Concept Generation

Introduction

The process of generating concepts is most effectively undertaken using tools such as morphological charts, biomimicry, crapshoot, forced analogy, anti-problem, and battle of perspectives. The concepts ideated through these methods are detailed in Appendix D of the evidence manual. Highlighted below are the top three high-fidelity and top five medium-fidelity concepts. Predominantly, the anti-problem tool was employed for concept generation.

Concept Generation Tools

The initial challenge addressed was devising a way for the sample to either fall or not be held in place. Potential solutions included removing the normal load, eliminating a mounting point, or suspending the sample with a string. Consequently, we developed a sample holder design that applies a normal load, potentially incorporating a set screw or clamp for securing the sample.

Next, we tackled how to avoid regulating the chamber's temperature. Suggested non-solutions involved leaving the heater or nitrogen supply continuously or excluding temperature control elements. This reverse brainstorming led us to a design that uses heaters and nitrogen to control the temperature range effectively.

The third problem was how to not calculate the coefficient of friction. By considering the elimination of the friction surface, applied load, and translational or rotational forces, we were guided to a solution that involves a frictional surface capable of rotation or translation relative to the test sample's bottom plane.

Lastly, we questioned how to ensure the system remains operational during emergencies. Contrary suggestions included maintaining uninterrupted power, ensuring the vacuum continues, and omitted a kill switch. These discussions brought us to the implementation of a kill switch that can swiftly terminate power in an emergency.

High Fidelity Concepts

Concept 1: Six Mini-Identical Tribometers Side by Side

The tribometer setup will feature six mini-tribometers arranged in two rows, with each row containing three devices positioned back-to-back. We will focus our analysis on a single tribometer unit. This tribometer will employ two slides to exert normal and lateral forces, which will be measured using load cells and strain gauges. It will include a copper slide chosen for its excellent thermal conductivity, paired with a detachable surface that induces friction. To regulate the temperature, Minco space heaters will warm the copper slide to up to 200 degrees Celsius, while a cooling system, anticipated to incorporate Swagelok components, will dissipate excess heat. This will essentially be a combination of the humidity and nitrogen cooled tribometers systems used at the lab. Figure 2 is a rough sketch of the concept.

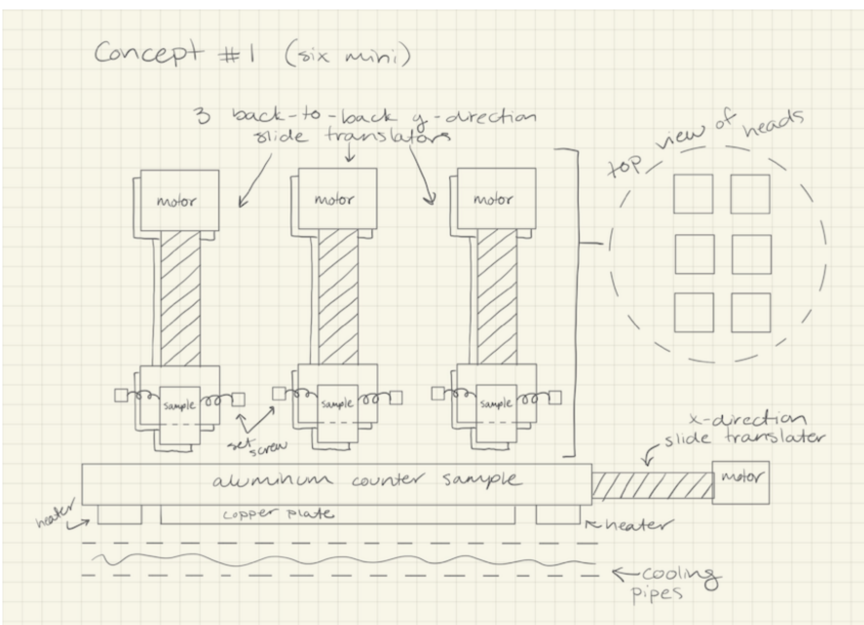

Figure 2. Six Mini-Identical Tribometers Side by Side.

Concept 79: Cross-Headed Sample Holder

This tribometer system works with a cross-headed sample holder in the top where four samples are loaded into the system, and it tests one sample at a time. After finishing the first test, a motor on top of the crosshead sample holder will rotate the head so the next sample will be tested. The parameter conditions applied to each sample are independent from each other. After ending each test, the system accepts the new inputs to regulate the parameters for the next test. The shape of the sample holder ensures there is no cross contamination between tests. The advantage of this system is that four samples can be tested without removing vacuum. Figure 3 is a rough sketch of the concept.

