Functional Decomposition

Introduction

Functional decomposition is the breaking down of larger actions and outcomes from the customer needs into smaller, more manageable and understandable parts or functions. The larger the action or outcome, the broader the overall categorical functionality; thus, further specification is required. The largest of the actions and outcomes posed for our project are inputs, outputs, and testing. To effectively organize our functions by systems, a hierarchy chart was created – Figure 1. To compare each function and determine which are most important a cross reference chart was created – Figure 2. The importance of each function was established by how many systems a particular function could satisfy.

Data Generation

The functions were determined based on both project scope and customer needs. These functions are meant to describe what the project needs to do and become more specific with the constraints outlined in the scope and customer needs. The customer needs were supplied by the primary market, Dr. Krick, Kylie Van Meter, Adam Delong and 3M. Their needs were interpreted into the functions of our system. The hierarchy chart in Figure 1 below shows the relationship of these functions.

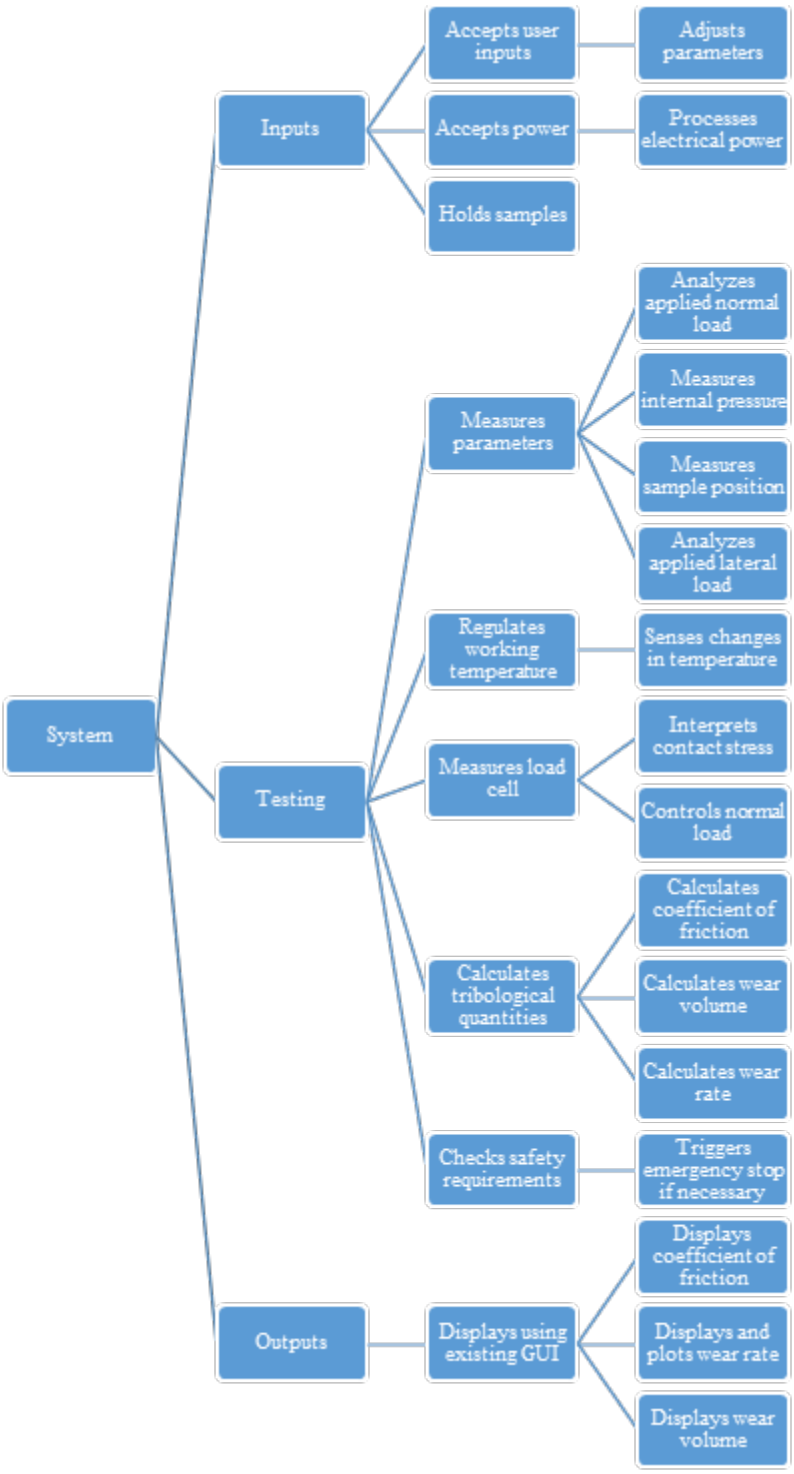

Figure 1. Hierarchy Chart.

