Optimal Lubrication of Nickel-Titanium as a Mechanical Material for Spacecraft.

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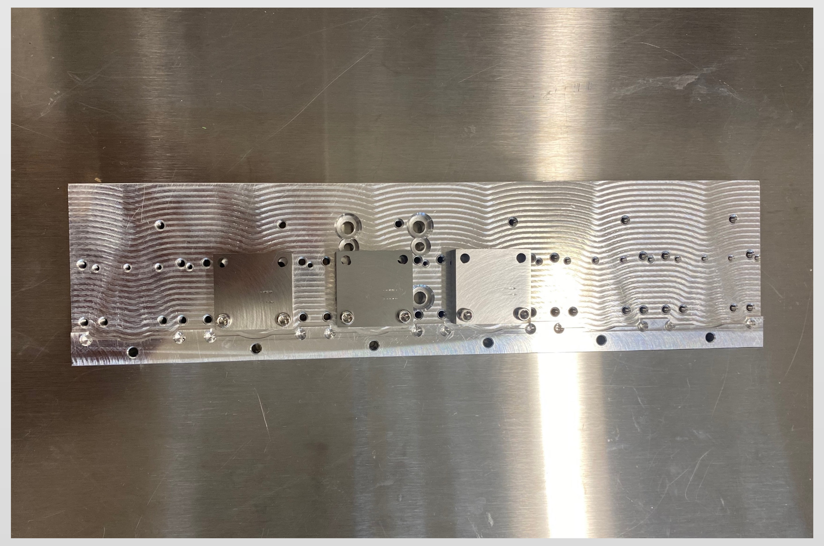
Background Research

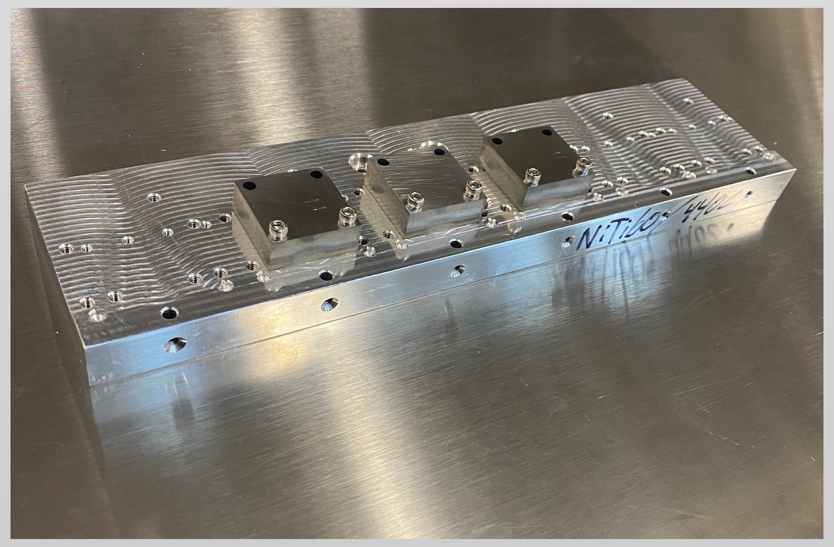
Conditions Materials Must Withstand in Space [2][5]:
- Low pressure between 10^{-13} and 10^{-16} torr
  - increases evaporation
- Temperatures as low as -270.42 degrees Celsius
- Thermal radiation
- Gamma and Microwave radiation
- atomic oxygen and atomic hydrogen

NiTi 60 (Nickel-Titanium)[1][3]:
- A binary shape memory alloy (SMA) comprised of nickel and titanium
- High corrosion resistant
- Shape memory and superelastic properties can be neutralized with temperature manipulation
- Nonmagnetic
- Electrically conductive
- High hardness

Question:
- What is the optimal orientation of nickel-titanium 60 (NiTi 60) in cryo-vacuum bearings?

