Design A lead Screw For Lathe Machine

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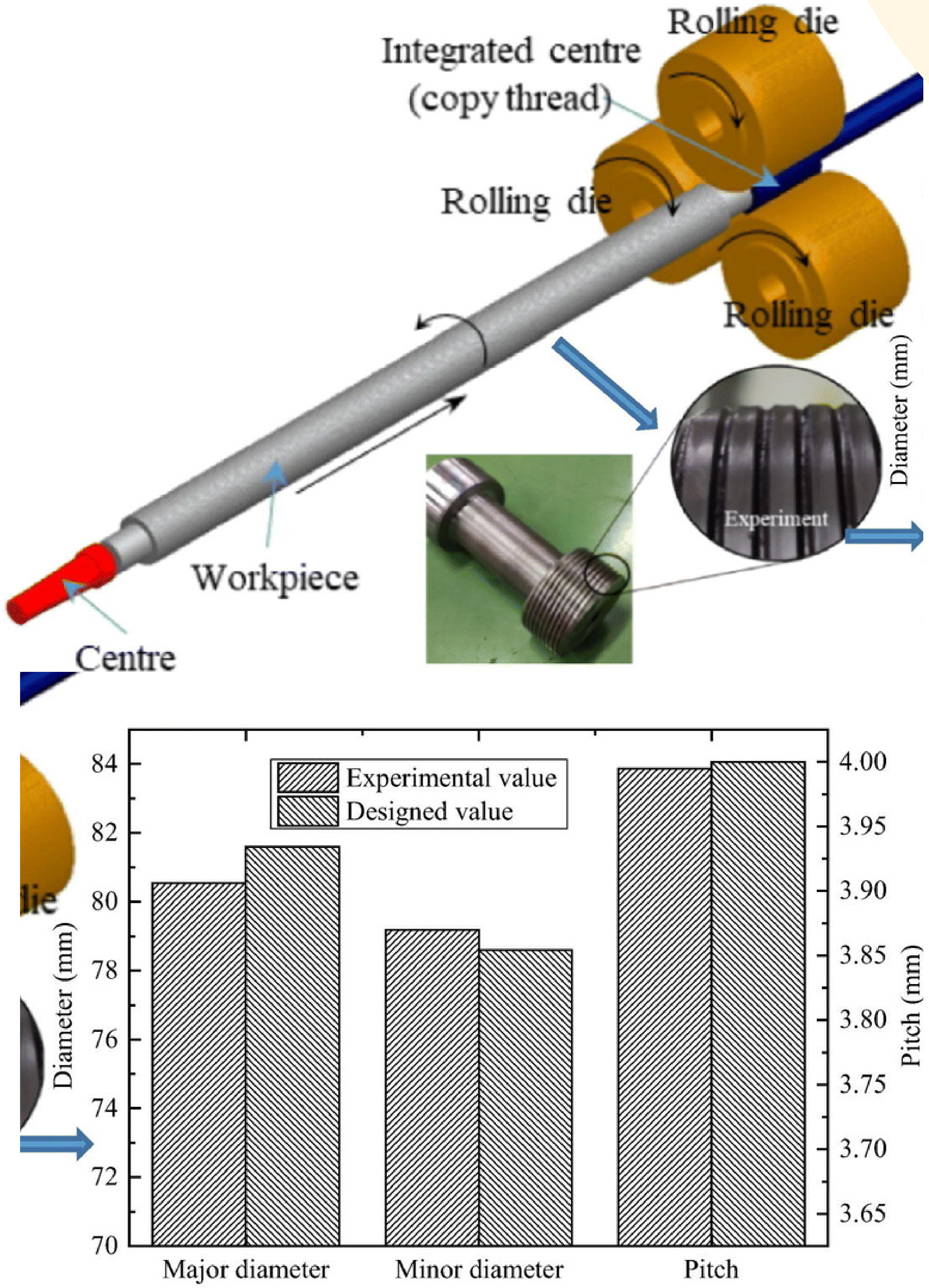
RESEARCH & INVESTIGATION

Review on "*[Investigation and implementation for forming lead screw by through-feed rolling process with active rotation]*" (paper 1)

