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STIRLING ENGINE: AN INTERMEDIATE PROJECT IN THERMODYNAMIC LEARNING PROCESS

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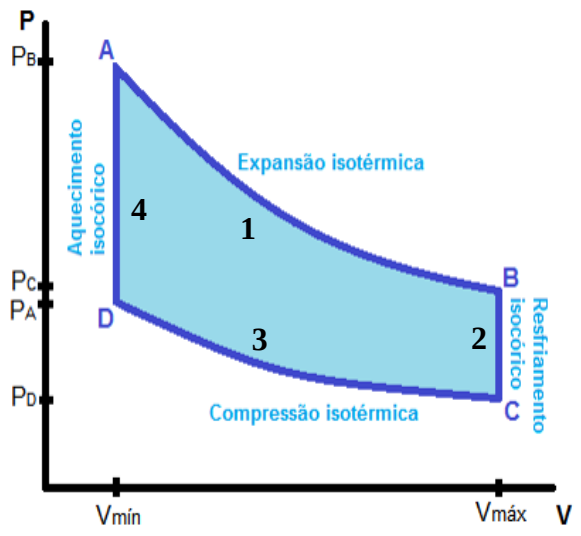
Graphical Abstract



Abstract.

The figure on the side is a simplified representation of the operation of the Stirling engine. This type of motor operates as a thermodynamic cycle composed of four phases and executed in two-times piston: an isothermal expansion (1), an isovolumetric cooling (2), an isothermal compression (3) and an isovolumetric heating (4). The engine consists of two chambers with different temperatures that heat and cool a gas alternately, causing cyclic expansion and contraction, which causes two pistons connected to a common axis to move.

Introduction

Invented in 1816 by Scottish shepherd Robert Stirling and his brother, the Stirling Engine is an external combustion engine. Its main intention was to replace the steam engines, which always caused several accidents in the industries, since at the beginning of century XIV steam engines exploded very easily. It is also referred to as "hot air engine", for using atmospheric gases as working fluid [1].

This type of motor operates as a thermodynamic cycle composed of 4 phases and executed in 2-stroke piston: isothermal compression (constant temperature), isovolumetric heating (constant volume), isothermal expansion and isovolumetric cooling. This is the idealized cycle (valid for perfect gases), which varies from the actual cycle measured by instruments. Much like the so-called Carnot Cycle, which establishes the maximum theoretical limit of thermal machines performance. A fact that

calls attention to the Stirling engine is its simplicity, since it consists of two chambers at different temperatures that heat and cool a gas alternately, causing cyclic expansion and contraction, which causes two pistons connected to a common axis to move.

When applied in Physics Teaching the motor becomes a great ally in the approximation of the theory of thermodynamics with the practice, concepts that are worked in the classroom. In this context, after construction and operation students will be able to better visualize the thermodynamic processes present in the motor cycle. Because it is a low-cost project, the objective is to facilitate the construction and use motivating students in their learning process.

Materials and Methods

For the construction of Stirling Engine, a search was made on the internet, where we found models and used materials that were easy to access and at a reduced cost. We use conservation cans, bicycle lanes, CD's, PVC pipes, clips, nuts, bolts, solder, keys, saw and glue. As shown in Figure 1.

