

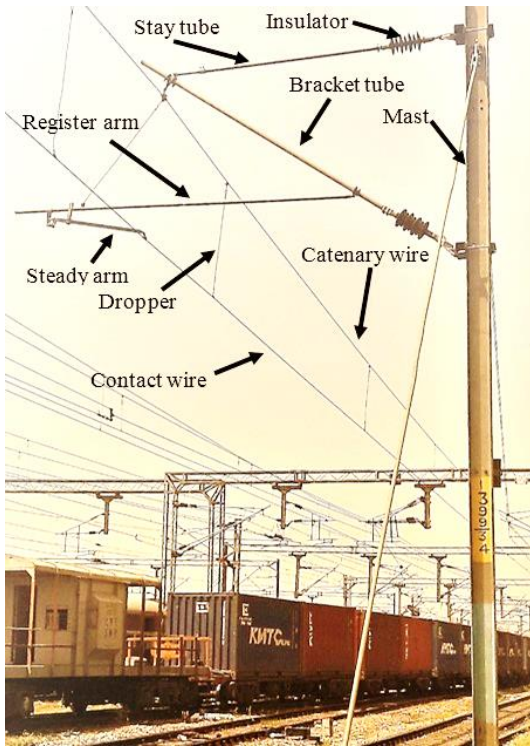
Design Analysis of Auto-tensioning device based in Multi-body Dynamics

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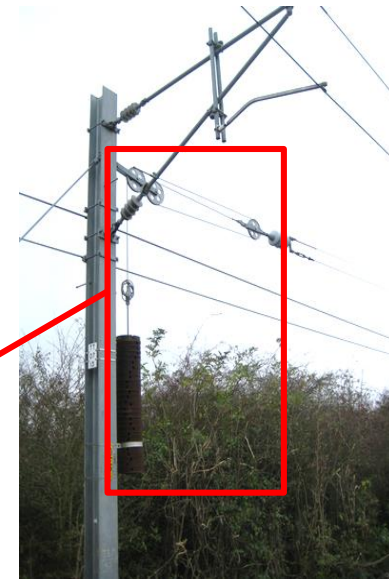
ATD- Auto-Tensioning Device for Railways **Raychem RPG**

- The overhead catenary system consists of a contact wire, catenary wire, droppers, registration arms, brackets, **tensioning devices** [1]
- Absence of proper tensioning would create sag or tightening of the overhead lines.



