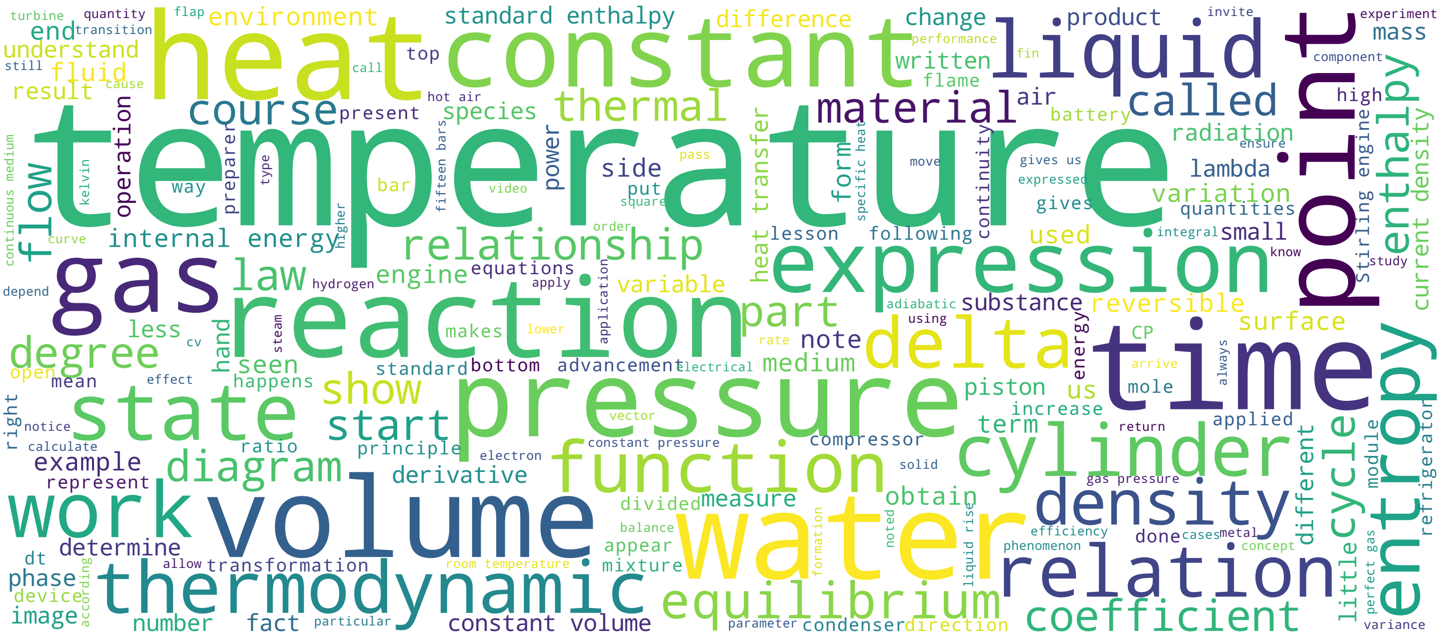
Thermodynamique

Expériences :
Cycles thermodynamiques

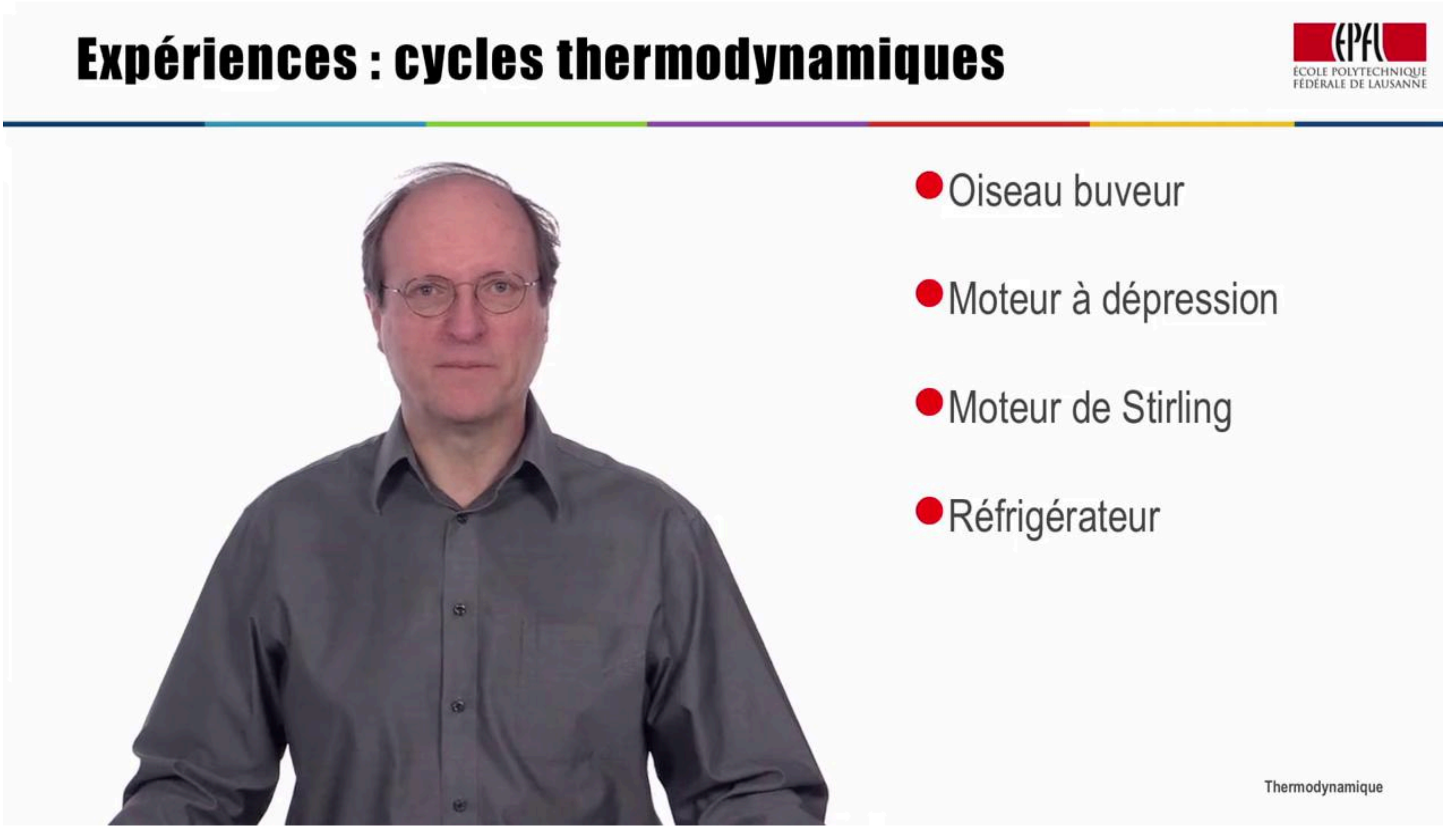
Prof. Jean-Philippe Ansermet

Nicolas Léonard Sadi Carnot,
1796-1832



Video

EPFL

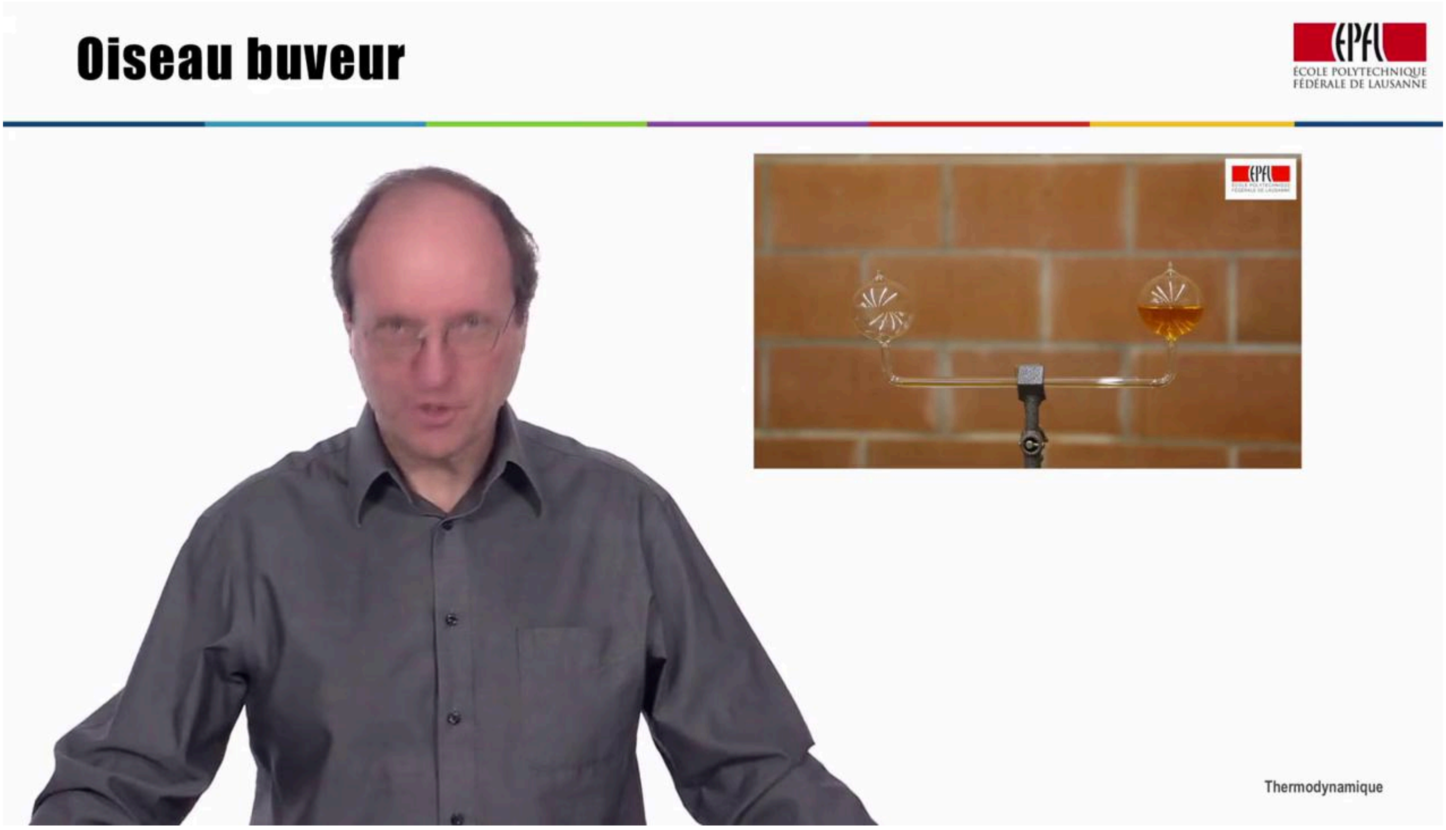


Here I am again to present you some experiences in this lesson. Etienne Robert showed you thermal machines. Here, I would like to show you some small experiments that illustrate how a thermal process can result in a job. We will start by trying to understand how a small toy that can be found in the shops works. Then, we will look at an engine vacuum engine, then a better defined engine which is the Stirling engine. Finally, we will look at the operation of a refrigerator.

