ENTROPY

THE KEY TO UNLIMITED RESOURCES

by

Sanjay Amin

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however. The power souuce for the steam engine was considered to be steam and the efficiency of the engine was measured in terms of the amount of steam it consumed. Many of these early ideas did improve the steam engine considerably, especially those of the Scottish inventor James Watt, who patented the first really efficient steam engine in 1769. Watts engine was so efficient that he was able to give it away rather than sell it directly. All the users of the engines had to pay Watt was the money saved on fuel costs for the first three years of operation of the engine. Watt and his partner Matthew Boulton became wealthy, and the Industrial Revolution in England received a tremendous boost from a new source of cheap power.

Convinced that France's inadequate development of the steam engine technology was a factor in its downfall, Sadi began to write a nontechnical work on the efficiency of steam engines. In his book, *Reflections on the Motive Power of Fire*, published in 1824, Carnot tackled the essence of the process of heat engines, not concerning himself as others had done with its mechanical details.

He saw that, in a steam engine, motive power is produced when heat drops from a higher temperature of the boiler to the lower temperature of the condensor, just like water when falling provides power in a water-wheel. He worked within a framework of the caloric theory of heat, assuming that heat was a gas which could be neither created nor destroyed. Though the assumption was incorrect and Carnot himself had doubts about it even while he was writing, many of his results were nevertheless true, notable the prediction that the efficiency of an idealized engine depends only on the temperature of its hottest and coldest parts and not on the substance (steam or any other fluid) which drives the mechanism.

Although formally presented to the Academy of Sciences and given an excellent review in the press, the work was completely ignored until 1834, when Emile Clapeyron a railroad engineer, quoted and extended Carnot's results. Several factors might account for this: the number of copies printed was limited and the dissemination of scientific literature was slower, and such a work was hardly expected to come from France, which was considered very backward in steam technology. Eventually Carnot's views were incorporated by the thermodynamic theory as it was developed by Rudolf Clausius in Germany (1850) and William Thomson (later Lord Kelvin) in Britain (1851).

When Carnot formulated his theory gravity was totally ignored as the technology then was so underdeveloped that it is hard to imagine if anyone would even think that gravity can have any subsequent impact on the processes of the steam engine. And gravity is the leading lady of the Amin Cycle.

Amin Cycle:

Let us analyze the Carnot's Cycle while considering the effects of gravitational forces on the gas. In classical thermodynamics Carnot's Cycle gives the maximum heat engine efficiency. The Carnot's Cycle consists of two isothermal and two adiabatic processes. A Carnot's Cycle using an ideal gas as a working substance is shown on a Temperature-Entropy diagram in Figure 5-1. It comprises the following steps:

(01) The gas expands isothermally at temperature T_2 absorbing heat Qh, (1-2).

(02) The gas expands adiabatically until its temperature drops to T_1, (2-3).

(03) The gas is compressed isothermally at T_1, rejecting heat Q_c, (3-4).

(04) The gas is compressed adiabatically back to its initial state at temperature T_2, (4-1).

Thus Q_h is equal to the work done by the gas during its isothermal expansion at temperature T_2, and considering the gas to be in a gravitation field:

$$Q_h = ne^{-mgh/kT2} RT_2 \ \text{In}\ V_2/V_1 \tag{56}$$

And change in Entropy:

