Sound Absorption and Resonance of Venturi Resonator Systems

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ABSTRACT

Venturi resonators allow for sound absorption in wind pipes while introducing minimal flow damping to the system. Utilizing this technology, it is possible to create sound abatement technologies for use in larger scale applications without utilizing volume outside of the pipe. To test this, A 3D printer was used to create Venturi resonators to test for flow excitation and absorption to verify the acoustical theory.

BACKGROUND

Aboard the International Space Station (ISS), many air pumps create loud noises that reverberate off of the walls, making it difficult for astronauts complete their missions. Since the ISS is too small to introduce new sound absorption equipment and it is very expensive to do so, a new technique was introduced to solve this issue by using 3D printing technology.

DESIGN

To build the Venturi resonators, 3D models were designed in FreeCAD (*Figure 1*), an open source 3D modeling software. FreeCAD was chosen because of it's Python console which would allow for designs to be modeled quickly through the use of programming. Utilizing this feature, we designed a program that would take size inputs from the user and then automatically build the respective resonator. This took a design job that would normally take 2 hours and reduced them down to about 30 seconds.

(A)

(B)

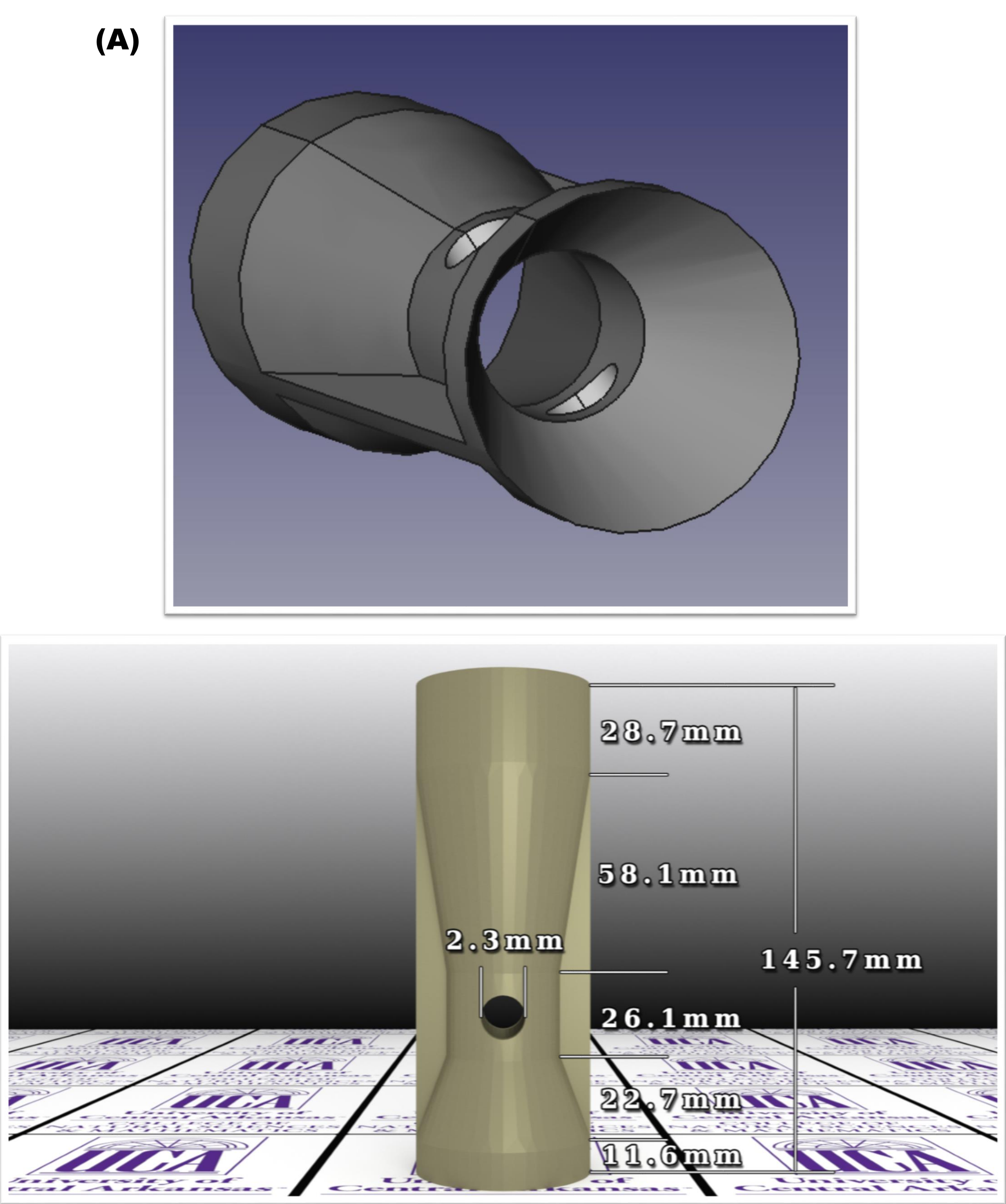

Figure 1 **– (A) 3D rendering of Venturi resonator in FreeCAD (B) 3D resonator measurements**

BUILD

Using a Makerbot Replicator, the 3D models of the resonators were printed (*Figure 2*). The physical models were then installed into pre-drilled PVC pipes with their edges sealed. Calibrated electret microphones were installed into the PVC holes and sealed. The microphones were then connected to a custom made circuit that allowed for the proper amplification of the input signals into an oscilloscope.

(A)

(B)

Figure 2 **– (A) 3D printed resonator installed in PVC housing; (B) Computer fan with custom printed adapter**

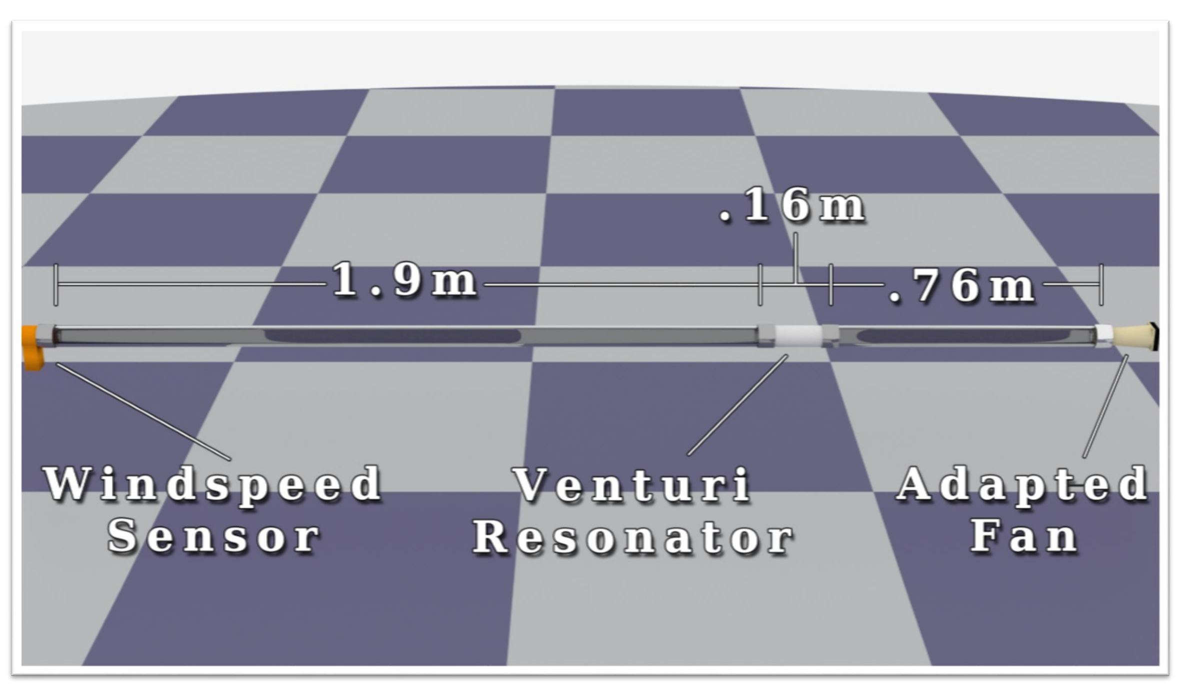

Figure 3 **– Resonator testing setup**

TESTING

To test the resonators, they were connected to a long tube and air was drawn through them using a custom adapted fan (*Figure 3*). The air speeds and relative resonant frequencies were measured in relation to the calibrated electret microphones. This data was then compiled, as seen in Figure 4, where the theoretical frequency was calculated with:

$$f_0 = \frac{v}{2\pi}\sqrt{\frac{S}{(L+1.7a)V}}$$

Where v is the speed of sound in air, S is the surface area of the opening, L is the depth of the opening, a is the radius of the opening, and V is the volume of the cavity. The phases were monitored through out the process and both microphones remained in phase for the entire experiment.

