Design Criteria and Target Specifications

George Lau, Jake Beattie, Jorge Preciado, Luka Braculj, Steven Lin

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Abstract

This is a document which explains the needs of the client and users and expands on the importance of those criterion which have been collected from benchmarking, and a client interview.

Introduction

The client has requested the students of the University of Ottawa to make an erosion testing system. As the second part of the design process, our team has taken the data from the client and users in order to create a list of requirements to base our design off of.

Related Work

Title: A new impact erosion testing setup through Coriolis approach

Coriolis wear testing is a valuable and practical approach to study the erosive wear of a material within a centrifugal slurry pump and other applicable systems. Impact wear mode is a significant component in erosive wear and simulation. Existing Coriolis erosion testers are primarily for evaluation of sliding wear. Although a few impact wear testing structures were previously proposed within a Coriolis wear testing apparatus, they presented major limitations and low effectiveness. …

Title: Accelerated High Speed Water Erosion Test for Concrete Wear Debris Analysis

This paper contains investigations of wear particles generated during the erosive wear of four different concrete, mixtures by high velocity water flow at velocities of about 700 m/s.[i] The wear particles were collected, dried and analyzed by sieve experiments. Based on the sieve analysis, specific surface and average grain diameter of the particle samples were estimated. 'Using simple, comminution relations, the specific crack length of every' sample is calculated. It is shown that all estimated parameters exhibit a strong relationship to characteristic material properties, such as compressive strength, Young's modulus, and absorbed fracture energy. …

Title: Control and evaluation of particle impact conditions in a sand erosion test facility

For the prediction of actual damage to plant component materials and for making the erosion mechanisms clear, it is important to control and to evaluate the particle impact conditions in a testing facility. A sand blast type erosion test rig, which can achieve the particle impact velocities up to 135 m s^{-1} and a wide range of impact angles has been constructed. The key factors in particle impact conditions of particle flux, impact velocity and impact angle were examined. The relative distance between particles and particle size was discussed, as the particle flux affected erosion rate of material. …

Benchmarking

Based on our research in past examples of solutions for erosion testing, we found that successful implementations of erosion testing systems tended to use a principle of high velocities to rotate the desired material, in order to be eroded. The use of centrifugal force to move the fluid would also increase the flow speed, causing more interactions between the material and the fluid of which is eroding the material. The use of concrete based materials would assist in lowering the amount of time per test, as well as increase the reliability of the results, allowing a better turnaround time for prototypes. Exposing the material to stress and erosion stimulates, such as acids or bases, would emulate real life conditions when rain falls on the tested materials at a given velocity, and pH level, Increasing the rate at which the material would erode.

Design Criteria

Based on the research conducted within the benchmarking stage along side the interview with the client, our team decided on a rating of importance of design criteria which have been organized into a table based on their relative categories.

Figure 1. Design Criteria Table.

High priorities (functional requirements)	**Non-functional requirements**
• ***The design must be safe for everyone (user, designer, customer, etc). Operate with fluid under 40ºC and regulated rpm to ensure safe testing*** • ***The product has to test erosion within 1-2 weeks for testing cycles*** • ***The design has to yield consistent and reproducible results***	• ***The total price of the design must be less than 100 CAD (maximum 120 CAD)*** • ***Test erosion by weighting the sample of material before and after the time frame*** • ***Test with different materials*** • ***Use a spinning system or high speed fluid flow***
Abrasive/Part Factors	**Results**
• ***Viscosity of the fluid*** • ***Energy inputs*** • ***Deformation form change in temperatures*** • ***Size*** • ***Material*** • ***Pressure*** • ***Density*** • ***Speed*** • ***Fatigue behavior*** • ***Work in ambient conditions***	• ***Results should be accurate and verifiable*** • ***Data collection methods should be repeatable and measurable*** • ***Use particle weight to determine erosion*** • ***Record conditions of erosion***
Metrics	**Constraints**
• **Determined testing cycle time** • **Data accuracy and repeatability (mass measurements, speed, stress, friction, forces)** • **Cost-effectiveness of materials**	• ***The system should not represent any safety setbacks for the builders or lab environment*** • ***Budget restriction for material and system prototype*** • ***The project should be done and working before mid-April (not constraint with the design but the time we have to make the design)***

As a result of the research conducted, our team decided that the importance of each section was: Functional Requirements, Constraints, Results, Metrics, Part Factors and then Non-functional Requirements in that order from most important to least important.

On top of the priorities of this list, specifications as to the results and construction constraints were also determined, with the use of our notes from the meeting with the client as well as the benchmarking that was completed. Based on this data, it was determined that any abrasive used would be specified to be a fine compound of sand in order to add grit to the erosion and to not damage the system at the same time. In respect to rotation specifications, it was determined that wheel specifications should be roughly 169mm in diameter, 12.7mm in width, with a clearance of 3mm between the wheel and the machine, as well as an rpm range of 400 - 1600. Due to severe budget and time constraints, utilizing cheaper alternatives to more effective materials is crucial in order to stay under budget. With this in mind, our team determined that using high quality plastics instead of steel or aluminium would reduce costs while maintaining an affective housing for the erosion testing. Using a high-density polymer between the density of 0.940 and 0.970 grams per cubic cm, at a casing of around 37.2 – 51.1 grams. Dimensions for the housing were also determined in order to house the disk of material being tested on. These dimensions would be 174mm x 174mm x 18mm for the size of the testing material as well as the clearance indicated earlier and 5mm thickness of the housing walls. The internal volume of the casing will have a value between 40,000 and 53,000 cubic millimeters. The area of the internal rotating plate would be around 4,000 to 15,000 square millimeters. In order to make sure the test rig is characteristic to standard water erosion conditions the ratio of sand to water would have to be 1 gram of abrasive to between 4 and 40 millilitres of water. As a result of safety precautions, it was also determined that the system must remain below 40 degrees Celsius as well as keeping the internal pressure between 96kPa and 106kPa, and that the pH of the system remains between 5 and 8. This is to ensure that if anything goes wrong with the machine and consequences will be minimal if workers are working closely with the machine.

Conclusion

In conclusion, the system should have safety systems in place in order to reduce the risk of injury to the users as well as maintaining a reliable and cheap system that to test the effect of erosion of real world while using fluid mixed with abrasive material in order to stimulate erosion on the test material.