Overhead contact system components

*Image courtesy: Akash Sharma, D.D.OHE, Muradabad Junction

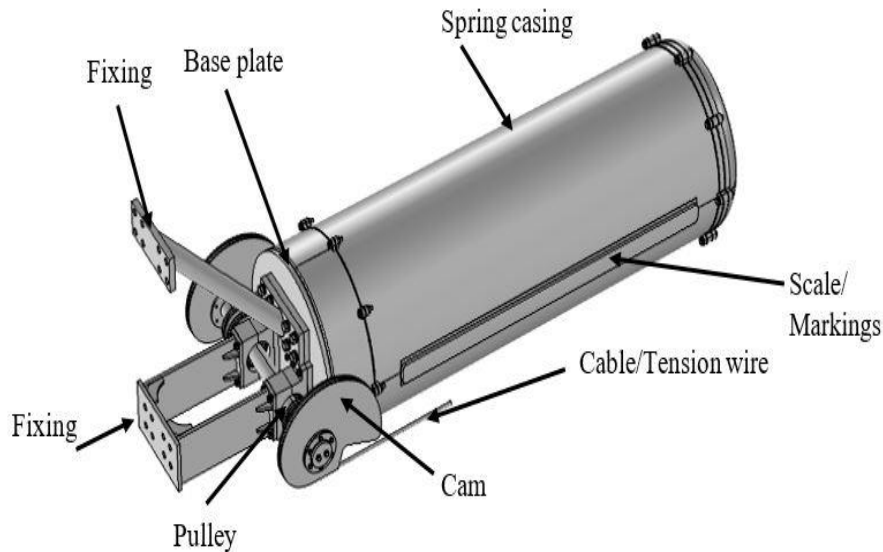


**Tensioning device
(Three-Pulley system)**

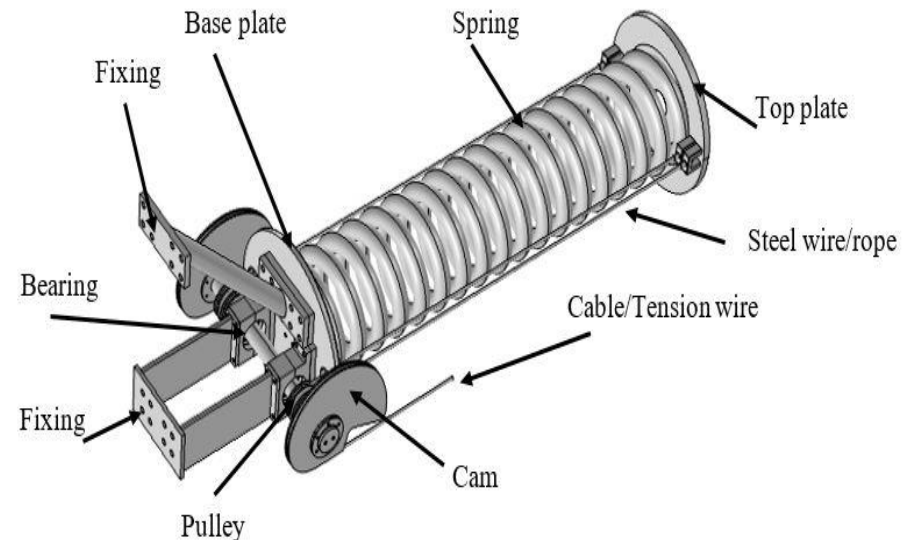
- The conductors of overhead lines are installed with a very specific tension value.
- This tension is variable over time and is closely dependent on the ambient temperature

Design Requirements

Full Tensioning Length	1.5 km
Catenary Wire	Cd-Cu, 65 mm ²
Contact Wire	Hard Drawn Cu, 107 mm ²
Tension to be maintained (T)	20 kN [both need to be tensioned]
Temperature Range	65 °C
compensation length	0.828 m



