Thermoacoustics in a nutshell...

Just as the name implies thermoacoustics is an interaction between temperature gradients (thermodynamics) and sound waves (acoustics) and how they effect the surrounding environment. The interactions between heat and sound are detailed from this excerpt from G. W. Swift’s paper on thermoacoustic engines.

"We ordinarily think of a sound wave in a gas as consisting of coupled pressure and displacement oscillations. However, temperature oscillations always accompany the pressure changes. The combination of all these oscillations, and their interactions with solid boundaries, produces the rich variety of thermoacoustic effects."

Thermoacoustics is a process that occurs naturally everyday. For every sound wave there is an increase in temperature. Ordinary human speech has the magnitude of 74 decibels (in sound pressure levels) or the relative pressure changes are in the order of one part per million. The accompanying variation in temperature difference is less than ten-thousandth of a degree Celsius. Even at the human auditory threshold of pain, 120 decibels, the temperature fluctuations is only about 0.02 degrees. Lets take a look at this process in detail. Suppose we take a parcel of gas, which is initially at an average temperature and pressure, and excite it with an acoustical sound wave. As the pressure increases in the parcel of gas the temperature will go up as well assuming the rise happens quick enough that the heat does not have time to flow away. On the other hand, we can add temperature to a parcel of gas and get it to expand.
The thermoacoustic occurrence by itself has no real world utility since the change in temperature is so minuscule. To increase the usefulness of this application, the gas must be in contact with a solid material. Naturally solids have a higher density and therefore have much higher heat capacity per unit volume than gases. Solids can exchange a considerable amount of heat without changing its internal temperature very much. If a sound wave carrying a parcel of gas is placed near a solid, the surface of the solid will tend to absorb the heat released when the parcel compresses, keeping the temperature stable. The converse is also true. The surface of the solid will release heat when the parcel expands, preventing it from cooling down as much as it otherwise would. Figure 1 show a parcel of gas and its interaction with the surface of a solid. By using this thermoacoustic phenomenon we can use it to create a thermoacoustic prime mover or a thermoacoustic driver (TAD). If we contain it in a vessel we can then produce a standing wave.

![Diagram of thermoacoustic interaction](image)

1 - Compression

2 - Heating

3 - Expansion

4 - Cooling

Figure 1. Thermoacoustic interaction between a parcel of gas and the surface of a solid.