TFRPAR creates a lead screw by,

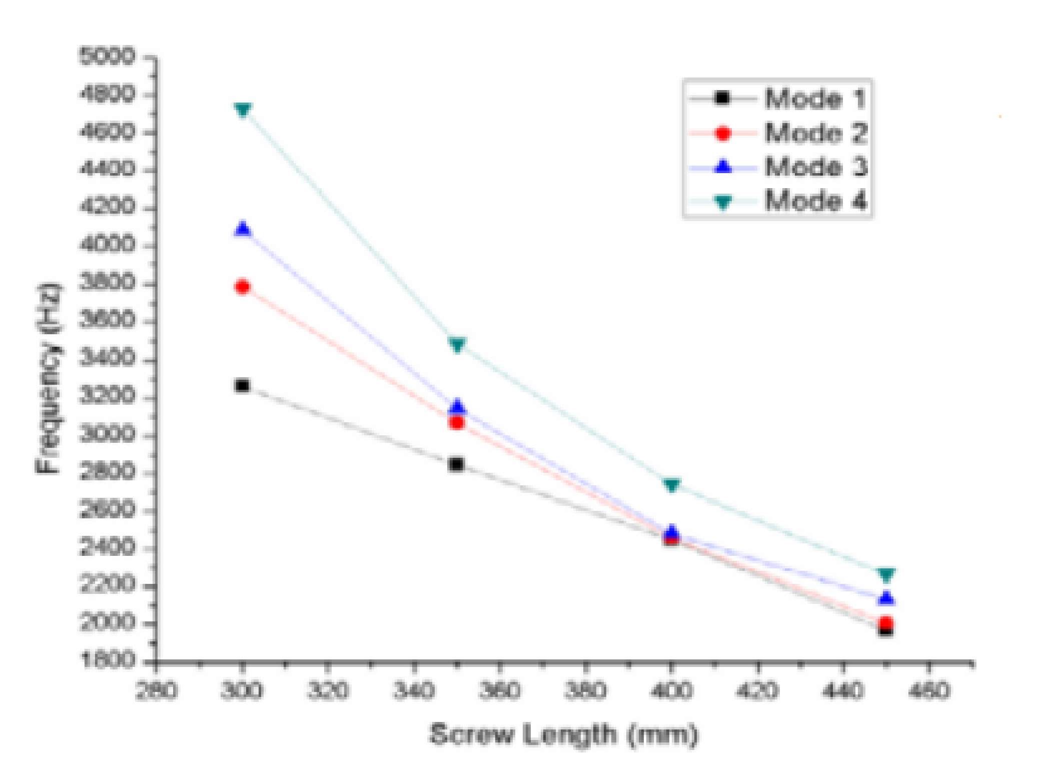
- utilizing parallel-axis rolling dies with a taper angle,
- active rotation of both the rolling die and workpiece

Feasibility verified through experiments for manufacturing long threaded parts with high thread and large deformation.

