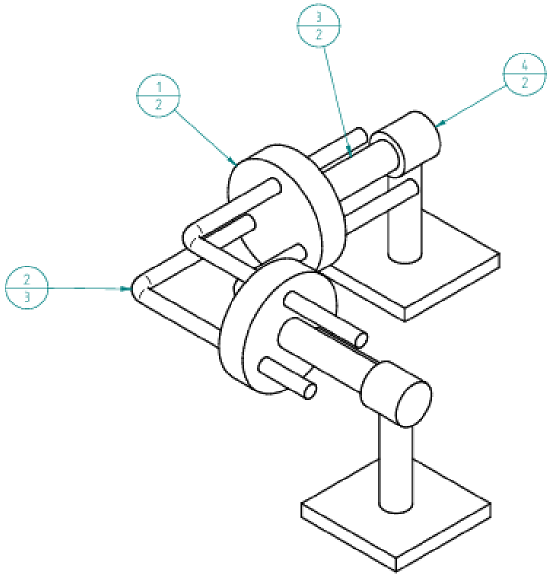
Production Drawing



SECTION A-A







Item Number	File Name (no extension)	Material	Quantity
1	HUB	Mild Steel	2
2	ELBOW_LINK	Mild Steel	3
3	SHAFT	Mild Steel	2
4	BEARING	Mild Steel	2

FIRST ANGLE PROJECTION

	NAME	DATE
DRAWN	Harshit	5/3/2025
CHECKED		
ENG APPR		
MGR APPR		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
ANGLES ±0.1°
2 PL ±X.XX 3 PL ±X.XXX

