NC STATE UNIVERSITY

College of Engineering

Department of Mechanical and Aerospace Engineering

MAE 496 - Undergraduate Research

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Development and Testing of lung phantoms to mimic pulmonary fibrosis and edema.

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1. Introduction

The primary objective of this project is to develop and evaluate lung phantoms capable of accurately replicating the characteristics of pulmonary fibrosis and edema. Lung phantoms are artificial models employed in medical imaging and research to mimic the anatomical and physiological properties of human lungs. By creating these phantoms, the aim is to establish a controlled and standardized environment for studying and diagnosing pulmonary fibrosis and edema using ultrasound, both of which are critical medical conditions.

To achieve this goal, the initial approach involves experimenting with various materials and designs of lung phantoms. This experimentation will allow us to create lung phantoms with customizable stiffness, closely resembling human lung tissues with conditions such as pulmonary fibrosis and edema.

The significance of this project lies in its potential to revolutionize the identification of lung diseases, including fibrosis, and medical conditions like edema. By providing a faster and more cost-effective means of diagnosis, it promises greater accessibility than traditional diagnostic methods. Furthermore, the success of this project could pave the way for the development of wearable devices utilizing ultrasound technology, potentially transforming the field of ultrasound imaging.

2. Procedure

In the pursuit of the project's primary objective, I have developed various designs to replicate pulmonary fibrosis and edema phantoms. These lung phantoms are instrumental in the field of medical imaging and research, as they emulate the anatomical and physiological features of human lungs. The approach is to design, and 3D print various models using hydrogels and PVA and use verasonics to collect data and identify trends.

To achieve this, I am experimenting with a new design that consists of individual layered lung phantoms that exhibit customizable stiffness, closely resembling the properties of human lung tissue. SolidWorks, computer-aided design (CAD) software, played a pivotal role in the modeling and design process, enabling construct these individual layer phantoms that can be assembled and adjusted to create larger and more intricate phantoms.

In addition to the individual layer design, I also worked on designing a specialized layer with the capability to hold water. This feature is essential for realistically and controllably replicating the edema condition, thereby enhancing the practicality of the project in the study and diagnosis of medical conditions.

3. Results

The following designs were created:

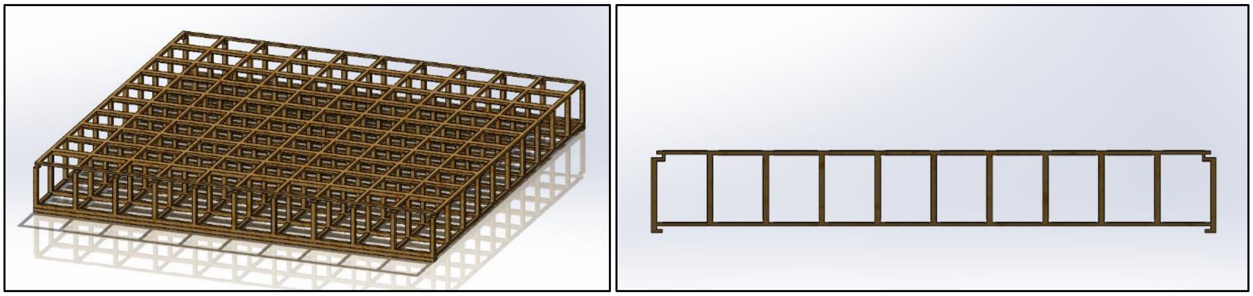

Figure 1, Individual layer design for phantoms.