Cad model of ATD-with casing



Cad model of ATD-without casing

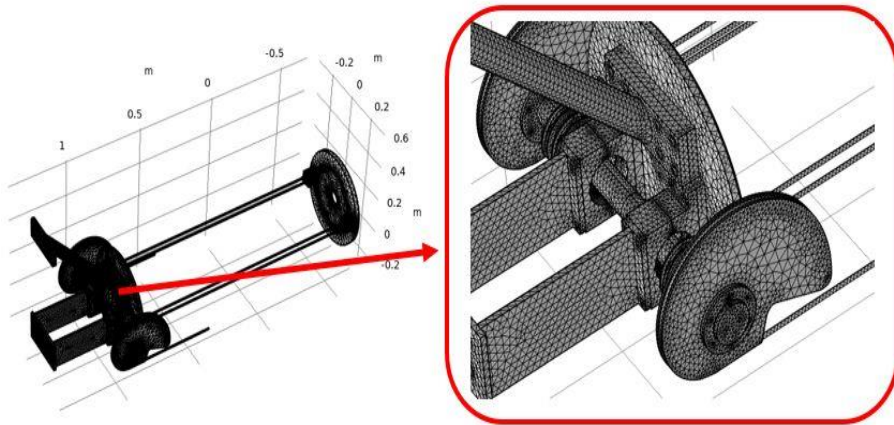
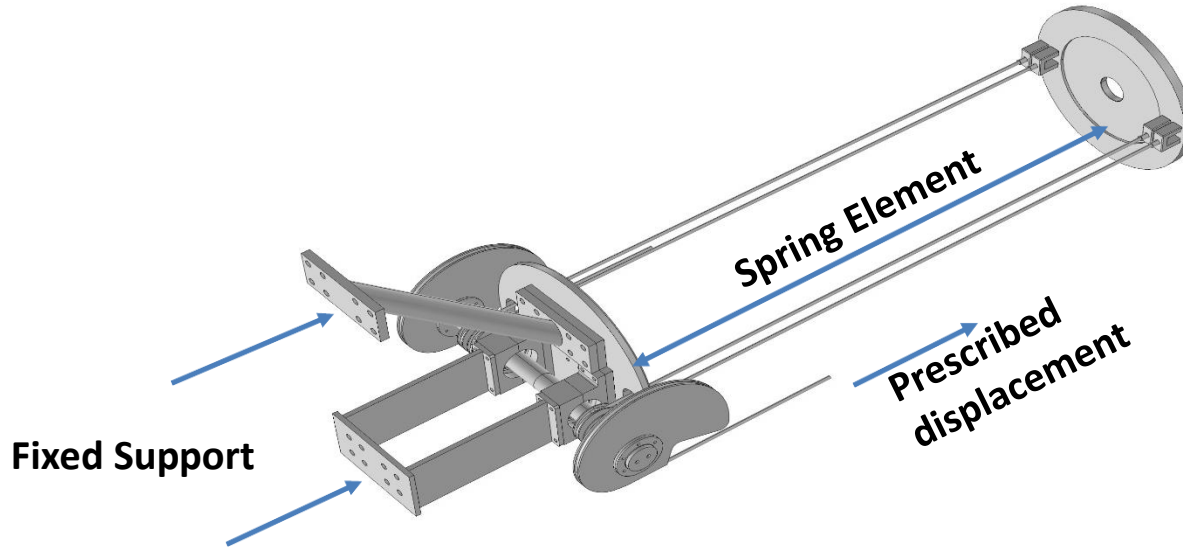
Need for FEA Analysis

- ATD needs Pull-Out test for which **large experimental** setup is required.
- To determine the correctness and efficiency of a design before prototyping
- **Validation of CAM profile** and other design parameters

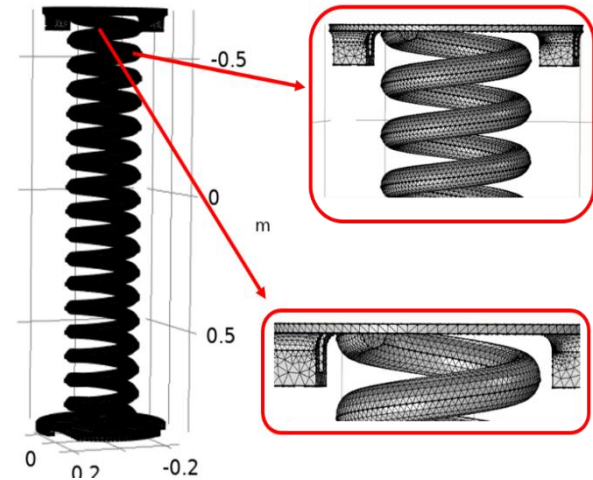
Problem Definition

- **To Validate working principle of ATD** based in MBD for Railway applications.
- **To verify constant tension** in the Catenary and contact wire.
- **To Optimize design and size** of mechanical components
- **To verify design** of mechanical components e.g. CAM.

