Stirling engine gets revisited

2010 Phys. Educ. 45 229

(http://iopscience.iop.org/0031-9120/45/3/F05)

ENERGY CONVERSION

Stirling engine gets revisited

One of the basic truths regarding energy conversion is that no thermodynamic cycle can be devised that is more efficient than a Carnot cycle operating between the same temperature limits. The efficiency of the Stirling cycle (patented by Rev. Robert Stirling in 1816) can approach that of the Carnot cycle and yet has not had the commercial success of the more familiar Otto and Diesel cycles used in the automotive industry. Recent developments by a company called Disenco, www.disenco.com, may change all that. A Stirling engine is at the heart of their combined heat and power (CHP) domestic unit, which could change the way that we use energy in our home. Every home may become a micro-generating unit and feed electricity into the mains. Now, we all know that the second law of thermodynamics imposes severe inefficiencies in a heat—mechanical conversion process; broadly speaking, only one-third of the energy consumed can be translated to mechanical power. Thus, in any electrical power station only one-third of the input energy becomes electrical energy and two-thirds is 'waste heat'. In the UK we have made little effort to recoup this colossal amount of energy and it is normally dissipated into the atmosphere.

Now, in the Disenco unit, a gas heater will be the external source of energy for a Stirling engine, which then drives a generator of about 4 to 5 kW. Since the running of a Stirling engine is relatively quiet it can easily be housed where a normal central heating unit would be situated. Although the primary function of the gas heater is to power the engine, the secondary function (equally important) is to heat the homestead.

In our homes [1] we use, typically, a few hundred watts for lighting and refrigeration for the bulk of the time and so most of the generator output could be sold to an energy utility company. For periods when high power is used, we would have to take energy from the mains and, of course, would be charged for this under some form of tariff agreement. However, over the course of a 24-hour day there would be a net power generation for the utility company and the sale of electrical energy would offset payment for gas. It is akin to district heating with the 'district' being one's own home.

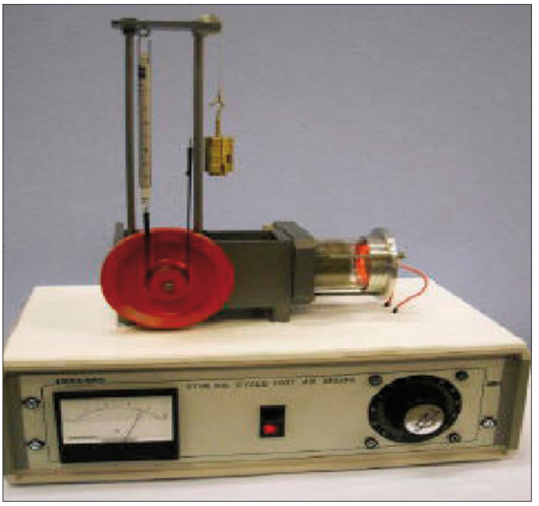

Figure 1. *Stirling engine manufactured by Cussons Technology Ltd.*

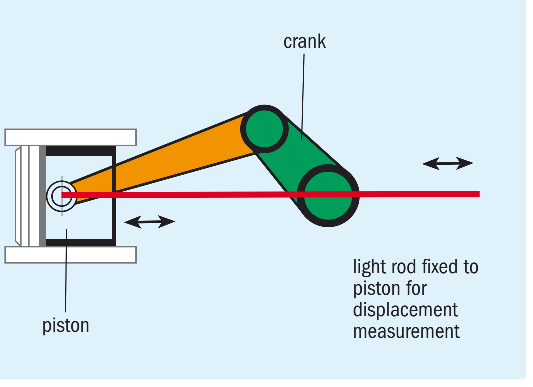

Figure 2. *Modification to crank assembly for piston displacement measurement.*

So, is this the time that Stirling engines are going to reign supreme?

To re-engage with this engine technology, it was decided to update an experiment reported in this journal more than two decades ago [2]. The Stirling engine under investigation was manufactured by Cussons, www.cussons.co.uk, and is illustrated in figure 1.

