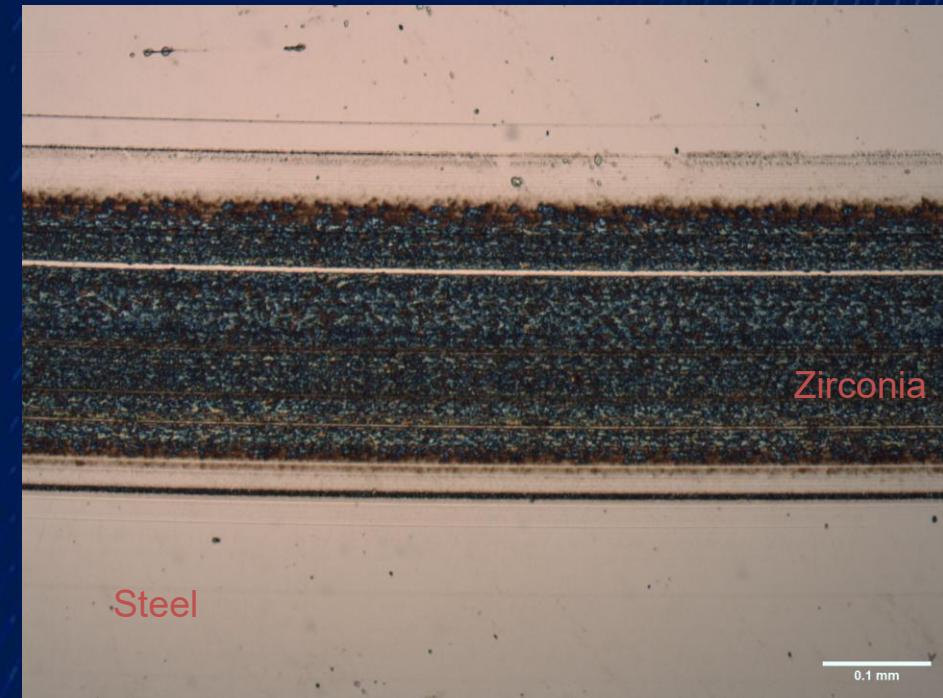


# ZrO<sub>2</sub> Nanoparticles as an Anti-Wear Grease Additive

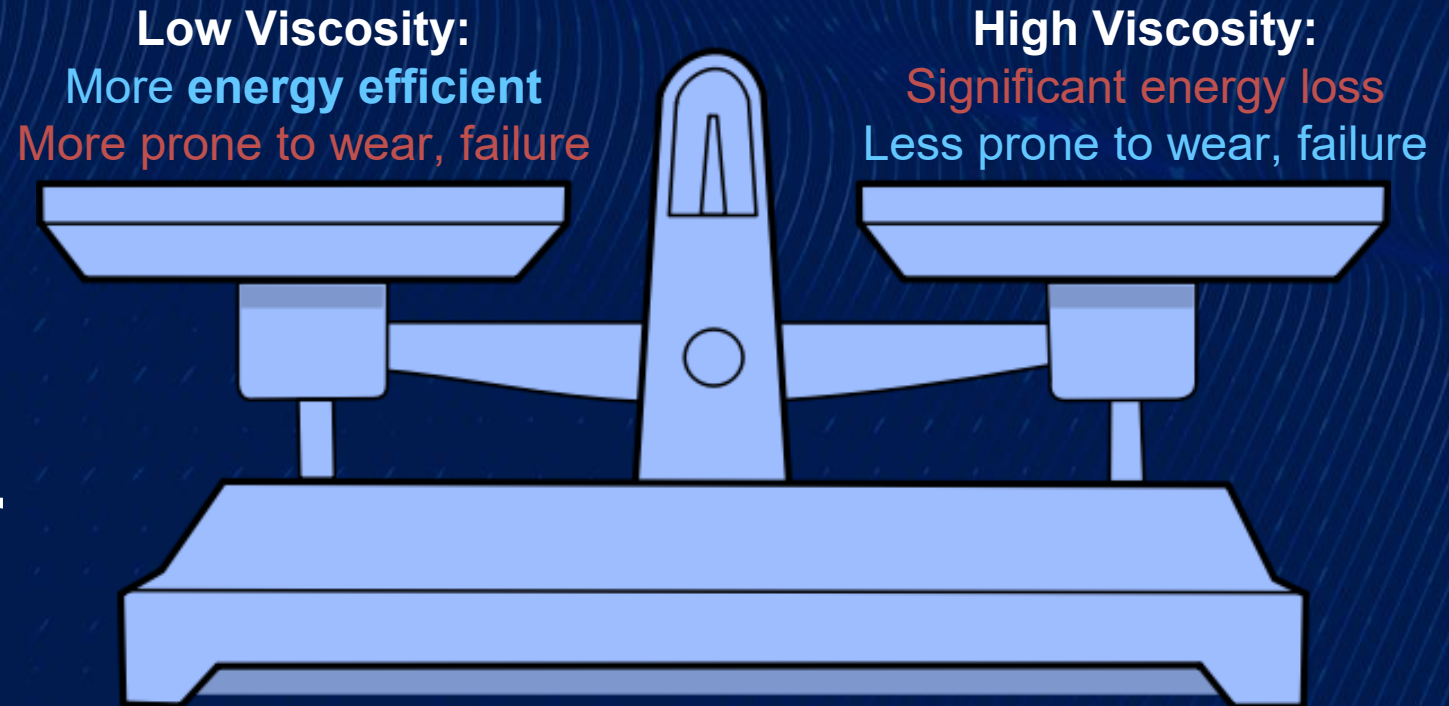
Nathan Hryniewicz  
*Summer 2025*





# Motivation: Energy Efficiency

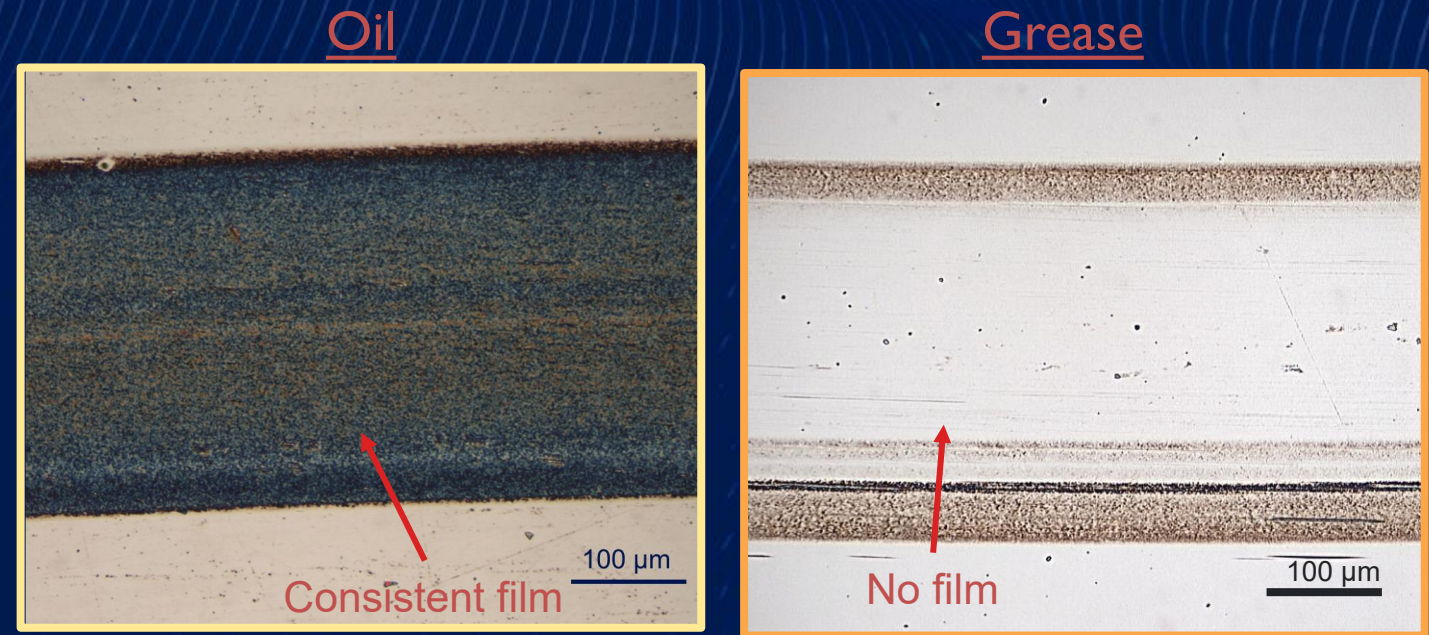
- Tribological losses = ~23% of global energy use<sup>[1]</sup>
- 80 to 90% of rolling element bearings are grease lubricated<sup>[2]</sup>
- **Additives *decouple* wear protection from viscosity to enable more efficient lubrication**





