Equine Lung Function Testing

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Abstract-- **The Cummings School of Veterinary Medicine at Tufts University is the only facility in New England with a non-invasive device for diagnosing equine respiratory issues. Following the work of the previous WPI design team and that of Dr. Mazan of the Cummings School of Veterinary Medicine, our team refined the display and functionality of the LabVIEW codes used for analysis, and made significant improvements to the mask design. The result of this project is a design capable of producing consistent and accurate measurements of respiratory function that is both lightweight and cost effective.**

I. INTRODUCTION

80% of stabled horses experience lung disorder. Due to their living environment, many stabled horses suffer from inflammatory airway disease [1]. Roughly 70% of competition horses that are kept in athletic facilities experience pulmonary disorders [2]. Poor air quality in stables leads to an increased risk of these diseases, and is typically caused by airborne hay, dirt, excrement, and dust.

The current method for testing equine lung function is an invasive procedure that takes pressure measurements using esophageal balloons. Additionally bronchoalveolar fluid samples are taken for clinical testing for respiratory disorders. These testing methods are expensive, and potentially traumatizing for the horse. These procedures are often ineffective in providing a prompt diagnosis for potentially life threatening pulmonary diseases such as COPD or Asthma [3]. The Fleisch pneumotachograph itself cost $8,000. The remaining system components cost approximately $10,000 resulting in a total system cost of approximately $18,000 [4].

Fig. 1: Current Fleisch Pneumotachograph

We continued upon the testing from last year's MQP to create an improved, non-invasive diagnostic device that would be a cost effective tool for the data collection and data analysis of horse lung function testing. The previous year's device used a hot wire anemometer, comparable to the fleisch pneumotachograph, but significantly more lightweight and inexpensive. Our MQP team validated the sensor and developed a mask housing system to be mounted on the horse during respiratory testing. Additionally we improved upon the existing LabVIEW and excel outputs for live data monitoring and data analysis.

II. DESIGN APPROACH

To meet Dr. Mazan's requirements, the design needed to be lightweight, attachable to a standard bridle, breathable, moisture absorbent, and easily applied and cleaned. In addition to the mask design, the LabVIEW code needed to be restructured and redesigned for better user interface (UI). The labview code needed to be updated to better reflect the respiratory patterns of a horse. Preliminary designs included a kinetics model on a replica horse and Solidworks models designed to fit a standard bridle.

We tested several materials for the framework of the mask which involved a comparison of material properties versus weight and price. The internal materials were tested for water absorption, breathability, and ability to direct airflow through the sensor housing tube. Our LabVIEW code provides a simplified monitoring display with minimal user inputs. The color scheme and layout of the individual graphs were altered for improved visibility and comparison. We removed global variables from the code, which improved the speed of the code, reduced file size, and limits errors when running tests on different computers.

III. FINAL DESIGN

The final design consisted of a frame made of 3D printed acrylonitrile butadiene styrene (ABS) and a neoprene mesh suspended within the frame. Expired air is directed through the neoprene mesh into the ABS tube on the front of the mask. The air then passes over the Rev C sensor which is connected to a computer which uses LabVIEW software to run our LabVIEW code for data analysis. Figure 2 below illustrates the final Solidworks model for the design.

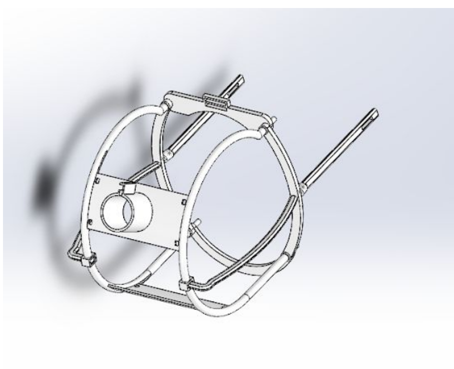

Fig. 2: Final Respiratory Mask Design

The LabVIEW display was updated and simplified in design and operation. The display presented a simplified grey background with two displays for the breathing rate in respect to velocity and in relation to volumetric breathing rate. The raw data is extracted to a local file on the user's hard drive, and may be reflected for additional display and peak ranges through an Excel or Matlab code.

IV. TESTING

Various materials were tested with an Instron 5543 in a 3pt bending testing (ABS mask design) for compressive and bending stresses, and tensile testing (neoprene mesh). Figure 3 below indicates the Load-Extension curve of the Neoprene mesh.

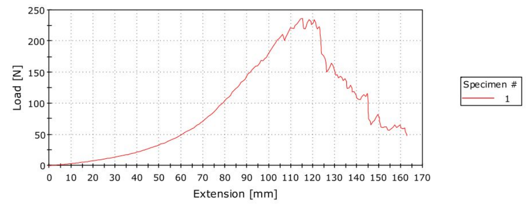

Fig. 3: Tensile Testing Neoprene Fabric

Additionally, the breathability and water resistance of the mesh were tested by using a contact angle test and breathability testing. We concluded from testing that ABS 3D printed material is the ideal material based on weight and cost, and neoprene is the ideal material for the internal mesh based on design specifications and cost.

V. FUTURE WORK

Future recommendations for the continuation of this project include the incorporation of respiratory Inductance Plethysmography (RIP) bands to the system and LabVIEW code, as well as designing a wireless alternative for mobile testing through the use of an Arduino, or other device capable of data acquisition. We recommend testing this sensor and code on live horses to gauge response to the system in action.

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