國立臺灣大學 103 學年度碩士班招生考試試題

Q1. (20%) Answer the following questions clearly and briefly.

(i) Somebody claims to have developed a new heat-engine cycle that is operating between the temperature limits of 300K and 700K and has a theoretical efficiency of 0.60. How do you evaluate this claim?

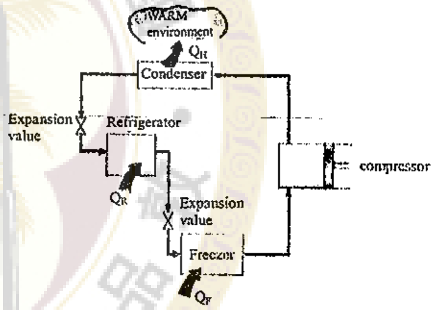
(ii) A system undergoes a process from state 1 to state 2. For which process, a reversible process or an irreversible process, is the associated amount of $\int_1^2 \delta Q/T$ greater (where appear the differential heat δQ and the absolute temperature T) ? Why?

(iii) Which one usually has a smaller back work ratio, the gas turbine engine or the vapor turbine engine? Why?

(iv) Which one is preferred in a vapor turbine engine, a working fluid having an inverted-U shaped saturation dome or a working fluid having an inverted-V shaped one? Explain it.

(v) What is the difference between a point function and a path function in thermodynamics? Give one example for each function.

Q2. (30%) Consider a multi-purposes refrigeration system using R-134a as the working fluid. The refrigerant leaves the condenser at 1MPa, enters the refrigerator at –6℃, and enters the freezer at –20℃. The mass flow rate of the refrigerant in the condenser is 0.1kg/s. The required cooling power in the freezer ($\dot{Q}_F$) is 10kW. Assume all components (expansion valves, heat exchangers, pipes, etc.) and processes are ideal except that the compressor has an isentropic efficiency of 0.92. Also assume the refrigerant leaves the condenser as saturated liquid and enters the compressor as saturated vapor.



(a) Sketch the T-s diagram of the cycle.

(b) Find the change in the quality of the refrigerant from its entering to its leaving the refrigerator.

(c) Find the overall coefficient of performance (COP).

Table 1: Saturated R-134a (*f*: saturated liquid, *g*: saturated vapor)

pressure	specific volume		enthalpy		entropy	
P, MPa	v_f, m³/kg	v_g, m³/kg	h_f, kJ/kg	h_{fg}, kJ/kg	s_f, kJ/kg.K	s_g, kJ/kg.K
1	0.0008700	0.020313	107.32	163.67	0.39189	0.91558
temperature	specific volume		enthalpy		entropy	
T, °C	v_f, m³/kg	v_g, m³/kg	h_f, kJ/kg	h_{fg}, kJ/kg	s_f, kJ/kg.K	s_g, kJ/kg.K
-6	0.0007608	0.085802	43.84	203.07	0.17489	0.93497
-20	0.0007362	0.14729	25.49	212.91	0.10463	0.94564

Table 2: Superheated R-134a at 1Mpa

temperature	enthalpy	entropy
T, °C	*h*, kJ/kg	s_f, kJ/kg.K
40	271.71	0.9179
50	282.74	0.9525
60	293.38	0.9850

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Q3. (26%) Consider a long resistance wire with a thermal conductance of 20 W/m·K and a radius of 5 mm generates heat uniformly at a constant rate of 50 W/cm^3. The wire (core) is coated and embedded in a 5 mm-thick insulator (skin) whose thermal conductance is 1.5 W/m·K. In a steady state when the outer surface of the insulator skin is 50°C, determine the temperature profile as a function of the radius, e.g., *T(r)*, in the (a) wire and (b) insulator.

Q4. (24%) A long equilateral triangular duct is composed of three long surfaces with an equal width of 1.5 m. In other words, the cross section of the duce is an equilateral triangle whose lateral length is 1.5 m. The first surface, maintained at a uniform temperature of 800 K, has an emissivity of 0.8. The second surface is regarded as a blackbody at 1000 K. The third surface is heated and well insulated on its outer surface. Consider the radiation in the long duct and determine (a) the temperature of the third surface, and (b) the rate at which heat must be supplied to the third surface per unit length to maintain the aforementioned operating conditions.