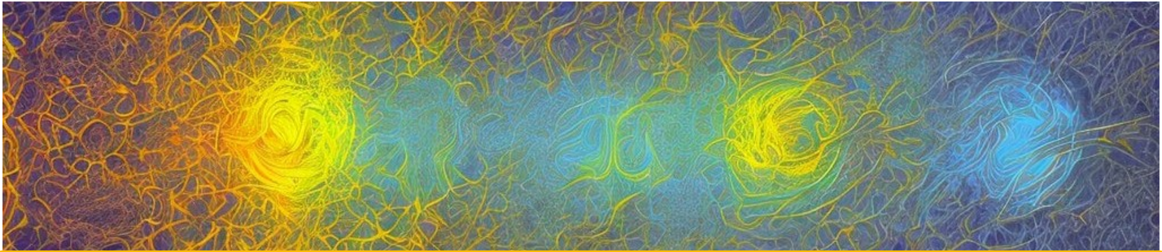

INVESTIGATION OF THE THERMOACOUSTIC EFFECT

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Introduction

Defenition [1]

Thermoacoustic effect is the conversion of heat energy to sound energy or vice versa

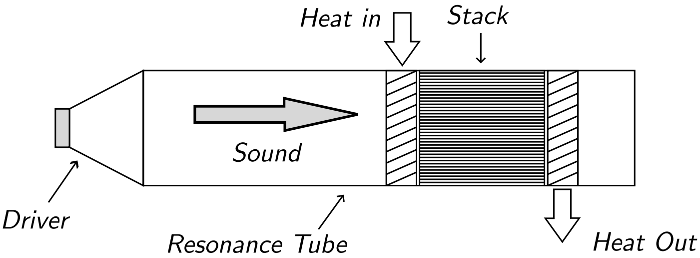

Figure 1: Schematic illustration of the thermoacoustic refrigerator

Theory [2], [3]

1. Adiabatic compression
2. Constant-pressure heat transfer
3. Adiabatic expansion
4. Constant-pressure heat transfer

The thermoacoustic heat flow rate along the plate [3]

$$\dot{Q} \approx -2S\delta_k p_1 u_1 \left(\frac{(\nabla T)_{mean}}{(\nabla T)_{crit}} - 1 \right)$$

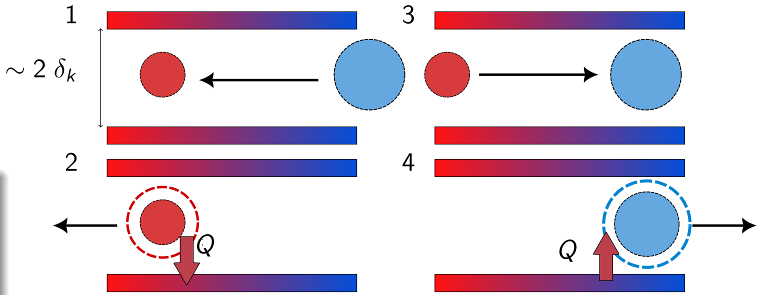

Figure 2: Heat transfer process in the stack

δ_k – thermal penetration depth, $S\delta_k$ – contact area of gas and wall of the stack,

p_1 – pressure oscillation, u_1 – gas particles velocity amplitude

Research design

1. What happens if you remove stack?
2. At what frequency the effect is more productive?
3. What changes when you change stack position (x)?

