Design A lead Screw For Lathe Machine

Presenters:

Ayman Khan (200108149)
Hasin Anjum Junayed (200108138)
Tarek Ahmed (200108144)
Nazmul Ahsan Nahid (200108135)
Ishtiyak Karim Ratul (200108136)

COMMUNICATING OUR ACHIEVEMENTS

Clarifying Problems Specifications and Constraints

Problems Specifications:

- Selecting Pitch and Diameter
- Knowing the number of starts
- Thread profiles
- Material selection
- Direction of the helix
- Spindle Rotation: 900-1500 rpm

Constraints:

- Load Capacity
- Vibration and Resonance
- Material availability
- Manufacturing Feasibility
- Lubrication methods
- Cost effective

Research and Investigation

- Zhang, D.-W., Li, D.-H., Liu, B.-K., Yu, Z.-C., & Zhao, S.-D. **(2022)**. **Investigation and implementation for forming lead screw by through-feed rolling process with active rotation.** Journal of Manufacturing Processes, 82, 96–112. https://doi.org/10.1016/j.jmapro.2022.07.062 **(paper 1) [@@@@]**

- Syriac, Alex & Chiddarwar, Shital. **(2019)**. **Dynamic characteristics analysis of a lead screw by considering the variation in thread parameters.** IOP Conference Series: Materials Science and Engineering. 624. 012007. 10.1088/1757-8999/624/1/012007. **(paper 2) [@@@@]**

- Brown, R. W., & Davis, M. E. **(2019)**. **Optimizing Backlash Reduction in Lead Screws for Enhanced Precision in Lathe Machines: A Design Optimization Approach.** In Proceedings of the International Conference on Manufacturing Engineering (pp. 234-245). Retrieved from https://www.conferenceproceedings.org/proceeding/86664933 **(paper 3)**

- Zhang, Y., Lu, C., & Ma, J. **(2017).** **Research on two methods for improving the axial static and dynamic characteristics of hydrostatic lead screws.** Tribology International, 109, 152–164. https://doi.org/10.1016/j.triboint.2016.12.035. **(paper 4)**

Paper 1

EFFECTIVE WAY

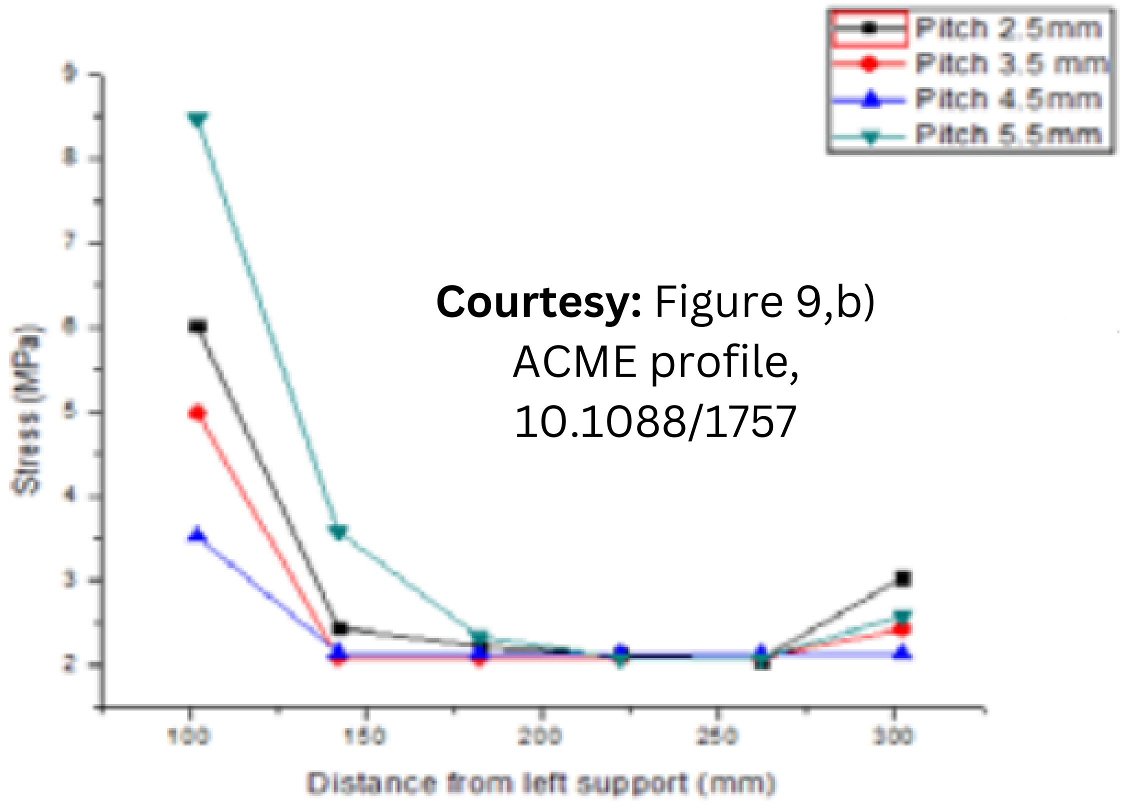
TFRPAR creates a lead screw by,

- utilizing parallel-axis rolling dies
- active rotation of both the rolling die and workpiece

