WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979 (Volume 2, Issue 12, Dec., 2021

DETERMINATION THE RATIO OF HEAT CAPACITY AT CONSTANT PRESSURE WITH CONSTANT HEAT CAPACITY VIA THE VELOCITY OF SOUND WAVES IN GASES

Mamadjanov Akhrorjon Ibragimovich
head of physics department, Namangan engineering-construction institute, Uzbekistan, Namangan 106103, Islam Karimov 12.

Soliyev Alisher Zokirjonovich
senior teacher, Namangan engineering-construction institute, Uzbekistan, Namangan 106103, Islam Karimov 12.

Hasanov Xojiakbar Bahodirjon o'g'li
student, Namangan engineering-construction institute, Uzbekistan, Namangan 106103, Islam Karimov 12.

Abstract
It is theoretically studied that the speed of sound waves in gases depends on the molecular kinetic theory and the laws of thermodynamics. Experimental methods have been developed for determining the ratio of heat capacity at constant pressure to heat capacity at constant volume for arbitrary gases.

Keywords: sound wave, gas, speed of sound, temperature, Poisson's ratio, heat capacity, pressure, adiabatic process, wave equation.

Introduction

An elastic wave in a gas consists of alternating regions of gas compression and dilution in the medium. This means that the pressure at each point in space periodically deviates from the average value from P to ΔP. Thus, the instantaneous value of pressure at a point in space can be written as follows [1].

$$P' = P + \Delta P$$

Let the sound wave propagate along the x-axis. The mass of the gas in this volume is equal to $\rho S \Delta x$, where ρ is the density of the wavy gas. Since Δx is small, the acceleration at all points of the cylinder can be considered the same and equal to $\partial^2 \xi / \partial t^2$.

WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979 (Volume 2, Issue 12, Dec., 2021

To find the force F acting on the gas volume, we need to take the product of the cylinder base surface $(x+\xi)$ by the pressure difference in the sections $(x+\Delta x+\xi+\Delta\xi)$ [2].

Using $F=-(\partial P'/\partial x)S\Delta x$, we set $\Delta\xi << \Delta x$. So, we have found the mass of the released volume of gas, its acceleration and the force acting on it. Now let's write Newton's second law for this volume of gas:

$$(\rho S\Delta x)\frac{\partial^2\xi}{\partial t^2}=-\frac{\partial P'}{\partial x}S\Delta x$$

If we reduce it to $S\Delta x$

$$\rho\frac{\partial^2\xi}{\partial t^2}=-\frac{\partial P'}{\partial x} \qquad (1)$$

This differential equation involves two unknown functions ξ and P'. To solve an equation, one of these functions must be expressed by the other [3]. To do this, find the relationship between the pressure P' of the gas and the relative change in its volume $\partial\xi/\partial x$. This connection depends on the nature of the gas compression or expansion process [4]. In a sound wave, gas compression and liquefaction follow each other so quickly that adjacent parts of the medium cannot keep up with each other.

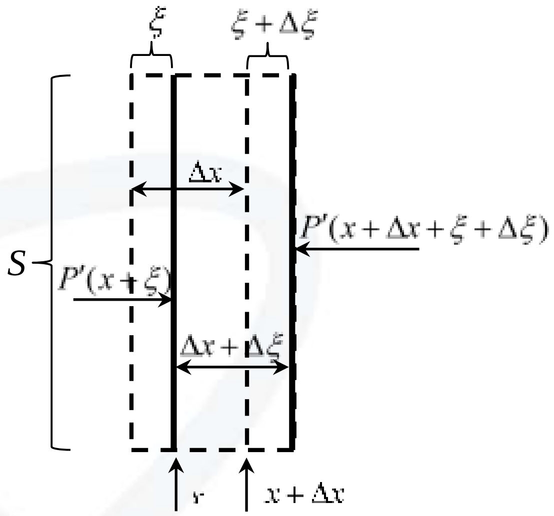


Fig.1

Therefore, the process can be considered adiabatic. For an adiabatic process, the ratio between pressure and volume of a given mass of gas is given by the formula $PV^\gamma=const$ [5]. Therefore, one can write:

$$P(S\Delta x)^\gamma=P'[S(\Delta x+\Delta\xi)]^\gamma=P'[S(\Delta x+\frac{\partial\xi}{\partial x}\Delta x)]^\gamma=P'(S\Delta x)^\gamma\left(1+\frac{\partial\xi}{\partial x}\right)^\gamma$$

Where γ is the ratio of the heat capacity of the gas at constant pressure to the heat capacity at constant volume.

WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979 (Volume 2, Issue 12, Dec., 2021

If we reduce this equation to $(S\Delta x)^{\gamma}$,

$$P = P'\left(1+\frac{\partial \xi}{\partial x}\right)^{\gamma}$$

Using the assumption that $\frac{\partial \xi}{\partial x} << 1$. We extend the expression $\left(1+\frac{\partial \xi}{\partial x}\right)^{\gamma}$ to the order $\frac{\partial \xi}{\partial x}$ and lower the upper limits. As a result, we find the following formula:

$$P = P'\left(1+\gamma\frac{\partial \xi}{\partial x}\right)$$

We solve this equation for Ṕ:

$$P' = \frac{P}{1+\gamma\frac{\partial \xi}{\partial x}} = P\left(1-\gamma\frac{\partial \xi}{\partial x}\right) \quad (2)$$

we can easily find the expression for ΔP from a certain relation:

$$\Delta P = P' - P - \gamma P\frac{\partial \xi}{\partial x} \quad (3)$$

Since ξ γ is close by one, from (3) one can find $\left|\frac{\partial \xi}{\partial x}\right| \approx \left|\frac{\Delta P}{P}\right|$. Thus, the physical meaning of the condition $\frac{\partial \xi}{\partial x} << 1$ is that the deviation from the mean pressure value is many times less than the pressure itself. This is indeed the case: the atmospheric pressure P is about 10^3 mm of wire. Even for very loud sounds, the amplitude of the air pressure fluctuations is 1 mm of the wire does not exceed the column [6].

If we differentiate expression (2) with respect to x, we find:

$$\frac{\partial P'}{\partial x} = -\gamma P\frac{\partial^2 \xi}{\partial x^2}$$

Finally, if we put this found value $\frac{\partial P'}{\partial x}$ into formula (1), we find the following differential equation.

$$\frac{\partial^2 \xi}{\partial x^2} = \frac{\rho}{\gamma P}\frac{\partial^2 \xi}{\partial t^2} \quad (4)$$

If we compare expression (4) with the following wave equation

$$\frac{\partial^2 \xi}{\partial x^2} + \frac{\partial^2 \xi}{\partial y^2} + \frac{\partial^2 \xi}{\partial z^2} = \frac{1}{\vartheta^2}\frac{\partial^2 \xi}{\partial t^2} \quad (5)$$

For the speed of sound waves in a gas, we obtain the following expression:

$$\vartheta = \sqrt{\gamma \frac{P}{\rho}} \qquad (6)$$

Where P and ρ are the pressure and density of the undulating gas.

At first glance, the speed of sound seems to depend on pressure. But in reality this is not so, because with a change in gas pressure, its density also changes [7].

The properties of gases at normal pressures are well represented by the following equation:

$$PV = \frac{m}{\mu} RT \qquad (7)$$

Here m is the mass of a gas with a volume of V , μ is the mass of 1 mole of gas, equal to the molar mass of the gas. Knowing that the ratio of the mass m of the gas to its volume is equal to the density ρ, equation (7) has the following form.

$$\rho = \frac{m}{V} = \frac{P\mu}{RT} \qquad (8)$$

Substituting this density in (6), we find the following formula for the speed of sound in gases:

$$\rho = \sqrt{\gamma \frac{RT}{\mu}} \qquad (9)$$

From this it can be found that the speed of sound in a gas depends on the temperature and the values of the quantities γ and μ that characterize the gas. The speed of sound in a gas does not depend on the pressure [8].

From formula (9) we obtain the formula for finding γ:

$$\gamma = \frac{\vartheta^2 \mu}{RT} \qquad (10)$$

By determining the velocity of sound in the air using the **Cassy Lab 2** program, it is possible to determine the ratio of the heat capacity at constant pressure to air to the heat capacity at constant volume, i.e. the Poisson's ratio. By comparing the result obtained with the previously determined results, it is possible to determine the ratio of the heat capacity at constant pressure to the heat capacity at constant volume for any gas, i.e. the Poisson's ratio [9].

WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979 (Volume 2, Issue 12, Dec., 2021

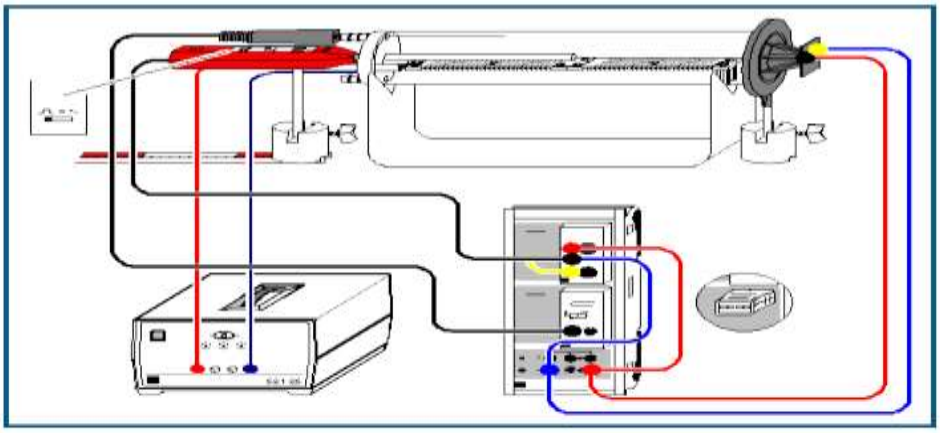
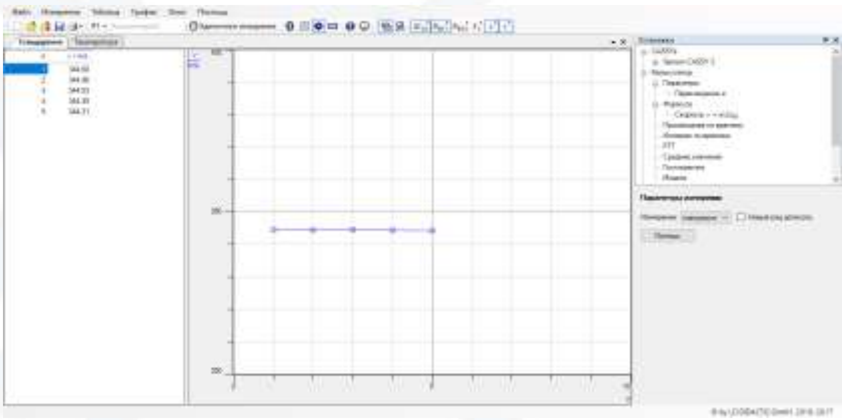


Fig.2. A general view of a sound device for determining the speed of sound.

This experiment determines the speed of propagation of a sound pulse in air with equal group and phase velocities. The sound pulse is generated by applying an intermediate voltage to the "vibrating" membrane speaker. This creates a shock wave in the air. The sound pulse is received by the microphone at a certain distance from the speaker.

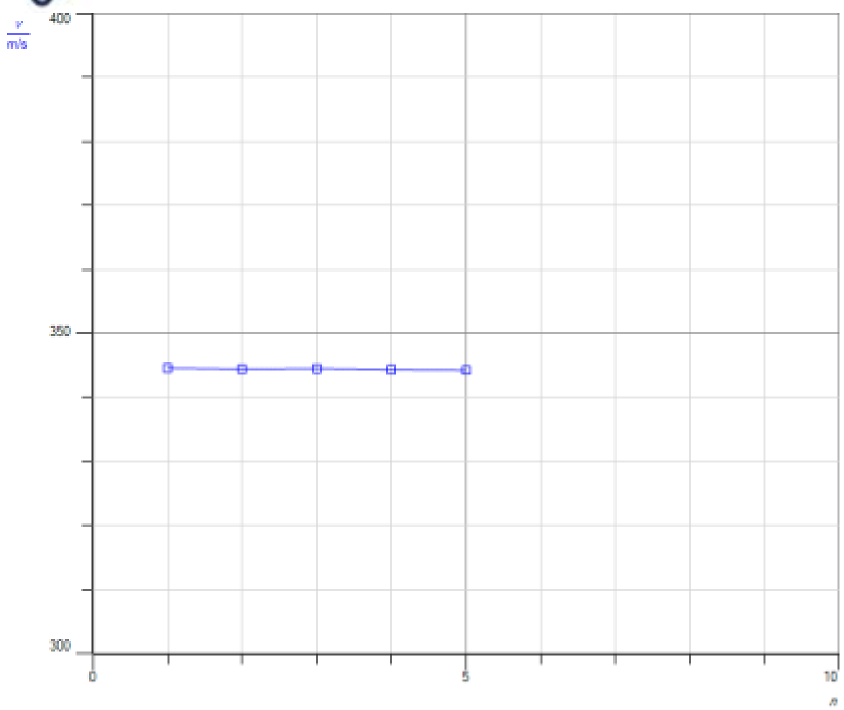
To determine the speed of sound ϑ, we measure the time Δt between the sound pulse being generated on the speaker and received at the microphone. This is determined using the **Cassy Lab 2** program. The distance S between the speaker and the microphone is determined by a scale rail and entered into the program. The speed of sound is determined by the formula $\vartheta = S / \Delta t$. The temperature at which the detected sound is detected can also be seen using **Cassy Lab 2**. That is, the temperature around the medium in which the speed of sound is determined is automatically determined by the program using a thermocouple[10].