Multibody dynamics of ATD



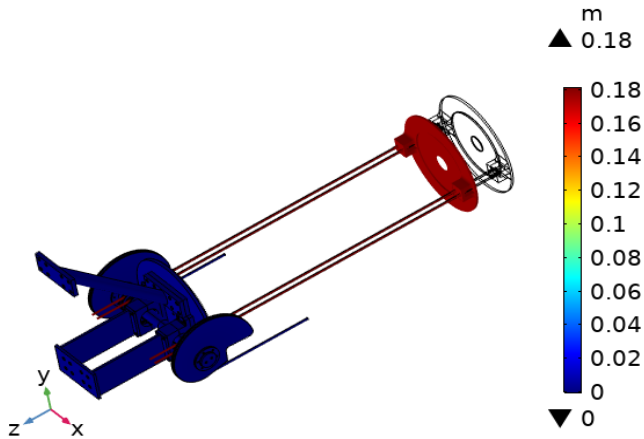
Meshed view of simplified geometry of ATD



Meshed view of spring

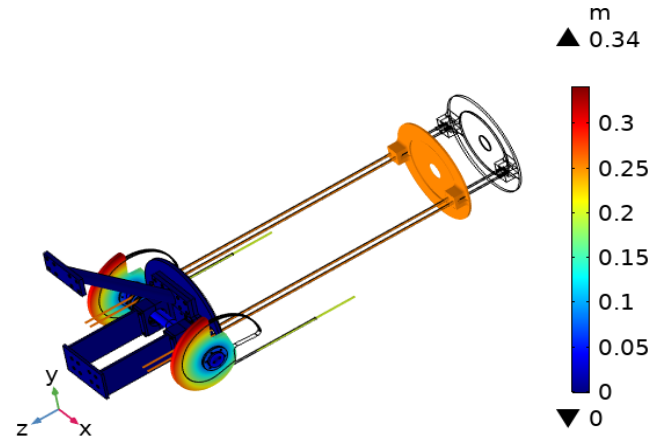
Results from MBD of ATD

para(1)=0 m Volume: Total displacement (m)



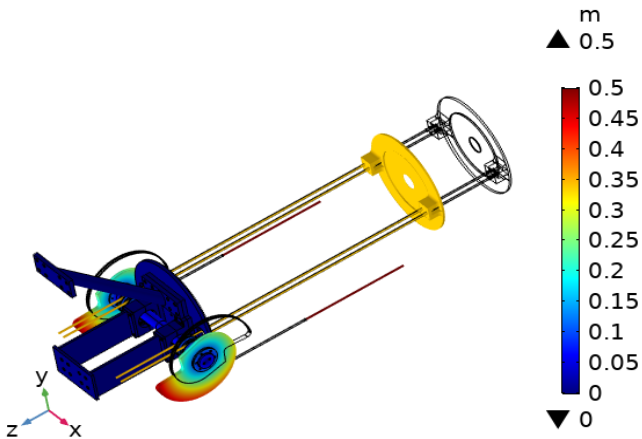
@ Cable displacement of 0 m

para(201)=0.2 m Volume: Total displacement (m)



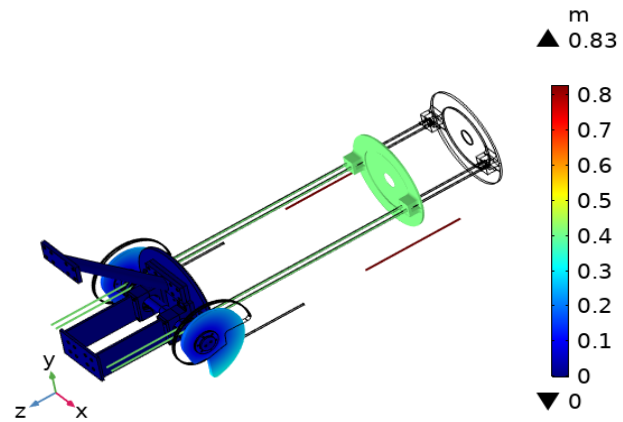
@ Cable displacement of 0.2 m

para(501)=0.5 m Volume: Total displacement (m)