GENERAL WAY

- Take A Cylindrical Bar
- Plug into Chuck
- Hold the end with Tailstock
- Use ACME Cutting tool

Paper 2



Courtesy: Figure 9,b) ACME profile, 10.1088/1757

Efficiency	Torsional Shear Stress (MPa)	Axial Stress (MPa)	Bearing Stress (MPa)	Bending Stress (MPa)	Force, F
57.91%	270.42	491.94	149.55	560.81	
50.17%	92.47	218.64	106.82	373.88	
47.02%	62.14	160.63	93.47	320.47	**5.7 KN** (max, 316)
44.23%	44.25	122.99	83.08	280.41	
37.55%	20.05	65.05	62.31	203.93	
34.11%	13.37	46.57	53.41	172.56	
27.74%	6.19	24.29	39.36	124.63	

Stress distribution: Stress amplitude decreases as the nut moves towards the center of the screw, but increases as it moves towards the rear end

Generate Alternative Design

Stress Analysis
Varying Diameter

Torsional Shear Stress (MPa)	Axial Stress (MPa)	Bearing Stress (MPa)	Bending Stress (MPa)
266.69	509.30	154.83	580.60
90.95	226.35	110.59	387.06
61.05	166.30	96.77	331.77
43.43	127.32	86.01	290.30
19.63	67.34	64.51	211.13
13.08	48.22	55.29	178.65
6.04	25.15	40.74	129.02

Square

270.17	493.07	149.89	562.10
92.37	219.14	107.07	374.74
62.07	161.00	93.68	321.20
44.19	123.27	83.27	281.05
20.02	65.20	62.46	204.40
13.35	46.68	53.53	172.96
6.18	24.35	39.45	124.91

ACME

270.42	491.94	149.55	560.81
92.47	218.64	106.82	373.88
62.14	160.63	93.47	320.47
44.25	122.99	83.08	280.41
20.05	65.05	62.31	203.93
13.37	46.57	53.41	172.56
6.19	24.29	39.36	124.63