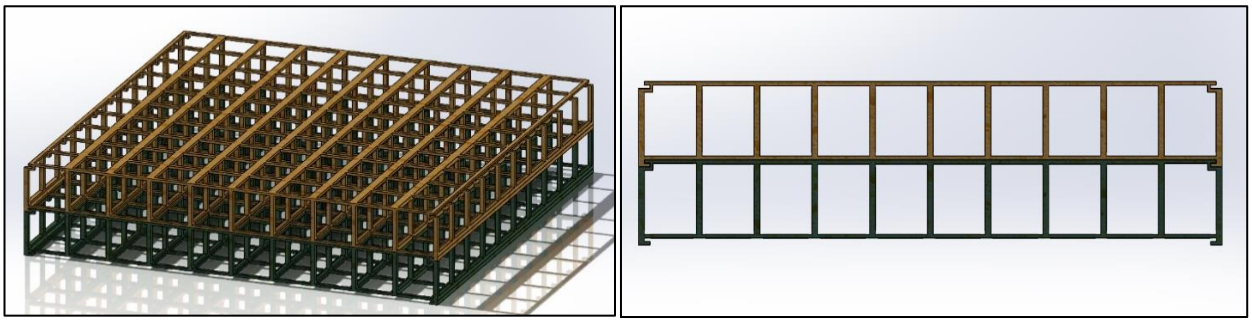

Figure 2, Individual layers combination example.

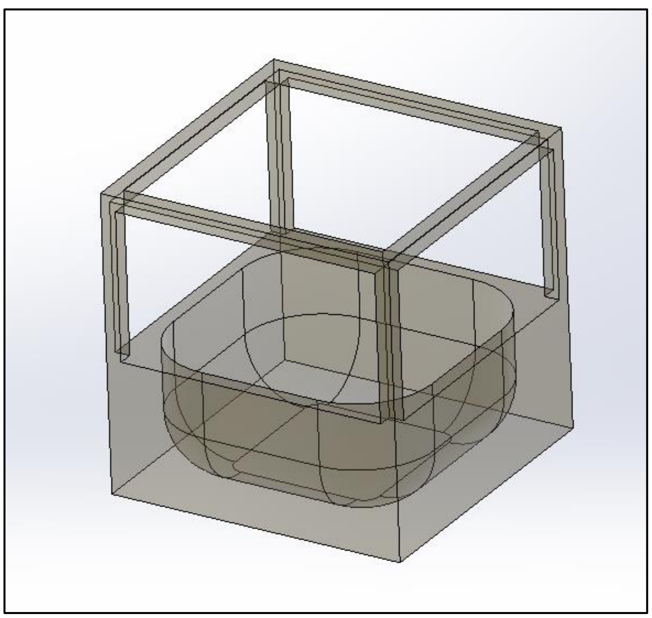

Figure 3, Single element design for phantoms capable of holding water.

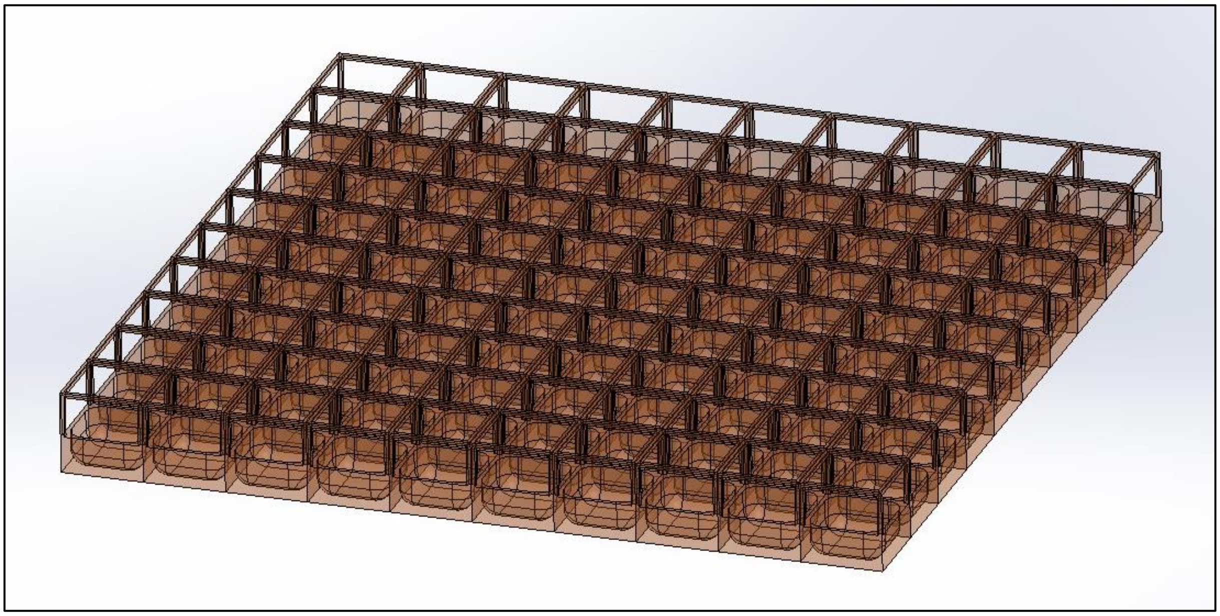

Figure 4, Individual layer design for phantoms capable of holding water.