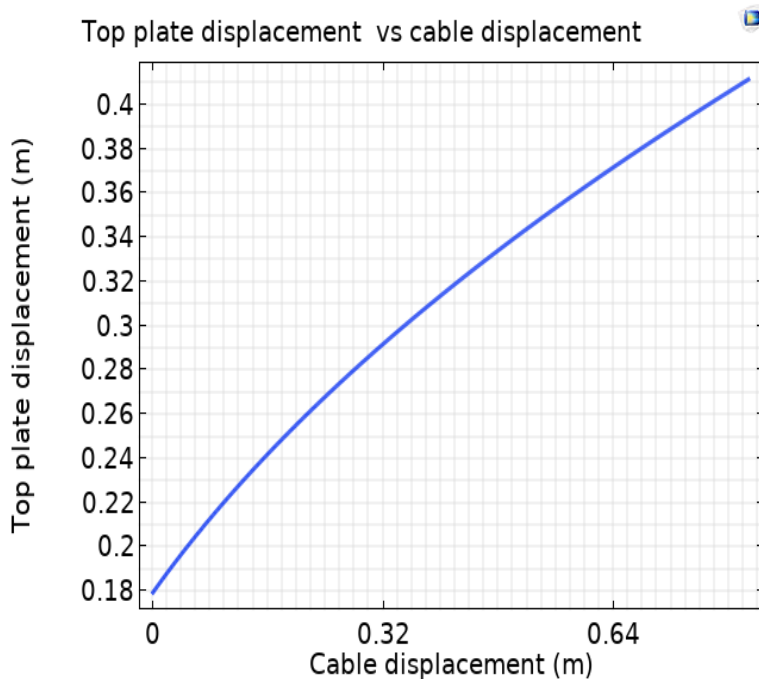


@ Cable displacement of 0.5 m

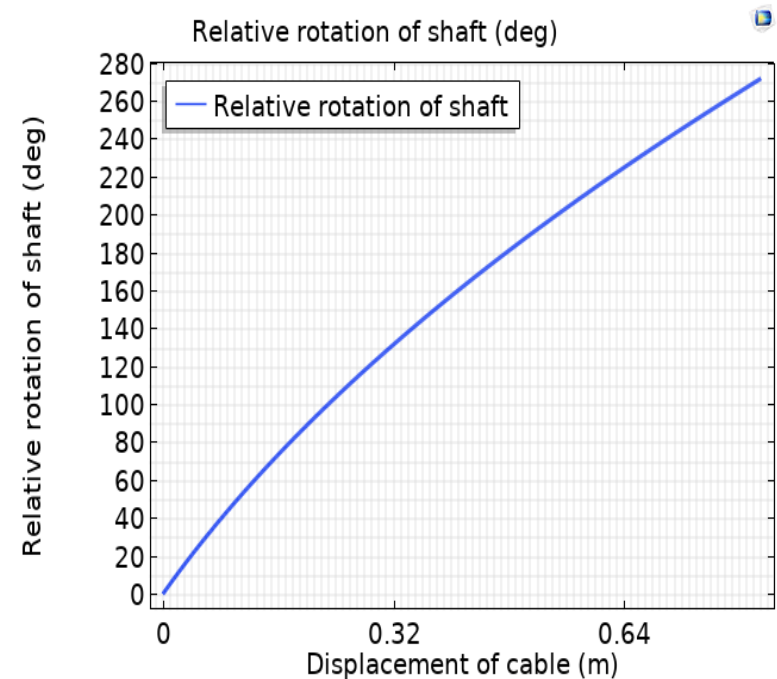
para(831)=0.83 m Volume: Total displacement (m)



