Abstract

1. Research Background

1.1 Standing wave visualization

Use simple materials to make a pipe, and use humidifiers, LED light strips, etc. to create standing waves through input audio, and present the changes in standing waves as data or experimental results.

1.2 Reduce the risk of Rubens tube

Use the light beam produced by the LED light and the smoke produced by the humidifier instead of the flame

Safety issue: flame is easy to cause fire

Convenience: No need to prepare fuel in advance, only electricity is needed, which is much more convenient

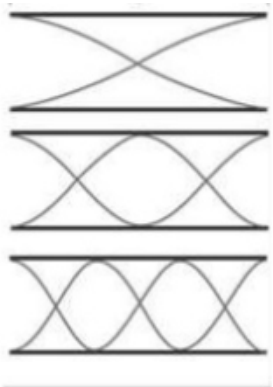
1.3 Draw conclusions about the effects of sound frequency and pressure on smoke

Through various tests, the speakers input sound waves of different frequencies and pitches, and observe the changes. And discuss under what circumstances this tube can show the most ideal effect.

2. Research Principle

Put the LED light into the tube body, make a row of small holes in the tube body. Then put a speaker and a humidifier on both sides of the tube, turn on the humidifier and speaker and observe the smoke of the device under different music.

The two nozzles of the tube are blocked by the speaker and humidifier, therefore most of the gas will only be discharged from the small opening above the tube; sound waves are introduced through the speaker to generate a standing wave which changes the air pressure in the tube, resulting in a pressure difference. And the gas discharged from the small mouth fluctuates, so as to realize the visualization of sound wave fluctuations.



3. Testing and data analysis

3.1 Observation results

If the sound wave of a fixed frequency is introduced into the tube, a standing wave is formed in the tube. When the pressure of the standing wave is the maximum, the speed of the smoke spraying from the small hole will be faster. On the contrary, when the standing wave pressure is the smallest, the amount and rate of smoke sprayed from the small holes will be smaller and slower. Therefore, as the sound wave distribution in the tube changes, the amount and rate of smoke discharged from the small holes will also change periodically.

3.2 The effect of sound pressure on smoke

It can be known from fluid mechanics that when the gas velocity is small, the flow pattern is laminar flow without turbulence. At this time, the height of the smoke is approximately proportional to the velocity, that is, h∝v.According to Bernoulli's principle, the flow rate of gas can be known

$$v \propto \sqrt{\frac{P_1}{P_2}}$$

Among them, p_1 is the air pressure inside the tube,and p_2 is the air pressure outside the tube, and the air pressure outside the tube p_2 is a constant. The theory of acoustic waves, acoustic standing wave is formed in a long tube uniformly limited, the total sound pressure is

$$P = 2P_i \left|\cos\left(\frac{2\pi}{\lambda}x\right)\right| e^{j(\omega t)}$$

Where p_i is the amplitude of the incident sound wave. Suppose the sound pressure in the air is p_0, and define the reference sound pressure value $p_0 = 20\mu Pa$, the sound pressure level is

$$SPL = 20\lg\left(\frac{P}{P_0}\right)$$

Sound pressure is

$$P = 20X10^{\frac{SPL}{20}}\mu Pa$$

Thus

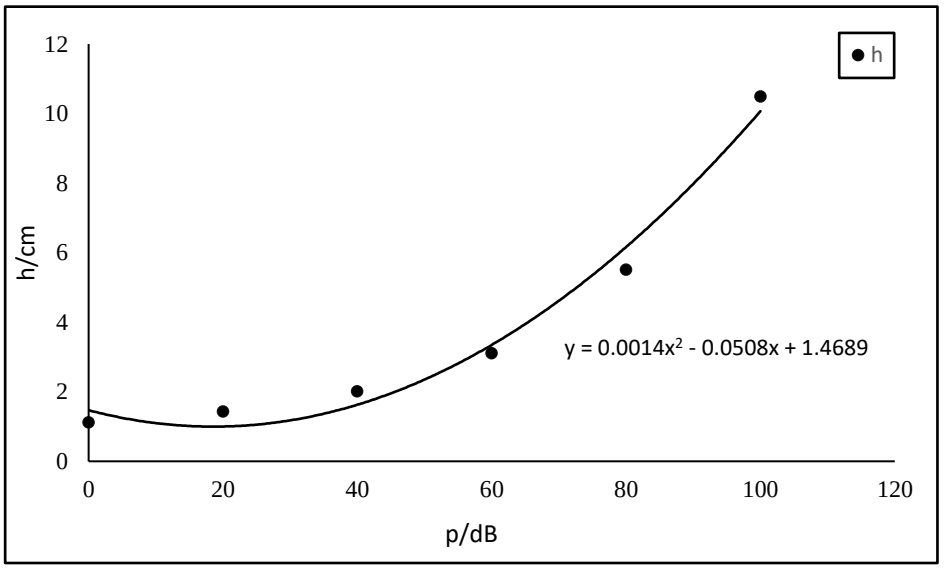
$$h \propto \sqrt{\frac{p + p_0}{p_0}}$$

