Model of a field of parabolic troughs (Item No.: P9508260)

Curricular Relevance

Area of Expertise: ILIAS

Education Level: Physik

Topic: Klasse 7-10

Subtopic: Wärmelehre

Experiment: Wärmekraftmaschinen

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	1 Student

Additional Requirements:

- Cold water

Experiment Variations:

- Student experiment: Model of a field of parabolic troughs (P9519300)

Keywords:

Solar energy, parabolic reflector, focal point, parabolic trough power plant, absorption, reflection

Teachers' briefing

Introduction

Principle

Parabolic reflectors focus the light of the sun into a focal point in which a piece of paper can even be set on fire. Parabolic troughs have a focal line in which pipes or tubes, for example, can be heated in a particularly efficient manner. In this experiment, a black test tube that is filled with water and a glass tube are illuminated by a 120 W reflector lamp.

Application

The reflector in the form of a parabolic trough that is used in this experiment is an example of the reflectors that are used in big parabolic trough power plants. In these power plants, an arrangement of two tubes (one inside the other) is located in the focal lines. The liquid in these tubes is heated until it boils, thereby powering turbines and generating electricity. The outer tube is the insulation for the inner tube through which the medium, which is to be heated, flows. This leads to an even higher efficiency.

This experiment also uses an arrangement of two tubes with one tube inside the other.

The water quantity of 4 ml ensures that the experiment can be performed quickly and that the water can be heated very strongly nonetheless.

The possibility to generate high temperatures and to select a suitable liquid provides the students with an impression of the mode of operation of a parabolic trough power plant.

Note

The water in the parabolic trough and the parabolic trough itself become very hot during the experiment (see the measurement values).

Material

Position No.	Material	Order No.	Quantity
1	Clamping holder with 2 clamping possibilit, 0-13 mm,fixing magnet	02151-08	2
2	Clamp on holder	02164-00	1
3	Concentrated solar power unit, 180 mm	02168-00	1
4	clamp, d = 16 mm, with mounting rod	05764-00	2
5	Glass beaker DURAN®, short, 400 ml	36014-00	1
6	Syringe 20ml, Luer, 10 pcs	02591-03	1
7	Demo Physics board with stand	02150-00	1
8	Support rod PHYWE,square, l 630mm	02027-55	1
9	Ceramic lamp socket E27	06751-01	1
10	Filament lamp, 220V/120W, with reflector	06759-93	1
11	Cobra4 Wireless/USB-Link incl. USB cable	12601-10	1
12	Cobra4 Sensor-Unit 2 x Temperature, NiCr-Ni	12641-00	1
13	Holder for Cobra4, magn.	02161-10	1
14	Immersion probe NiCr-Ni, steel, -50...400 °C	13615-03	1
15	USB power supply for Cobra4 Mobile-Link 2 and Wireless/USB-Link	07932-99	1
16	Software Cobra4 - multi-user licence	14550-61	1
Additionally required:			
17	PC with USB port, Windows XP or newer		

The following articles are additionally required for carrying out the test without a PC:

Test with Mobile-Link:

Position No.	Material	Order No.	Quantity
1	Cobra4 Mobile-Link 2 incl.accessories	12620-10	1
2	Cobra4 Display-Connect TX, transmitter for using the Cobra4 Mobile-Link with large-scale displays	12623-00	1
3	Cobra4 Display-Connect TX, receiver for using the Cobra4 Mobile-Link with large-scale displays	12623-01	1
4	Large-scale display, digital	07157-93	1