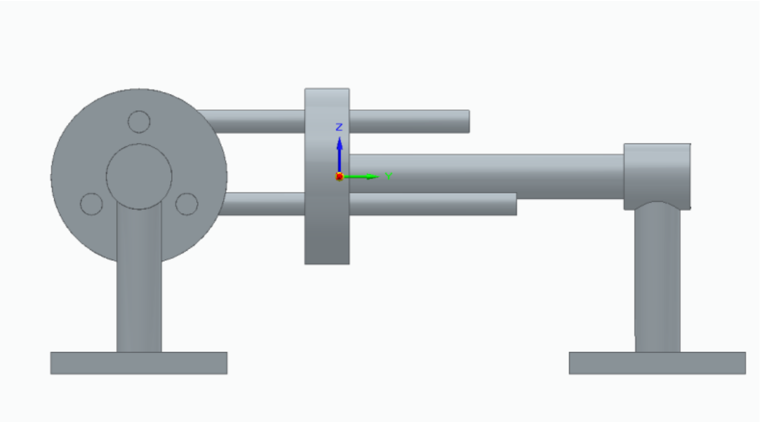
TITLE
IIT HYDERABAD

SIZE A2 | DWG NO IITH/MINI_PROJECT/GROUP-1 | REV

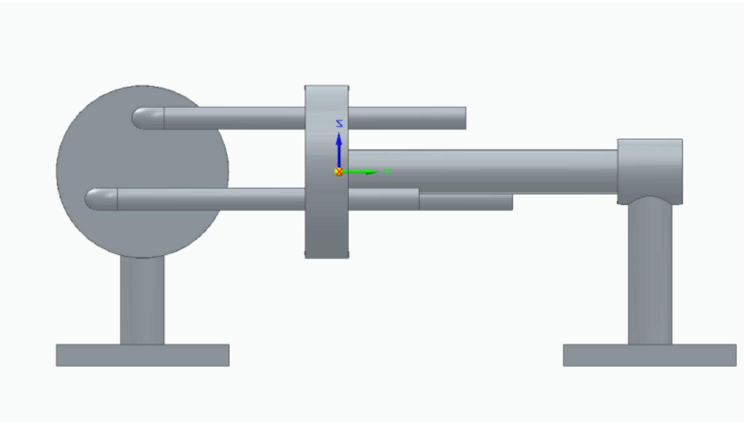
