PROJECT IDEA SUBMISSION – *RESEARCH*

LABORATORY INFORMATION

Name: IMPULSE Research Lab **Date:** 09/12/2024

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PROJECT NAME

UNDERWATER AUTOMATED LEVELLING TABLE

GENERAL PROJECT DESCRIPTION

This project focuses on automating the sample leveling process in ultrasonic nondestructive evaluation, where samples are submerged underwater for characterization using different frequency transducers. In traditional pulse-echo data acquisition, the inspection surface must be perpendicular to the transducer, a task that currently requires manual adjustments. The proposed solution is to design an automated leveling table that can be submerged in water and hold the samples, allowing precise alignment of the surface. The system aims to achieve a leveling precision of 15 µm, streamlining the process and improving accuracy.

WHAT IS THE MECHANICAL ENGINEERING PROBLEM (APPARATUS) YOU ARE WANTING SOLVED (BUILT)?

Problem Statement: The current manual process of leveling a sample for ultrasonic NDE system requires repeated adjustments to ensure the surface is perpendicular to the transducer. This manual adjustment is inefficient and prone to error.

Desired Apparatus: There is a need for an automated, submersible leveling table with motorized, independently adjustable legs. The table must be able to hold and precisely adjust the sample surface to within a 15 µm tolerance, ensuring perpendicularity to the ultrasonic transducer. The system must function underwater, allowing smooth operation and remote control for fine adjustments.

WHY IS THIS PROBLEM (APPARATUS) WORTH SOLVING (BUILDING)? (Value Proposition)

This problem is worth solving because it addresses the inefficiencies of manual adjustments in ultrasonic scans. Currently, aligning the sample surface to be perpendicular to the transducer requires at least 10 iterations, with manual adjustments between each scan, taking 40-60 minutes overall. This process is not only time-consuming but also prone to human error, leading to inconsistent results.

An automated leveling apparatus has the potential to significantly improve precise alignment and reducing the iterations. Automating this task could enhance inspection consistency and repeatability. However, developing such a system will require collaborative effort from the team to design, prototype, and fine-tune the apparatus to ensure it meets industry standards for accuracy and precision.

WHAT ARE THE MOST IMPORTANT FUNCTIONAL REQUIREMENTS AND SPECIFICATIONS FOR THIS PROJECT?

Requirement 1: The apparatus must automatically adjust the sample surface to be perpendicular to the ultrasonic transducer.

- ***Spec 1:*** The leveling table must have three or four motorized, adjustable legs.
- ***Spec 2:*** Each leg must be independently controlled to achieve precise height adjustments.

Requirement 2: The apparatus must function in a submerged environment for ultrasonic testing.

- ***Spec 1:*** The table and motors must be waterproof and corrosion resistant.
- ***Spec 2:*** The table must hold the sample securely underwater without movement during adjustment.

Requirement 3: The leveling system must achieve precise surface alignment.

- ***Spec 1:*** The apparatus must provide alignment accuracy of 15 µm (0.01 µs) or better.
- ***Spec 2:*** The system must use real-time feedback for adjustment, ensuring the surface is perpendicular within two iterations.

Requirement 4: The system must operate efficiently to reduce iteration time.

- ***Spec 1:*** The automated process must complete the leveling and alignment within 5 minutes.
- ***Spec 2:*** The adjustment must reduce the number of scans required to 2, compared to the current 10 manual iterations.

WHAT DO YOU ANTICIPATE THE STUDENTS DESIGNING, ANALYZING, BUILDING/PROTOTYPING AND TESTING? BE AS SPECIFIC AS POSSIBLE.

Design: Students will design an automated leveling table with motorized, adjustable legs capable of precise adjustments in a submerged environment. This includes creating a robust frame to securely hold samples underwater, selecting appropriate waterproof motors and control systems, and integrating sensors for real-time feedback on surface alignment. They will develop a control algorithm that ensures the sample surface aligns perpendicularly to the ultrasonic transducer, achieving a precision of 15 μm.

Analyze: Students will analyze the mechanical stability and durability of the table under submerged conditions. This includes load-bearing analysis for the legs and frame, ensuring the motors can withstand water pressure and corrosion. They will also evaluate the precision of the leveling system, determining the effectiveness of the control algorithm and sensor feedback in achieving the required surface alignment with respect to different sample weights.

Build: Students will prototype the automated leveling table using 3D-printed or machined components, waterproof motors, and electronic control systems. They will assemble the system, ensuring that all components are sealed and protected for underwater use. The prototype will include the motorized legs, sensors, and control electronics, integrated into a compact, submersible structure that can hold samples securely.

Test: Students will test the apparatus in an ultrasonic tank, evaluating the system's ability to automatically level the sample surface to within 15 μm. They will conduct repeated ultrasonic scans for different samples to compare the results of the automated system against manual adjustments, measuring time savings and precision.

WHAT IS YOU BEST ESTIMATE OF THE COST OF THE HARDWARE, COMPONENTS, MATERIALS, … OF THE PROPOSED PROTOTYPE?

- Electronics (**$3500),** Frame and Materials **($1300),** Miscellaneous (**$ 200)**
- Estimated Total Cost**: $ 5,000**

HOW MUCH TIME AND EFFORT WOULD YOU EXPECT TO SPEND ON THIS PROJECT IF YOU WERE DOING IT INTERNALLY?

Total time: 200 hours (Development and advising)

Timeline: 4 months

DO YOU BELIEVE THE PROJECT CAN BE COMPLETED WITH EXISTING TECHNOLOGY, IF NOT, ELABORATE ON NEEDED DEVELOPMENTS?

Yes, I believe the project can be completed using existing technology, but the design and development process will require significant student effort. While components like waterproof stepper motors, motor drivers, precision sensors, and corrosion-resistant materials are commercially available, students will need to research, select, and integrate these technologies into a custom solution. The challenge lies in adapting these components to work together in a submerged environment while maintaining the required 15 µm precision. Key aspects, such as waterproofing, sensor accuracy, and control system development, will need to be carefully engineered and tested by the team.

CONCERNS OR OTHER RELATED INFORMATION ASSOCIATED TO THE PROPOSED PROJECT?

Concerns: **NONE**

Other Info:

ATTACH ANY APPROPRIATE SKETCHES, DRAWINGS, STANDARDS, DATA, PHOTOS, … USEFUL IN JUDGING APPROPRIATENESS AND SCOPE OF PROPOSED PROJECT.

NA

ARE YOU WORKING WITH ME SENIORS WHO YOU WOULD LIKE ON THIS PROPOSED PROJECT? YES/NO (If YES, provided what information you can.)

NAME	PUID	PHONE	EMAIL

Save this filled out .docx with the following naming nomenclature: “RESEARCH_*project name* – *student point of contact full name*.docx” where the *italic strings* get replaced with appropriate actual text strings.

If you have any questions concerning a proposed project or completing this form please contact Professor Greg Jensen.

To submit this document for consideration, please complete the survey using either the QR code or the link below.

https://purdue.ca1.qualtrics.com/jfe/form/SV_bkCjo7jyE5Wb7ro

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