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Set-up and procedure

Set-up

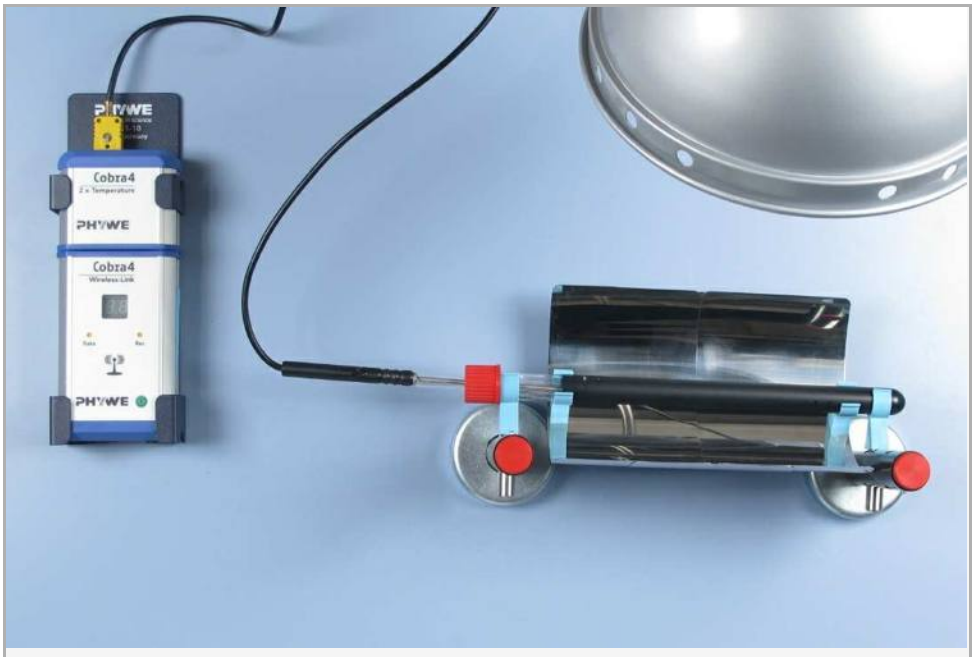

Fig. 1: Experiment set-up

- Attach the clamp holders with 2 clamping points to the board with a distance of approximately 21 cm between them. The left holder must be 1 cm higher than the right holder. Fasten the clamp holders (Fig. 1).
- Fill the 400 ml beaker with cold water.
- Use the syringe to withdraw 4 ml of water from the beaker and fill it into the test tube. Then, add the screw cap with the seal and tighten it slightly. Insert the glass tube so that it protrudes from the cap by 2 cm. Tighten the screw cap completely.
- Fasten the reflector to the test tube and fasten the test tube into the clamp holders with the aid of the clamps with mounting rods (see Fig. 1).
- Fasten the clamp on the holder tightly to the upper edge of the board and clamp in the Phywe support rod. Fasten the reflector lamp to the end of the support rod (see Fig. 2).

Fig. 2: Lamp set-up

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- Aim the reflector lamp centrally at the test tube. The distance to the test tube should be approximately 28 cm.
- Adjust the reflector of the parabolic trough as parallel as possible with regard to the incident light (identical distance between the two side edges and the lamp). Ensure that the left side is still 1 cm higher than the right side.
- Insert the temperature sensor into the riser tube (Fig. 1).

Procedure

- Start the PC and Windows.
- Connect the Cobra4 Wireless Manager to the USB port of the PC.
- Start the "measure" software package on the PC.
- Connect the Cobra4 Wireless-Link to the Cobra4 Sensor-Unit. After it has been switched on, the Sensor-Unit will be automatically detected and an ID number will be assigned to the Cobra4 Wireless-Link. This number will be displayed. The communication between the Cobra4 Wireless Manager and the Cobra4 Wireless-Link is indicated by way of the data LED.
- Switch the Cobra4 Wireless-Link with the connected Cobra4 Sensor-Unit 2x Temperature on. The Sensor-Unit and the quantity T_1 are displayed as the measuring channels.
- Load the experiment (Experiment > Open experiment > ...). The program will now open all of the required presettings for the measurement data recording process (Fig. 3).