Previous Studies[3][4]:
- comparison the lubrication of NiTi 60 with the lubrication of 440C steel (a frequently used material) as "high-performance bearings"
- results revealed that Nitinol can be sufficiently lubricated just as steel can by withstanding its key properties





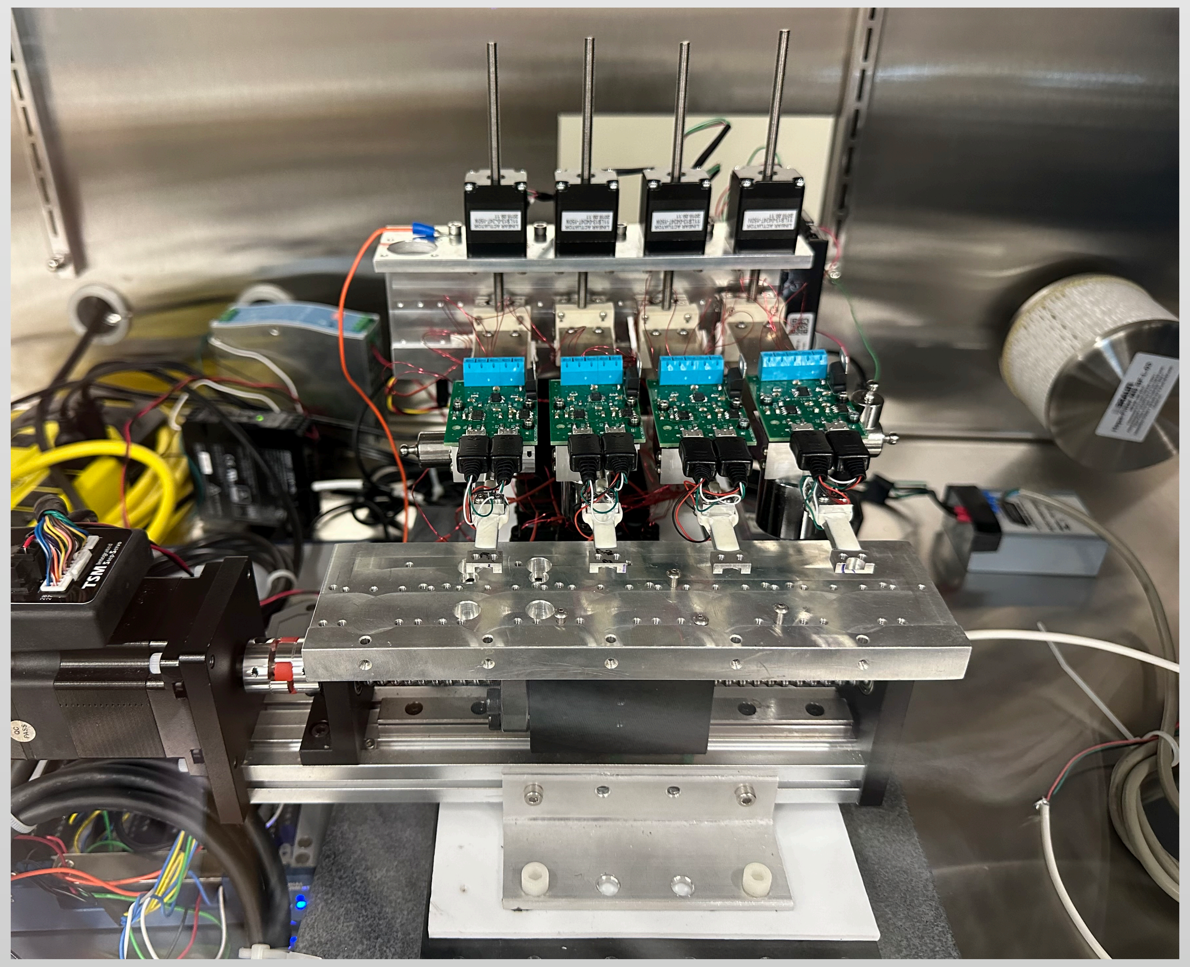
Figures 1& 2. NiTi60 samples.

Methods

Materials:
- 3 samples of 440 C (Stainless Steel) and 3 samples of NiTi 60 (Figure 1&2.)
  - Polished to similar roughness: 0.191 microns
  - Similar hardness: 8 Gpa
- 3 counter sample materials
  - NiTi 60
  - Si3N4 (silicon nitride)
  - 440 C

Equipment:
- White light Interferometer
  - Make surface profiles and measure roughness
- Multistage tribometer (Figure 3.)
  - Tests the friction wear rates of the samples
- Glove Box
  - Encases tribometer for a controlled dry nitrogen atmosphere

Test Conditions:
- Perform stripe test on tribometer: the repetitive scratching of a surface of samples
- We conduct 5 Incremental Test Cycles
  - 100 cycles: 5mm stroke length
  - 500 cycles: 4mm stroke length
  - 1000 cycles: 3mm stroke length
  - 5000 cycles: 2mm stroke length
  - 10000 cycles: 1mm stroke length
- Speed of 2mm/sec
- Force of 1N (newton)



Figures 3. Multistage tribometer.

