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Inline Air Permeability Inspection System

Introduction

Non-woven fabrics have become a fast-growing versatile material used in a wide variety of applications due to their many ideal properties including efficient filtration, bacterial barrier, sterility, environmental and economic sustainability, light weight, resiliency, enhanced absorbency, stretch, softness, thermal and acoustic insulation, flame retardance, washability and cushioning [1]. Since non-woven textiles are an ideal filter media, inspecting the fabric is crucial for quality control and determining filter efficiency.

The primary objective was to design and prototype an apparatus to be installed on a textile production line that will measure and record non-woven textiles' pressure differential. The apparatus performs like a traditional Frazier pressure differential air permeability test and hence can be used in various textile inspection applications. This device is meant to provide a direct solution for the textile industry's problem of not being able to inspect the middle of the non-woven fabric roll, reduce the risk of recall when the fabric roll is incapable of meeting specifications, and provide a mechanism to inspect textiles in the line of production through the means of a nondestructive testing approach. This is aligned with the industry's commitment to continuous quality planning, control, and improvement initiatives to deliver enhanced customer value.

Abstract

The textile industry was exploring an avenue to inspect non-woven fabric to eliminate the widely employed destructive testing methods. The primary objective of this capstone project was to design and prototype an inline air permeability inspection apparatus, installed on the textile production machine, which will measure and record the moving non-woven textiles' pressure differential.

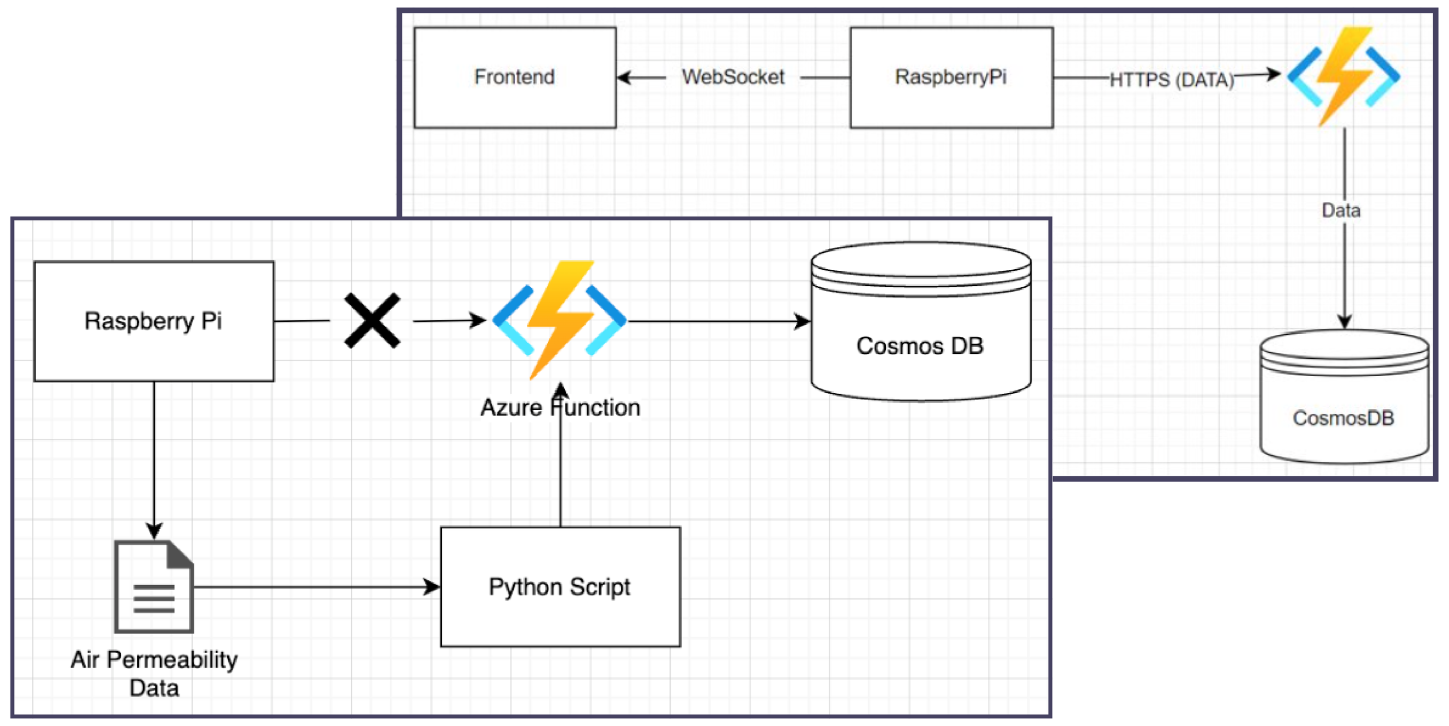
The air stream is pulled through the test head and the manifold by a vacuum pump. The manifold, used to direct airflow to each test head in a cyclic sequence, is equipped with a mass flow rate controller which controls the volumetric air flow rate. The selected components and the determined acceptable pressure differential range has allowed minimal accumulated error in air permeability readings and has increased system reliability. This apparatus is meant to provide a potential solution for the textile industry to meet quality metrics for the entire roll, increase efficiency and reduce overall material waste in the quality control process.