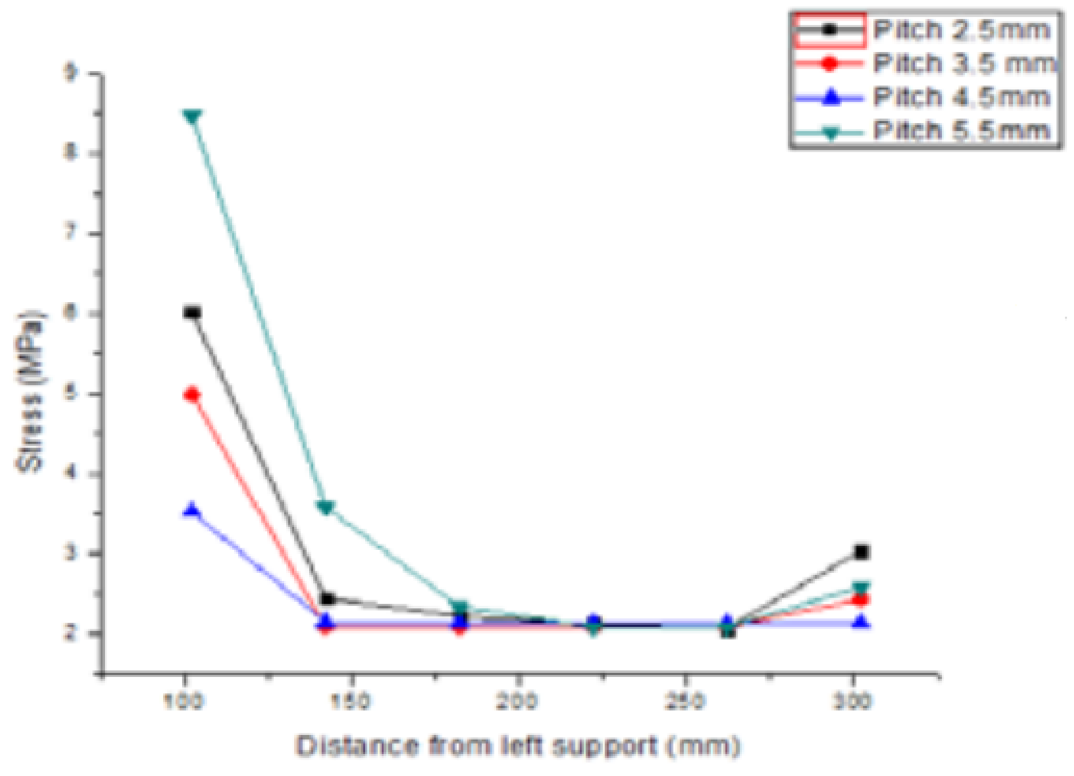


Courtesy: https://ars.els-cdn.com/content/image/1-s2.0-S1526612522005308-ga1.jpg

Review on "*Dynamic characteristics analysis of a lead screw by considering the variation in thread parameters.*" (paper 2)



Courtesy: Figure 5,a)
Mode 1 to 4, from paper



Courtesy: Figure 9,b)
ACME profile, from paper

Natural frequency: The natural frequency is affected by screw length and worktable position

Formula:
Frequency = (Lead / Screw Length) * RPM

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

Review on "*Optimizing Backlash Reduction in Lead Screws for Enhanced Precision in Lathe Machines: A Design Optimization Approach*" (paper 3)

- **Backlash** Analysis
- **PV curve** defines the safe limits of load and speed (100000 watt vs 13000 watt), an **observation**

Formula:

PV = (Load/Projected area) * Velocity

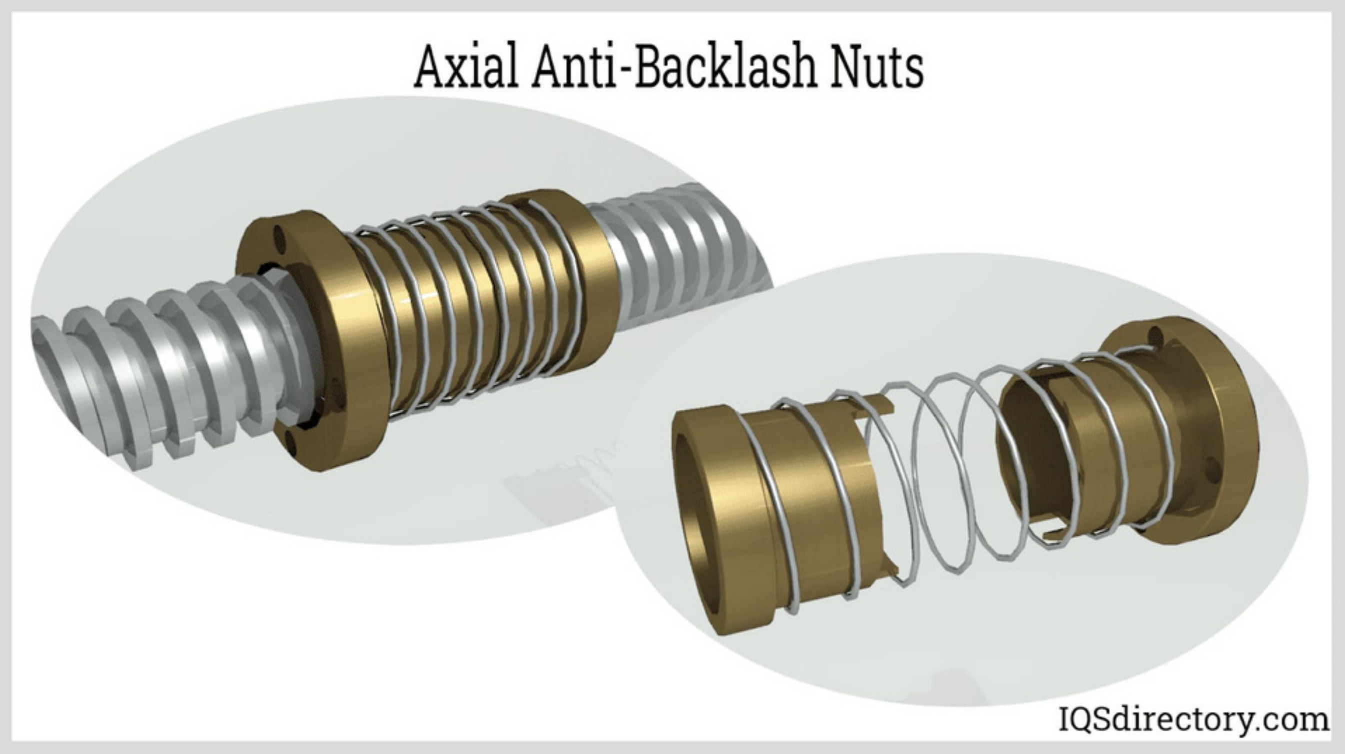


Fig 1 **Courtesy:** https://www.iqsdirectory.com/articles/ball-screw/lead-screws/axial-anti-backlash-nuts.jpg

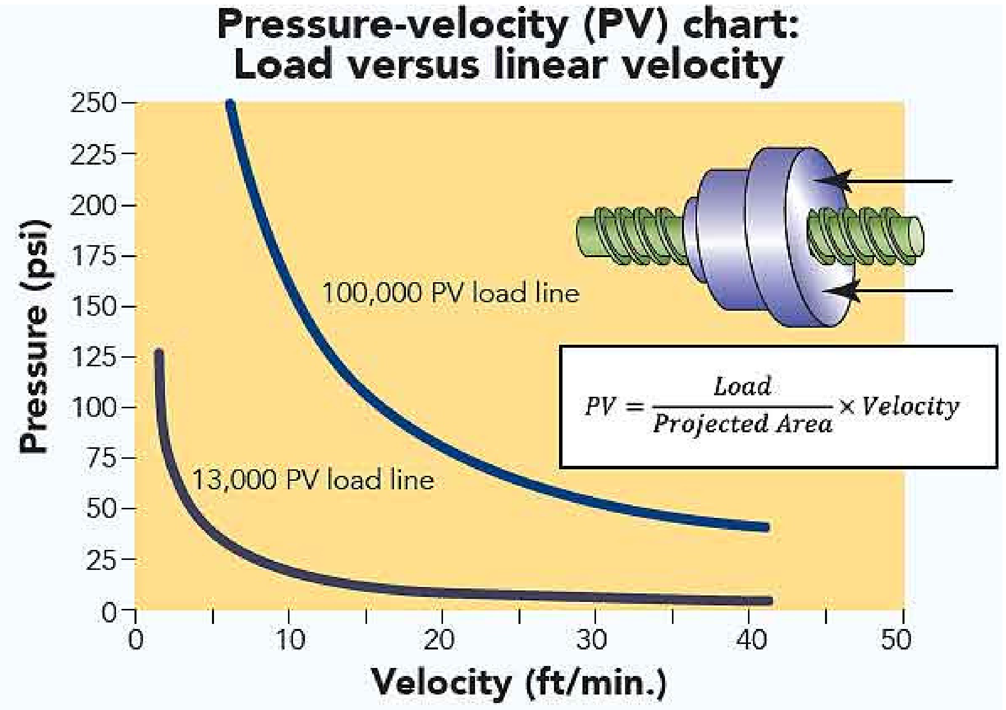


Fig 2 **Courtesy**: https://www.linearmotiontips.com/wp-content/uploads/2015/08/pressure-velocity-chart.jpg

Review on "*Two methods for improving the axial static and dynamic characteristics of hydrostatic lead screws*" (paper 4)

Method 1: Implementing a **membrane restrictor**

- Reduces total flow and pumping power
- Improves axial load capacity,
- Stiffness coefficient
- Damping coefficient