Notes

Summary

0m 04s



I start with this little toy. I suggest you to look at what happens when this little bird dips its beak into the water. Watch what happens to the liquid in the bird's body. When the bird tips over, the liquid sinks back to the bottom. At the bottom of the bird and little by little, the liquid rises. Like this. What makes the liquid rise? To clarify this, the preparators measured the temperature of the bird's beak. First, they mounted a very thin thermocouple on the nozzle. In a second step, they used an infrared camera observing. Here is the temperature measurement of a thermocouple mounted on the duck's beak. When the spout is out of the water, it cools down. And then it returns to room temperature. This is the temperature of the water in the glass. Now you see an image obtained with an infrared camera. On the right, you have a bar that indicates the. Which makes the correspondence between the color and the temperature. So the bottom of the bird is about the temperature while the top and a few degrees at a temperature of some degrees below room temperature. We still need to understand why, as the duck's head cools, the liquid rises. To understand this phenomenon, Preparers have another device to make things clearer.

Notes

Summary

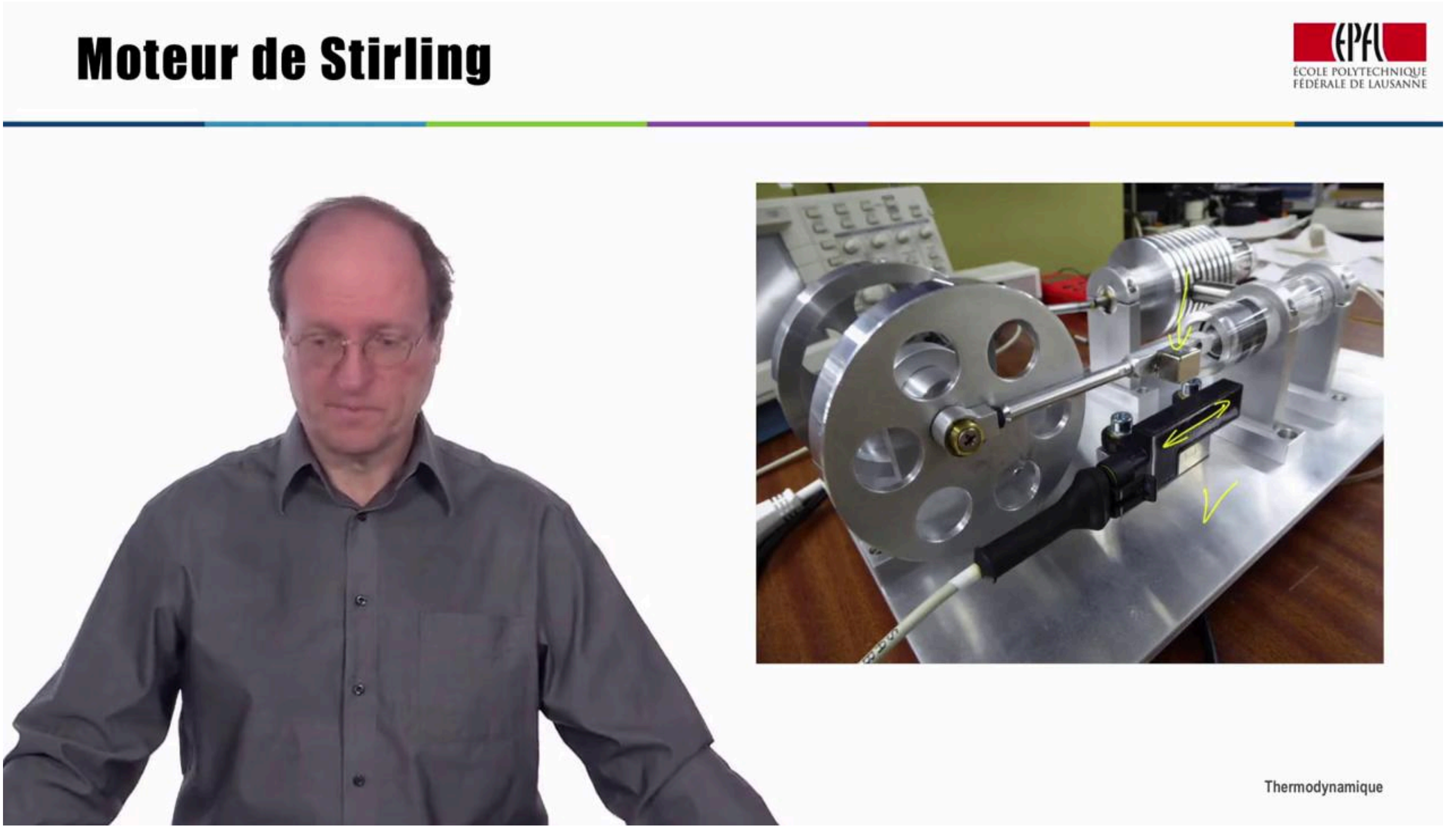
0m 47s

I'll let you take a look. Here you have a similar liquid enclosed in these two balls connected by a tube. And as you can see, when you heat one side, the liquid leaves the other. We will do the opposite experiment. Now we're going to cool down one side. It is the equivalent of what happens in the head of the drinking bird. And you see the liquid leaving the colder side. I now turn to another device, a motor called a vacuum motor. Here you have an alcohol stove that heats the air