Methodology

Software:

The software system was designed to persist information created by the inspection system in a way that allows users to query and view data from specific positions on the textile. To achieve this, the system sends data to an Azure function, which processes and saves it in CosmosDB, a NoSQL database. Since this is quite an internet dependent, an offline workflow was also created. This process could store data locally until the internet became available to send the data to the cloud.

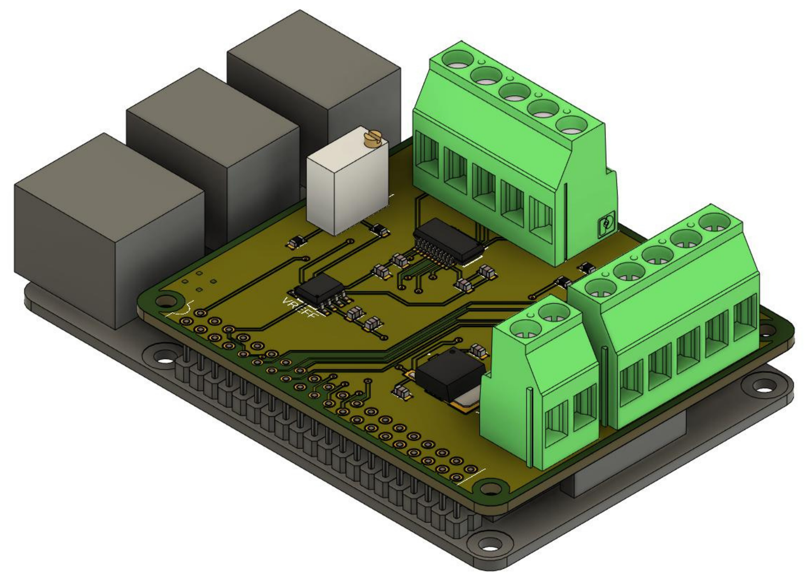
Another requirement was real-time data visibility to help operators identify problem areas in the fabric quickly. For this purpose, the system uses WebSockets to stream data to a React front-end, providing an overview of the fabric over time.



Methodology

Electrical:

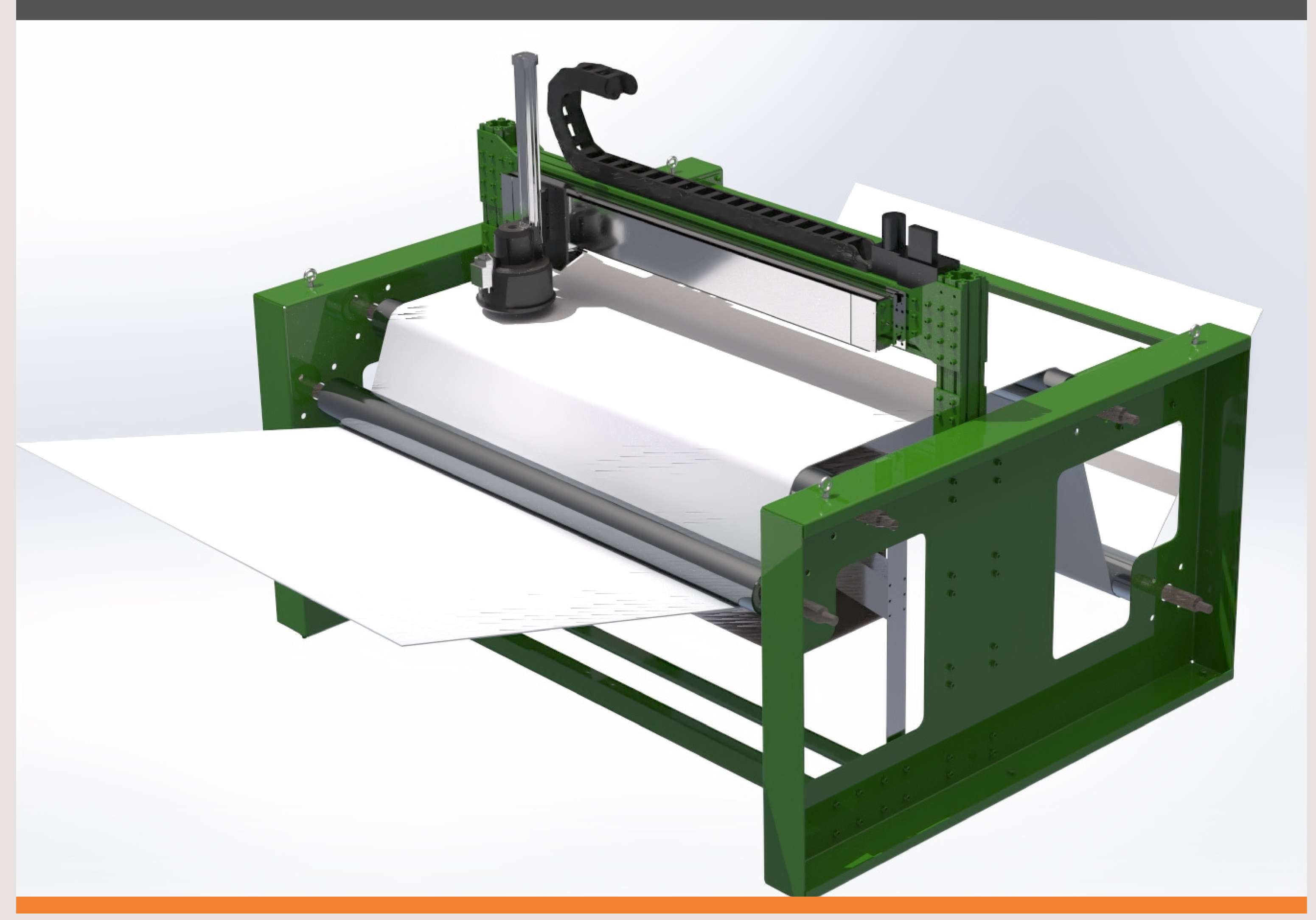
The Electrical design aimed to integrate the Raspberry Pi mini computer to be able to control motor function as well as sensor interpretation. To accomplish this a custom printed circuit board (PCB) was designed and manufactured in order to contain all controlling aspects and to clean up external wiring. To design the PCB, Fusion 360 was used to iteratively design a wiring schematic that would allow the Raspberry Pi to drive the motor as well as collect sensor data. This wiring schematic was then used to lay out the components and a final PCB design was sent to PCBway for manufacturing. The last step was to solder all the different components onto the PCB.



Methodology

Mechanical:

The mechanical design of this project aimed to construct a simple machine that was able to measure the pressure differential across a moving web of non-woven fabric without interfering with the existing production line. This was accomplished by iteratively designing the apparatus around the CAD model of the production line and obtaining feedback from the project sponsors along the way. Most parts were designed around off-the-shelf components and combined in an easy-to-assemble way. To ensure accurate measurements, careful thought was put into selecting components that have a combined error of less than 3%.



Acknowledgements

We would like to express our gratitude to the team at Roswell Textiles for their valuable contributions and support throughout our capstone project. Their expertise and dedication have been instrumental in the advancement of this project.

We would also like to thank our academic advisor, Uzair Syed, for his guidance and feedback, which helped us to develop and refine our ideas.

About Our Sponsor

Roswell Textiles is a global leader in OEM (Original Equipment Manufacturer) nonwoven technologies and materials and the first and largest Canadian manufacturer of best-in-class meltblown fabric for high performance, regulated medical, food grade, industrial filtration and consumer applications[2]. The company is committed to providing eco-friendly, sustainable and innovative products to support health, wellness and an enhanced quality of life. For example, they developed ECOFUSE, which is 100% compostable nonwoven fabrics using sustainable sourced plant based materials for use in domestic production and for export to global manufacturers. The plant derived nonwoven materials are used commercially today in filtration media for procedural masks and respirators, youth and pediatric soft loop masks, elastic laminations, and in materials across various industries around the globe. Roswell Textiles also provides industry solutions and offers a wide range of testing and production services that can be customized at request.

ROSWELL
TEXTILES

Impact

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Future Work

In future developments, the focus will be on integrating the inline air permeability inspection system with production textile producing machines, reducing the need for manual inspections, and minimizing textile waste. Additionally, efforts will be made to enhance the system's sensitivity and accuracy by improving existing sensitivity and updating processing algorithms. This will ensure consistent and reliable air permeability measurements, ultimately improving the quality control process in textile manufacturing.

References

[1] "Nonwoven fabric," Wikipedia. https://en.wikipedia.org/wiki/Nonwoven_fabric#:~:text=Nonwoven%20fabrics%20provide%20specific%20functions

[2] R. Textiles, "Roswell Textiles," Roswell Textiles. https://roswelltextiles.ca/home

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