FILE NAME: TRANSMISSION_ASSEMBLY_3.dft

SCALE: 1 : 1 | WEIGHT: | SHEET 1 OF 1

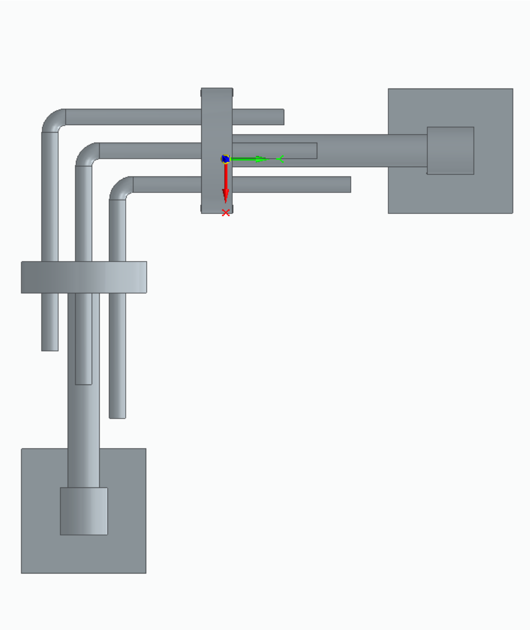
CAD Model



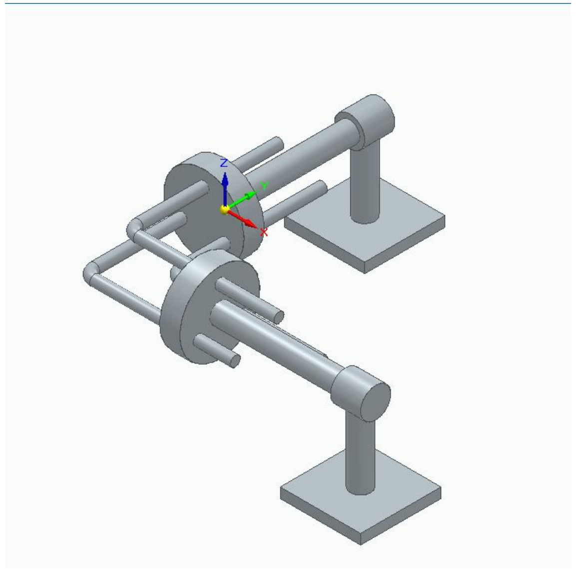
Front View



Left View

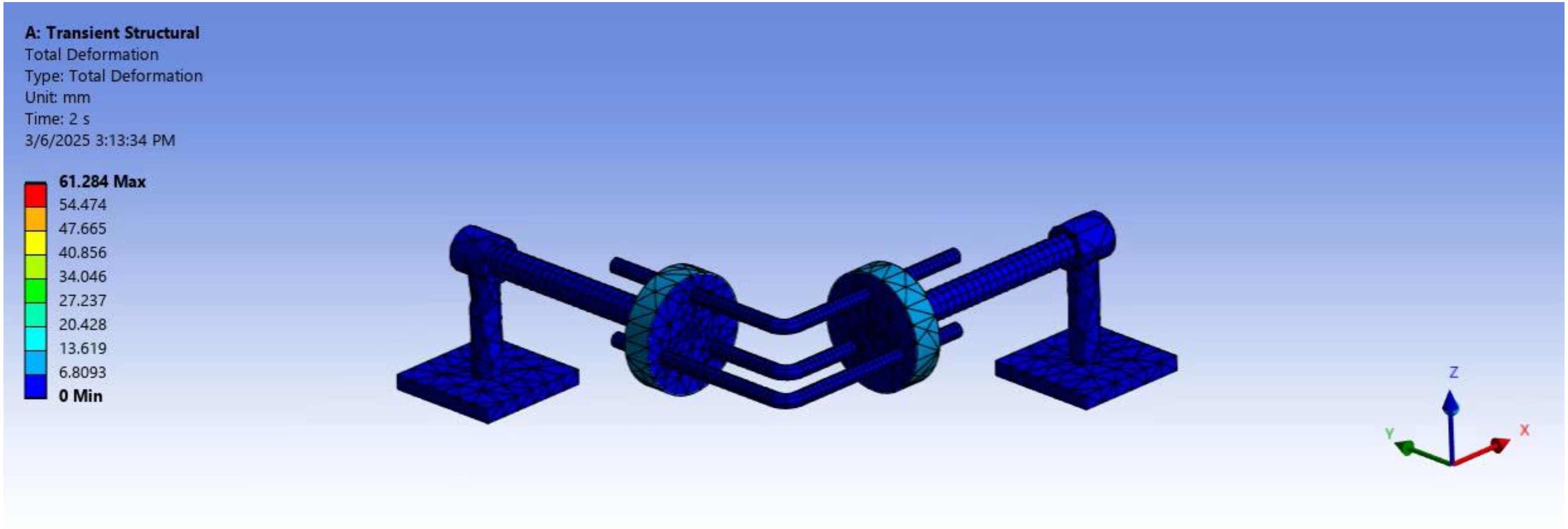


Top View

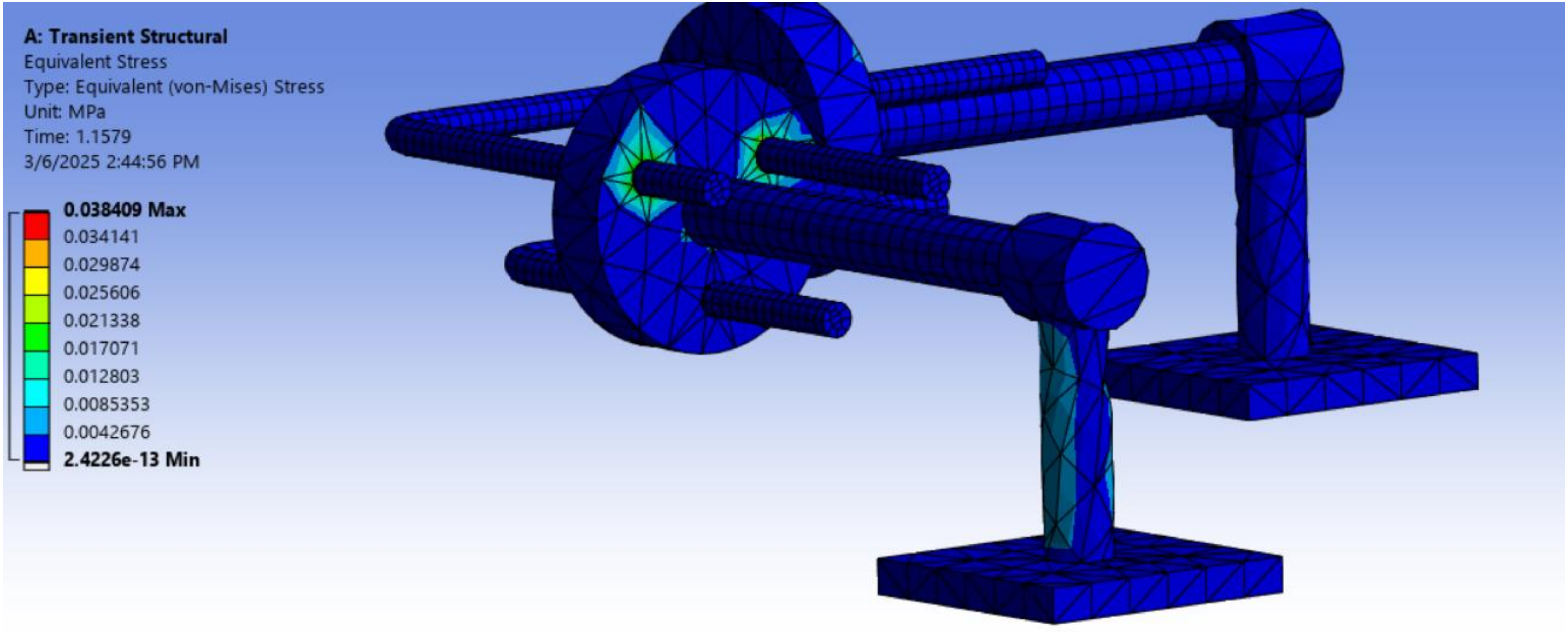