(A)

(B)

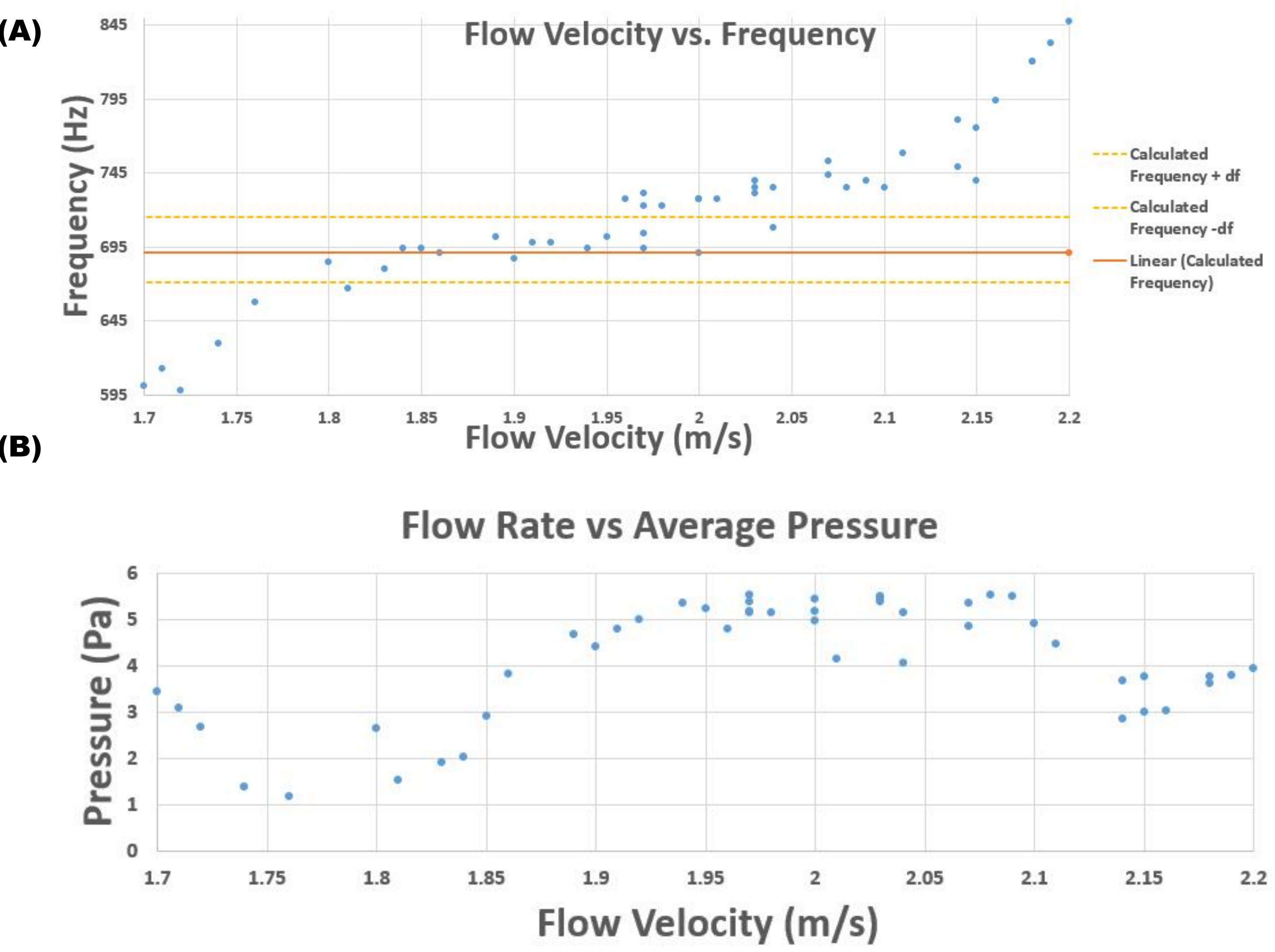

Figure 4 **- (A) Measured resonant points with 3D printed resonator (B) Measured average pressure of both microphones**

FUTURE WORK

To test the consistency of the theoretical model, more Venturi resonators will be printed in varying sizes and tested. Sound absorption properties of each resonator will also be tested by introducing a frequency sweep into the chamber and recording the transmitted decibels on the other side.

ACKNOWLEDGEMENTS

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