APPLIED THERMODYNAMICS (SKMM 2423)
TEST 3 (Sem 1 2016/2017)
11/12/2016
(10:30 am – 12:00 pm)

ANSWER THE QUESTION

Question 1 ***(10 marks)***

A ship is driven by a natural aspirated direct injection (SI) diesel engine. The engine has 10 cylinders and operated on 4-stroke cycle. At engine speed of 240 rpm, it produces brake load of 39.8 kN with a torque arm length of 1.5 m. Cylinder bore and stroke sizes of the engine is 415 mm and 500 mm, respectively. During the operation, the engine consumes 10 liters of diesel fuel within 1 minute and 23 seconds. Assume the fuel density is 0.85 kg/liter and the lower calorific value of the fuel is 43000 kJ/kg. Calculate:

a) The brake power, [kW].
b) The brake mean effective pressure, [bar].
c) The brake specific fuel consumption, [kg/kW.hr].
d) The brake thermal efficiency, [%].

Question 2 ***(10 marks)***

An air conditioning system working on the ideal vapour compression cycle uses refrigerant-134a as the working fluid. The refrigerant at a rate of 0.06 kg/s that is dry saturated enters the compressor at 2.3444 bar and there is 3.86 K under-cooling of refrigerant in the condenser at 10 bar. Calculate:

a) Sketch T-s and p-h diagrams.
b) the power required to drive the compressor, [kW]
c) the refrigerating effect, [kW]
d) Coefficient of performance (COP).

Saturated refrigerant-134a—Temperature table

		Specific volume, m^3/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg·K		
Temp., T °C	Sat. press., P_{sat} kPa	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
−20	132.82	0.0007362	0.14729	25.39	193.45	218.84	25.49	212.91	238.41	0.10463	0.84101	0.94564
−18	144.69	0.0007396	0.13583	27.98	192.01	219.98	28.09	211.55	239.64	0.11481	0.82908	0.94389
−16	157.38	0.0007430	0.12542	30.57	190.56	221.13	30.69	210.18	240.87	0.12493	0.81729	0.94222
−14	170.93	0.0007464	0.11597	33.17	189.09	222.27	33.30	208.79	242.09	0.13501	0.80561	0.94063
−12	185.37	0.0007499	0.10736	35.78	187.62	223.40	35.92	207.38	243.30	0.14504	0.79406	0.93911
−10	200.74	0.0007535	0.099516	38.40	186.14	224.54	38.55	205.96	244.51	0.15504	0.78263	0.93766
−8	217.08	0.0007571	0.092352	41.03	184.64	225.67	41.19	204.52	245.72	0.16498	0.77130	0.93629
−6	234.44	0.0007608	0.085802	43.66	183.13	226.80	43.84	203.07	246.91	0.17489	0.76008	0.93497
−4	252.85	0.0007646	0.079804	46.31	181.61	227.92	46.50	201.60	248.10	0.18476	0.74896	0.93372
−2	272.36	0.0007684	0.074304	48.96	180.08	229.04	49.17	200.11	249.28	0.19459	0.73794	0.93253

Superheated refrigerant-134a (*Concluded*)

T °C	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 0.80 MPa (T_{sat} = 31.31°C)				P = 0.90 MPa (T_{sat} = 35.51°C)				P = 1.00 MPa (T_{sat} = 39.37°C)			
Sat.	0.025621	246.79	267.29	0.9183	0.022683	248.85	269.26	0.9169	0.020313	250.68	270.99	0.9156
40	0.027035	254.82	276.45	0.9480	0.023375	253.13	274.17	0.9327	0.020406	251.30	271.71	0.9179
50	0.028547	263.86	286.69	0.9802	0.024809	262.44	284.77	0.9660	0.021796	260.94	282.74	0.9525
60	0.029973	272.83	296.81	1.0110	0.026146	271.60	295.13	0.9976	0.023068	270.32	293.38	0.9850
70	0.031340	281.81	306.88	1.0408	0.027413	280.72	305.39	1.0280	0.024261	279.59	303.85	1.0160
80	0.032659	290.84	316.97	1.0698	0.028630	289.86	315.63	1.0574	0.025398	288.86	314.25	1.0458

Saturated refrigerant-134a—Pressure table

		Specific volume, m^3/kg		*Internal energy,* kJ/kg			*Enthalpy,* kJ/kg			*Entropy,* kJ/kg·K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
700	26.69	0.0008331	0.029361	88.24	156.24	244.48	88.82	176.21	265.03	0.33230	0.58763	0.91994
750	29.06	0.0008395	0.027371	91.59	154.08	245.67	92.22	173.98	266.20	0.34345	0.57567	0.91912
800	31.31	0.0008458	0.025621	94.79	152.00	246.79	95.47	171.82	267.29	0.35404	0.56431	0.91835
850	33.45	0.0008520	0.024069	97.87	149.98	247.85	98.60	169.71	268.31	0.36413	0.55349	0.91762
900	35.51	0.0008580	0.022683	100.83	148.01	248.85	101.61	167.66	269.26	0.37377	0.54315	0.91692
950	37.48	0.0008641	0.021438	103.69	146.10	249.79	104.51	165.64	270.15	0.38301	0.53323	0.91624
1000	39.37	0.0008700	0.020313	106.45	144.23	250.68	107.32	163.67	270.99	0.39189	0.52368	0.91558
1200	46.29	0.0008934	0.016715	116.70	137.11	253.81	117.77	156.10	273.87	0.42441	0.48863	0.91303
1400	52.40	0.0009166	0.014107	125.94	130.43	256.37	127.22	148.90	276.12	0.45315	0.45734	0.91050