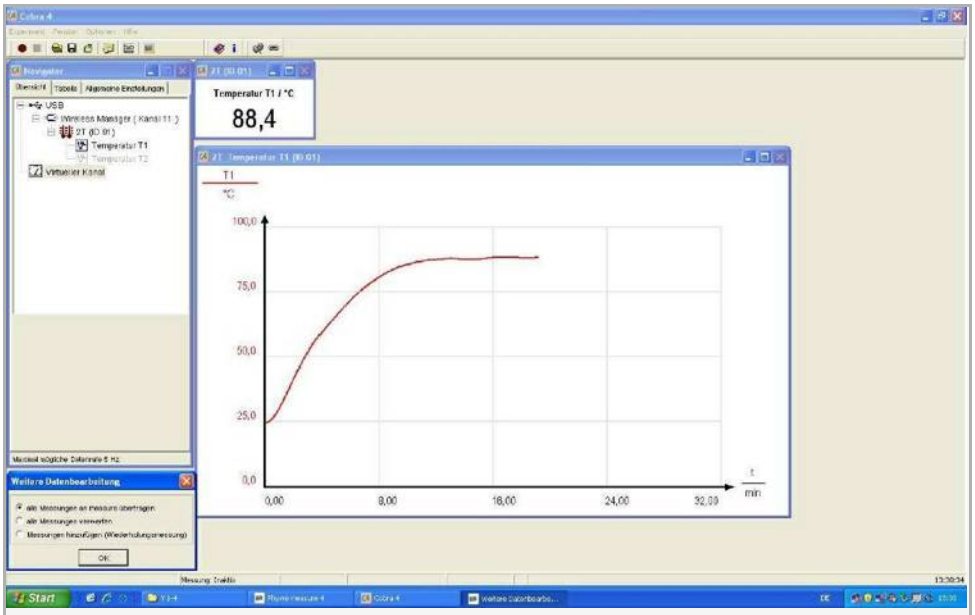

Fig. 3: Measurement data recording

- Switch the lamp on and start the measurement data recording process in "measure" ☐.
- During the experiment, observe whether condensate forms and, if so, where it forms.
- Stop the measurement data recording process after approximately 20 minutes in "measure" ■.
- Switch the lamp off.
- Transfer the measurement values to the "measure" main program.
- Let the test tube cool, take it out of the holders, and then remove the parabolic trough. Pour the water out of the test tube.

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Observation and Evaluation

Observation

Within approximately 8 minutes, the temperature of the water rises to 80°C.

In addition, condensation can be observed on the glass near the screw cap after this period of time.

Evaluation

The black test tube that is filled with water absorbs the incident light so that the water is heated. The mirror, which reflects additional light onto the glass, leads to a much higher temperature rise.

The test tube is located directly in the focal line of the parabolic trough if the latter is clamped onto the glass. In the ideal case, light is then reflected from every part of the reflector onto the glass where it is absorbed.

The condensate that can be observed after several minutes demonstrates the high temperature inside the tube. The water that evaporates in the middle condenses thereafter on the cold walls.

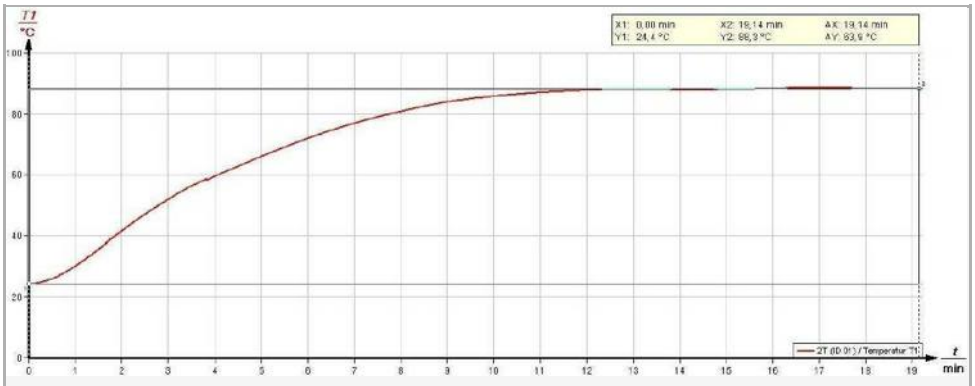

Fig. 4: Measurement data evaluation

The values in the table or the function "Survey" can be used in combination with the measurement curve in order to determine the temperature increase.

Initial temperature in °C	Final temperature in °C	Temperature increase in °C
24.4	88.3	63.3