# How can we utilize nanoparticle additives in grease?

- Nanoparticle additives form a protective film at contact<sup>1</sup>
- Film formation mechanism is well studied in oil, **not grease**
- **How can we achieve a reliable film in grease?**

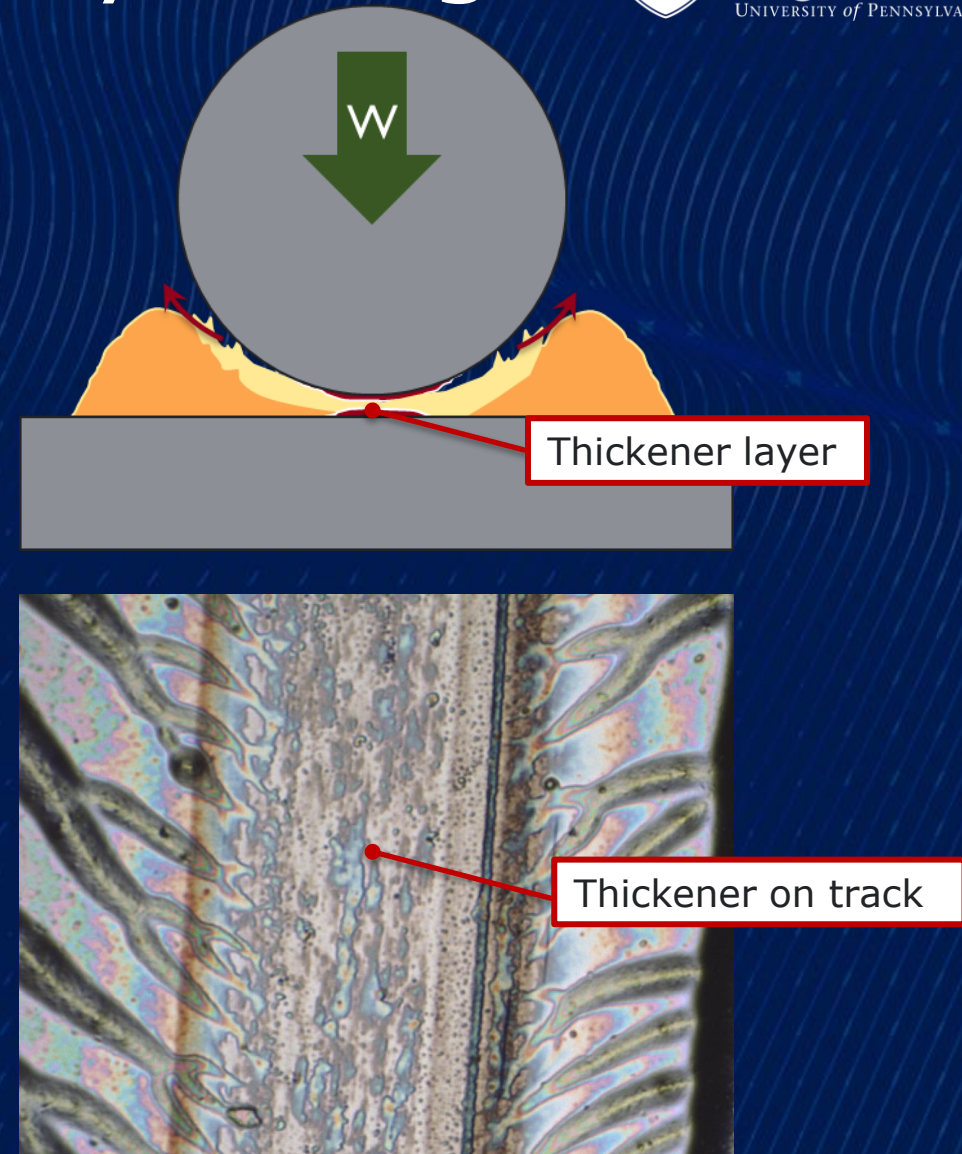


\*Comparison is under identical conditions



# Hypothesis: Thickener layer might prevent *tribosintering*

- To form a film, nanoparticles must be under stress<sup>1</sup>
- The thickener structure of grease could prevent this
- **To overcome this, higher stress conditions could be required**