When there is no sound source input, adjust the air intake so that the height of the smoke is 1 cm. At this time, the ambient noise sound pressure level is 35.6dB. As the sound pressure level increases, the height of the smoke also increases.

Sound pressure in aerosol height abscissa ordinate depicted curve, using the formula

$$h \propto \sqrt{\frac{p + p_0}{p_0}}$$

Fitting, the fitting degree R^2= 0.94, the fitting degree is high, and the fitting curve is shown in the figure.



3.3 The effect of frequency on smog

In the experiment, the volume is constant and the frequency is gradually increased. It is found that the period of the flame height change gradually becomes smaller, which corresponds to the half-wavelength of the corresponding sound wave.

According to the wave theory, when a sound wave forms a standing wave inside the Rubens tube, the distance between adjacent antinodes (or nodes) is equal to half of the wavelength of the sound wave, and the distance between the highest or lowest point of two adjacent smoke is measured. Obtain the wavelength λ value of the sound wave. The speed of sound c can also be obtained from the product of the wavelength λ value and the sound wave frequency f. In the course of the experiment, a set of data on the wavelength and frequency of sound waves was measured, and it was found that the speed of sound has a gradually increasing trend with the increase of frequency. According to the principle of acoustics, the speed of sound will

gradually increase with the increase of temperature. During the experiment, the humidifier continuously sprayed out smoke, releasing a large amount of heat and gradually accumulating to increase the temperature of the gas in the Rubens tube, causing the speed of sound to increase.

Relationship between frequency, wavelength and speed of sound						
$\boldsymbol{f/Hz}$	550	600	650	700	750	800
$\boldsymbol{\lambda/cm}$	31.5	28.3	26.4	24.7	23.0	21.6
$\boldsymbol{c/(m \cdot s^{-1})}$	341.0	342.4	344.6	345.3	346.2	347.5

In addition, it can be noticed that when the sound wave frequency is increased to about 700 Hz, the tube body has an obvious resonance phenomenon, and the periodic phenomenon of smoke tends to disappear. From this, it can be judged that the natural frequency of the tube is about 700 Hz. When the frequency is equal, mechanical resonance occurs, and the Rubens tube has a large amplitude vibration, which is no longer a stable system. The distribution of the smoke emitted by the humidifier tends to be uniform, and the periodic changes in the height of the smoke emitted by the small holes are no longer obvious.

4. Conclusion

4.1 Color

During the test, we tried to observe the different phenomena of smoke with different colors. If we want to achieve the clearest and most obvious rendering effect, red color will be the best choice.

Red is one of the three primary colors. It has the longest wavelength and the lowest

frequency in visible light. Light scattering refers to the phenomenon that part of the light changes direction in many ways when light passes through a dusty medium.

4.2 Sound wave

Sound waves are usually a combination of sine plane waves, which include frequency and wavelength. The higher the pitch, the higher the frequency and the shorter the wavelength. The larger the wavelength, the wavenumber of the standing wave will decrease. Therefore, when the loudspeaker plays high-pitched music, the effect is better than the low-pitched music.

When the input frequency is too high, the tube body will produce obvious resonance phenomenon. The tube has a large amplitude vibration and is no longer a stable system. The pressure distribution of the gas tends to be uniform, and the periodic change of the smoke is weakened. The result becomes unobvious.

4.3 Temperature

The experiment found that the height of the smoke increased regularly with the change of the boost pressure. The shape of the smoke corresponds to the shape of the standing wave. As the experiment progresses, the wave speed tends to gradually increase. This is caused by the accumulation of heat, which is related to the increased temperature.