Discussion

The objective for this project is to design and implement a system to test multiple samples simultaneously using a tribometer within a vacuum. Looking at our customer needs, we determined that it is necessary for the system to accept user inputs, be able to run tests, and give outputs back to the user. These high-level functions fall under the first level of the design for the system.

The first group selected on our functional hierarchy chart was input. The system will be responsible for accepting user input. This will allow the user to run the tribometer under the specific parameters they wish. The system must also be able to measure parameters such as temperature, load, and pressure as well as displacement and the coefficient of friction of the sample. Temperature must be accounted for because it affects the mechanical properties of the samples which in turn affect friction and wear. The load applied must be accounted for to determine contact force between surfaces, greater contact force leads to greater wear. Pressure distribution can affect the overall wear pattern of the sample and must also be accounted for. Displacement provides information on the wear pattern and deformation of the materials in contact, wear rate is a function of the displacement of the sample and therefore is necessary to control. Lastly, the system will be able to store these inputs for calculations and so the user and future users can review the parameters set for testing and make changes when necessary.

The next high-level function of the system is testing. The testing function pertains to everything the tribometer will do within the vacuum chamber. First, the tribometer will initiate sensor readings. While the system is running within the vacuum it will test applied normal force under the controlled parameters mentioned above for at least one sample. The normal force represents the load applied perpendicular to the sample and surface in contact. It directly impacts the

contact force, wear, and deformation of the sample which all can be used to calculate the coefficient of friction of the sample. The system must also test for an applied lateral force under controlled parameters for at least one sample. The lateral force is the resistance to relative motion between the sample and the surface. It is responsible for overcoming the friction between the surfaces. Using the results from the forces applied the system will then be able to calculate the critical targets, coefficient of friction and wear rate. Ideally, the system will be able to perform these tests to multiple samples simultaneously.

The last high-level function for the system is output. Outputs are essential because they serve as the results for testing. The system returns stored inputs to validate the conditions established for the test. The system should use the conditions set by the user to return critical targets based on the test to calculate the desired outputs, coefficient of friction and wear rate. Tribometry is the study of friction and wear, therefore they should be explicitly outputted by the system. The resultant outputs would be used to clarify the mechanical properties of the different samples.

Functional Relationships

Table 3
Functional Cross Reference Table.

	Inputs	**Testing**	**Outputs**
Accepts user input.	X	X	
Accepts power.	X	X	
Holds samples.	X	X	
Measures parameters.		X	X

Regulates working temperature.	X	X	X
Measures load cell.		X	X
Calculates tribological quantities.		X	X
Checks safety requirements.	X	X	X
Displays using existing GUI.			X

The functional cross-reference above gives an overview of the priority level for each system based on the number of functions required by each of the final goals of the project. Testing ranks above every function in the system followed by outputs and then inputs. The chart also serves as a reference guide for the function's relationships and the way they interact in the overall system. The overlap between the functions and their respective categories demonstrates how each category helps the next. The input parameters provided by the user set the tribometer up for testing and the test results are then used for calculations which are outputs of the system. By using the chart, we determined that two subcomponents are critical for our system to function correctly. Regulating working temperature is a function that is first established by the user in the inputs section, then it keeps working through the testing conditions and is displayed in the outputs to calculate the critical targets expected from our system. Also, interpreting contact stress has a similar roll because when establishing a load parameter in the inputs, the system uses the contact area of the sample to interpret a stress in the testing section, and finally displays this stress in the output section to calculate parameters such as wear rate.] Inputs represent the data the system takes in from both the user and sensors. This section is the least important according

to the output of the cross-reference table. However, the most important factors to the inputs categories consist of user inputs, active measurements, and storing initial inputs to output later. The testing feature is where the set inputs create the wanted environment and the system starts its process to determine the desired outputs for the material. During the test, sensor readings must be initiated and then a normal and lateral force will be applied. The sensors will work to keep the environment steady and to gather data for the critical targets.

In this system, the functional relationships among the various components and outputs work together to form the overall system. The system begins by storing the initial inputs related to the sample then it measures the contact stress applied to the sample. It calculates the coefficient of friction and wear rate. Additionally, the system displays the coefficient of friction, wear rate, sample displacement, contact stress, and temperature to convey information to users. Overall, integrated functional relationships are vital for the system.