Gas and Vapor Power Cycles Questions

Latest Gas and Vapor Power Cycles MCQ Objective Questions

Question 1:

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The efficiency of Rankine cycle is lower than that of corresponding Carnot cycle because

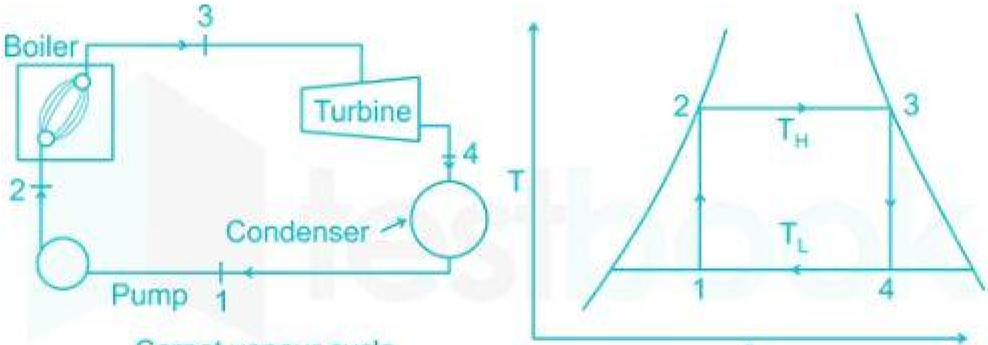
1. the Carnot cycle has gas as working substance and Rankine cycle has steam as working substance
2. the Rankine cycle efficiency depends upon properties of working substance whereas Carnot cycle efficiency is independent of the properties of working substance
3. the temperature range of Carnot cycle is greater than that for Rankine cycle
4. the average temperature at which heat is supplied in Rankine cycle is less than that corresponding Carnot cycle

Answer (Detailed Solution Below)

Option 4 : the average temperature at which heat is supplied in Rankine cycle is less than that corresponding Carnot cycle

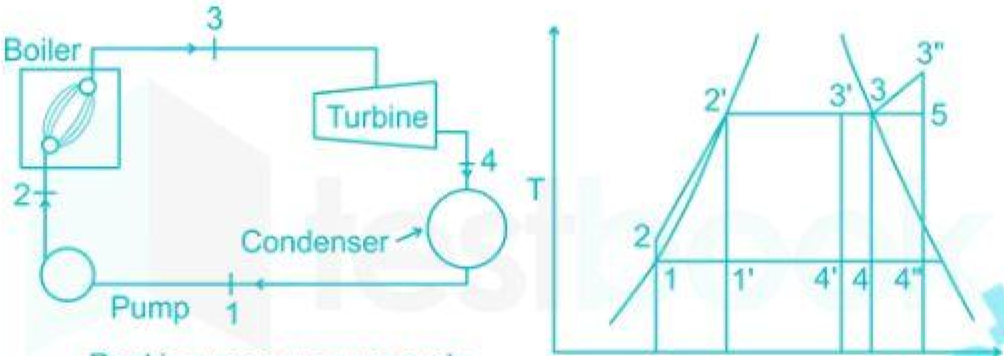
Gas and Vapor Power Cycles Question 1 Detailed Solution

Concept:



Carnot vapour cycle

T-s diagram



Ranking vapour power cycle

T-s diagram Ranking power cycle

Note that the **Rankine cycle has a lower efficiency compared to the corresponding Carnot cycle** 2′-3-4-1′ with the same maximum and minimum temperatures. The reason is that the average temperature at which heat is added in the Rankine cycle lies between T_2 and T_2' and is thus less than the constant temperature T_2' at which heat is added to the Carnot cycle.

It is very difficult to build a pump that will handle a mixture of liquid and vapour at state 1' (refer T-s diagram; Carnot Vapor Cycle) and deliver saturated liquid at state 2′.

It is much easier to completely condense the vapour and handle only liquid in the pump (Rankine Cycle)

Additional Information

In the Carnot cycle, the compression is wet compression so the pump work requirement is more compare to the Rankine cycle where the pump compresses only the saturated liquid. **Thus the specific work output for the Rankine cycle is more than the Carnot cycle for the same maximum and minimum temperature.**

Also, the **work ratio** is defined as the ratio of net-work to the work done in the turbine.

$$r_w = \frac{W_{net}}{W_T} = \frac{W_T - W_C}{W_T}$$

Thus the work ratio is low for the Carnot Cycle.

Question 2:

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Consider an air standard cycle in which the air enters the compressor at 1.0 bar and 20°C. The pressure of air leaving the compressor is 3.5 bar and the temperature at the turbine inlet is 600°C. For 1 kg of air, determine the efficiency of the cycle:

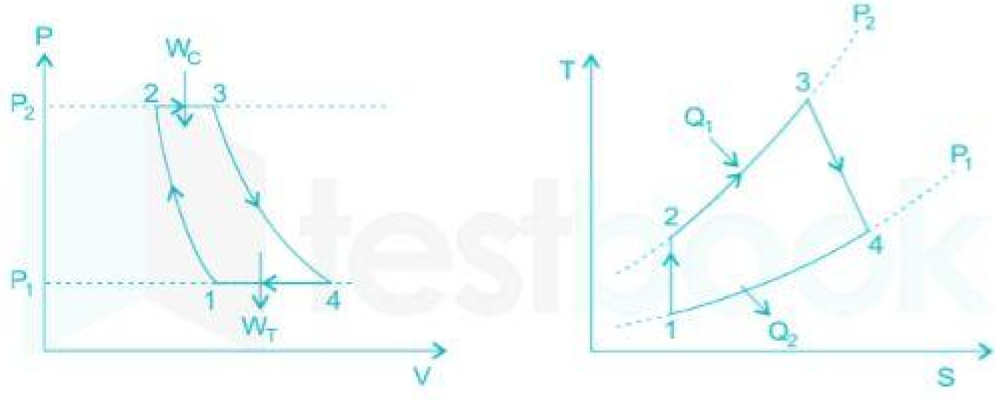
1. 25%
2. 35%
3. 30%
4. 32%

Answer (Detailed Solution Below)

Option 3 : 30%

Gas and Vapor Power Cycles Question 2 Detailed Solution

Concept:



Brayton Cycle

The efficiency of an ideal Brayton cycle can be determined using the given pressure ratios and specific heat ratio.

The thermal efficiency formula is given by:

$$\eta = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

Calculation:

Given:

Initial pressure at compressor inlet, $P_1 = 1.0\,\text{bar}$

Initial temperature at compressor inlet, $T_1 = 20°\text{C} = 293\,\text{K}$

Pressure at compressor outlet, $P_2 = 3.5\,\text{bar}$

Temperature at turbine inlet, $T_3 = 600°\text{C} = 873\,\text{K}$

Specific heat ratio, $\gamma = 1.4$

Calculate the temperature after compression (T_2):

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 293(3.5)^{0.2857} \approx 420\,\text{K}$$

Calculate the temperature after expansion (T_4):

$$T_4 = T_3\left(\frac{P_1}{P_2}\right)^{0.2857} = 873\left(\frac{1}{3.5}\right)^{0.2857} \approx 608\,\text{K}$$

Efficiency Calculation:

Using the temperatures, the efficiency can also be given by:

$$\eta = 1 - \frac{T_4 - T_1}{T_3 - T_2} = 1 - \frac{608 - 293}{873 - 420} = 1 - \frac{315}{453} = 1 - 0.695 \approx 0.305 \approx 30.5\%$$

The efficiency of the Brayton cycle is approximately 30.5%.