Isometric View

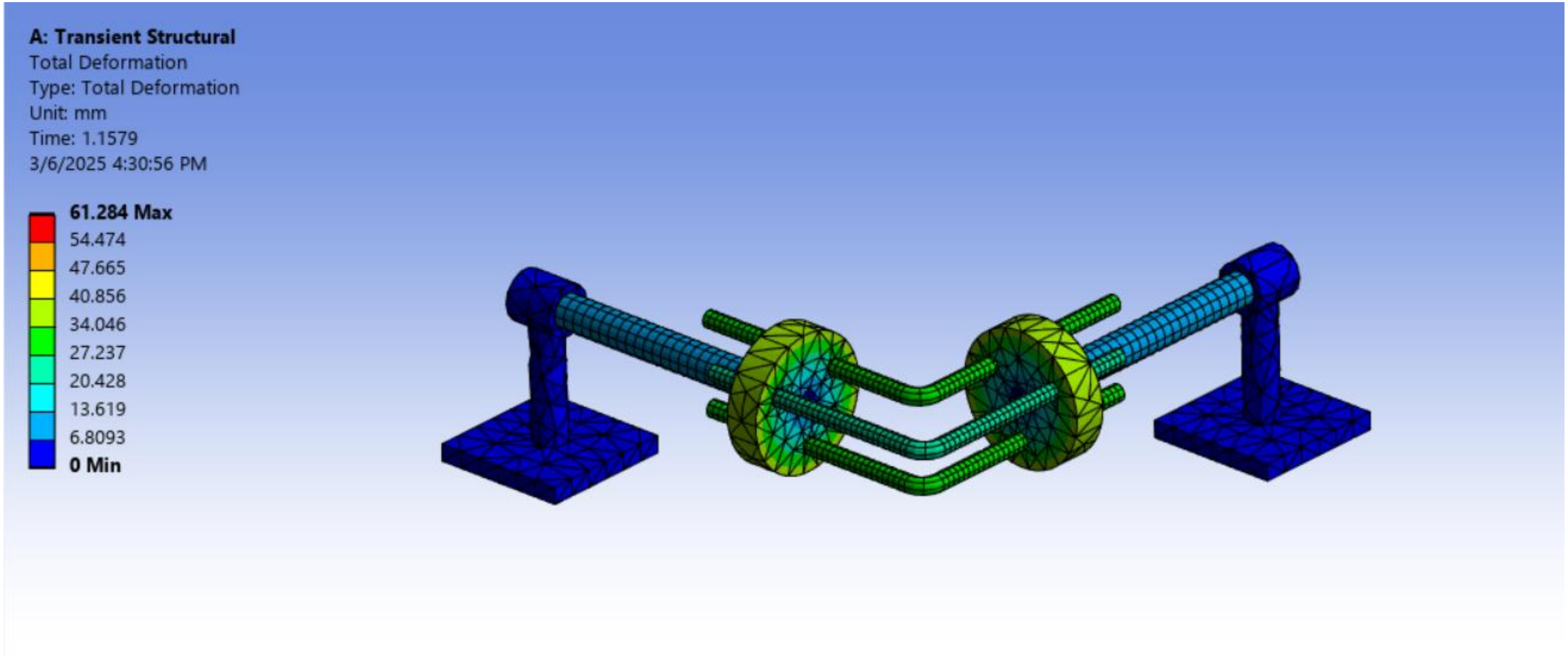
FEM Analysis



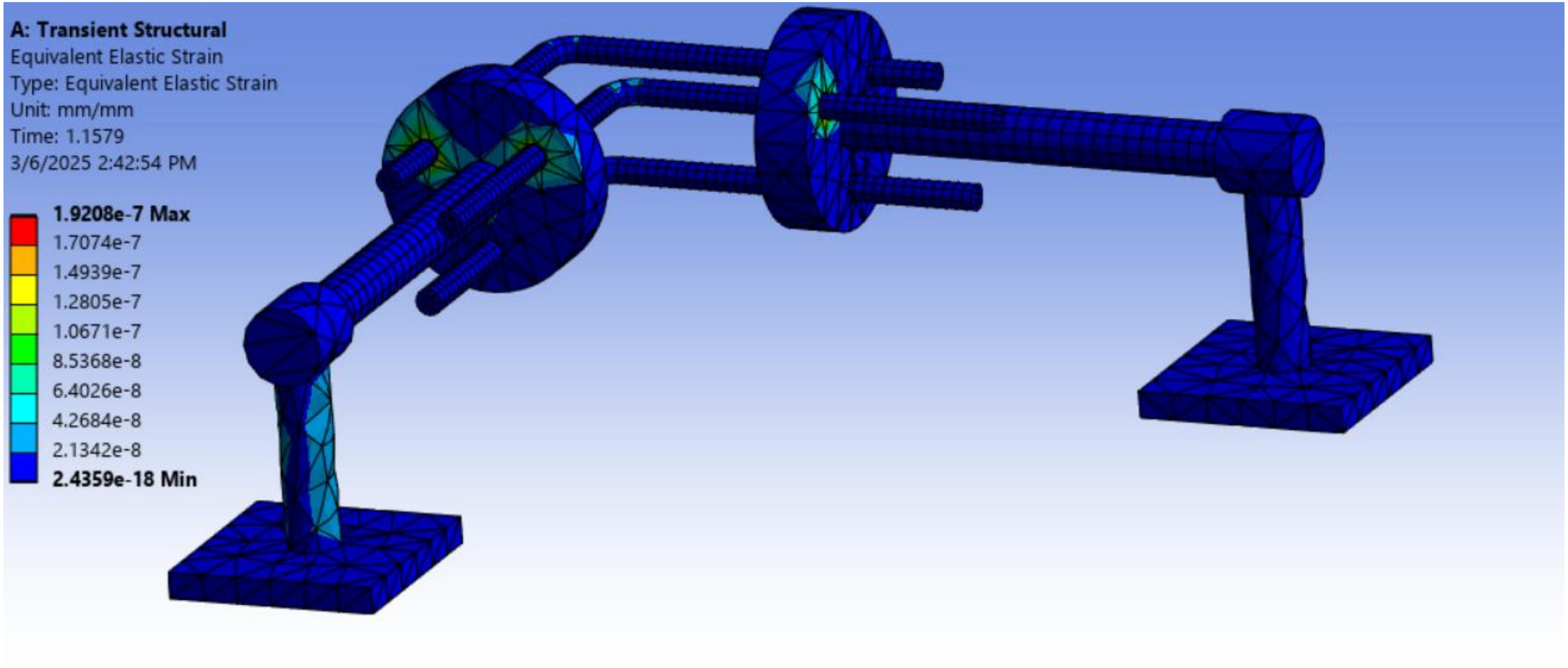
Equivalent Stress (von - Mises)