Experimental setup I

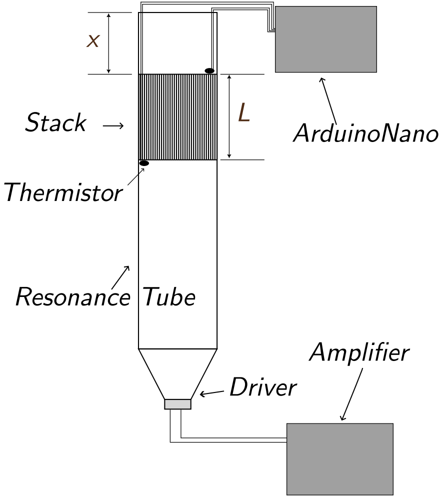

Figure 3: Schematic illustration of the setup

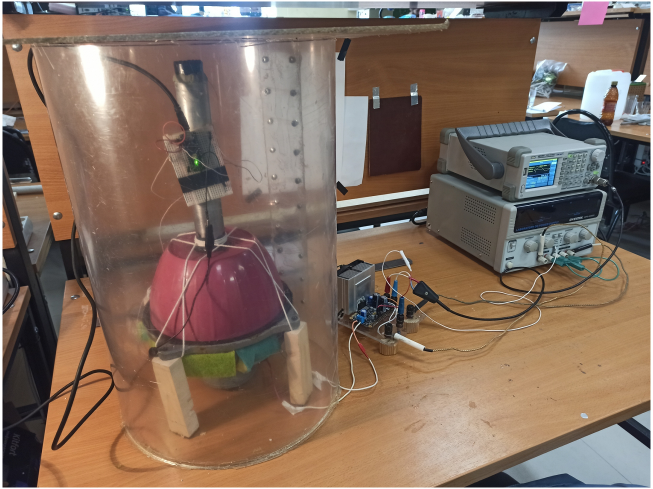

Figure 4: Setup photo

Experimental setup II

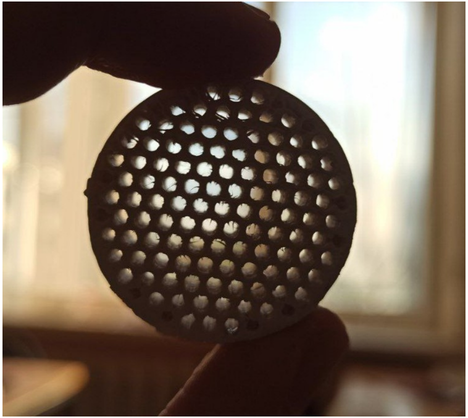

Figure 5: 3D printed stack; hole diametr 2 mm

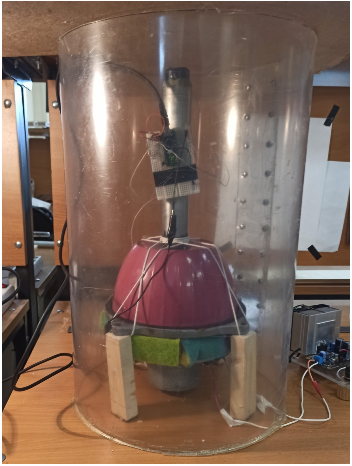

Figure 6: Resonance tube with driver

The need for a stack I

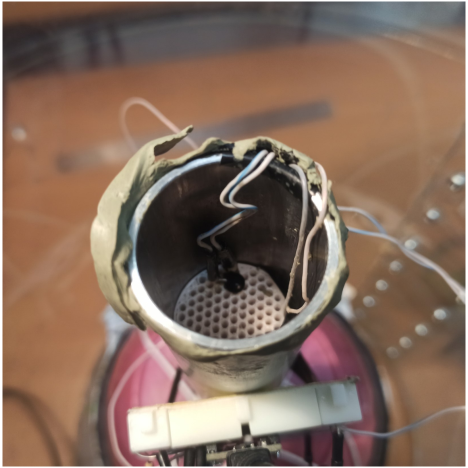

Figure 7: Stack 45 mm long inside the resonance tube

Figure 8: Thermistors without stack

The need for a stack II

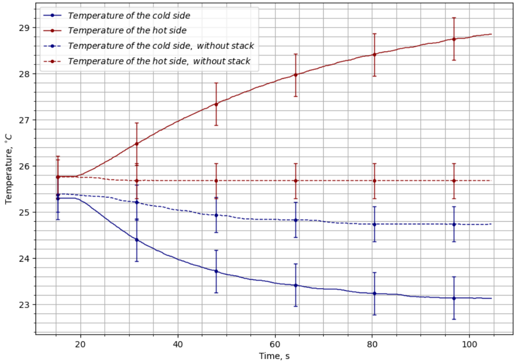

Figure 9: Dependence of the temperatures of the cold and hot sides of the stack on time