$$S_{Qh} = ne^{-mgh/kT2} R \ \text{In}\ V_2/V_1 \tag{57}$$

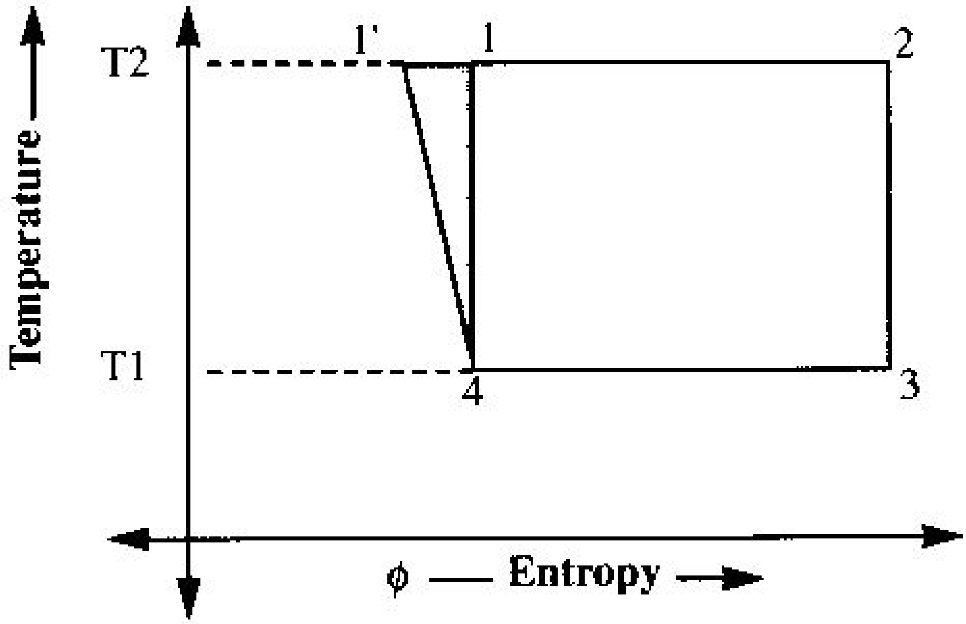

FIGURE 5-1. Temperature–Entropy diagram of the Amin Cycle and the Carnot's Cycle. (1' - 2 - 3 - 4 is the Amin Cycle) (1 - 2 - 3 - 4 is the Carnot's Cycle).

Similarly:

$$Q_c = ne^{-mgh/kT1} RT_1 \ln V_4/V_3$$
$$= -ne^{-mgh/kT1} RT_1 \ln V_3/V_4 \quad (58)$$

This quantity is negative because V4 is less than V3. The ratio's of the two quantities of heat is thus:

$$Q_c/Q_h = (-T_1 e^{-mgh/kT1} \ln V_3/V_4) / (T_2\, e^{-mgh/kT2} \ln V_2/V_1) \quad (59)$$

The equation can be simplified further by use of the temperature volume relations for an adiabatic process. We find for the two adiabatic processes:

$$T_2 V_2^{\,c-1} = T_1 V_3^{\,c-1}$$
$$\text{and } T_2 V_1^{\,c-1} = T_1 V_4^{\,c-1}$$

Dividing the first of these equations by the second, we find:

$$V_2^{\,c-1} / V_1^{\,c-1} = V_3^{\,c-1} / V_4^{\,c-1}$$
$$\text{and } V_2 / V_1 = V_3 / V_4$$

Thus the two logarithms in equation (59) are equal and the equation reduces to:

$$Q_c/Q_h = (-T_1 e^{-mgh/kT1}) / (T2\, e^{-mgh/kT2}) \quad (60)$$

The efficiency of the engine is the net work divided by the heat input and

$$\varepsilon \quad = \quad W/Q \quad = \quad 1 - T_1/T_2\, e^{-mh/k\ (g/T1\ -\ g/T2)} \qquad (61)$$

This simple result says that the efficiency of the Carnot's engine depends not only on the temperature difference but also on the gravitational force acting on the gas, and the Temperature-Entropy diagram would be as shown in Figure 5-1.

The shaded area shows the decrease in entropy which is given by the equation:

$$(1 - e^{-mh/k\ (g/T1\ -\ g/T2)}.$$

The above Cycle is a more universal cycle as it takes the gravitational forces into consideration and we shall hereafter call the universal cycle as the Amin Cycle.

The conventional Carnot's Cycle is a limiting case of the Amin Cycle as when the value of g is equal to zero, "e^{-0}", is equal to one and the efficiency of the Cycle is:

$$\varepsilon \quad = \quad 1 - T_1/T_2 \qquad (62)$$

Expression (62) is the efficiency given by the Carnot's Cycle. In Science old theories are never made obsolete by new theories, they just become subsets of the new theories which are more general and encompass more parameters in their formulation than the theories which become their subsets.

For example Einstein's theories are more general in applications and they make Newton's theories a subset.; When some of the parameters in Einstein's equations are reduced, Einstein's equations also reduce to Newtonian equations. That is the beauty of Science, it always looks forward acquiring ever more knowledge and understanding of the universe we live in.