Knowing the molar mass for air and the universal gas constant, it is possible to determine the ratio of the heat capacity at constant pressure at a given temperature to the heat capacity at constant volume, i.e. the Poisson's ratio.

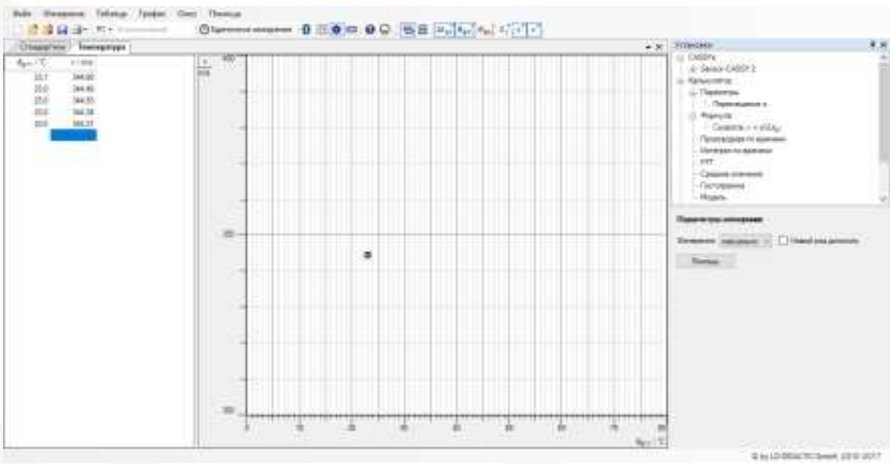


a)

WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979 (Volume 2, Issue 12, Dec., 2021



b)



c)

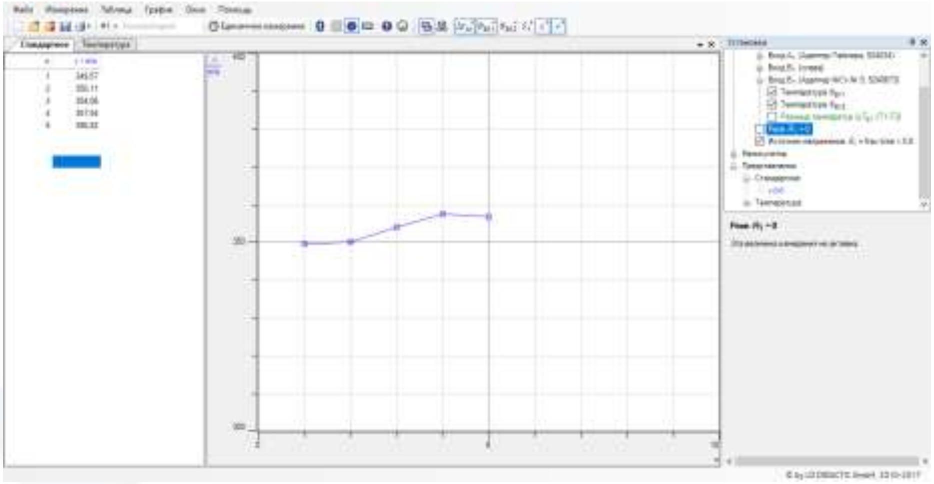
Fig.3-a,b,c. Speed velocities in air for 23°C temperature by experiment.