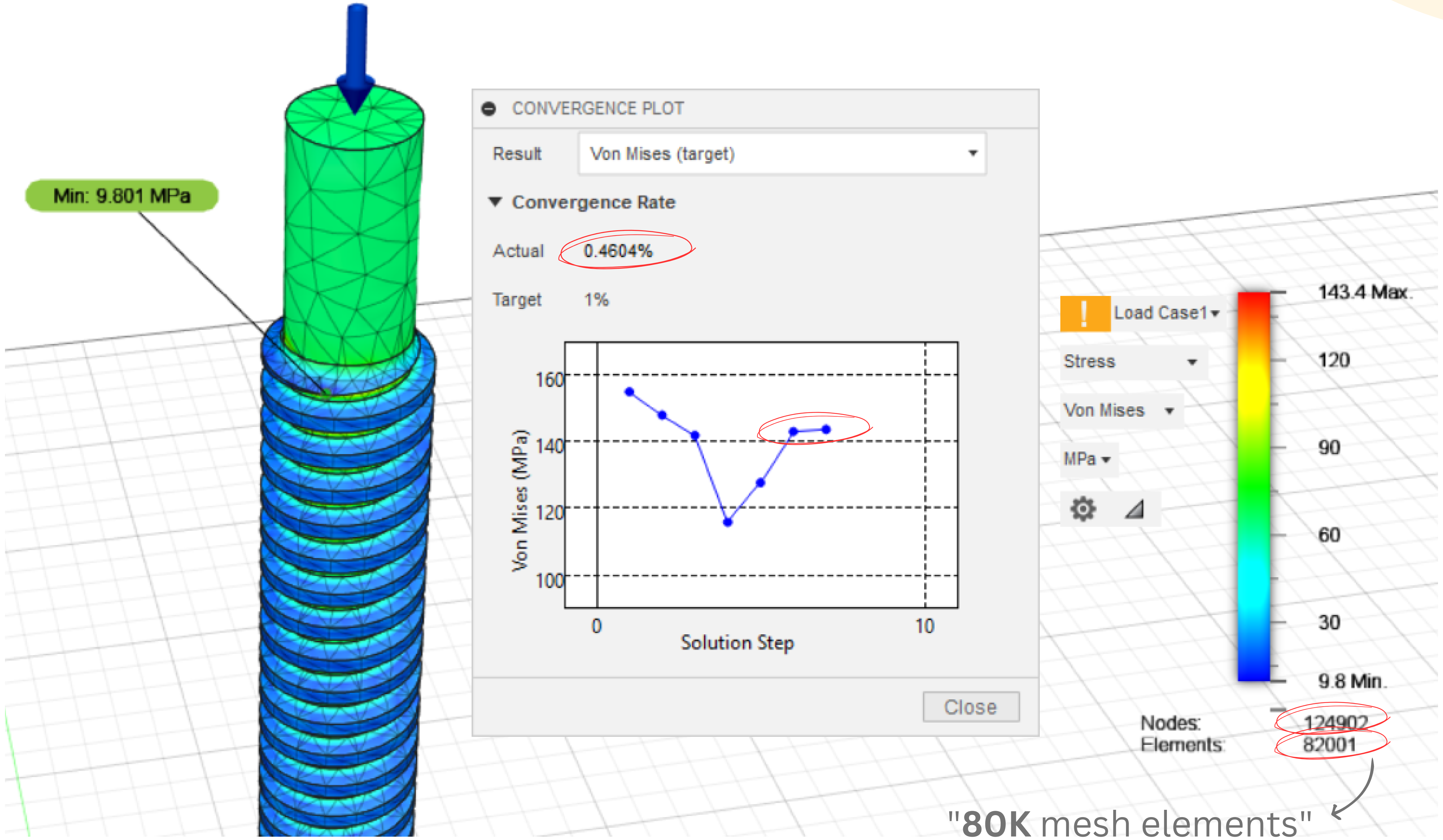
Trapezoidal

Stress Analysis Varying Pitch

Thread	Torsional Shear Stress (MPa)	Axial Stress (MPa)	Bearing Stress (MPa)	Bending Stress (MPa)
Square	43.78	166.30	206.43	663.54
	90.95	226.35	110.59	387.06
	194.59	325.95	79.40	309.65
	454.17	509.30	64.51	290.30
	1255.32	905.41	56.30	309.65
	4853.93	2037.18	51.61	387.06
	43920.37	8148.73	49.15	663.54
ACME	44.73	161.00	199.86	642.40
	92.37	219.14	107.07	374.74
	196.92	315.57	76.87	299.79
	458.52	493.07	62.46	281.05
	1265.26	876.58	54.51	299.79
	4886.65	1972.29	49.96	374.74
	44181.31	7889.18	47.59	642.40
Trapezoidal	44.80	160.63	199.40	640.93
	92.47	218.64	106.82	373.88
	197.09	314.84	76.69	299.10
	458.83	491.94	62.31	280.41
	1265.97	874.56	54.38	299.10
	4889.02	1967.77	49.85	373.88
	44200.19	7871.07	47.48	640.93

Choose and Justify the Optimal Solution

Major Diameter,d	PItch, p	Efficiency
6	1	57.91%
8	2	50.17%
9	3	47.02%
10	4	44.23%
13	5	37.55%
15	6	34.11%
20	7	27.74%