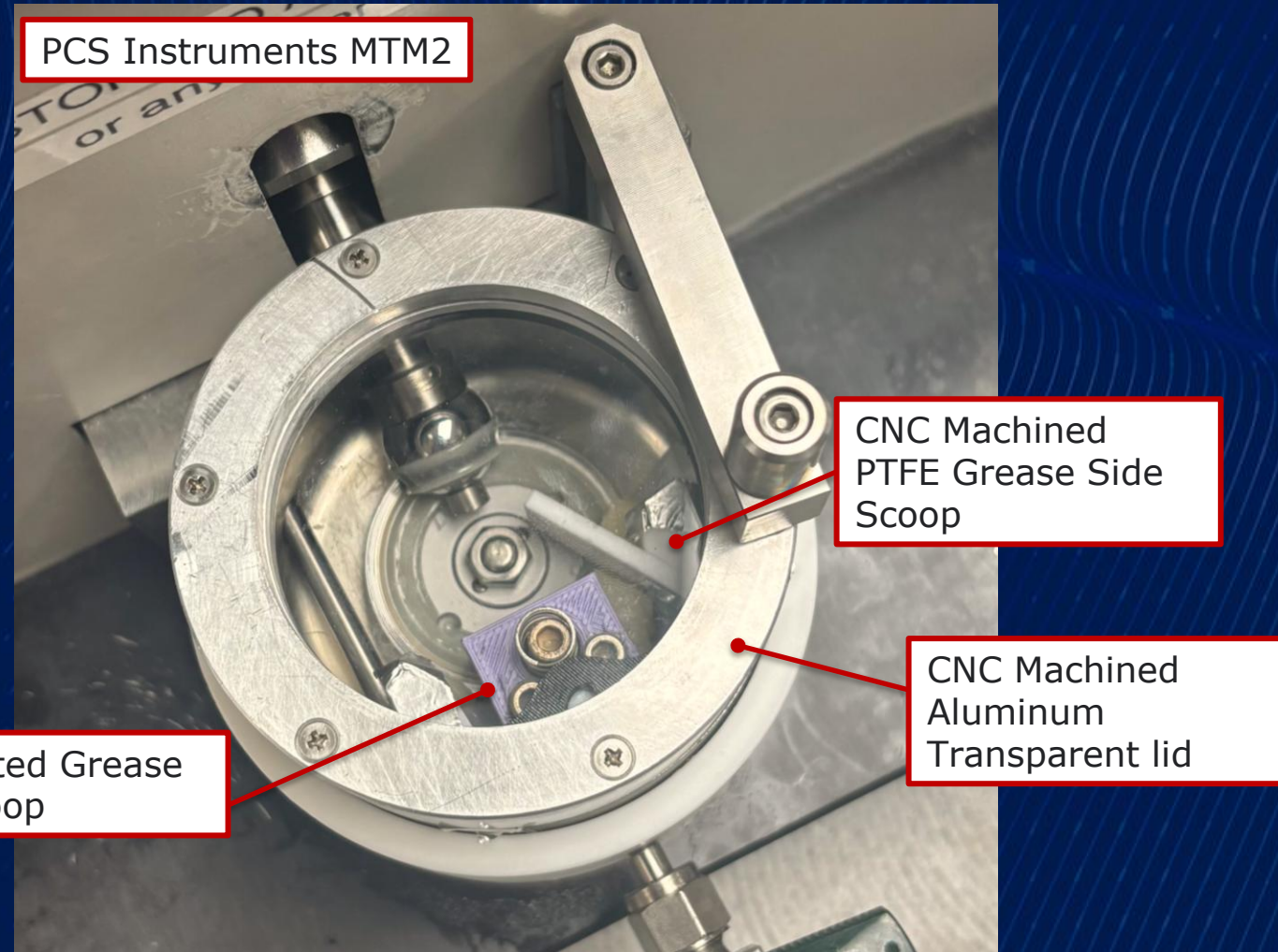




# Experimental Setup

- These results would not be possible without the custom fixtures that were custom designed and manufactured for this project