If we put in the expression (10) the values of the sound velocity determined by the above experiment, the temperature in the experiment, the universal gas constant and the molar mass for air, the ratio of the heat capacity at constant pressure to air to the heat capacity at constant volume, that is, the Poisson's ratio can be determined. The results obtained from Figures 3-a,b,c show that the ratio of the heat capacity at constant pressure determined for air to the heat capacity at constant volume, i.e. the Poisson's ratio, has the same value as the values determined by other experiments.
According to the experiments in Figures 4-a,b, an increase in temperature increases the speed of sound, but the ratio of the heat capacity at constant pressure to the heat

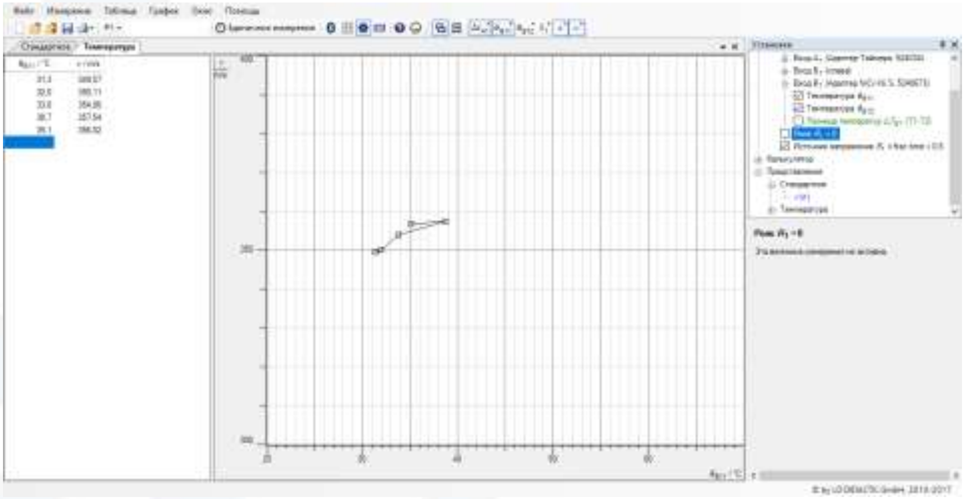
WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979 (Volume 2, Issue 12, Dec., 2021

capacity at constant volume, i.e., the value of the Poisson's ratio, remains unchanged. That is, it is the same as the previously defined values.

Hence, by using the **Cassy Lab 2** laboratory device, the ratio of the heat capacity at constant pressure to the heat capacity at constant pressure for these gases, i.e., the value of the Poisson's ratio, can be determined by determining the filtration rate in an arbitrary unknown gas or gas to be tested. as long as possible. This means determining one of the thermodynamic parameters of the gases.



a)



b)

Fig.4-a, b. Speed velocities in air for different temperatures by experiment.

Therefore, by determining the speed of sound in an arbitrary gas using the laboratory device **Cassy Lab 2**, it is possible to determine the ratio of the heat capacity at constant pressure to the heat capacity at constant pressure for these gases, i.e., Poisson's ratio. This means the determination of one of the thermodynamic parameters of gases.

In this work, a method is developed for determining the thermodynamic parameters of gases using a modern teaching experimental device. Methods for checking the value of the adiabatic index are studied for various temperatures. The theoretical expression for the adiabatic index was tested using modern teaching experience.

References

1. Savelev I.V. Umumiy fizika kursi. 1-qism. Toshkent. O'qituvchi. 1975.
2. Gulyamov G., Umarov U.Q., Soliyev A.Z. FarPI ITJ, 2020, T.24, maxsus. №2.
3. Mamadjanov A.I., Nazarov Sh.R., Turg'unov A.R. NamDu ilmiy axborotnomasi. 5-son, 2021.
4. Gulyamov G., Gulyamov A.G.. Semiconductors vol 49, No 6, pp.819-822. 2015.
5. Bobokhuzhaev K.U., Bazarbaev M.I., Nazyrov D.E., Soliev A.Z. 2011.11.15.
6. Гулямов Г., Гулямов А.Г., Шахобиддинов Б.Б., Мажидова Г.Н., Муҳиддинова Ф.Р. Научный вестник НамГУ 8-сон, 2020 йил.
7. Гулямов Г., Гулямов А.Г., Шахобиддинов Б.Б., Мажидова Г.Н., Усманов М.А. NamDu ilmiy axborotnomasi. 4-son, 2020.
8. Гулямов Г., Гулямов А.Г., Шахобиддинов Б.Б., Мажидова Г.Н., Абдукаримов А.А. Бухоро давлат университети илмий ахбороти, 2020/4/80.
9. Гулямов Г., Эркабоев У.И., Шахобиддинов Б.Б., Давлатов А.Б. Бухоро давлат университети илмий ахбороти, 2019/3/75.
10. Гулямов Г., Эркабоев У.И., Шахобиддинов Б.Б., Давлатов А.Б. Научный вестник НамГУ 1-сон, 2019 йил.