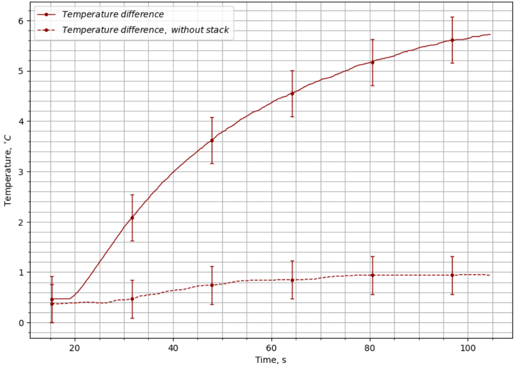

Figure 10: Dependence of the temperature difference on time

Frequency optimization

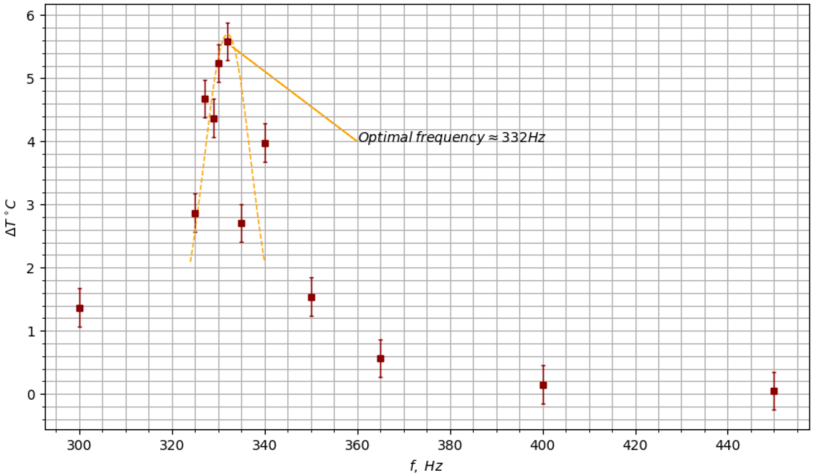

Figure 11: The dependence of the temperature difference reached in 75 seconds on the oscillation frequency of the driver

Stack position optimization

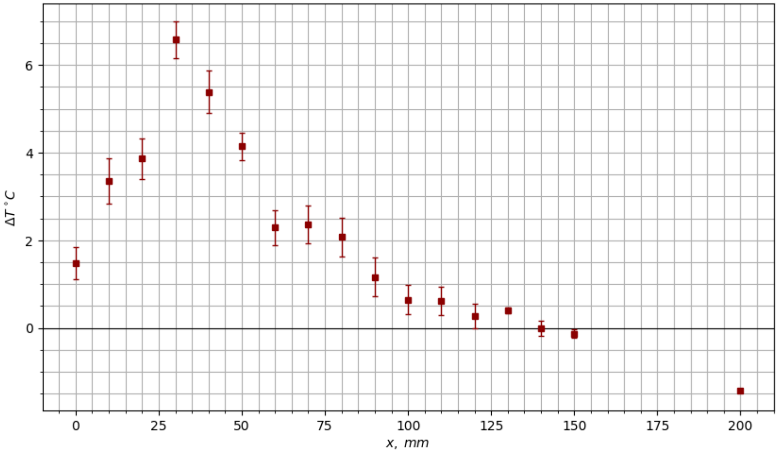

Figure 12: Dependence of the temperature difference at the ends of the stack on its position

Conclusions

Results

- A Thermoacoustic effect was observed, namely, a temperature gradient was obtained due to the acoustic wave
- The optimal frequency for my setup was found
- The optimal stack position has been determined $\approx 30mm$ from closed end. This is about $1/10$ of the length of the pipe from the closed end
- It was noticed that starting from a certain distance, the direction of the temperature gradient changes to the opposite

Further study

- Measure the pressure distribution to confirm the hypothesis of the best stack position
- Extend the measurement range for the stack position
- Investigate the behavior of a thermoacoustic refrigerator when the stack length changes

References

[1] Amirin. *Experimental study of thermoacoustic cooling with parallel-plate stack in different distances*. IOP Publishing Ltd, 2019.

[2] Kajurek J. and Rusowicz A. *Experimental Investigation on the Thermoacoustic Effect in Easily Accessible Porous Materials*. Energies, 2021.

[3] M. E. H. Tijani. *Loudspeaker-driven thermo-acoustic refrigeration*. Technische Universiteit Eindhoven, 2001.