@ Cable displacement of 0.83 m



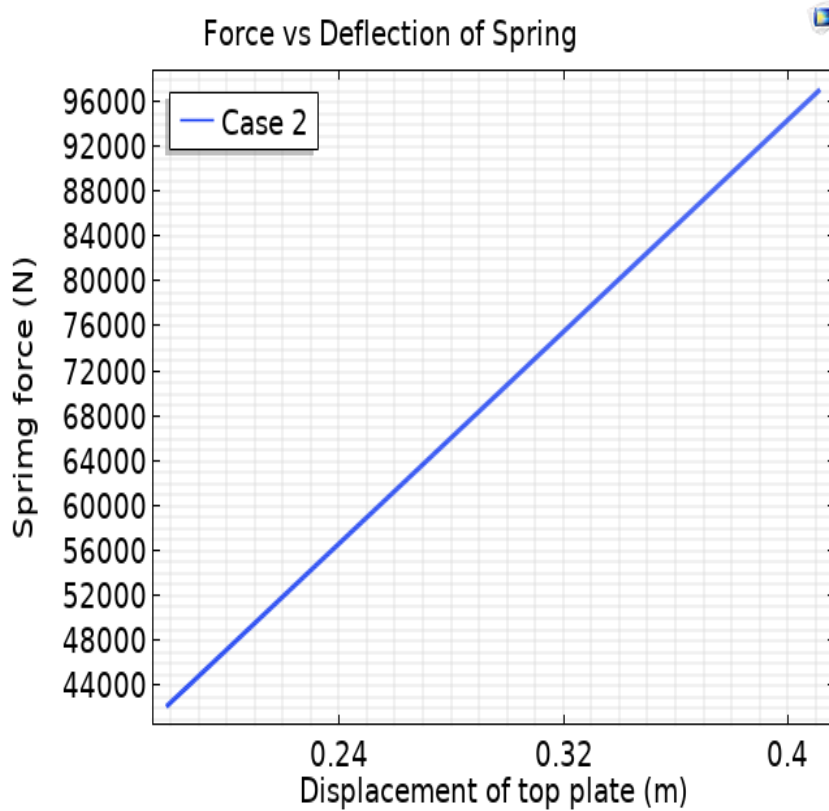
Displacement of top plate w. r. t. cable movement



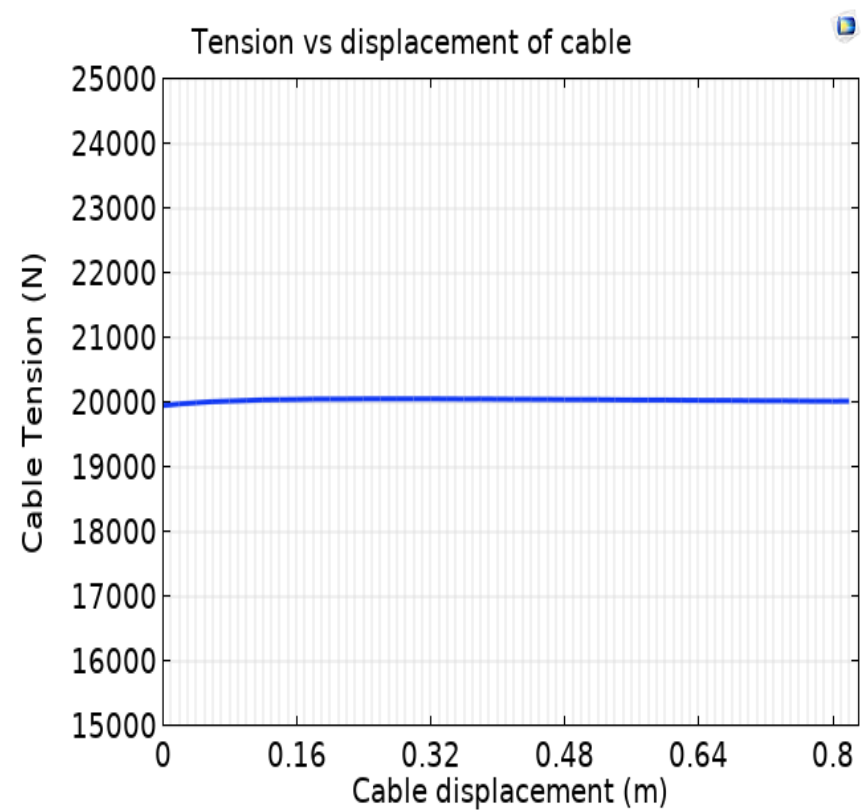
Rotation of shaft w.r.t cable movement

- Deflection of 41 cm in spring for 83 cm displacement of cable.
- Actual rotation of the 263° with respect to 83 cm of cable movement.