in the vicinity. A flap. Who opens a cylinder. Equipped with a piston mounted on a flywheel. I have an image. Here you can see the schematic diagram. You have two rods. You have a piston in the cylinder that is cooled by fins. You have hot air at the entrance of the cylinder. You have a flap that opens with a phase shift in relation to the movement of the piston in the cylinder. I invite you to watch the video of the engine in operation. You can see that you need to generate a good flame for the system to work. Here it is in full operation. And the preparers. To make it clearer what is going on. We make an image with a fast camera. With the fast camera, you see? The flap that will open, that pushes the air out. Which was in the cylinder. And now hot air enters. We'll go over it a second time. The air is hunting. And the hot air coming in.

Notes

Summary

3m 30s

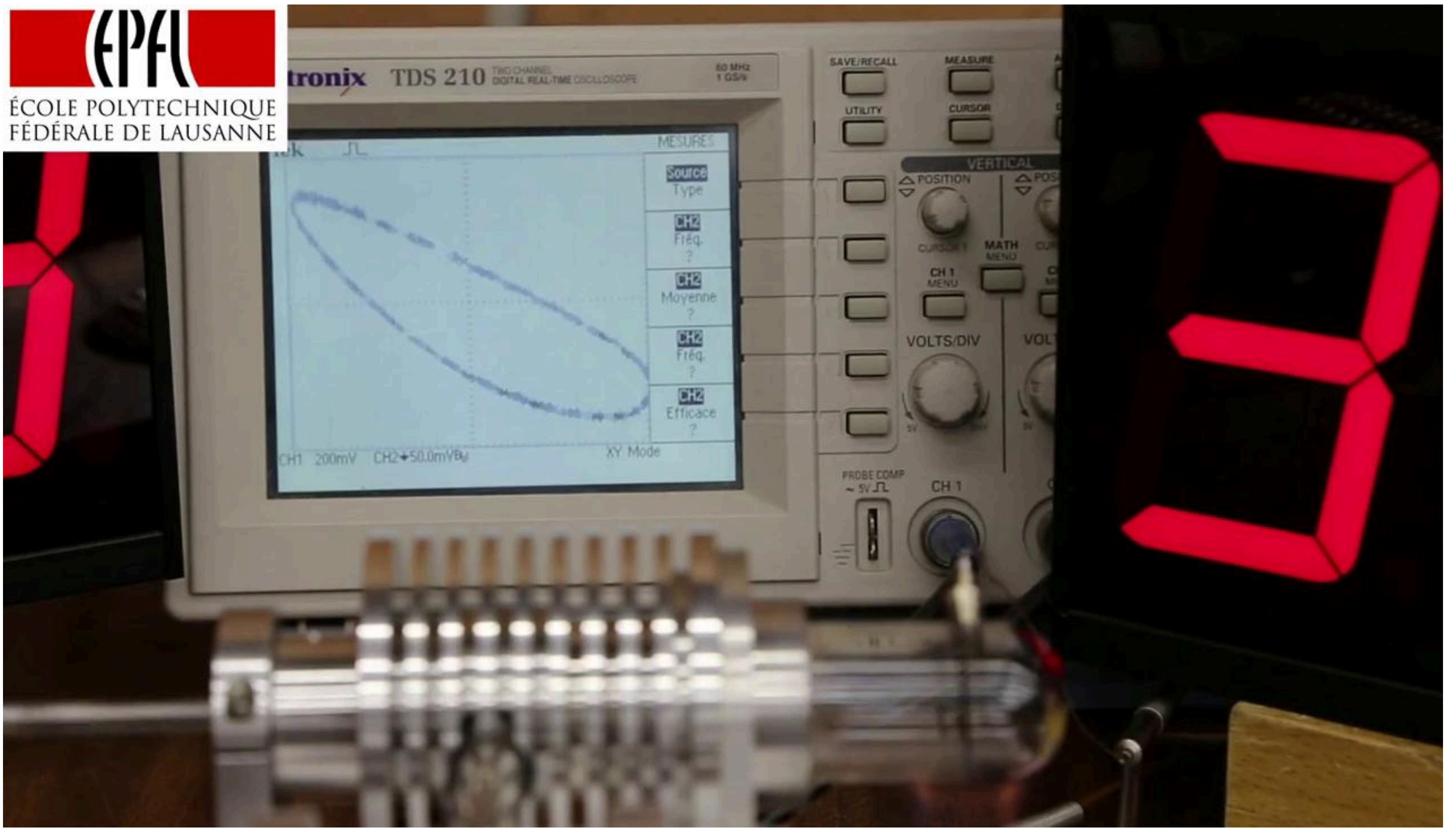


I would like to show you now an engine whose principle is better defined. Here is a construction. I take this opportunity to salute the preparer who built us this model of a machine called Stirling. See on the right? A cylinder in green on top of an alcohol stove. The base of the cylinder is contained in a metal part with cooling fins. And we have several sensors. First, we will measure the temperature. Here. And so the temperature on the side of the flame and the temperature on the fin side. There is a second cylinder. Which is operated. As we will see later in the piston is actuated by a connecting rod attached to the flywheel that we see on the back of the image, and we measure the gas pressure at this point. If we now look at the device from the steering wheel side. We distinguish here a magnet. And here a position sensor that will give us an indication of the volume of the gas.