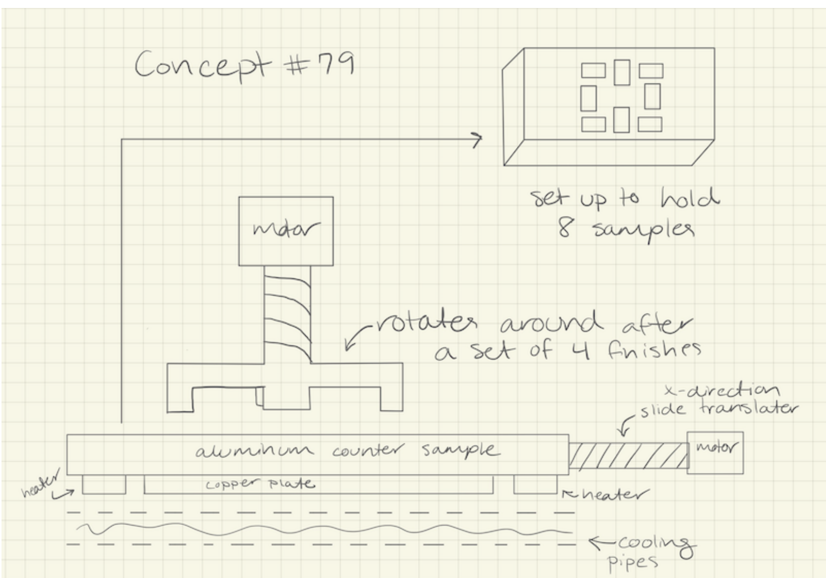

Figure 3. Cross-Headed Sample Holder.

Concept 4: Weights Loaded on Samples to Produce Normal Load

This tribometer system features a series of six hollow tubes, each designed with an end capable of securing a sample via set screws. Upon the placement of a predefined mass into the tube for y-axis translation, ensuring proper contact. Meanwhile, a separate mechanism facilitates x-axis movement to generate friction on the sample's bottom surface. The system incorporates a thermally conductive copper slide with a replaceable friction surface. Temperature control is achieved through Minco space heaters and a Swagelok component-based cooling system. All signal and signal processing hardware will be selected later. Figure 4 is a rough sketch of the concept.

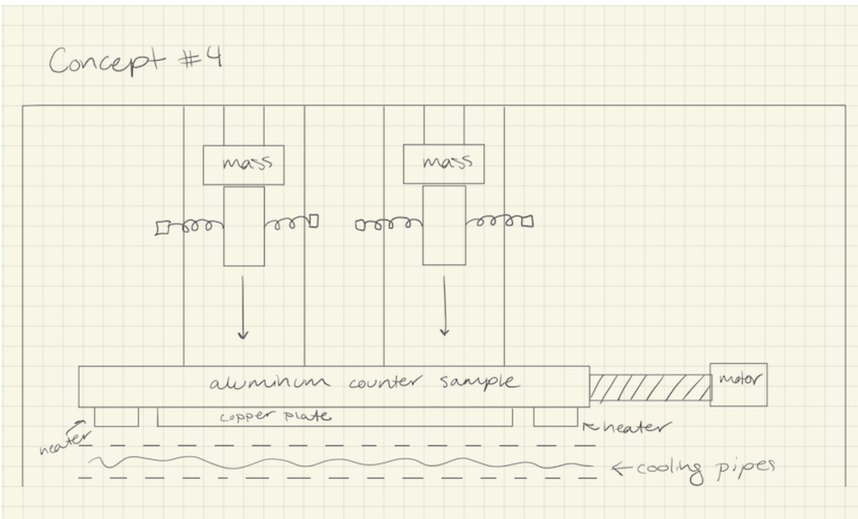

Figure 4. Weights Loaded on Samples to Produce Normal Load.

Medium Fidelity Concepts

Concept 97: Tribological Samples are Nested Together

This concept involves changing the way a traditional tribometer holds test samples. It places progressively smaller specimens within each other, allowing for testing at different scales in a single experiment. Sample preparation will be crucial to prevent errors or inaccuracies when testing. Each sample would still need its own testing parameters. This can be accomplished by testing the outermost sample and working inwards towards the smallest sample. The advantage of this concept is that it will allow comparison of samples side by side, allow testing of different sample sizes and the time that would be saved pressurizing the vacuum chamber. Figure 5 is a rough sketch of the concept.

