**Решение задачи №10 «Трубка Рийке»**

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**Слайд 1.** Hello, my name’s Artem Redko, I’m the member of the 12FM team from the city of Novosibirsk, Russia. I want to represent you the solution of the problem №10 «Rijke’s tube».

**Слайд 2.** The condition of the problem you can see on the screen.

**Слайд 3.** During the study of theoretical material we made a hypothesis: if the vessel is filled with elastic air and communicates with the atmosphere, then it is capable of making sounds.

The aim of the study is to investigate the formation’s principles of the thermoacoustic oscillations in gases on the example of standing oscillations in Rijke’s tubes.

**Слайд 4.** The objectives you can see on the slide.

**Слайд 5.** Now I’d like to observe the basic theoretical concepts that were used in our study.

In [physics](https://en.wikipedia.org/wiki/Physics), a standing wave – also known as a stationary wave – is a [wave](https://en.wikipedia.org/wiki/Wave) in a medium in which each point on the axis of the wave has an associated constant [amplitude](https://en.wikipedia.org/wiki/Amplitude).

The thermoacoustic system is a system where we can observe the conversion of thermal energy into acoustic. The thermoacoustic effect was first obtained by Lord Raleigh.

**Слайд 6.** In 1859, scientist Paul Rijke first described the sound’s emergense in a pipe with a metal grid installed inside it during the heating. He put in a vertical 1meter long pipe a grid that was located at a distance of 20 cm from the lower end of the pipe. Because of the heated air’s convection flow, a standing sound wave appeared.

**Слайд 7.** The most intense sound was observed when the heated mesh was located a quarter of the length of the pipe from the lower end. If the grid is shifted to the top of the tube, the oscillations are weakened and extinguished.

If the grid is heated by fire or electric current, then warm and light air from this grid will rise up the tube, and cold air will start to flow from the outside into the lower part of the tube. The tube will generate traction, and it will start to sound.

**Слайд 8.** Let’s observe our experimental part of the study.

The purpose of the first experiment is to simulate the thermoacoustic resonator under controlled conditions.

We selected metal, glass, and plastic tubes with the length of 1 meter and of different diameters of 25, 50 and 70 mm. For each tube we made flat metal nets and used steel sponges of different rigidity.

Based on the results of the experiment, we formed an optimal set of equipment, with which we carried out all subsequent experiments. So, for conducting further experiments, we selected 1 meter tubes with a diameter of 50 mm with flat steel mesh. We heated the tubes using candles.

**Слайд 9.** The purpose of the next experiment is to define the dependence of the formed sounds’ loudness in tubes made of plastic, glass and metal, having the same length and diameter.

To do this, we placed a flat metal mesh at a distance of 25 cm from the edge. Heating was carried out for 60 seconds. The volume of the generated sound was measured by a sensor. The results of measurements are in the table. The slide shows average values of measurements for 25 experiments, rounded to the tenth.

Thus, we made the conclusion that the volume of sound oscillations doesn’t depend on the substance of the resonator. Since the tube’s size is the same, the volume of air enclosed in them is also the same.

**Слайд 10.** The purpose of the third experiment is to define the dependence of the sound’s loudness from the location of the heated mesh.

The results of measurements are shown in the table.

As you can see, the perceived sound is created when the heated mesh is located from 10 up to 35 cm. The maximum loudness of the sound vibrations is got when the mesh is located on the one-fourth of the tube’s length.

**Слайд 11.** The following experiment was carried out with the aim of defining the dependence of the sound vibrations on the radius of the tube.

For this experiment we selected metal tubes of 1 meter length. Flat metal grids were located at a distance of 25 cm from the bottom edge and heated for 60 seconds. Radii of the tubes were 12.5, 25 and 35 mm.

During the experiment, sound vibrations were recorded in a tube with a radius of 25 mm (loudness 62.5 dB) and 35 mm (loudness 8.5 dB). In the narrow tube, the sound wasn’t recorded.

Had made the necessary calculations, we made sure that, for a tube with a diameter of 35 mm, the optimum length for excitation of sound vibrations is 80-100 cm. But this effect disappeared in a tube less than 48 cm. For a tube of 25 mm in diameter, the maximum length at which stable sound is still observed, is approximately 200 cm. For a tube with a diameter of 35 mm at such a length, the oscillations couldn’t be recorded.

Thus, the ratio of the length and radius of the tube plays an important role for sound vibrations appearing in the tube.

**Слайд 12.** The purpose of the fifth experiment is to study the process of stable sound oscillations’ occurrence from the temperature difference in the lower and upper parts of the air column.

The slide shows photographs of the digital laboratory monitor ReLab. The first photo shows the natural noise in the classroom, then the appearance of a new wave and its amplification.

Thus, the temperature difference in the lower and upper parts of the air column, limited by the walls of the tube, affects the appearance of thermoacoustic oscillations.

**Слайд 13.** The purpose of the last experiment is to study the process of stable sound vibrations’ occurrence from the spatial location of the tube.

To do this, we heated the metal mesh, located at a distance of 25 cm from the bottom edge, for 60 seconds. We recorded the presence or absence of sound for a different spatial position of the tube.

We made the conclusion that the stable sound vibrations can be observed with the vertical arrangement of the tube, the sound stops with its horizontal position or with overlapping of the bottom hole.

**Слайд 14.** The concept of an installation demonstrating thermoacoustic vibrations in gases is thermoacoustic organ. For each organ note we calculated the tube length using the previous formula. The frequency value of each note we found on the Internet.

**Слайд 15.** In order to be able to adjust the volume of the organ, it’s necessary that it operates on electric current. To do this, we picked up 4 ceramic tubes, wound them on a copper-cadmium wire and attached to a wooden pole.

**Слайд 16.** Then we created the scheme that includes rheostat, switch and plug.

**Слайд 17.** After that we combined these two components, and, after a while, the wire began to glow.

**Слайд 18.** Thus, we made the following conclusions:

1. The higher the temperature difference in the air column enclosed inside the tube is, the higher the frequency of sound vibrations is;
2. The best sound is provided by a tube with a diameter of 40 mm;
3. sound vibrations generated in a plastic pipe may be obtained by injecting cold air;
4. When the air is pumped into the pipe, sound is formed in any of its locations, and when the air is heated, only in the vertical one.

**Слайд 17.** References are on the slide. Thank you very much for your attention, I’m ready to answer your questions.