Notes

Summary

6m 07s



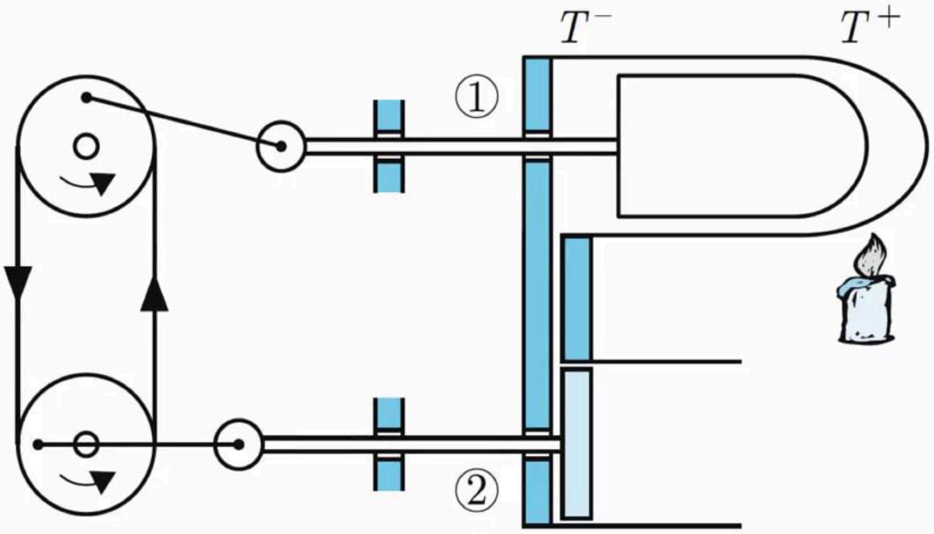
I invite you to watch the video. This is the biker. The flame is lit. The temperature on the hot spring side increases. And the preparer will start the system. Thanks to the sensors that give us pressure and volume, we can make a picture of the PV diagram of this engine.

Notes

Summary

7m 44s

Moteur de Stirling



Thermodynamique

To understand what is going on, I would first like to draw your attention to one particular point of this engine, is that you have in the large cylinder the one exposed to the flame. You have a plunger that is shaped like a large glass bulb. And when this piston moves inside the cylinder, the volume of the gas remains constant.