"**80K** mesh elements" is considered high quality

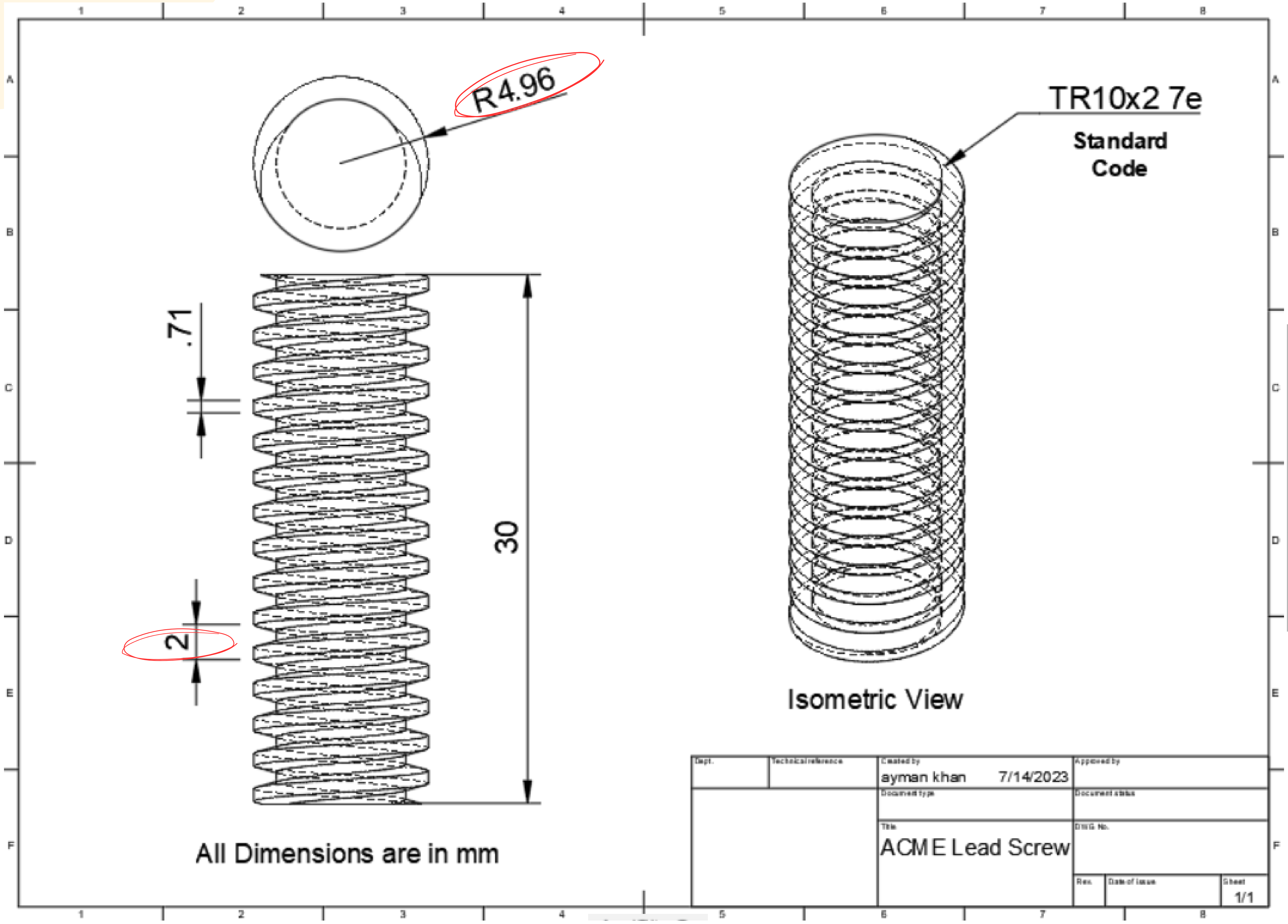
Goal:

High Efficiency, but <50%. Skipping additional cost of installing brakes for vertical loads.

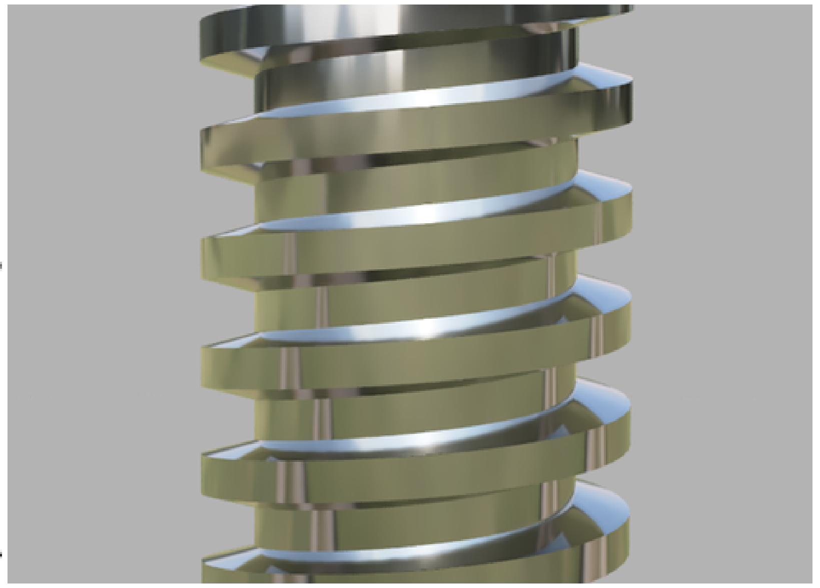
Materials:

- SS grade 304/304H <--Sut = 515 MPa
- SS grade 316L[@@] <--Sut = 485 MPa

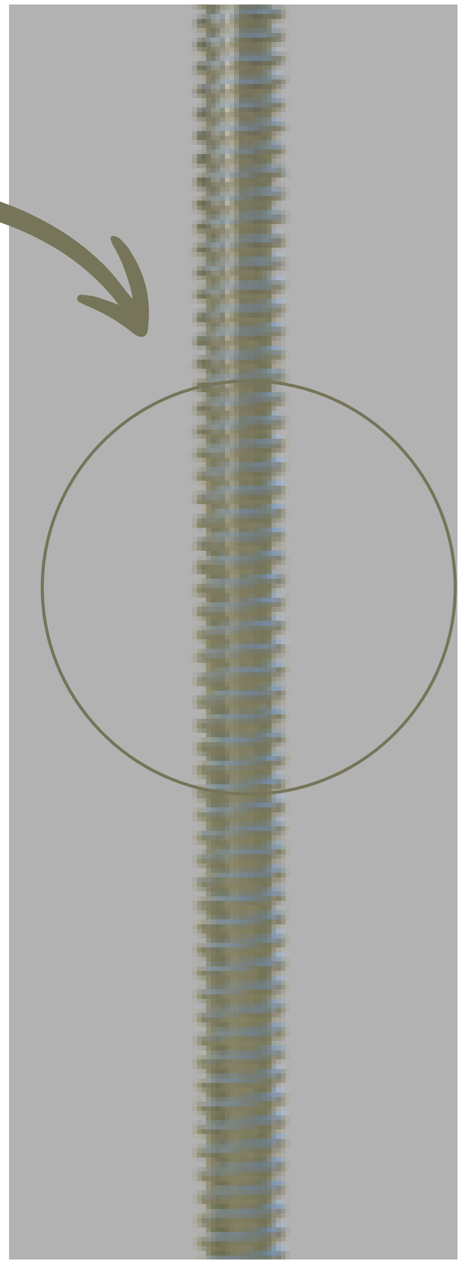
Develop A Prototype



