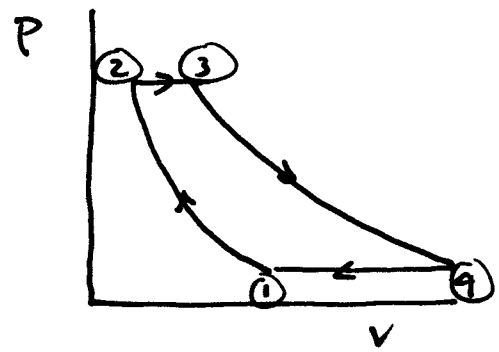
T7 SOLUTIONS BY WAITZ



a) PRESSURE AND TEMPERATURE

① $p_1 = 100\,kPa$, $T_1 = 300\,K$

② adiabatic compression by factor of 13.

$P_2 = 1300\,kPa$, $\left(\frac{P_2}{P_1}\right)^{\gamma-1/\gamma} = \frac{T_2}{T_1} = 2.08$, $T_2 = 624\,K$

③ Constant pressure heating to 1400 K

$P_3 = 1300\,kPa$, $T_3 = 1400\,K$

④ q-s, adiab. expansion by factor of 13

$P_4 = 100\,kPa$, $\left(\frac{P_4}{P_3}\right)^{\gamma-1/\gamma} = \frac{T_4}{T_3} = 0.481$ $T_4 = 673\,K$

b) IDEAL EFFICIENCY

$$\eta_{TH} = 1 - \frac{T_1}{T_2} = 1 - \frac{1}{2.08} = 0.52$$

c) FROM WEB PAGE (NOTE THESE #'s WILL BE DIFFERENT DEPENDING ON WHEN YOU LOOK THEM UP)

TOTAL GAS ENERGY FLOW = 67.4 KBTU/s = 71.1 MW

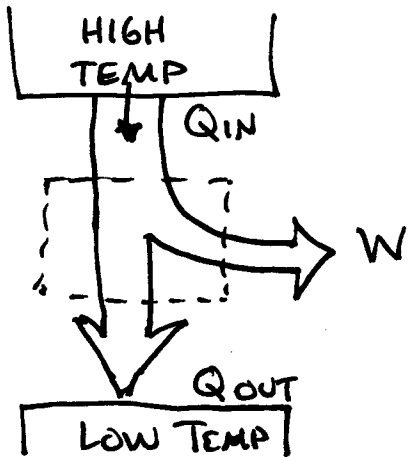
ACTIVE LOAD = 18.6 MW

$$\eta_{TH} = \frac{18.6}{71.1} = 0.26$$

A VARIETY OF NON-IDEAL PROCESSES CAUSE THE EFFICIENCY TO BE SIGNIFICANTLY LESS THAN THE IDEAL VALUE

PEOPLE THAT DESIGN GAS TURBINE ENGINES SPEND MUCH OF THEIR TIME TRYING TO IMPROVE THESE PROCESSES.

d) GENERALIZED SCHEMATIC OF A HEAT ENGINE

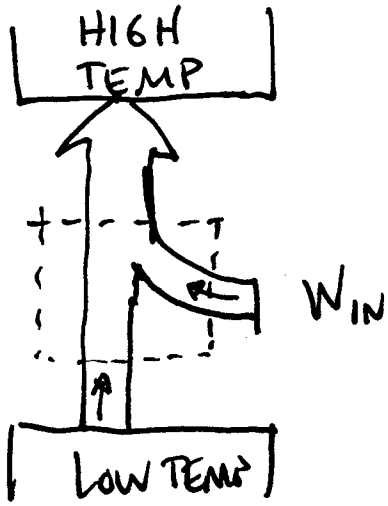


fuel energy

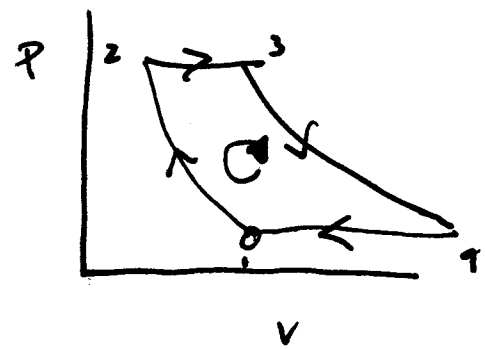
$$W = Q_{IN} - Q_{OUT}$$

waste heat

FOR A REFRIGERATOR IT IS THE OPPOSITE. ELECTRICAL WORK IS USED TO MOVE ENERGY FROM A LOW TEMPERATURE RESERVOIR (FOOD) TO A HIGH TEMPERATURE RESERVOIR (ROOM)

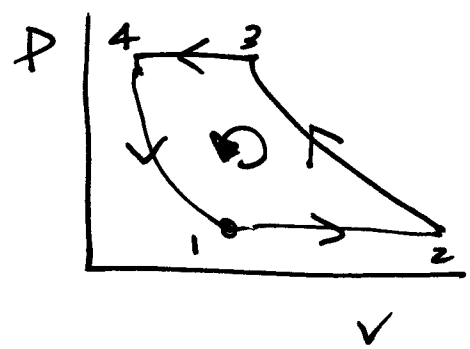


e) MOST ANY CYCLE CAN BE REVERSED SO THAT IT USES W_{IN} TO TRANSFER ENERGY FROM LOW TEMP TO HIGH TEMP.



BRAYTON HEAT ENGINE

$Q_{IN} - Q_{OUT} = W > 0$



BRAYTON REFRIGERATOR

$Q_{IN} - Q_{OUT} = W < 0$

IN PRACTICE, SOME CYCLES ARE EASIER TO IMPLEMENT OR MORE EFFICIENT THAN OTHERS