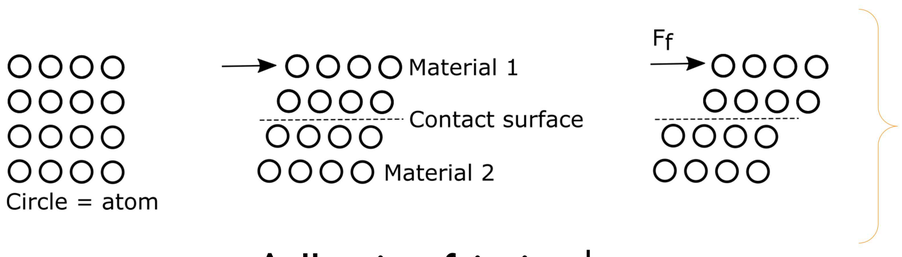
SAND2019-8345D

Friction and Wear to Inform Material Selection

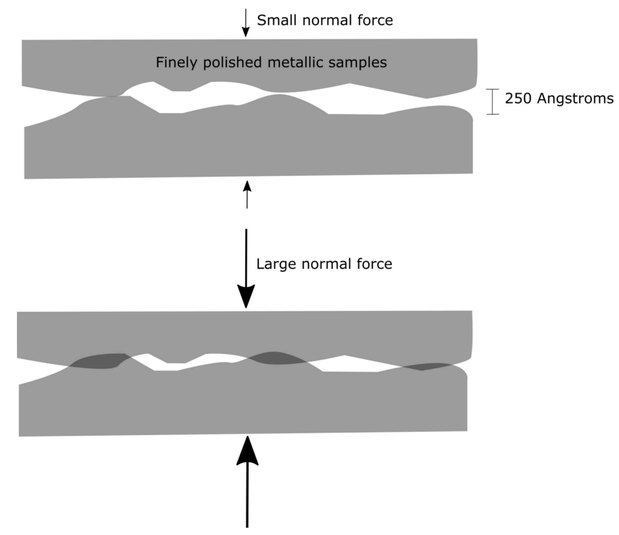
Objective: predict assembly/disassembly forces and wear of component surfaces by quantifying the friction and wear between material combinations of interest

What is FRICTION really?



Adhesive friction[1]

There are two main mechanisms of friction: (1) adhesive and (2) abrasive. It is generally accepted that adhesive friction accounts for the majority of frictional forces[1]



Close-up view of contact surfaces

How to quantify friction and wear?

Experimentally. Friction and wear are very dependent upon the circumstances – (1) materials in contact, (2) surface conditions (roughness, lubricated vs. dry, surface finish), and (3) environmental conditions (temperature, humidity). Thus, experimental conditions mirroring conditions of application yield useful results[3]

Tribology: the science of interacting surfaces in relative motion

In general, friction and wear are directly proportional to the normal force applied and can be captured with the friction coefficient and wear rate[2, 5]

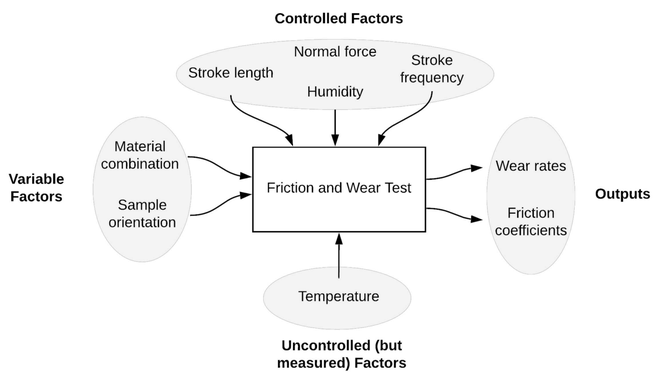
$$\mu = \frac{F_t}{F_N}$$

Friction coefficient[1]

$$K = \frac{V}{L * F_N} \quad \left[\frac{mm^3}{N - m}\right]$$

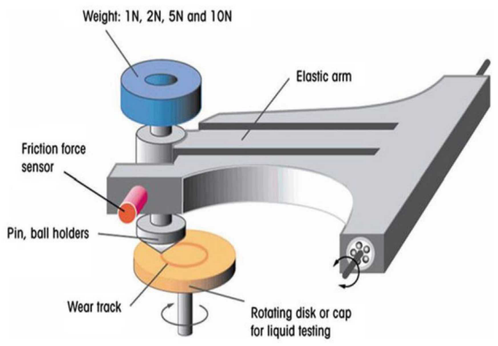
Wear rate[1,5]

Experimental design and analysis plan



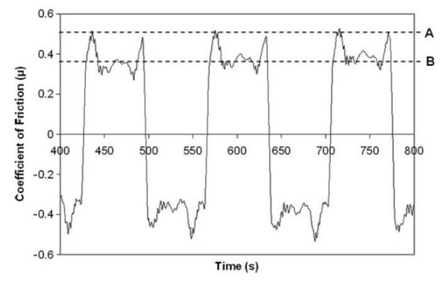
Experimental Summary

Friction and wear data between two material combinations (Aluminum / UHMWPE and UHMWPE / GFRP) will be gathered in a table similar to the table below and summarized as the friction coefficient and wear rate



Experimental Tooling Example[2]

A linear reciprocating tribometer will rub two material samples together with a constant normal force while measuring the resultant tangential (frictional) force. Wear is determined by removing the samples and measuring volumetric loss either by weight, profile, or some visual means[4]



Tribometer output example[2]

Statistical analysis plan

Two-way ANOVA – to determine statistical significance of difference in friction and wear between (1) material combinations and (2) orientations

Anticipated outcomes

The outputs of the tribology will be used to calculate the friction coefficient and wear rate between each material combination. With an understanding of the friction forces and wear characteristics, the team will be better informed in making the component material choices

Deliverables of tribology experiment

Material combination (top / bottom)	Orientation of glass fibers (relative to motion)	Friction Coefficient			Wear Rate		
		Mean	Standard Deviation	Coefficient of Variation	Mean	Standard Deviation	Coefficient of Variation
Al / UHMWPE	N/A						
UHMWPE / GFRP	Parallel						
Al / UHMWPE	N/A						
…	…	…	…	…	…	…	…

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References:
1. Bowden, F. P. Friction; An Introduction to Tribology. (1973).
2. Menezes, P. L. Tribology for Scientists and Engineers. Springer Science Textbook (2013). Part 1, Chapter 4.
3. Gobind. Techniques of Measuring Wear for Bulk Materials and Advanced Surface Coatings. Journal of Mechanical and Civil Engineering (2015).
4. ASTM G133: standard test method for linearly reciprocating ball-on-flat sliding wear
5. Holmberg, K. Coatings Tribology: Properties, Techniques and Applications in Surface Engineering. Tribology Series, 28 (1994).

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