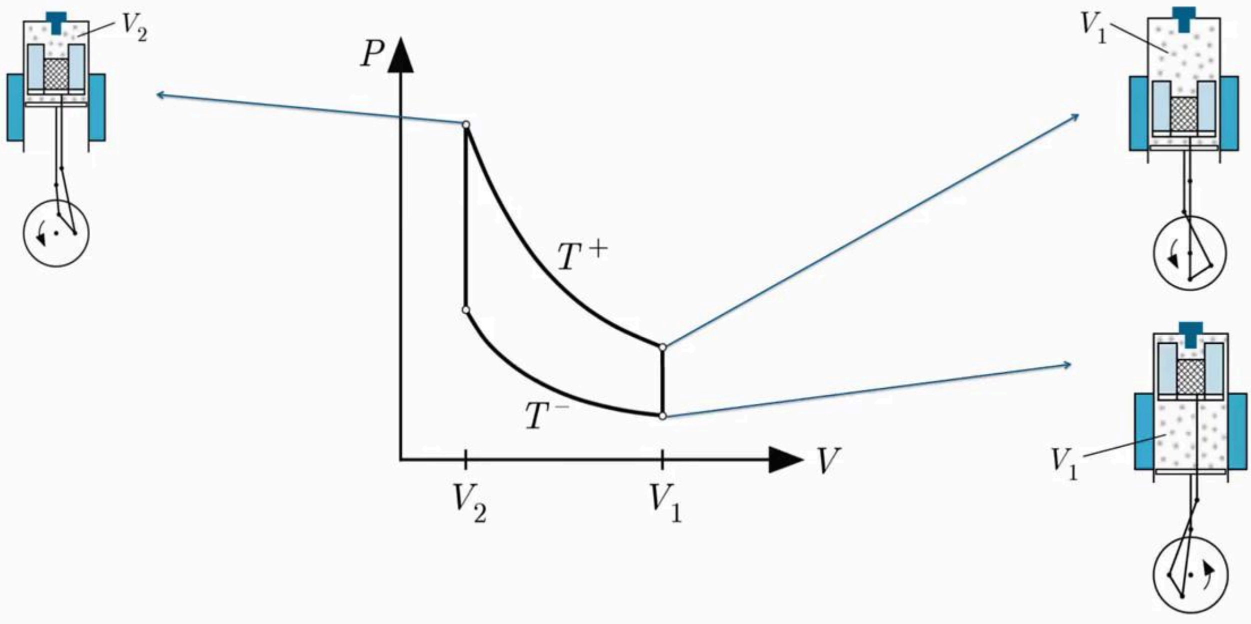
Notes

Summary

8m 21s

Moteur de Stirling

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE



Thermodynamique

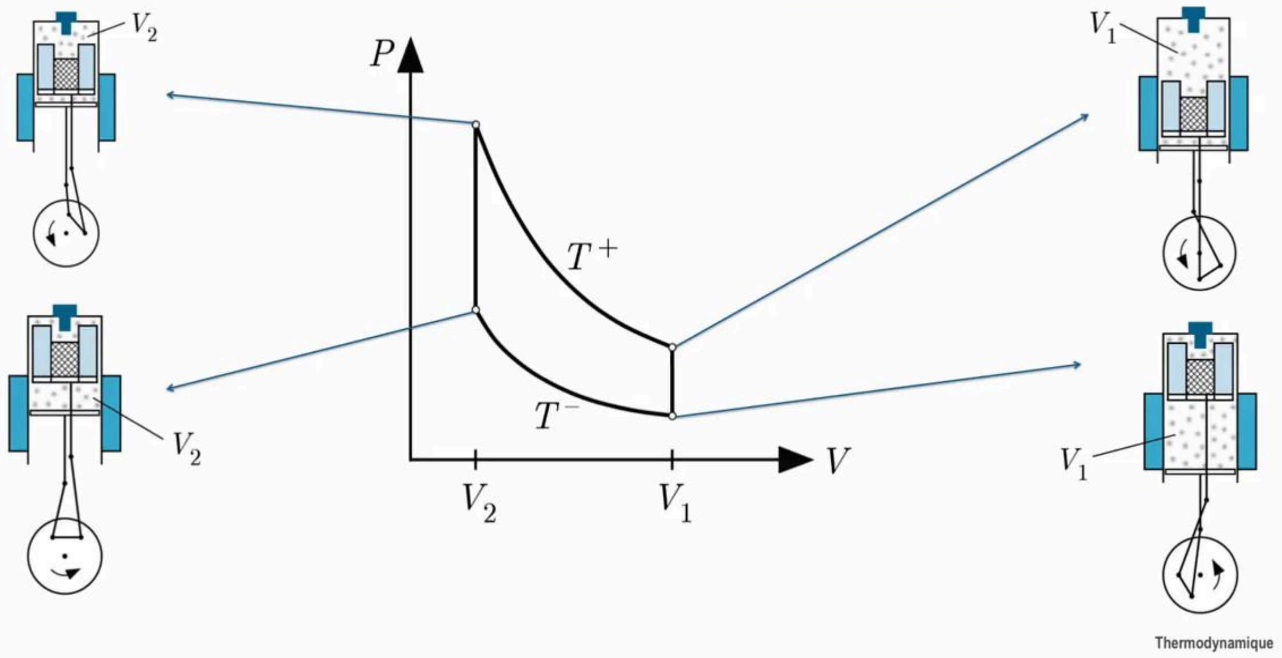
I now move to a schematic diagram of the Stirling engine. Here is the Stirling cycle on a PV diagram. I start with this top of the diagram and I show you here a variant of the Stirling engine or the. Instead of having two separate cylinders, the cylinders are together, but there are of course two pistons. We are here in the state of the system where the volume is the smallest, and the gas is confined to the side exposed to the hot source. At this point, the gas undergoes an ISO term expansion at temperature T. More until we get to that state where we have the maximum volume that I have noted v1 on this diagram. And now the system will make the gas do an ISO body transformation. The volume is constant but the gas will move from the hot side to the cold side. On the device that I have drawn schematically here, the gas passes through a grid called a regenerator. You realize that if the gas goes from the temperature T no longer at the control temperature, its internal energy changes. But since the volume is constant, there is no work to be done on this gas. Therefore, there must be a heat exchange. The regenerator allows this heat exchange in the most efficient way.

Notes

Summary

8m 47s

Moteur de Stirling



We are at the end of the transformation ISO body with the same volume V1 at the temperature of the cold source. At this point, we do an ISO compression. Term like this. To reach the next state where we have again the minimum volume. But this time, the gas is confined to the area exposed to the cold source. All that is left to do is to make a ISO record transformation to return to the initial state.