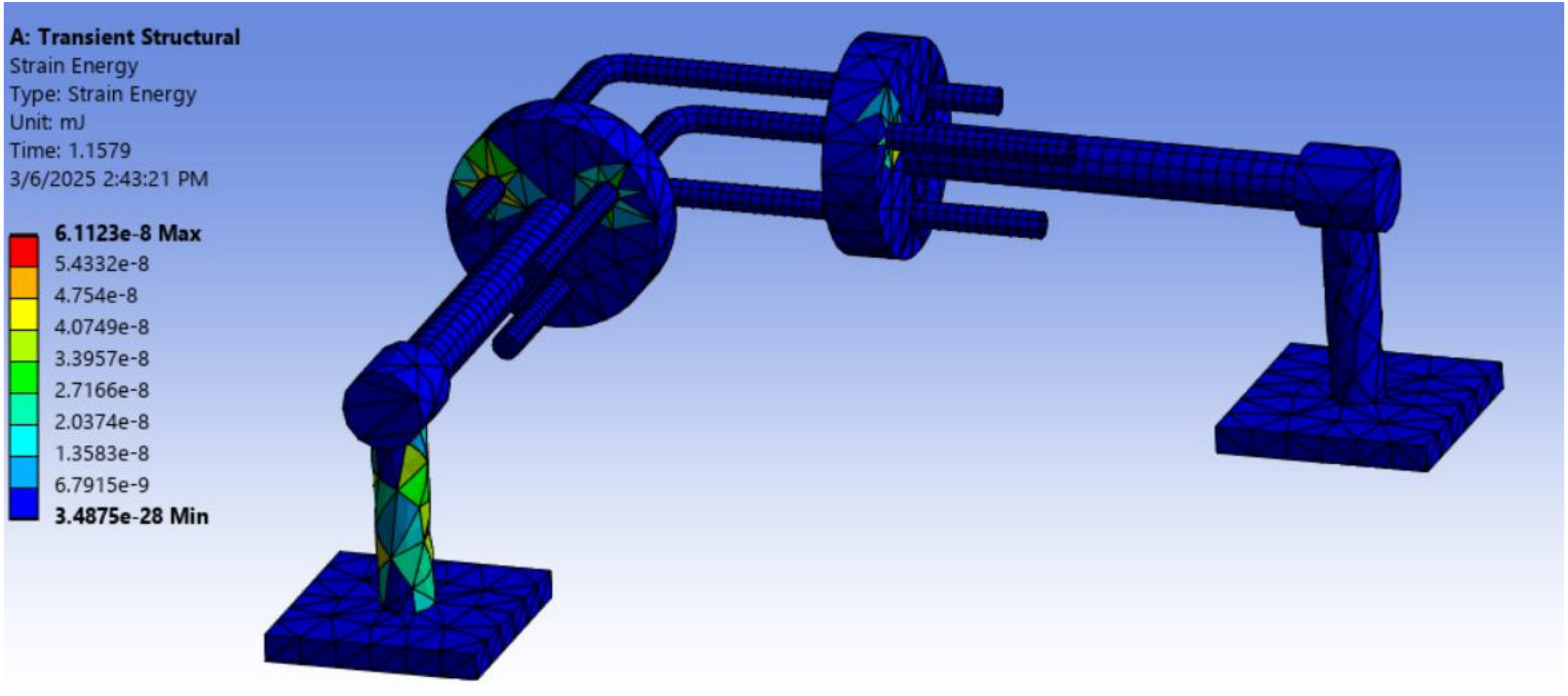
Deformation



Equivalent Elastic Strain



Strain Energy



Scalability and Safety Measure

- **Scalability Considerations:**
  - Use high-strength materials for durability.
  - Enhance load capacity with stronger joints.
  - Customize for various transmission angles.
  - Integrate with automation for industrial use.
  - Optimize for both large-scale and miniaturized applications.
- **Safety Measures:**
  - Reinforce joints to prevent failure.
  - Lubricate pivot points for smooth movement.
  - Ensure even load distribution to avoid breakage.
  - Use protective enclosures to prevent accidents.
  - Implement emergency stop mechanisms in automation.
  - Perform regular maintenance to ensure reliability.

Thank You