Mobile Temperature and Humidity Control Chamber

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***Abstract*—Point-of-care (POC) testing devices aim to bring affordable and convenient illness detection to resource limited locations. Our lab has developed a POC tool that detects human papilloma virus (HPV) by applying lateral flow immunoassays and fluorescence detection. However, this device requires specified temperature and humidity settings to produce reliable results. Therefore, when examining samples in the field, the need for a portable, climate-controlled chamber is prominent. By combining low cost electronics and household items, a simple feedback loop is designed to regulate the internal conditions of a potential testing environment. The ability of our chamber to maintain a desired climate will be tested for accuracy and stability to ensure that it is competent for in-field usage.**

~Index Terms: Point-of-care, climate chamber, portable, assay

INTRODUCTION

POC devices provide on-site disease detection, making them ideal for impoverished areas where medical care is not readily available [1]. By bringing diagnostic tools to these settings, residents may receive crucial health information that was previously unattainable. Our lab focuses on HPV as it accounts for over 70% of cervical cancer cases and is prevalent in low resource settings [2]. The POC device we developed uses lateral flow immunoassays and fluorescence-based detection to identify the virus. However, the sensitive nitrocellulose membrane found on assays requires a controlled climate for reliable results. In order for medical professionals to offer on-site findings, an environmental chamber that can maintain a specified temperature and humidity is required. Though commercial climate chambers exist, they are expensive, immobile, and impractical for austere environments. Therefore, the objective was established and the mission to develop a low-cost, transportable, and efficient chamber was underway.

To regulate the internal environment, a simple feedback loop is designed. The Adafruit HTU21D-F sensor is installed on the inner wall of a conventional cooler [3]. The sensor data is interpreted by the Arduino MKR 1010 and the error between the current climate values and set points is calculated. This information is used by the controller to modify the enclosed conditions as needed. A bang-bang and PID controller are implemented and their effectiveness is compared. We believe the PID controller will be capable of greater precision than the bang-bang's simple logic. Because the device is powered by a DC source, efficiency is of great importance. By implementing a state machine to permit a sleep mode, we expect the power consumption to be reduced and the longevity of the device to be extended.

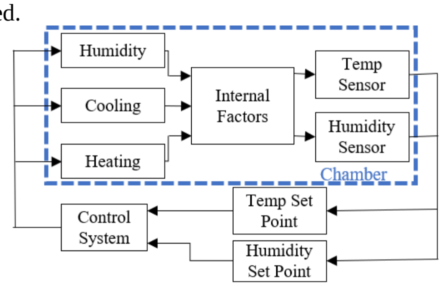

Figure 1: Device Feedback Loop Block Diagram.

The chosen commercial cooler has a built-in Peltier device. The thermal electric tool consists of a junction between n and p-type conductors. When current flows between, heat may be transferred from one side of the apparatus to the other [4]. Furthermore, a homemade ultrasonic humidifier controls the moisture of the air contained. The module holds a rapidly vibrating diaphragm which converts water into a light mist that is evenly distributed by a small fan [5]. Though the two climate modifiers are cost efficient and low maintenance, we expect that it will be challenging to control the environment with precision. For instance, powering on the humidifier for only seconds may drastically affect the RH percentage. Preliminary testing of the effectiveness of the temperature and humidity controllers will be performed to get an idea of the devices' capabilities. It is likely that pulse width modulation (PWM) will be used to manipulate the average power being supplied to the thermoelectric plates and humidifier.

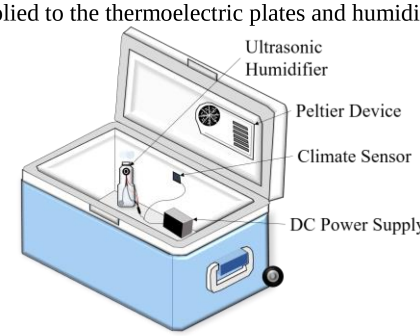

Figure 2: Prototype of Climate Control Chamber

Our chamber is put through a series of tests to gather data regarding its precision, efficiency, and stability in realistic field scenarios. For example, the device must be capable of sustaining a specified climate when the lid is opened and closed multiple times. It is vital that our device demonstrates internal stability and accuracy over a range of external environmental conditions. And, the efficiency of the device is examined to ensure a stable setting may be maintained for the duration of the testing process. It is expected that a fully functioning temperature and humidity control chamber will be developed for in field usage by the end of the REU program.

AKNOWLEDGEMENT

This research is sponsored in part by NSF REU Award number 1540040

REFERENCES

[1] Gubala, Vladimir, Harris, Leanne F. Ricco, Antonio J., Tan, Ming X., and Williams, David E. "Point of Care Diagnostics: Status and Future." *Analytical Chemistry 84* (2012): 487-515.

[2] Ewaisha, R., I. Meshay, J. Resnik, B. A. Katchman and K. S. Anderson, "Programmable protein arrays for immunoprofiling hpv associated cancers", PROTEOMICS 8 (2016).

[3] Adafruit Industries, "Adafruit HTU21D-F Temperature & Humidity Sensor Breakout Board," *adafruit industries blog RSS*. [Online]. [Accessed: 06-Jun-2019].

[4] Francis J., Disalvo. "Thermoelectric Cooling and Power Generation." *Science 285.5428* (1999): 703-706.

[5] Ediger, Glen W., Israel, Gary P. "Ultrasonic Humidifier." Washington D.C: U.S. Patent and Trademark Office. (2013)