INVESTIGATING A PNEUMATIC HORN

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ABSTRACT

A simple air horn can be constructed by stretching a balloon over the opening of a small container or cup with a tube through the other end. Blowing through a small hole in the side of the container can produce a sound. The relevant parameters which affect the sound have been investigated in this research as one of the problems in IYPT 2017.

1 Introduction

An air horn is a pneumatic device designed to create an extremely loud noise for signaling purposes. Air horns are widely employed as vehicle horns, installed on large semitrailer trucks, fire trucks, trains, and some ambulances as a warning device and on ships as a signaling device. An air horn consists of a flaring metal or plastic horn or trumpet attached to a small air chamber containing a metal pipe or diaphragm in the throat of the horn.

Compressed air flows from an inlet line through a narrow opening past the pipe or diaphragm, causing it to vibrate, which creates sound waves. The flaring horn serves as an acoustic "transformer" to improve the transfer of sound energy from the diaphragm to the open air, making the sound louder. In most horns it also determines the pitch of the sound. There are different types of acoustic pipes, open ended pipe or closed ended pipe. In this problem we need to use open ended pipe it means if the sides of the pipe are open.

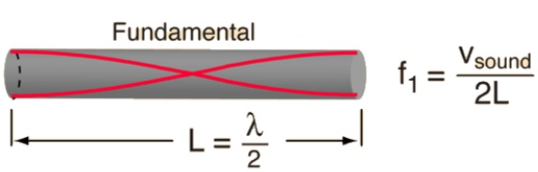

Fig.1: Standing waves in open ended pipe

2 Theory and Modeling

This phenomenon occurs when we blow to the air horn then a certain amount of air goes into the bottle. Normally, a given volume of air inside the bottle has the temperature and pressure same as outside the bottle[1]. But when you blow to the air horn , the pressure inside the bottle becomes more than the pressure outside but here it is investigated as an ideal gas, $PV=nRT$.

Sound is a longitudinal wave that the direction of propagation is parallel to the direction of vibration. When a person blows to this air horn balloon, the balloon starts getting up and the inducement is that the high pressure area enters it and because of keeping out of the pipe, the internal pressure reduces. Therefore, it connected to the container again (Fig. 2) [2].

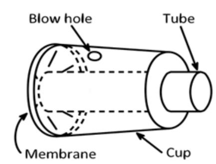

Fig. 2: Experimental Airhorn Balloon structure

2-1 Voice pipe

The quality in a sound of being deep is called resonance. When the inherent frequency of voice pipe resonance with frequency wave , it creates better sound. (When the inherent frequency becomes as same as the frequency wave).One of the most important parameters is voice pipe because it has a dramatic effect on the sounds and frequency. Different diameters and pipe length are also important factors in a distinct frequency.

2-2 Membrane (Balloon)

The membrane has a dramatic effect on the sound too. lasticity, thickness and also material of the membrane are onsidered as important factors in experiments and results.

3 Hole

The size of the hole has much effect on sound. When the hole is small, the person has to blow into it strongly. But when it is bigger the sound will spread easily.

3 Experiments

By different sizes of airhorn (Fig. 3) , all the produced sounds are analyzed by FFT (Fast Fourier transform analysis) which converts a signal from its original domain (often time or space) to a representation in the frequency domain and vice versa.

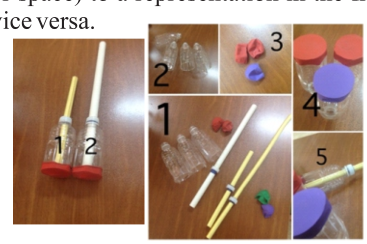

Fig. 3: Different sizes of Airhorn Balloon in our experiment

FFT analysis and natural frequencies of the cup are shown in figures (4 and 5).

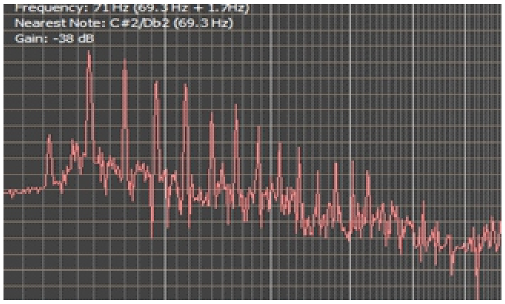

Fig. 4: FFT analysis in air horn [3]

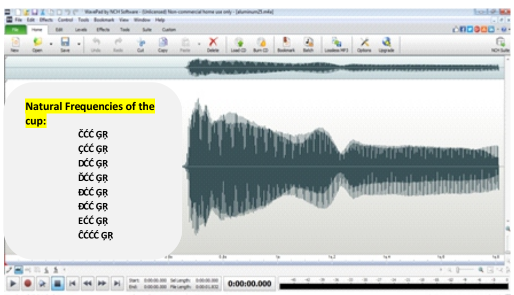

Fig. 5: Wave Pad Sound Editor application

4 Results

Tubes with different lengths and materials are used to find the frequency as in tables (1 and 2).

Table 1: Changes of frequency in different lengths and materials of airhorn

Tube Size and Material	Frequency
20 cm aluminum	678(Hz)
50 cm aluminum	270(Hz)
20 cm Galvanized	425(Hz)
30 cm Galvanized	406(Hz)
40 cm Galvanized	309(Hz)
50 cm Galvanized	265(Hz)
18 cm plastic	506(Hz)
21 cm plastic	431(Hz)

Different materials of cup are considered in this experiment too (table 2).

Table 2: Changes of frequency in different lengths and materials of airhorn

Cup Size and material	Frequency
15 Cm Plastic	130 Hz
15 Cm Aluminium	120 Hz
18 Cm Plastic	200 Hz

5 Conclusion

Different parameters like the shape, size and material of the components have been investigated. Membrane has an important effect on the sounds in airhorn with the significant impact by its elasticity, thickness and also material. If the traction of balloon becomes further, the voice becomes thinner and vice versa. Also by different tubes, it is suggested a tube with effective length for the best sound.

References

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[2] Billah KY., and Scanlan RH., 1991."Resonance, Tacoma Narrows bridge failure, and undergraduate physics textbooks." American Journal of Physics: 59, 118 , math.arizona.edu

[3] NTCH software.,"WavePad Sound Editor application", https://wavepad.en.softonic.com/