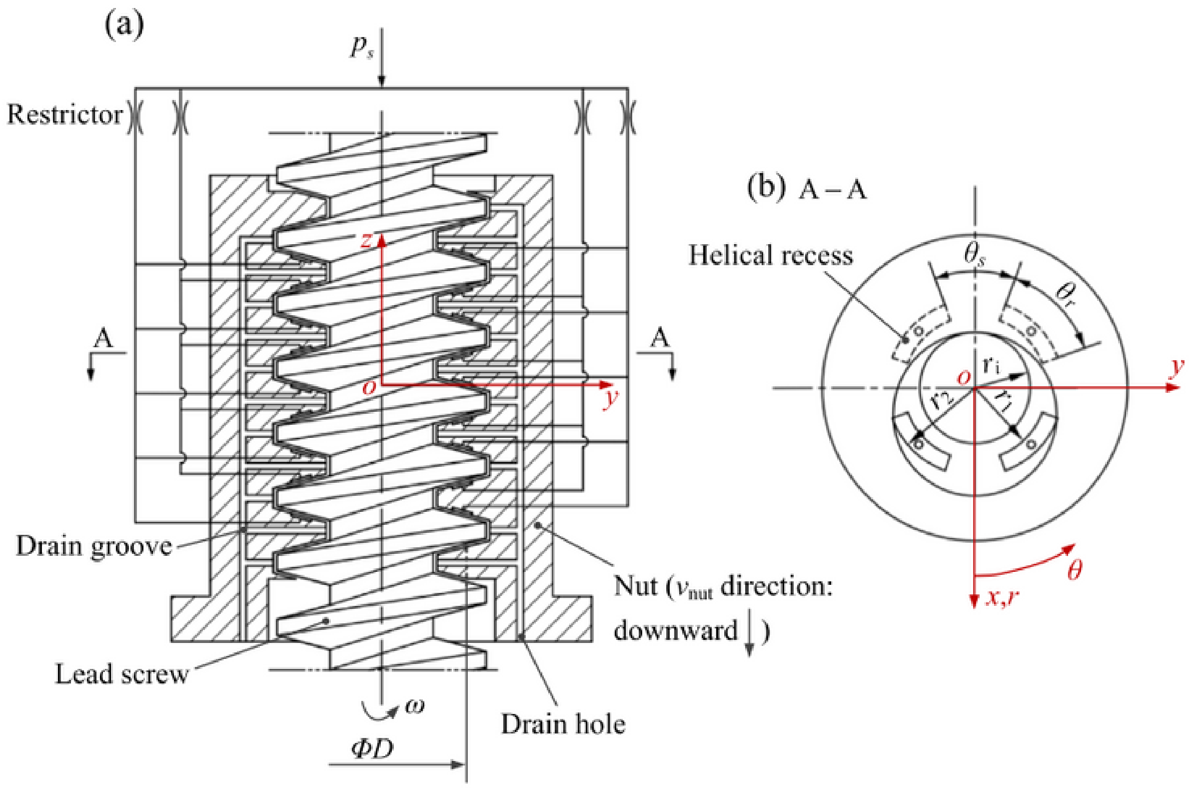


Fig. 1. (a) Hydrostatic lead screw and (b) cross section of the hydrostatic nut.

Courtesy:https://scihub.se/https://doi.org/10.1016/j.triboint.2016.12.035

<u>Review on "*Two methods for improving the axial static and dynamic characteristics of hydrostatic lead screws*" (paper 4), CONT'D</u>

Method 2: Introducing intentional periodic pitch errors in the hydrostatic nut ,

- Generates hydrodynamic effect of lubricating film
- Enhances axial load capacity

