CARNOT ENGINE

Background: A Carnot engine is an engine which operates on the reversible Carnot cycle. The basic model for this was developed by Nicolas Sadi Carnot in 1824. A heat engine acts by transferring energy from a warm region to a cool region of space and in that process, converting some of that energy to mechanical work. The cycle may also be reversed. The system maybe worked upon by an external force and in the process, it can transfer energy from a cooler system to a warmer one, thereby acting as a refrigerator or heat pump rather than a heat engine.

Carnot's theorem:

No engine operating between two heat reservoirs can be more efficient than a Carnot engine operating between the same reservoirs.

W is the work-done by the system
Q_H is the energy put into the system
T_c is the absolute temperature of the cold reservoir
T_H is the absolute temperature of the hot reservoir

Description of the flow-sheet:

Gas at high temperature (in this case Helium at 600K) absorbs heat from **heat reservoir** reversibly and hence undergoes an
isothermic expansion this is modeled with the help of a **valve** (also called the **isothermal expander**). Now the outlet from this is sent to an **adiabatic expander**
where the gas undergoes an expansion and hence a decrease in its temperature till it reaches the temperature of the **cold reservoir**. The gas now rejects heat isothermally into the cold reservoir reversibly and this can be modeled as an isothermal compression using a **valve** (also called the **isothermal compressor**).
Now the gas is sent into an **adiabatic compressor** where its temperature and pressure are increased until its properties are identical with that of the inlet stream this is accomplished using the recycle block.

Results:

1) Temperature of gas before and after isothermal expansion is 600 K

2) Entropy change of gas after isothermal expansion = (7.755234-6.288268) = 1.466966 KJ/Kg.K. Therefore heat energy absorbed = 1.466966*600 = 880.1796 KJ/kg.

3) Temperature of gas before and after isothermal compression is 475.023 K

4) Entropy change of gas after isothermal compression = (6.288268-7.755234) = -1.466966 KJ/Kg.K Therefore heat energy absorbed = -1.466966*475.023 = -696.8425 KJ/Kg.

5) Total heat energy absorbed = (880.1796-696.8425) = 183.3368 KJ/Kg.

6) Hence efficiency is equal to (183.3368/880.1796) = 0.20829 or 20.83%.

7) Efficiency from Carnot's formula is equal to 1-(475.023/600) = 0.208295 or 20.83%. Hence the results match.

8) Total work done by adiabatic compressor and adiabatic expander are equal to 648.9549 KW.

Reference:

http://romulus.sdsu.edu/testcenterdev/testhome/Test/problems/chapter09/chapter09Local_1.html