Notes

Summary

10m 25s

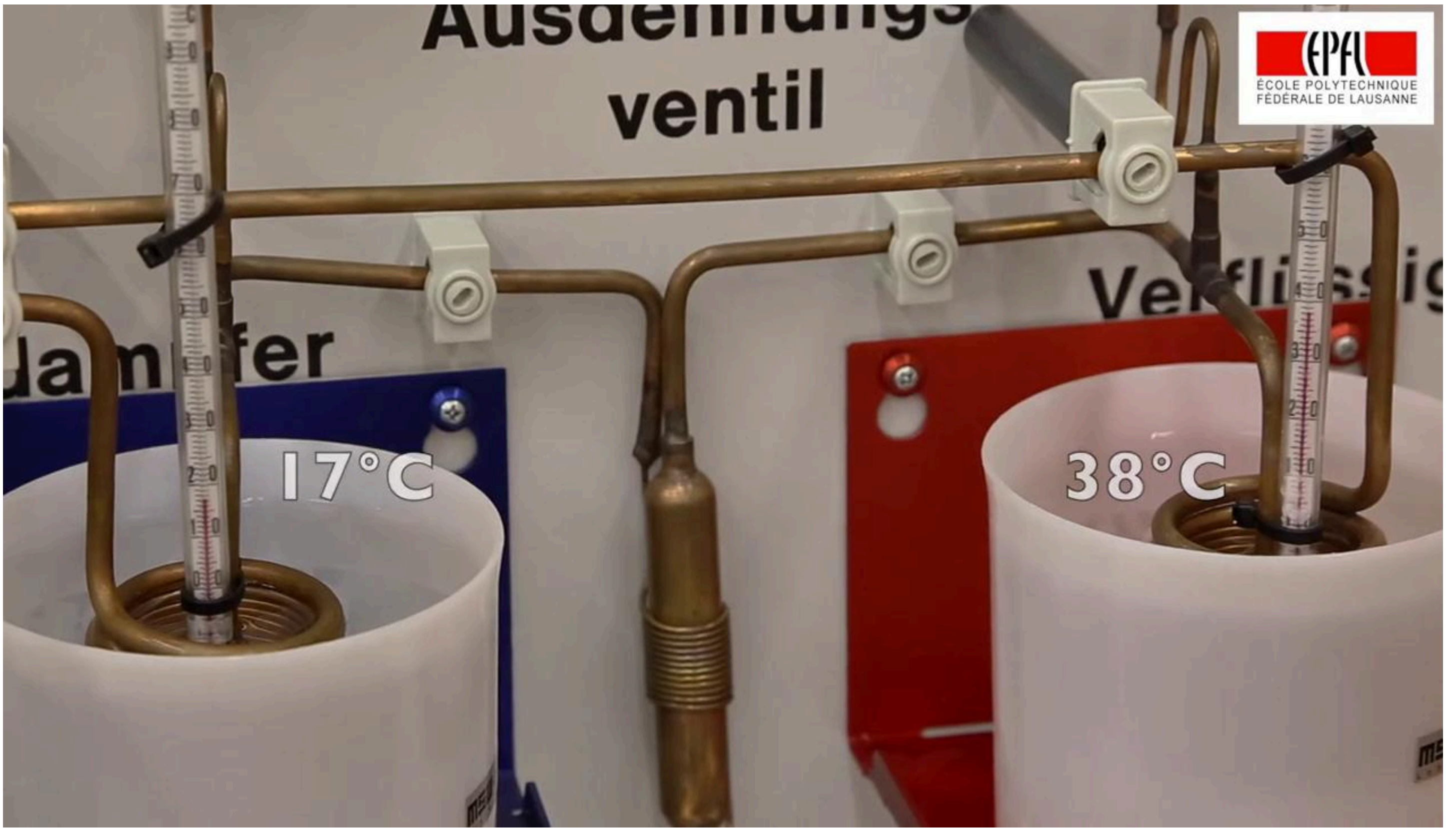
Modèle de réfrigérateur

Finally, I would like to show you how a refrigerator works. Here you have a refrigerator of which we have only kept the operating principle, if you will. To mark on the image the presence of a compressor that is electrically powered. There is a security device which ensures that the pressure does not rise too high in the system. You have here a condenser, we observe. Note here that we have a gas pressure which is about fifteen bars when the system is running. And we will condense the heat transfer gas in the condenser, which will make, since we have a condensation of the gas that the water around the spiral. Here the water will have a high temperature. Then the gas. Finally, the liquid passes through an expansion valve, which will lower its temperature. After the regulator, there is a capillary, which will ensure the pressure difference. You will notice here a high pressure of about fifteen bars and a much lower pressure on the liquid side. On this side. You now have an evaporation of the liquid that takes place which will cause a lowering of the water temperature. The gas can then pass in the compressor observing the device in operation.

Notes

Summary

11m 01s



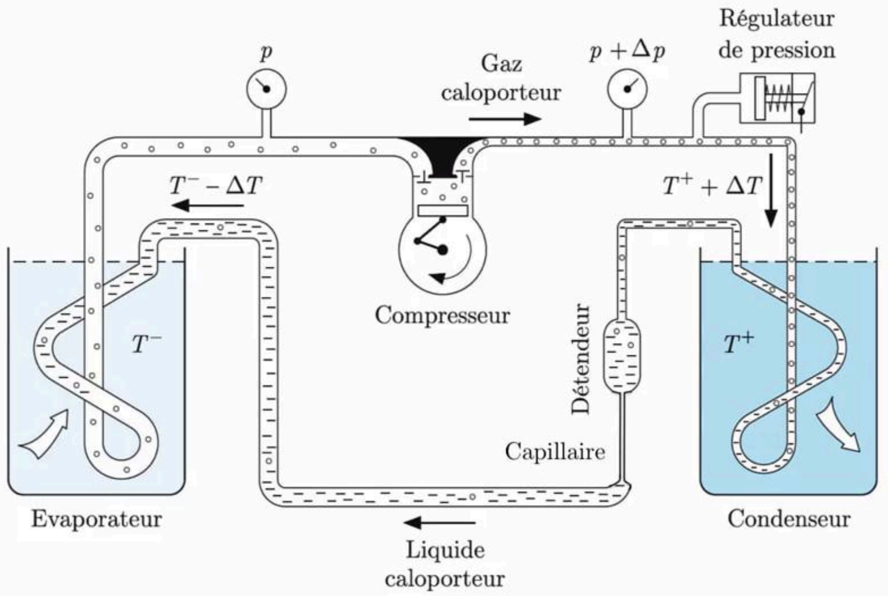
Preparer switches on the compressor to note the pressure increase on the right manometer. Initially, the water is somewhat at room temperature. And after some time, we get to about fifteen bars and two bars. For gas pressure. And cash. And the water reaches a temperature of 17 degrees on one side and 38 degrees on the other.