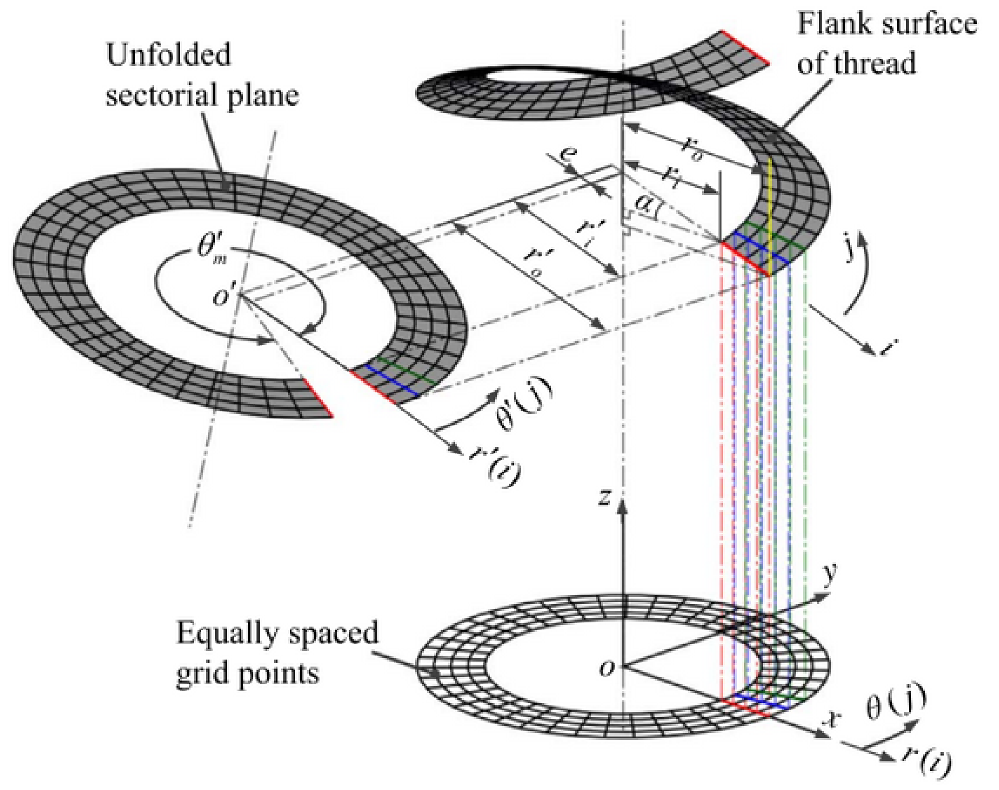


Fig. 3. Approximately unfolded drawing of the flank surface of threads and grid points.

Courtesy:https://scihub.se/https://doi.org/10.1016/j.triboint.2016.12.035,

Formula: (Periodic pitch error)

$$\begin{cases} f_1(\theta) = E \times \sin\left(\frac{2\pi}{T}\theta + \varphi_1\right) \\ f_2(\theta) = E \times \sin\left(\frac{2\pi}{T}\theta + \varphi_2\right) \end{cases}$$

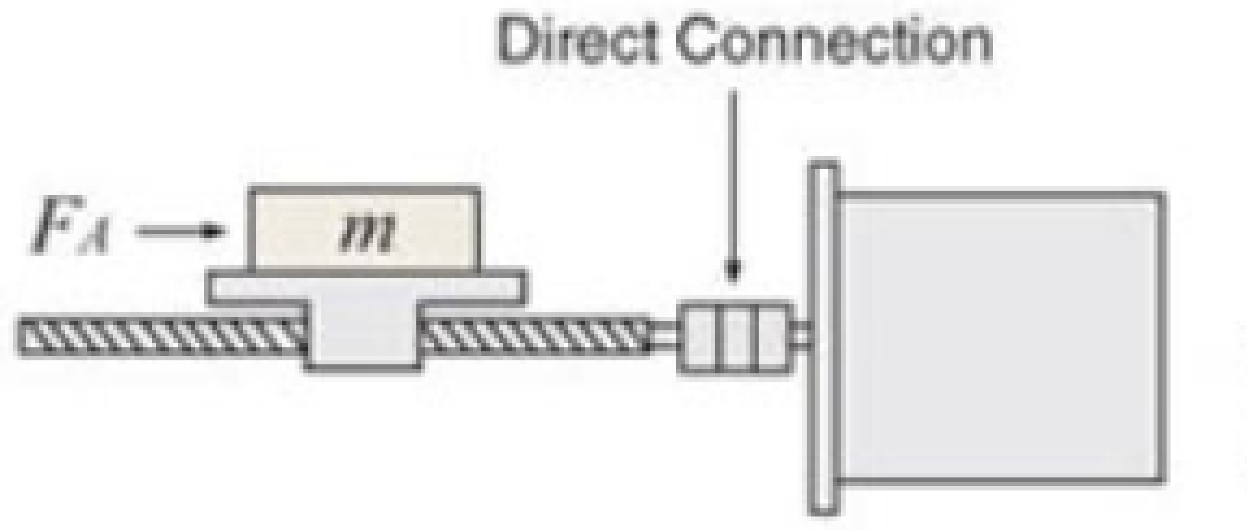
Citations:

- 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)**

Generate Alternative Design

Design Elements:

- Force (6400N is selected)
- Coefficient of friction, f = 0.08
- Major Diameter, d = 8mm
- Acme Thread Pitch, p = 2mm
- Length, L = 290mm



Courtesy:
https://www.orientalmotor.com/images/technology/load-torque-calculation-ball-screw-drive.jpg

Major Diameter Varied

Major Diameter,d	Thread Depth	Thread Width	Pitch Diameter	Minor DIameter	Lead	T(raise)	T(lower)	Efficiency
6	1	0.97	5	4	2	3.35	-0.75	60.79
8	1	0.97	7	6	2	3.86	-0.24	52.81
9	1	0.97	8	7	2	4.11	0.01	49.55
10	1	0.97	9	8	2	4.37	0.27	46.66
13	1	0.97	12	11	2	5.13	1.03	39.70
15	1	0.97	14	13	2	5.64	1.54	36.11
20	1	0.97	19	18	2	6.92	2.82	29.44

