OUTREACH REPORT

THERMOACOUSTIC COOLING

Explore Thermoacoustic – the magic way of energy conversion

Ziyang 'Schoen' Cao
University of Cambridge
zc282@cam.ac.uk

Declaration

Due to the COVID-19 crisis and UK lockdown, all unnecessary activities are suspended, and this results in the outreach event to fall victim. The construction of the demonstration material is unable to achieve. This report will only outline the proposed events that could be delivered.

Relevance

One of the earliest concepts of the thermoacoustic engine and its effect was discovered by Lord Rayleigh in 1870s, and there wasn't much progress on the research until recently. The outreach event will be based on the original Rayleigh thermoacoustic piston engine. Unlike the internal combustion engines, the thermoacoustic engines are more unintuitive. Therefore, such simple experiments will be able to inspire the school kids and broaden their knowledge in engineering and physics.

A purposely-made thermoacoustic piston engine *(online picture)*

Outreach activity

Thermoacoustic piston engine: Introduction

The design of a thermoacoustic piston engine is rather simple. The working principle is based on the standing acoustic wave being generated in a closed-end tube. The acoustic wave is in principle similar to those generated by blowing air across a water bottle. Two facts are used here: the frequency of the air depends on the dimension of the device, and a higher temperature gradient in the regenerative wire wool results in a higher power output. The outreach event is expected to provide a chance for the students to understand the working principles and the affecting factors of the thermoacoustic effects.

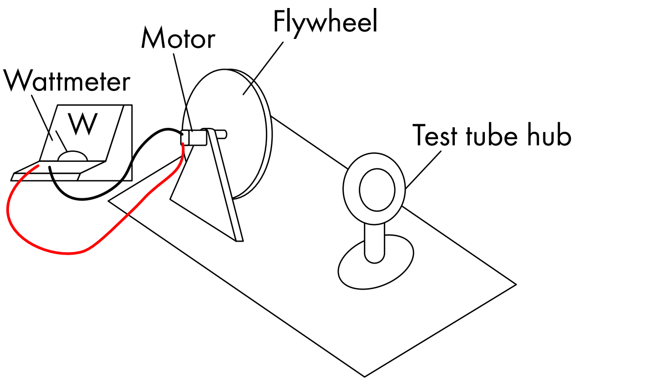
Material

If the outreach event has happened, the following configurations would be used for the building kit. The dimension and material mentioned are for reference only, it can only be determined when an experimental test-run is completed.

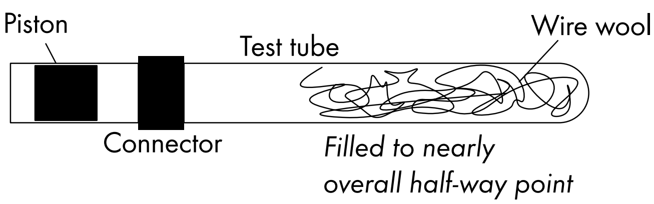
- Test tube – preferable 7mL size with 12mm inner diameter.
- Perspex tube – with same diameter as the test tubes, as the piston hub.
- Piston rod – steel rod with ca.1.5 mm diameter.
- Piston, material preferable perspex, TBC.
- Wire wool – whatever spec obtainable in Dyson Centre.
- Equipment stand – 3D printed.

- Flywheel assembly pre-assembled with machined metals, plywood, and/or 3D printed pieces.
- Bunsen burner or electric heater depends on safety regulation.
- IR temperature gun.
- Electric motor, wiring, and wattmeter.

Assembly



Base assembly



Test tube assembly

The expected experimental assembly is roughly sketched in the figures.

Procedure

The activity procedures are based on students being divided into groups of more than two people. Each group of students will receive a building kit for the thermoacoustic engine, while each building kit will have different tube length.

Students will be instructed to construct the building kit into a thermoacoustic piston engine within half an hour (roughly, and if time is not permitted, a ready-to-work piece will be provided).

Once the device is constructed, the students can ignite the Bunsen burner, with the supervision of course. Around 3-5 seconds (expected) after igniting the burner, one student will be asked to turn the flywheel, and a constant movement should be seen escalating on the device. Immediate after this, one student will be asked to measure the wire wool temperature near the flame using the infrared temperature gun. The other student will be responsible for reading from the wattmeter and record the number. It's expected to have a higher power when the temperature difference is larger.

When the temperature is stabilised, students will be asked to count the rotational frequency of the flywheel. A longer tube, corresponds to longer wavelength, is expected to have a slower rotational speed.

After measuring the frequencies, students will then be instructed to repeat the temperature measuring procedure. Meanwhile, cover-up and switch-off the Bunsen burners, measuring the wire-wool temperature until the piston is stopped.

Health and safety precaution

The experiment involves high-temperature flame and surfaces, moving parts, and low-power electricity. These activities need to put extra precautions, especially when the Bunsen burner is involved. However, a sensible school child with capable knowledge in STEM should not be expected to harm themselves:)

Expected outcome

The students are expected to understand thermal energy can be transformed into acoustic energy, then to mechanical energy and eccentrically electricity.

Students should also learn that the longer the wavelength, the lower the frequency. Furthermore, the temperature difference across the regenerative wire wool will have a positive correlation with the output power.

Further material

Similar devices can be easily seen online, several YouTube vide will be useful for understanding the working principle.

https://youtu.be/wg96lDw7sNw
https://youtu.be/J4JAiI3R72k

Ziyang 'Schoen' Cao
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