Results from MBD vs Metallic spring



Force vs deflection of spring

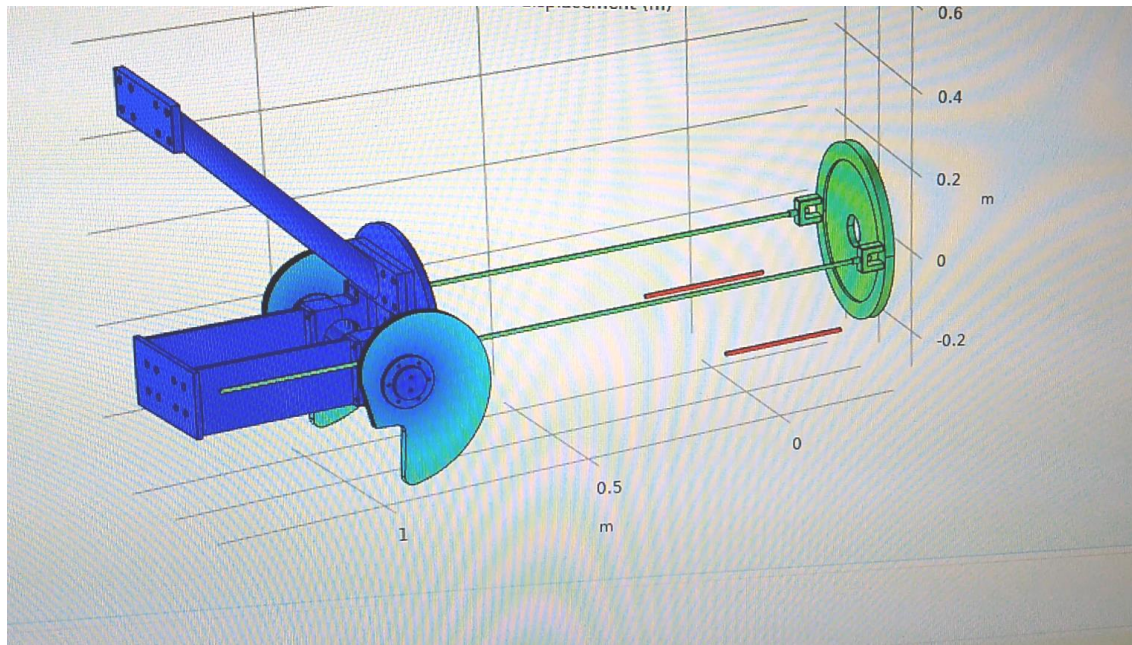


Tension in the cable

- The spring force varies from 42.5 kN to 98.1 kN
- whereas the tension in outer cable remains 20 kN

Multibody Dynamics

- Multibody dynamics is done to get the tension in outer cable along with the variation in spring force
- Spring constant is used in place of actual spring to avoid complexity and to reduce computational time.



- **A New Method adopted for solving rope and pulley system.**
- **A New Spring Based Mechanism for ATD has been designed.**
 - CAM designed and optimized to get constant tension in the Overhead wire with compensation with 83 cm.
 - Constant radius pulley size are optimized for minimum spring length and Minimum spring force variation.
 - Variation in spring force was verified.
 - After multiple iterations, at radius of pulley as 0.7 m and cam angle of 263 °.
- **A polymer spring can be an alternate to Metallic spring.**
 - FEA of the same has been started using hyperelastic module.
 - Optimization based on Uniaxial/Biaxial testing data.

Acknowledgement: Ajit Bhuddi, Pawan Soami, Pankaj Nerikar, Damini Singh

And Others from Team COMSOL and Raychem RPG

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THANK YOU