CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY

Name(s)
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Project Number
S1516

Project Title
Thermoacoustics: Creating Sound with Heat

Abstract

Objectives/Goals
The objective is to understand and demonstrate the thermoacoustic phenomenon, which uses heat to initiate the oscillation of gas without moving parts. The second objective is to characterize the properties of a thermoacoustic engine. The third objective is to use solar energy to power the engine and to test different engine designs. My hypothesis is that the sound intensity, pitch and sound onset depend on the size of the resonant cavity and the power applied.

Methods/Materials
The engine is made of a thermoacoustic stack inside a Pyrex tube. Electrical power is applied at one end of the stack to create a steep temperature gradient along its length. When the temperature gradient exceeds a critical value, noise is generated. The stack is a solid matrix with flow channels. I studied three stack designs: a ceramic cube with flow channels, rolled metal foils with parallel channels and a wire mesh of random flow paths. I also used a parabolic solar concentrator to create the temperature gradient across the stack. I varied the stack position and the power levels to study the generated sound. Data collected include the applied power, time of sound onset, the temperature of the hot end, and the sound intensity and frequency.

Results
The results of my tests are divided into two sections. First, I fixed the stack position and plotted the hot temperature, the sound intensity, and time of onset as a function of the applied power. The temperature at the hot end and sound onset time decrease and the sound intensity increases as the applied power is increased. Second, I plotted the time of sound onset, the hot temperature and the applied energy as a function of the stack position. The time of onset, the temperature at the hot end, and applied energy are minimized when the stack is at the middle of the test tube. The frequency of the generated noise depends on the length of the test tube because the engine produces a standing wave with a wavelength that is four times the length of the test tube.

Conclusions/Discussion
The thermoacoustic engine can generate sound using only heat and without moving parts. It is environmentally friendly because it also uses inert gases as the working fluid and can be powered with solar energy or rejected heat. As the applied power to the stack is increased, the intensity of the generated sound is increased. The optimal position of the stack is near the middle of the test tube.

Summary Statement
I studied and tested different types of solar powered thermoacoustic engines to demonstrate that it is possible to generate sound by using applied heat and to determine the optimal working conditions of the engine.

Help Received
My mother helped format various materials. My father helped build the apparatus and edit the report.