Notes

Summary

12m 46s

Modèle de réfrigérateur



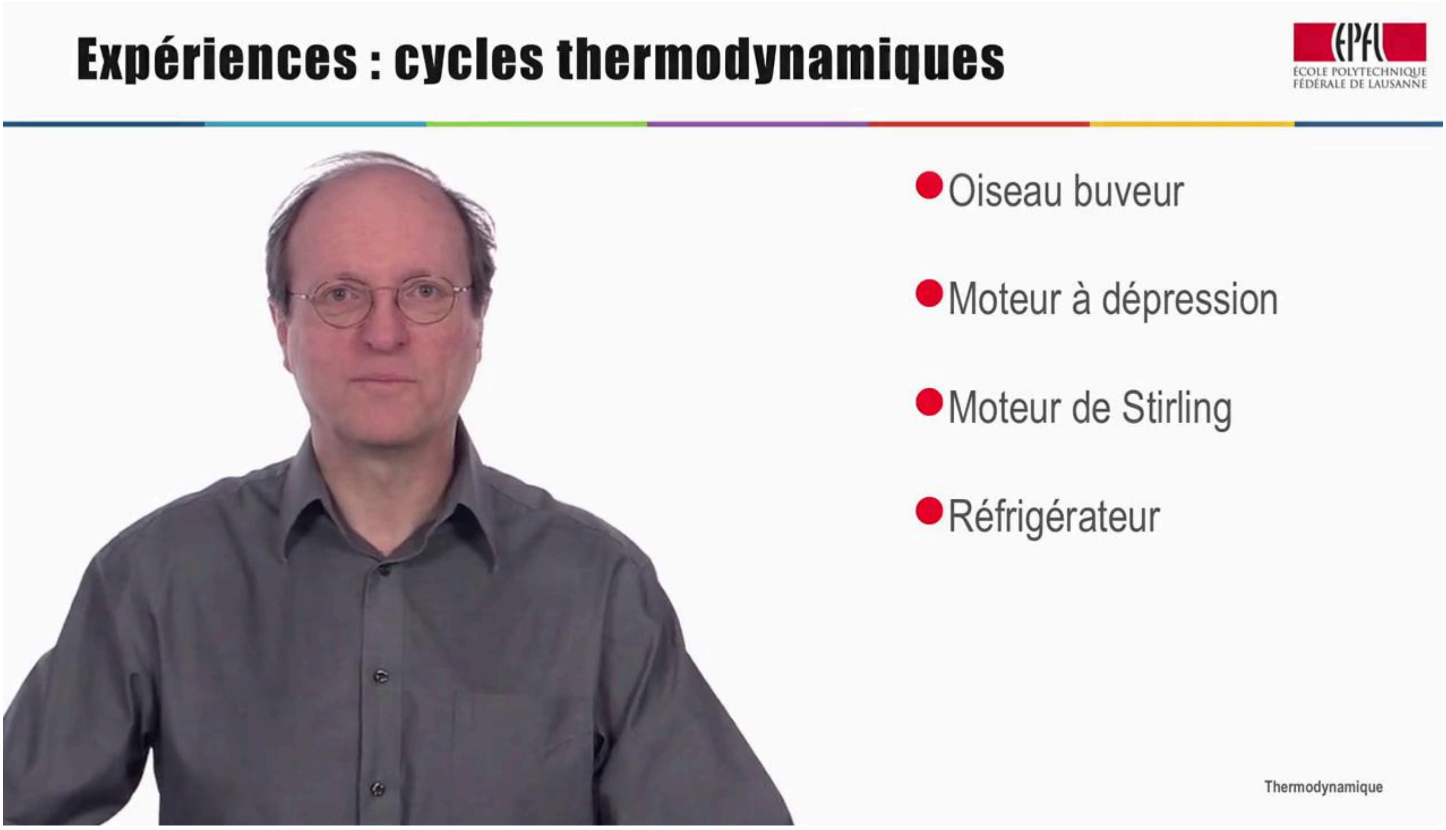
Thermodynamique

Here is a diagram that summarizes the operating principle of this refrigerator. You recognize the two pools of water, the spirals. On the one hand, there is condensation. On the other hand, there is evaporation. There is a regulator followed by a capillary to ensure that the liquid pressure difference is maintained between the two branches of the heat transfer fluid circuit. And then, in the middle, of course, the compressor.

Notes

Summary

13m 23s



In summary. In this module, we have analyzed the thermal principle that makes this toy work that I called the drinking bird. We have seen a vacuum engine working. With, we saw it very clearly, a hot spring. The flame and a cooling system fins on the cylinder. Then, the mode of operation of a Stirling engine was analyzed. Then we looked at a refrigerator disassembled so that all the parts can be seen. Thank you for your attention.

Notes

Summary

13m 53s