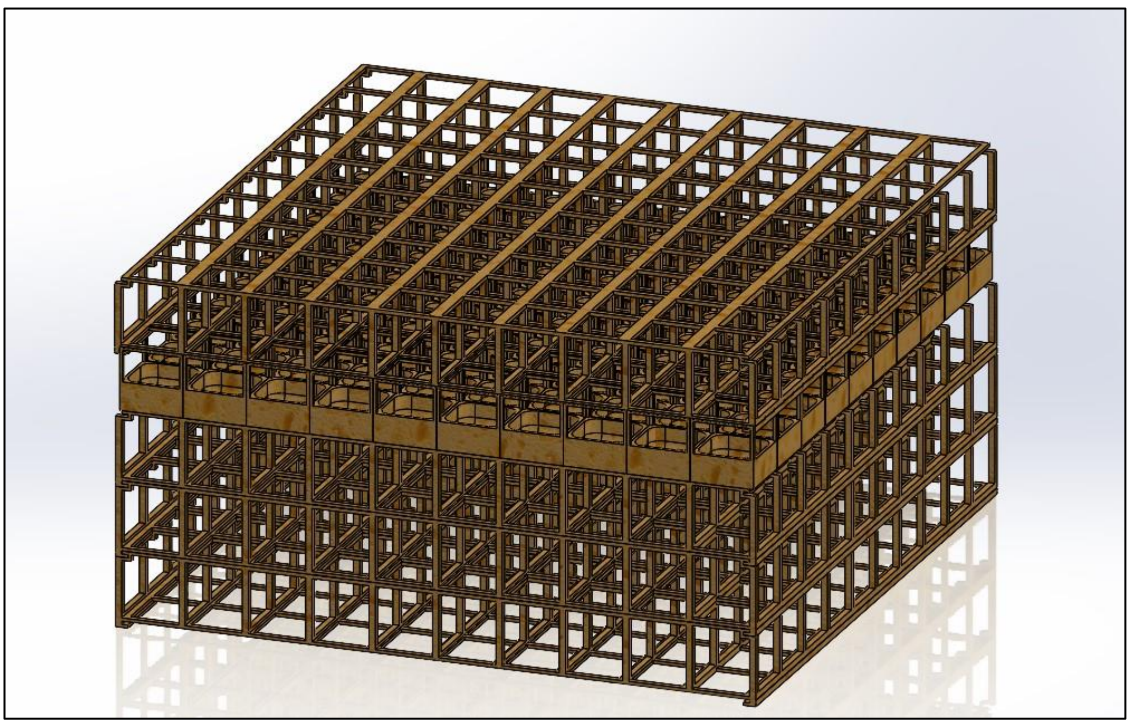

Figure 5, Phantom structure with one layer capable of holding water

4. Conclusion

In conclusion, the next phase of the project will involve evaluating the practicality of the designs I've developed. While these designs look promising on paper, it is important to investigate whether they can yield comparable outcomes to the traditional lattice structures already existing in the laboratory. Additionally, I need to create a new design that incorporates solid elements within the layers to more effectively replicate edema, which appears to be a superior approach to addressing the issue.

To mimic fibrosis, we will employ hydrogel lattice structures with entirely empty lattices, which will gradually absorb water and thicken the structure. Conversely, hydrogel lattice structures with partially filled lattices offer a suitable approach to mimic edema. These steps collectively represent the next stages of our research.

Furthermore, we will utilize the water tank setup to conduct experiments aimed at determining the speed and sound absorption characteristics of both hydrogel and PVA structures. Once this data is acquired, we can proceed to utilize Verasonics for data collection and trend identification.