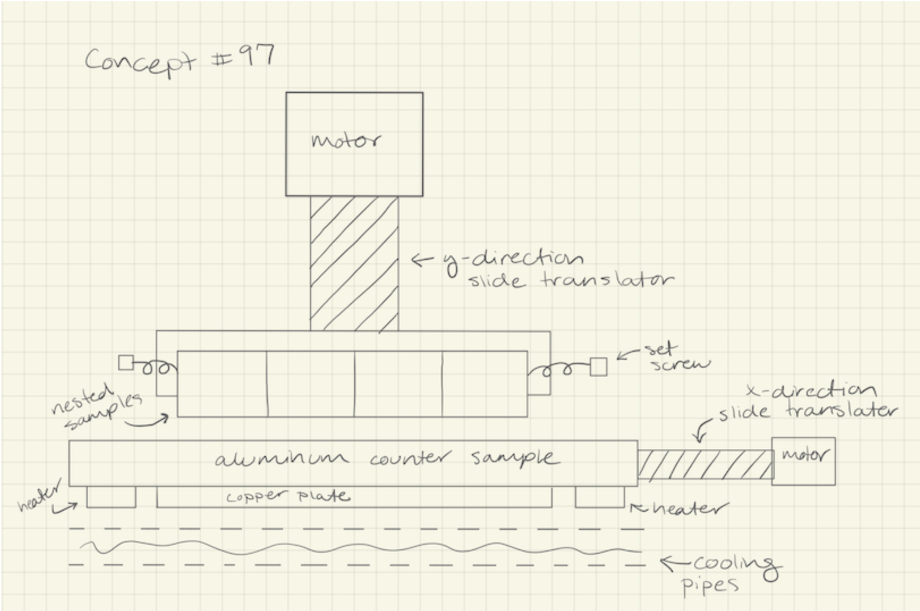

Figure 5. Tribological Samples are Nested Together.

Concept 8: Pin-on-Disk Tribometer with Four Different Samples at Different Radii

This system consists of a variation of the Pin-on-Disk Tribometer where more than one sample is tested using the same contact surface. The samples are going to be held simultaneously at different radiuses on a disk which is going to rotate using the torque generated by a motor. This system will allow the user to test 6 different samples at the same time. The samples are going to share conditions such as temperature and pressure, but parameters such as normal force applied on the sample can vary. The advantage of this concept is the amount of data collected from one test. Figure 6 is a rough sketch of the concept.

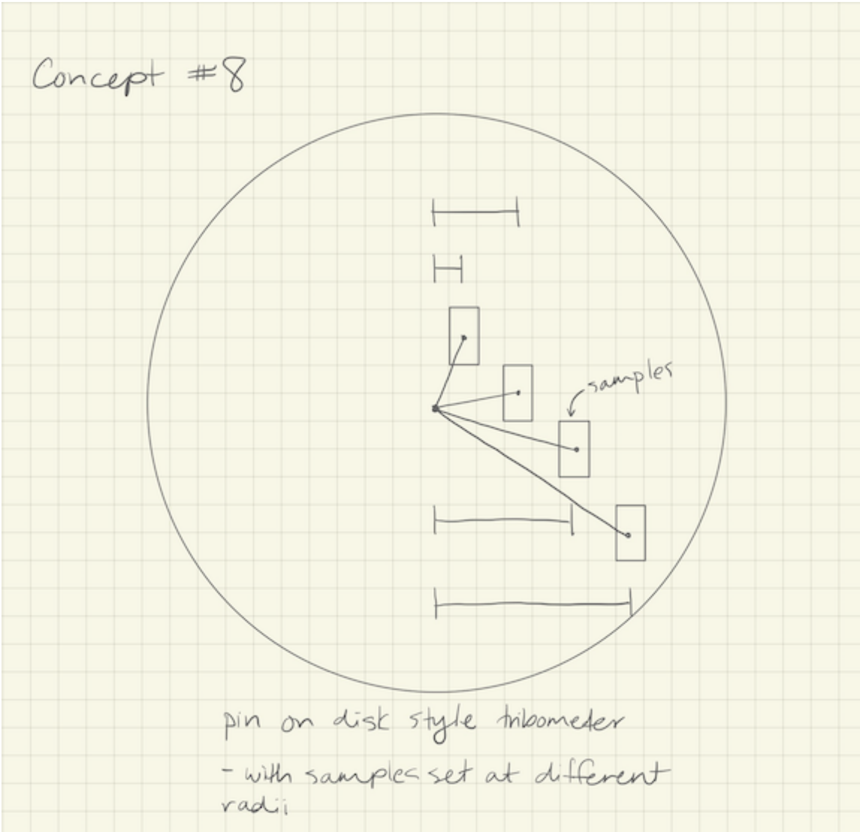

Figure 6. Pin-on-Disk Tribometer with Four Different Samples at Different Radii.