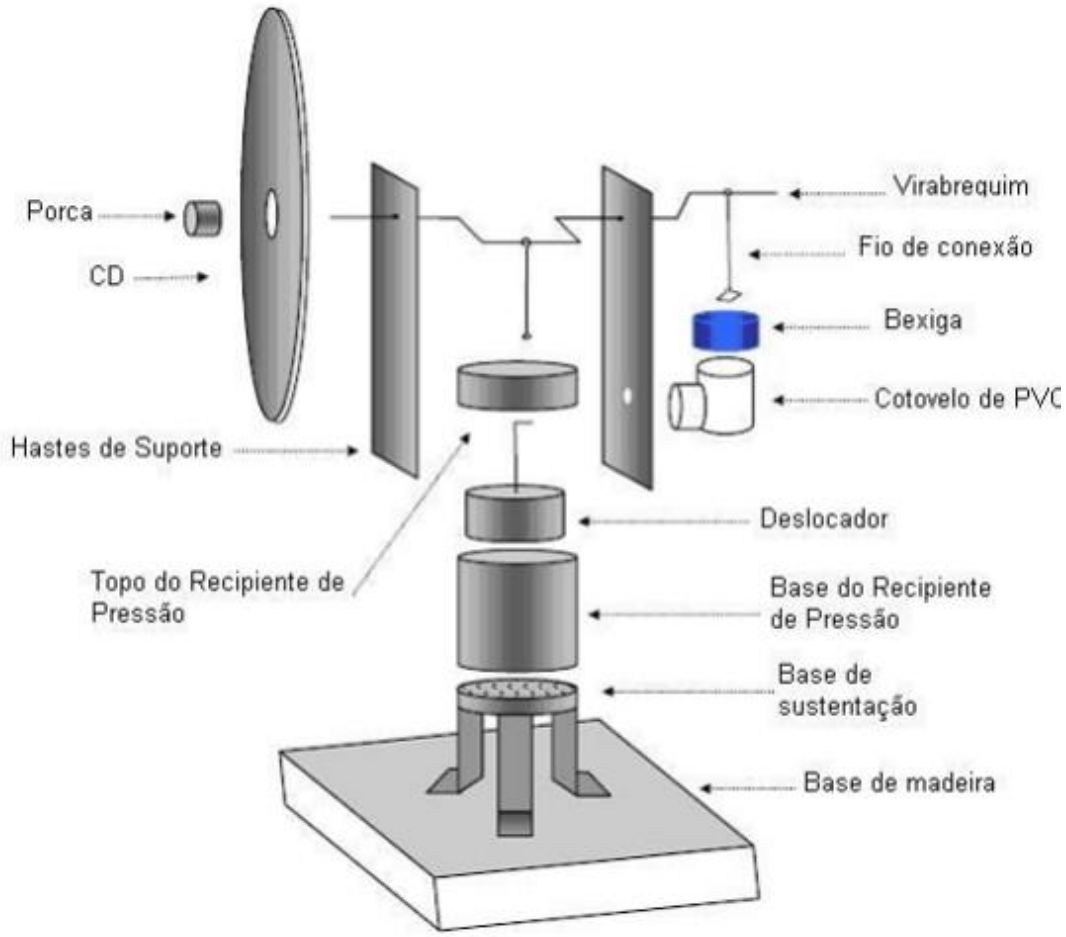


Figure 1: Illustrative image of the Stirling engine project

Results and Discussion

After obtaining the materials, the Stirling engine was constructed as shown in Figure 2.

Figure 2 - Engine image completed

In order to understand the thermodynamic cycle involved in the Stirling motor, we describe the processes in a detailed way during their operation:

1. An external heat source with the gas at the same time expands its constant temperature. When supplying a quantity of heat Q1, the gas expands with the volume Vmín the Vmáx isothermally, therefore, a pressure should decrease according to the equation PV = NRT
2. The heat is withdrawn from the gas, the gas maintains a constant volume and its pressure decreases. The gas is cooled to the temperature and, consequently, to its internal energy, the work done W = 0
3. The gas is cooled as its volume decreases, returning to its initial state and cooperating so that its temperature does not increase. That it is a heat loss Q3. There is also a compression of the gas volume in the cylinder. In addition to the internal pressure isothermal, making the formation cycle possible, thus keeping its internal energy equal to zero.
4. For the cycle to be completed, at the last moment of the process, there is an increase in the temperature, causing it to return to its initial state, while the volume remains constant, emphasizing that there is an increase in the internal pressure of the system.

Advantages and disadvantages of the Stirling engine:

- Used gases never leave the engine, because there are no exhaust valves that release high-pressure gases, which gives it greater efficiency.
- Low pollutant, since combustion is continuous.
- There is no explosion inside, they are quieter.
- Works with any heat source as long as there is a significant temperature difference inside.
- Its major disadvantage is the difficulty of starting and varying the speed of rotation quickly, being complicated its use of vehicles.
- Sterling's engines are more expensive, in both acquisition and maintenance.

Applications: Aviation, Submarines, electric cars, even in nuclear power projects.

Conclusions

When applied in Physics Teaching the motor can become a great ally in the approximation of the theory of Thermodynamics with practice. In this way, students get a better visualization of the thermodynamic processes and the concepts worked in the classroom through the construction and operation of the engine. Because it is a low-cost project, the idea is to build teams that motivate students in their learning process.

References

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[2] Disponível em: https://sites.google.com/site/motordestirling/motor-de-stirling/aplicações, Acesso em 18-out-2018