Results

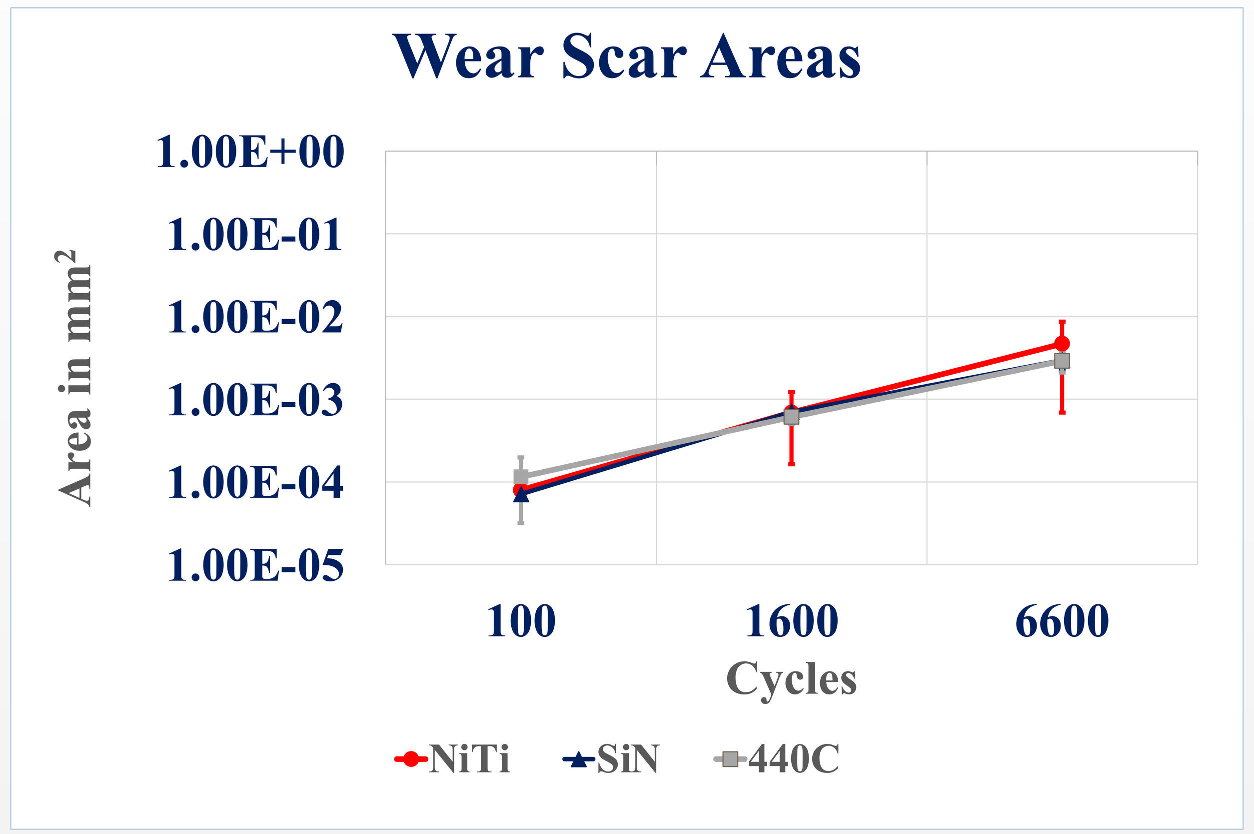


Figure 4. Areas were collected from the 100, 1000 (1600 total) , and 5000 (6600 total) incremental test cycles on the wear scars.