Concept 52: Inverted Existing Tribometer

This concept puts a spin on the traditional tribometer setup. Traditionally, the tribometer head holds a sample flush to a translational stage. In this design the translational stage is between the tribometer head and the sample. This modification enhances the versatility of the tribometer. This new configuration allows for finer control of parameters, improved accessibility of the samples, and reduced contamination from tests. This concept can test multiple samples by using a batch testing method. Multiple samples can be aligned in the testing chamber and texted by the overhead translational stage. Other options for high throughput testing include an automatic sample loader and a rotating lower platform to switch between samples. Figure 7 is a rough sketch of the concept.

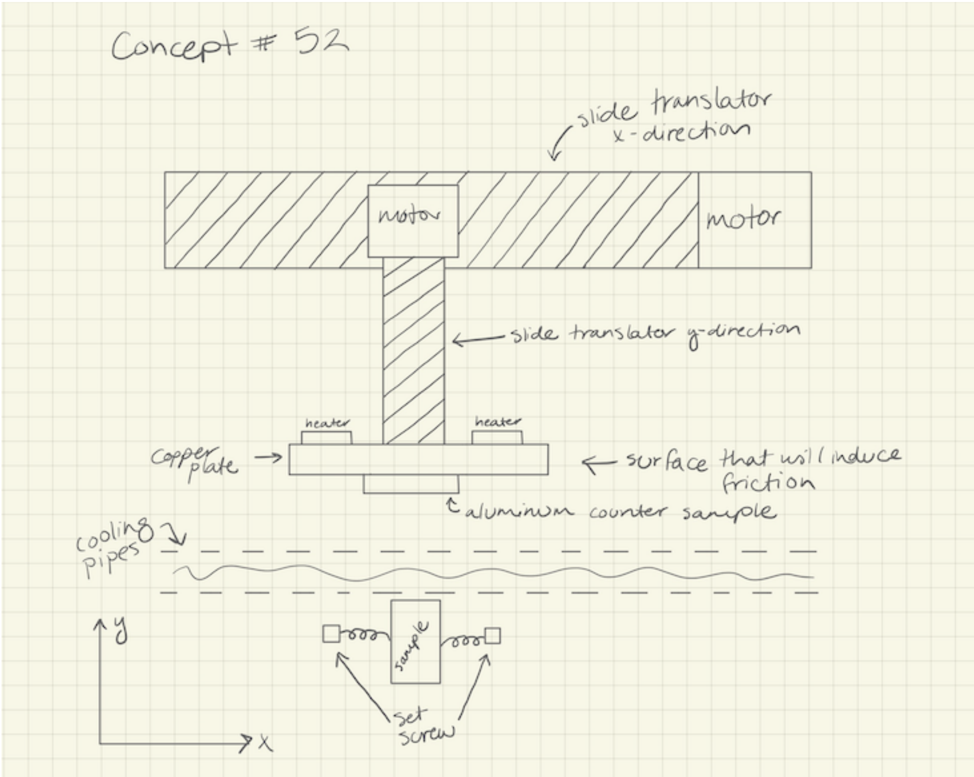

Figure 7. Inverted Existing Tribometer.

Concept 51: Rake Tribometer

This concept involves designing the arms like a rake. By doing this the user can test up to six samples at once. It involves a motor in the y-direction applying a similar load onto each sample. A motor in the x-direction is used to slide the aluminum counter sample against the samples. Cooling and heating are connected to the aluminum counter sample to regulate heating and cooling. The advantage of this concept is the high throughput of samples. Figure 8 is a rough sketch of the concept.