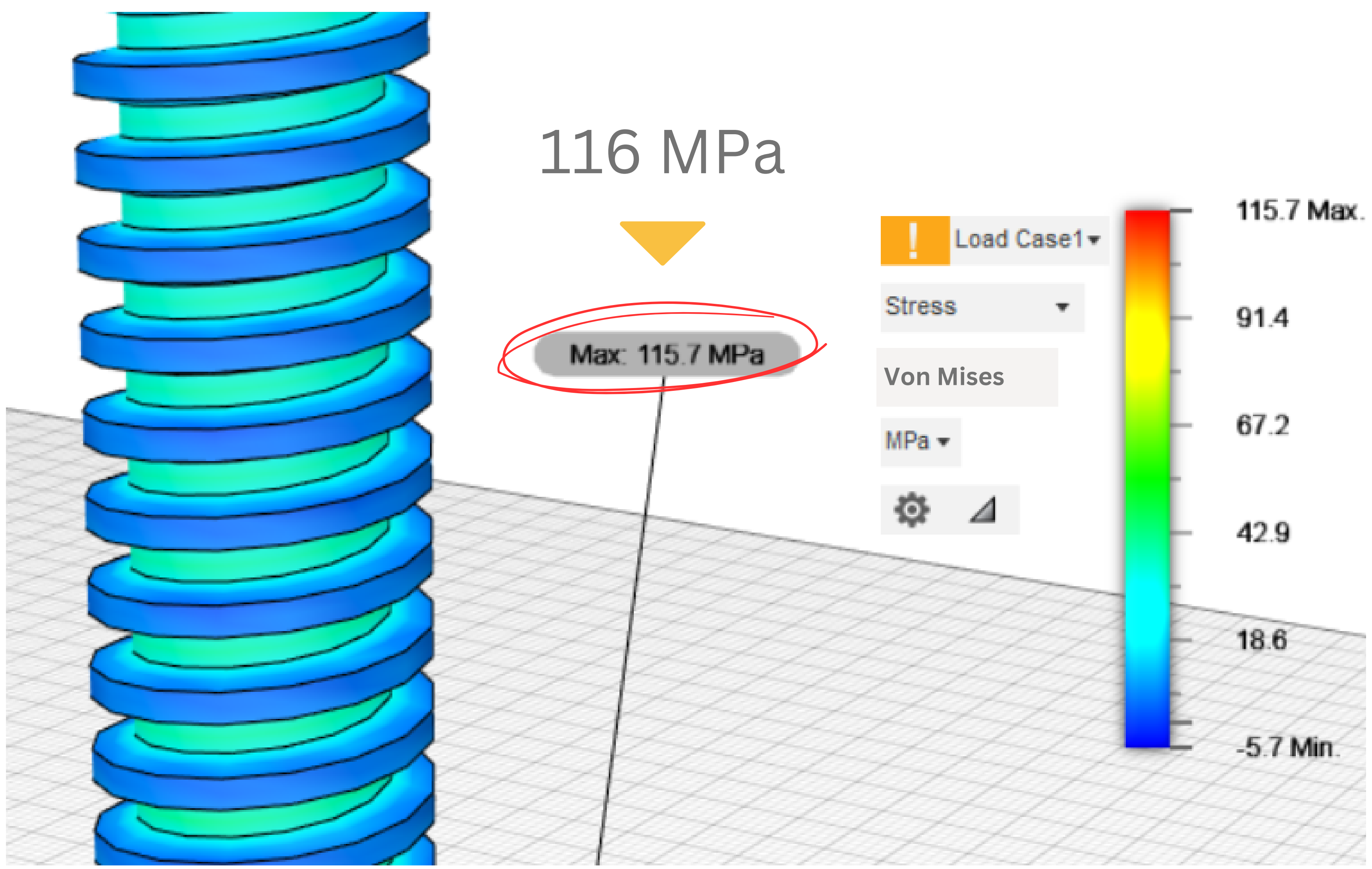
- $d = 10$ mm
- $p = 2$ mm



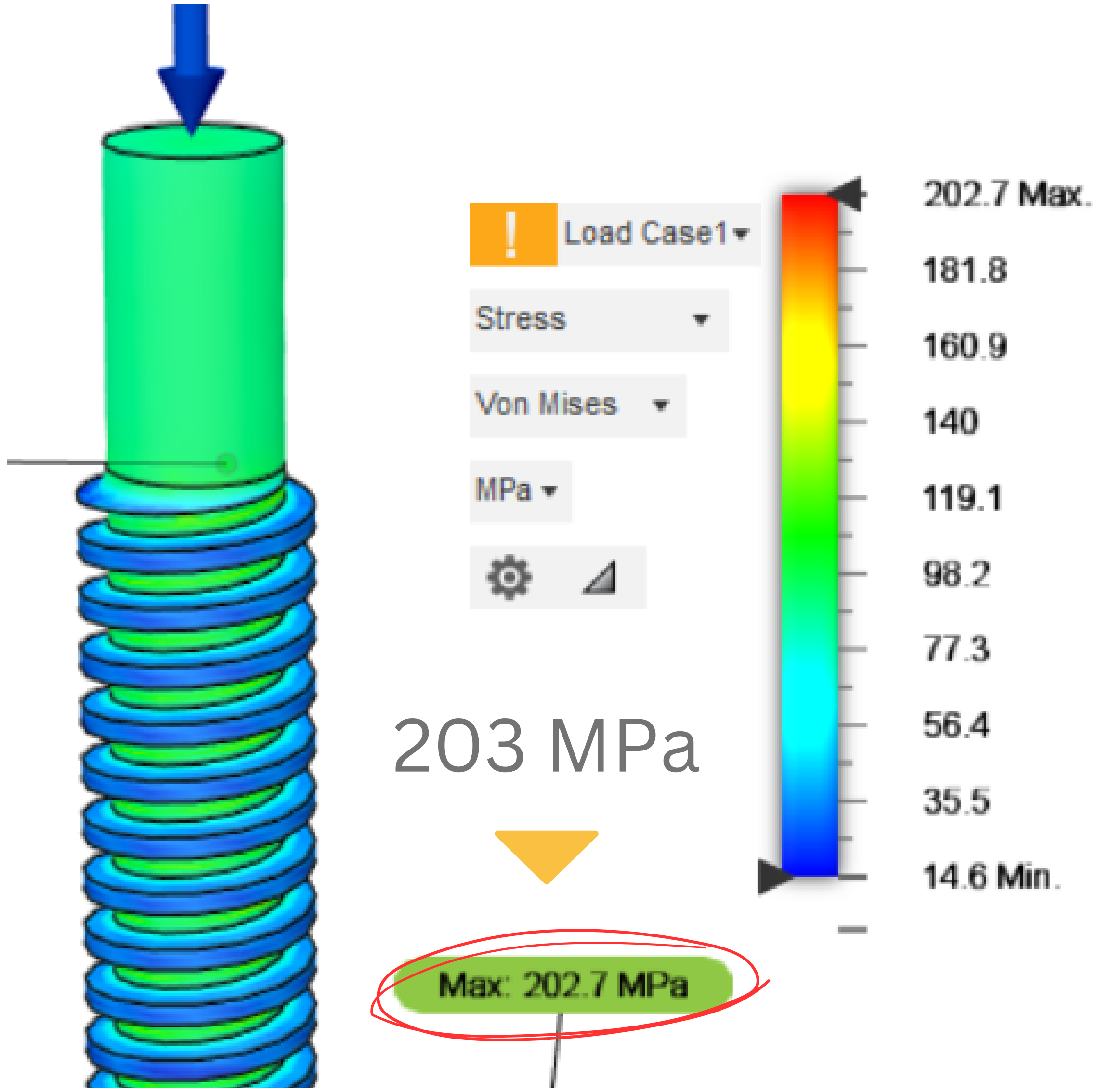
ACME
Thread Rendered
(OPTIMAL SOLUTION)



