Thermodynamic Experiments

Stirling Engine

Experiment 5

儀器名稱	實驗前	實驗後
Stirling engine ×1		
Torque meter ×1		
Chimney for stirling engine ×1		
Meter f. stirling engine, pVnT ×1		
Sensor unit pVn for stirl. eng. ×1		
Syringe ×1		
Screened cable ×2		
Oscilloscope ×1		
Thermocouple ×2		
Graduated cylinder ×1		
Raw alcohol		

Principle

The Stirling engine is submitted to a load by means of an adjustable torque meter. Rotation frequency and temperature changes of the Stirling engine are observed. Effective mechanical energy and power are assessed as a function of rotation frequency. The amount of energy converted to work per cycle can be determined with the assistance of the PV diagram. The efficiency of the Stirling engine can be estimated.

Equipment

Stirling engine, transparent
Torque meter

Chimney for stirling engine
Meter f. stirling engine, pVnT
Sensor unit pVn for stirl. eng.
Syringe 20ml
Screened cable
Oscilloscope
Thermocouple NiCr-Ni, sheathed
Graduated cylinder, 50 ml, plastic
Raw alcohol for burning

Tasks

1. Determination of the burner's thermal efficiency
2. Calibration of the sensor unit
3. Calculation of the total energy produced by the engine through determination of the cycle area on the oscilloscope screen, using transparent paper and coordinate paper.
4. Assessment of the mechanical work per revolution, and calculation of the mechanical power output as a function of the rotation frequency, with the assistance of the torque meter.
5. Efficiency assessment.

Set-up and procedure

Experimental set up should be carried out as shown in Fig. 1. The base plate (mounting plate) of the Stirling engine must be removed, so that the latter can be fixed on the corresponding mounting plate of the pVn sensor unit. The incremental transmitter of the pVn sensor unit is firmly connected to the axle of the Stirling engine. The latter is then fixed upon the large base plate.

Before switching on the pVnT meter, make sure it is connected to the pVn sensor. Connect the p and V exits respectively to the Y and X oscilloscope channels.
After having been switched on, the pVnT meter display shows "cal". Both thermocouples must now be set to the same temperature, and the "Calibration T" button depressed. This calibration of the temperature sensors merely influences the temperature difference display, not the absolute temperature display.

The upper display now shows "OT", which means "upper dead centre point". At this point, the engine is at its minimum volume. Now bring the working piston down to its lowest position by turning the engine axle, and press the "calibration V" button. Wrong calibration will cause a phase shift in the volume output voltage, and thus lead to a distortion of the pV diagram. The three displays should now be on, showing 0 revs/min, and the actual temperatures for T_1 and T_2.

1. Thermal output of the burner

The amount of alcohol in the burner is measured before and after the experiment with a measuring glass (or a scale). The corresponding duration of the experiment is recorded with a watch or clock.

2. Calibration of the pressure sensor

The pressure sensor must be calibrated so that the pV diagram can be evaluated quantitatively. This is carried out by means of a gas syringe.
The flexible tube is removed from the mounting plate, and the voltage corresponding to atmospheric pressure p_0 is determined with the oscilloscope. The latter should be operated in DC and Yt mode, with calibrated Y scale. The piston of the airtight gas syringe is drawn out (e.g. up to 15 or 20 ml), and the syringe is connected to the flexible tube. The pressure (voltage) display on the oscilloscope screen is varied through isothermal increase and decrease of the syringe volume. The actual pressure inside the syringe can be calculated.

3. Presentation and drawing of the *pV* diagram

The oscilloscope is now operated in the XY mode, with calibrated scales. Place the lighted burner below the glass cylinder, and observe the temperature display. When the

temperature difference has reached approximately 80 K, give the flywheel a slight clockwise push to start the engine. After a short time, it should reach approximately 900 revs/min, and a Stirling cycle ought to show on the oscilloscope screen.

Before carrying out measurements of any kind, wait until temperatures T_1 and T_2, as well as the rotation frequency, are approximately constant. The lower temperature should now be about 70°C.

Rotation frequency and temperatures are recorded. Voltages corresponding to maximum and minimum pressures are read from the oscilloscope. The pV diagram is copied from the oscilloscope to a sheet of transparent paper. Make sure to look perpendicularly onto the screen when doing this. The Y axis ground line is drawn, too. Transfer the diagram to coordinate paper, in order to be able to determine the diagram surface.

4. Effective mechanical energy

In order to load the engine with a determined torque, the scale of the torque meter is fixed on the large base plate, and the inner metallic piece of the pointer is fixed on the axis before the flywheel. Friction between the pointer and the set-on metallic piece can be varied by means of the adjusting screw on the pointer. Adjustment must be done carefully, to make sure that the pointer will not begin to oscillate.

Start carrying out measurements with a low torque. After each adjustment, wait until torque, rotation frequency and temperatures remain constant. All values and the pV diagram are recorded.

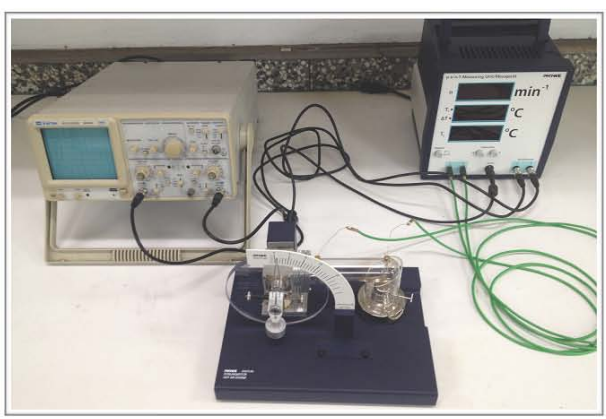

Fig. 1