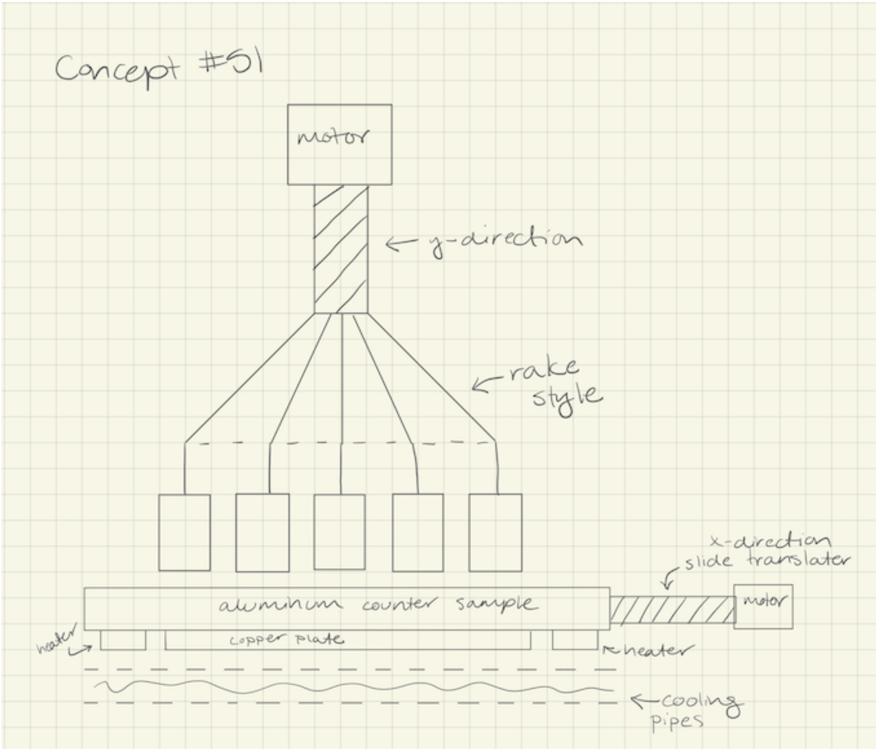

Figure 8. Rake Tribometer.

Concept 89: Modular Tribometer

This concept involves designing a system for a tribometer that will have interchangeable parts which can include sample holders, load cells, stages and sensors. This versatility of the tribometer will allow for the test of multiple samples depending on the conditions needed for the test. The idea behind this concept is to design the tribometer in a way that it can be easily assembled and disassembled. Standardized interfaces, rail systems, mounting plates, quick release fasteners, and interchangeable stages are all ways to make a modular tribometer. The advantages of this design will be the flexibility it offers, the reduced cost due to the interchangeable parts and the scalability for future use. Figure 9 is a rough sketch of the concept.

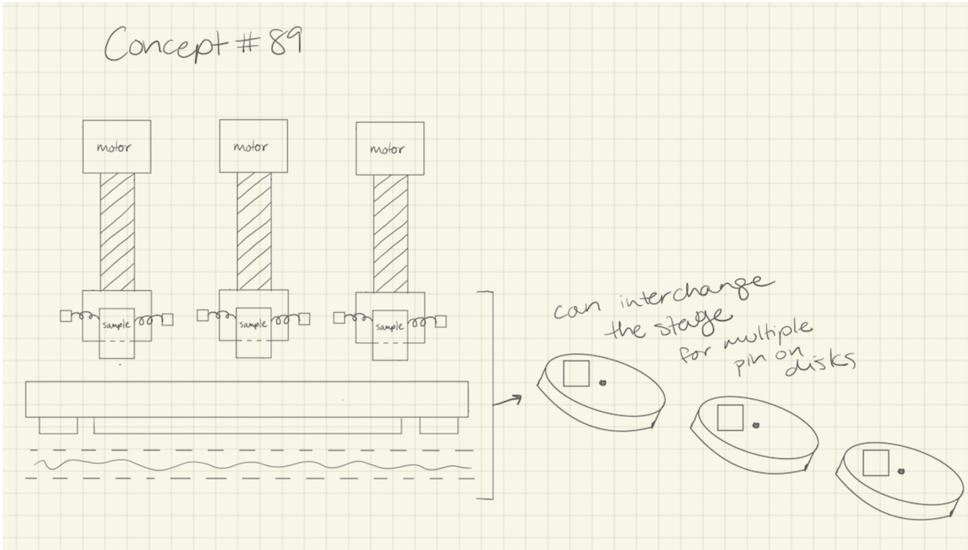

Figure 9. Modular Tribometer.