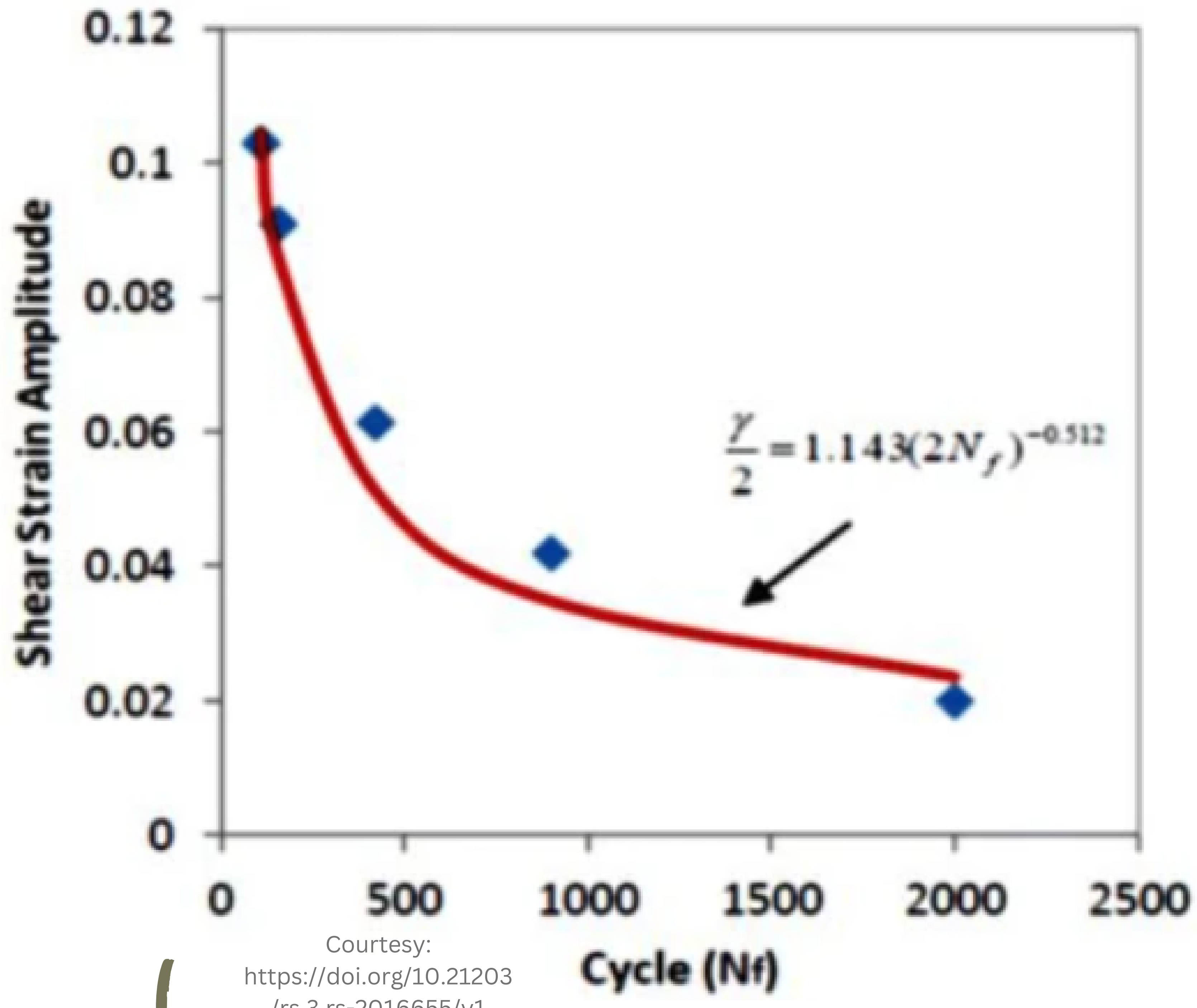
Test and Evaluate



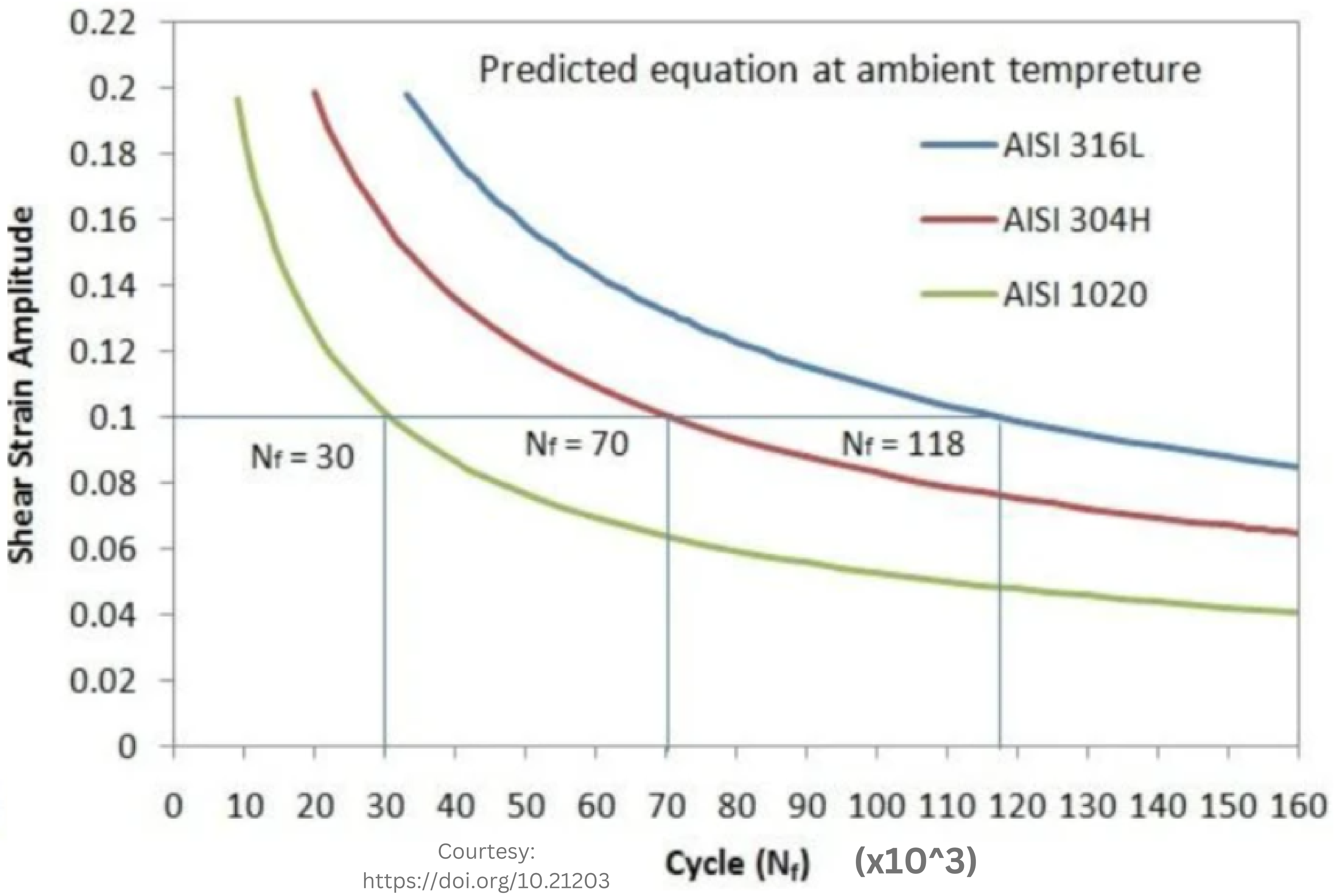
Axial Stress



Bending Stress



Courtesy:
https://doi.org/10.21203/rs.3.rs-2016655/v1



Courtesy:
https://doi.org/10.21203/rs.3.rs-2016655/v1

Mean percentage erro between the Experimental data nad the predicted equation is 4%

Fatigue Life Comparison:

- AISI 316L (L--> Low in Carbon) [@@]
- AISI 304H (H --> High in Carbon)

Redesign and Solution

Specifications	Value
Major Diameter, d	10 mm
Pitch, p	2 mm
Pitch Diameter, Dp	9 mm
Minor Diameter, Dm	8 mm
Force, F	6.0 kN (approx.)
Target Tolarence	1.00%
Actual	0.46%
Rasing Torque, Tr	4.44 Nm
Torsional Shear Stress (MPa)	44.19 MPa
Axial Stress (MPa)	123.27 MPa
Bending Stress (MPa)	224.07 MPa
Efficiency	44.39%

MOST IMPORTANT SEGMENT

V&V --> Verification and Validation

- matching simulated values [✓]
- matching experimented values [✕]

Parameters	Axial Stress	Bending Stress
Theoretical value	123	224
Simulated value	116	203
Error	5.70%	9.37%

THANK YOU