Efficiency Decreased

Pitch Varied

Major Diameter,d	Thread Depth	Thread Width	Pitch Diameter	Minor DIameter	Lead	T(raise)	T(lower)	Efficiency
8	1	0.97	7	6	2	3.86	-0.24	52.81
8	1	0.97	6	6	2	3.60	-0.50	56.53
8	1	0.97	5	6	2	3.35	-0.75	60.79
8	1	0.97	4	6	2	3.10	-1.00	65.70
8	1	0.97	3	6	2	2.85	-1.25	71.39
8	1	0.97	2	6	2	2.62	-1.49	77.88
8	1	0.97	1	6	2	2.42	-1.69	84.31

Efficiency Increased

DESIGN

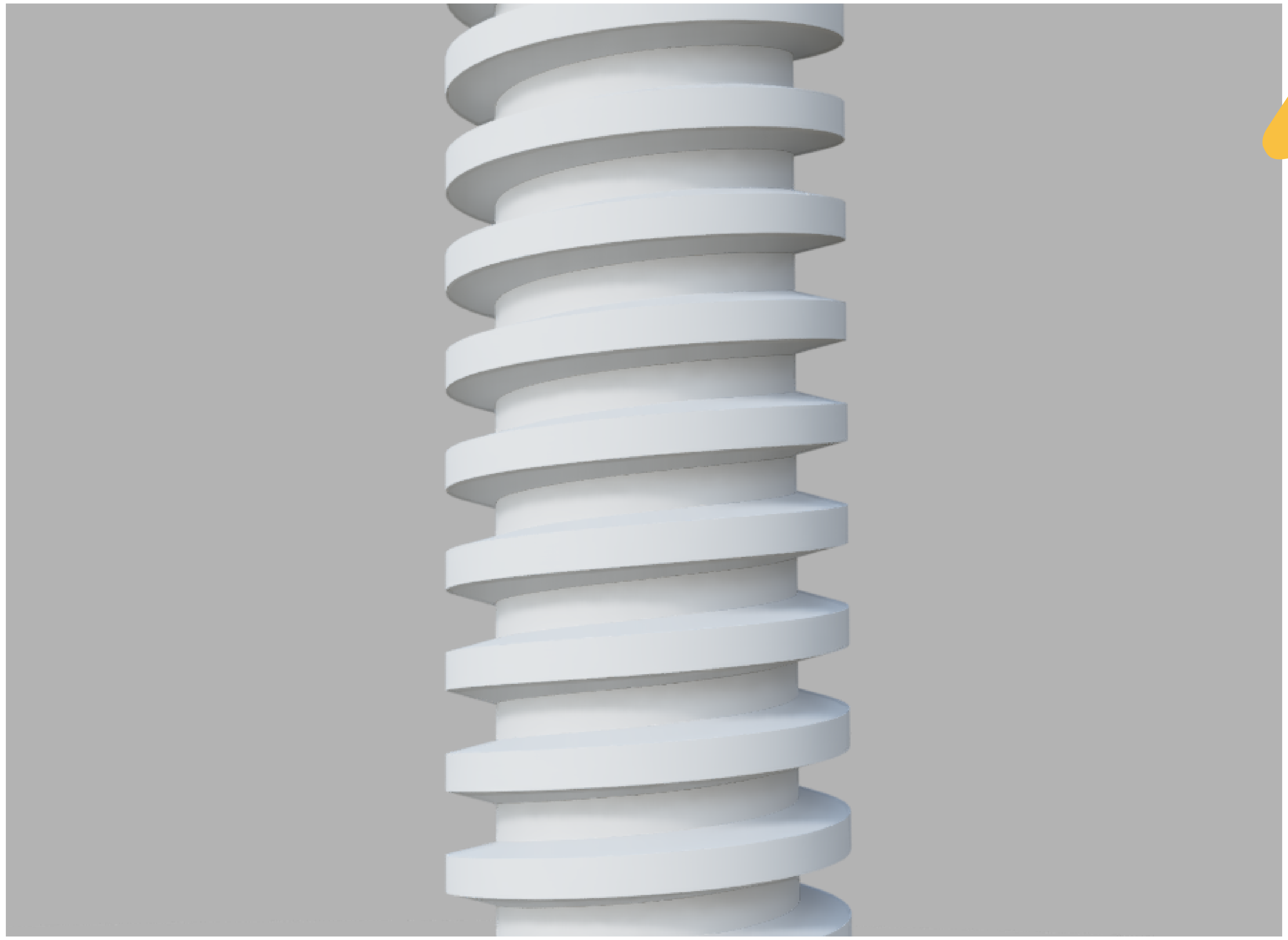


Fig 2: Zoomed in section

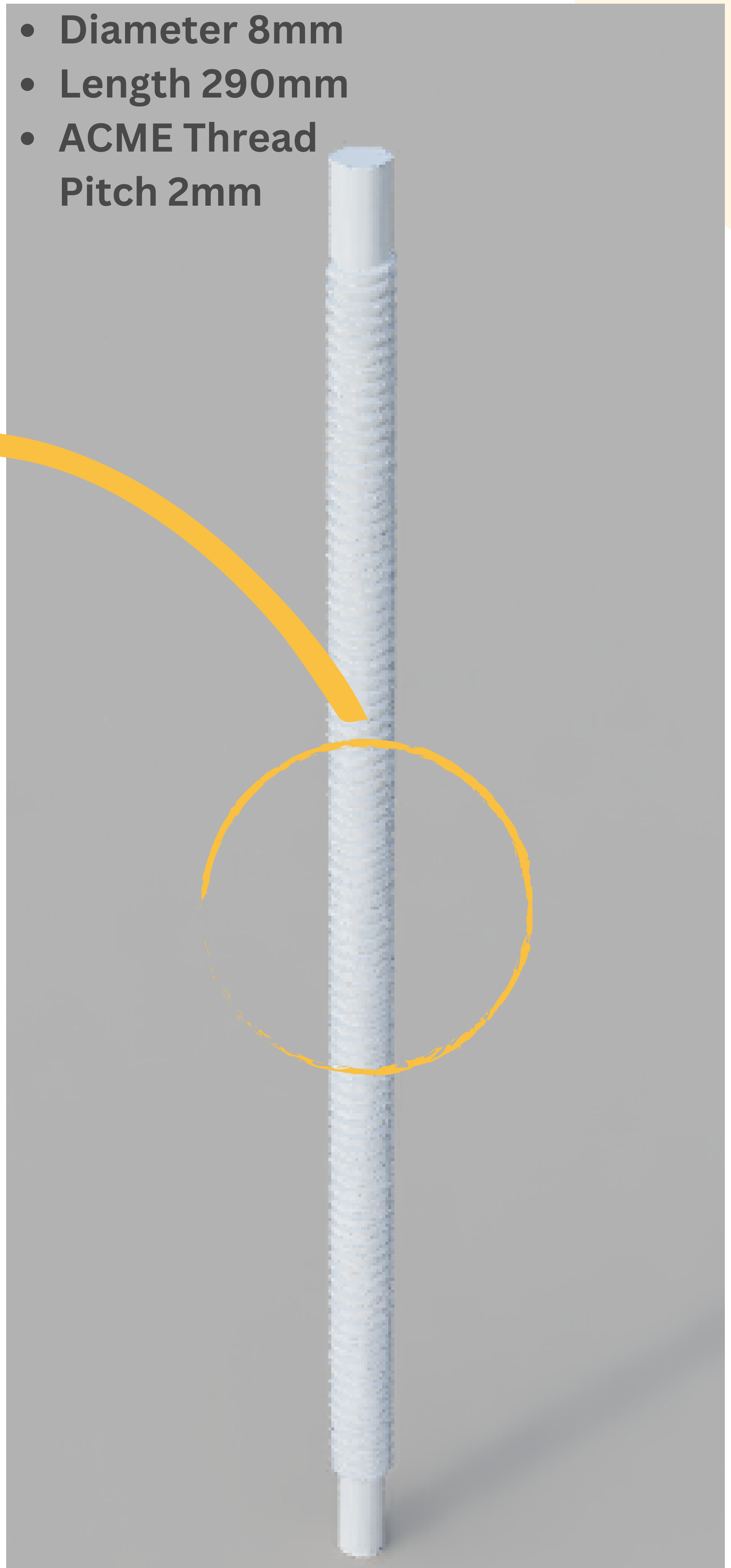


Fig 1: 8mm **Lead Screw**

<u>Courtesy:</u> Rendered from Autodesk Fusion 360

THANK YOU