The main theme of the article [2] was that sensors were fitted to the engine so that a pressure—

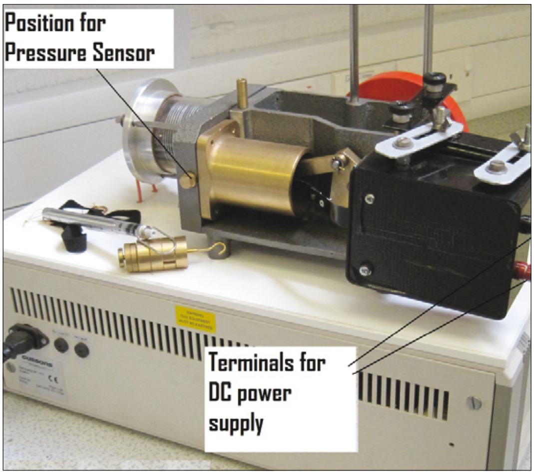

Figure 3. *Modification of Cusson's engine for inclusion of sensors.*

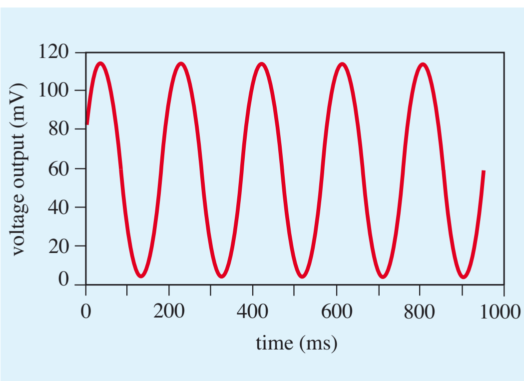

Figure 4. *Voltage output from the displacement sensor.*

volume graph could be displayed so leading to a better understanding of the Stirling cycle. It was relatively easy to fit a pressure sensor because a tapped hole was provided in the cylinder wall for this purpose. The volume sensor was simply a displacement sensor because, as with any engine, the piston moves in a cylinder of constant cross-sectional area; i.e. monitoring of the piston displacement will also monitor volume. Figure 2 shows how a rod is attached to the piston bearing for this purpose.

To avoid repetition, the article [2] can be consulted at https://sth-se.diino.com/f.thompson/migrated_data/EandH under the title Stirling-Eng1. Also on the Diino site is a copy of the worksheet P5691 provided by Cussons; this is entitled Stirling-Eng2 together with a video of the sensor operation, Video_Stirling_Engine.

The novelty in this article is that an array of light-emitting diodes (LEDs), 9×6 array, provides the illumination source rather then an incandescent bulb [2]. The arrangement is shown in figure 3.

Nine high-brightness LEDs, part number SFH4350, were connected in series on a tripad circuit board (Maplin JP52) and a 22 ohm, 5 W resistor acted as a series 'ballast' resistor. Six similar diode chains were then connected in parallel to the terminals depicted in figure 3. A DC voltage source, typically 12 V, was connected to the terminals. This diode array has two advantages:

- the apparatus is more compact
- the heating of the photovoltaic cell is less of a problem then before [2].

As figure 4 shows, the photovoltaic cell is not completely shielded by the mask at the lower extremity of travel of the piston but it is only the peak-to-peak voltage that is important.

The P–V diagram is displayed in the manner described previously [2].

These are just some ideas for experimentation with a Stirling engine. Because this type of engine is being used in a CHP unit suitable for domestic applications it is likely that there will be increased interest in Stirling-engine technology. In the broader national scenario we know that the UK will need increased generating capacity in the next decade or so as older nuclear and coal-fired power plants are switched off [3]. These new domestic CHP units could therefore fulfil a very important role in supplementing the National Grid.

References

[1] Thompson F 2009 Metering homes can cut carbon *Phys. Educ.* **44** 454
[2] Thompson F 1980 An inexpensive linear transducer using a photovoltaic cell *Phys. Educ.* **15** 244
[3] Forston D 2010 Power giant's plea: use less energy *Sunday Times* 18 April 2010 p 11

Frank Thompson *Department of Electrical Engineering and Electronics, University of Manchester, UK (e-mail f.thompson@manchester.ac.uk)*