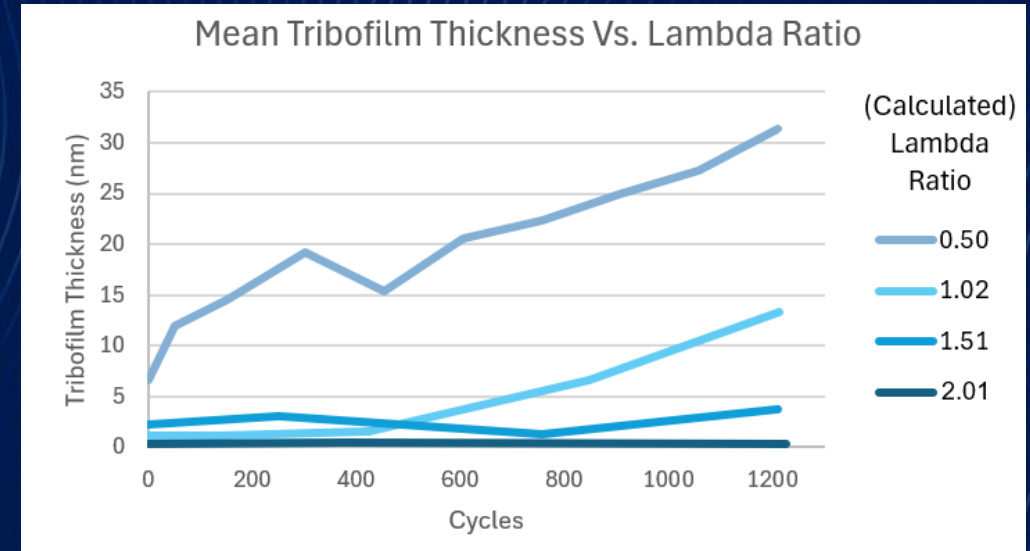
(<https://nhryn.tech/Summer24.pdf>)



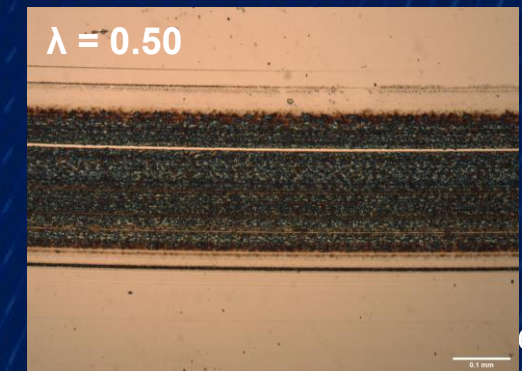


# Experimental Results

- Tribometer tests show a clear relationship between stress and tribofilm growth
- Jump in film thickness at  $\lambda = 0.50$  suggests a threshold, or possibly a yield point of the thickener



Lambda ratio: Lubricant film thickness/Composite roughness  
 Lower lambda = higher stress  
 \*Film thickness is calculated by EHL formulas based on testing parameters for oil lubrication, not measured

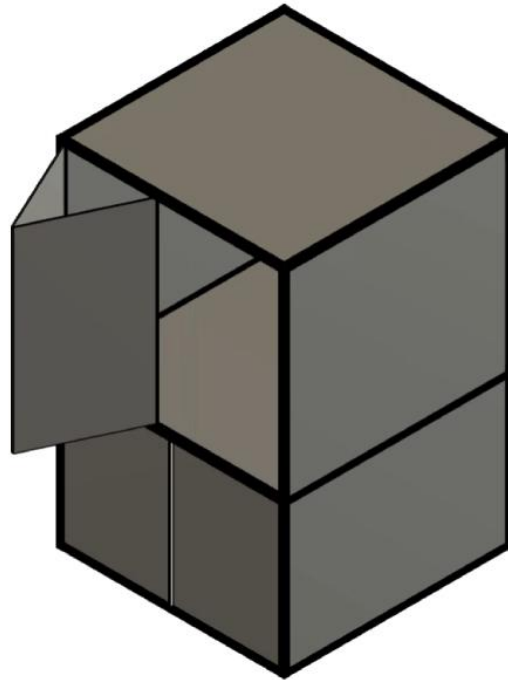


# Side Project: Atomic Force Microscope Environmental Enclosure

## Outdated AFM Enclosure had issues: **Solution: Sliding Bifold door**

### Outdated AFM Enclosure had issues:

- One door would not close
- Still used temporary rigging in some places
- No lighting inside
- Door obstructed view of instruments when using the computer



[Video Demonstration](#)

### Key Components:



UHMWP Door Glide<sup>1</sup>



Custom Machined  
Glide Mounting Bracket

### Advantages:

- Improves vibration isolation when door is open
- Improves ergonomics by removing door obstruction
- Door is less obstructive of walkway when opened

<sup>1</sup><https://8020.net/40-2051.html>