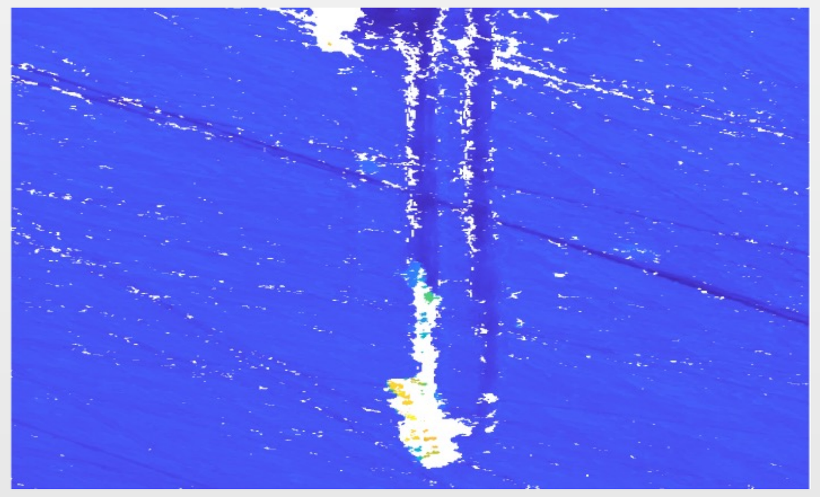


Figure 5. Sample 1 wear scar after 100 cycles against the NiTi 60 countersurface

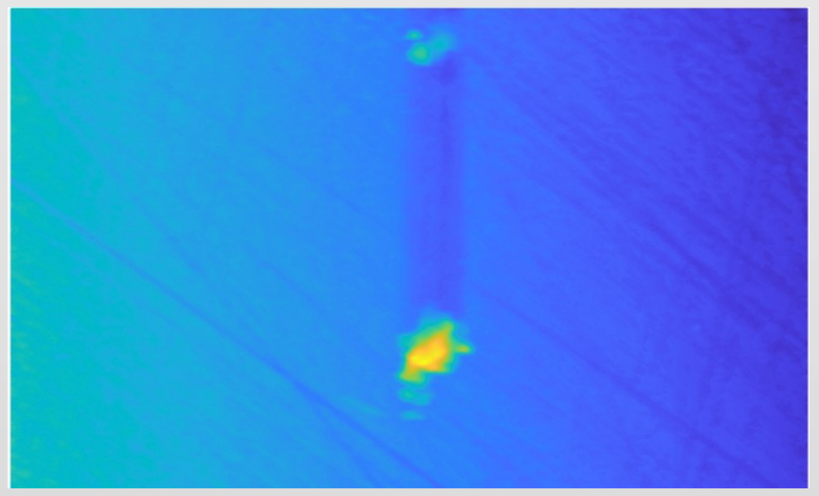


Figure 6. Sample 2 wear scar after 100 cycles against the SiN countersurface.

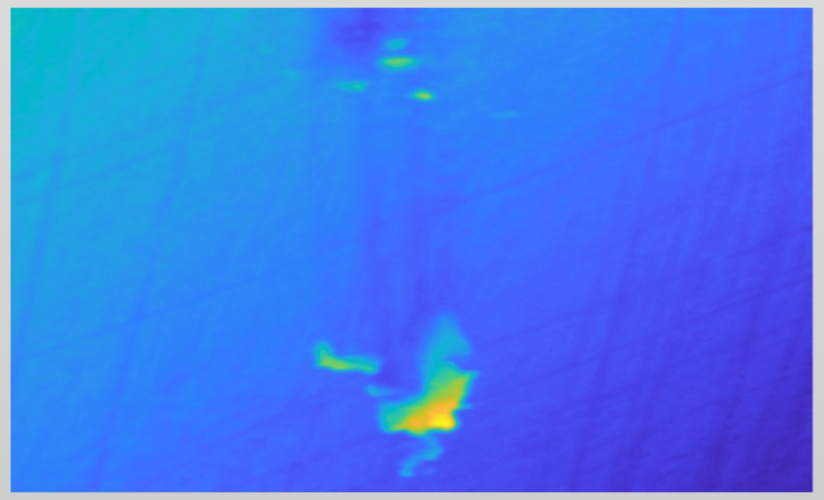


Figure 7. Sample 3 wear scar after 100 cycles against the 440 C countersurface.

Conclusion

- NiTi 60 shows a constantly stable relationship after frequently scratching the surface
- Similar wear integrity is shared against NiTi 60, SiN, and 440 C counter samples
- In the further progression of this project, we intend to inspect the wear behavior against coated NiTi samples of DLC or MoS2 in relation to the coated 440 C samples

References

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Acknowledgments

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