(SKMM 2423) Test 3

Question 1

a) $bp = \frac{2\pi N T}{60}$

$= \frac{2\pi(240)(59.7)}{60}$

$= 1500.4\ kW$ #. — (3)

$T = F \times R$

$= 39.8(1.5)$

$= 59.7\ kNm$

b) $bp = \frac{1}{2} P_b \cdot L \cdot A \cdot N \cdot n$

$1500 = \frac{1}{2} P_b (0.5)\left[\frac{\pi}{4}(0.415)^2\right]\left(\frac{240}{60}\right)(10)$

$1500 = 1.352\ P_b$

$P_b = 1108\ kPa$

$= 11.1\ bar$ #. — (2)

c) $bsfc = \frac{\dot{m}_f}{bp}$

$= \frac{0.1024}{1500} \times 3600$

$= 0.245\ kg/kWh$ #. — (3)

10 ml = 83 sec

$\dot{V}_f = 0.1205\ l/s$

$\dot{m}_f = \dot{V}_f \times \rho$

$\dot{m}_f = 0.1205(0.85)$

$= 0.1024\ kg/s$

d) $\eta_{th} = \frac{bp}{\dot{m}_f\ C.V}$

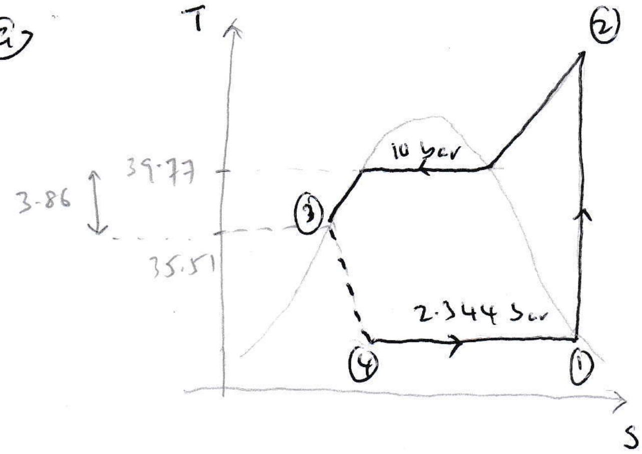
$= \frac{1500}{(0.1024)(43000)}$

$= 34.1\%$ # — (2)

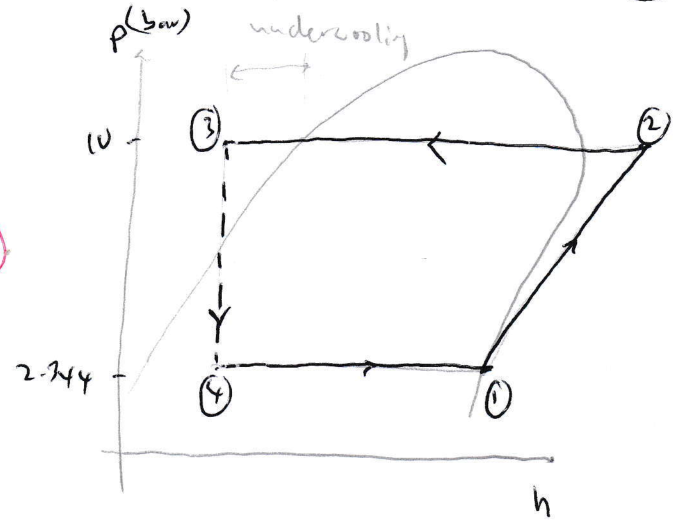
Question 2

(2)

(a)



(2)



(b) $\dot{W}_{12} = \dot{m}(h_2 - h_1)$

$= 0.06(278.63 - 246.91)$

$= 1.9$ kW — (2)

from table:

$h_1 = 246.91$ kJ/kg — (1)

$s_1 = s_2 = 0.93497$ kJ/kgK

h	s
271.71	0.9179
h_2	0.93497
282.74	0.9525

$\therefore h_2 = 278.63$ kJ/kg — (1)

(c) $\dot{Q}_{41} = \dot{m}(h_1 - h_4)$

$= 0.06(246.91 - 101.61)$

$= 8.72$ kW — (2)

$h_3 = h_4 = h_f @ 35.51°C$

$= 101.61$ kJ/kg. — (1)

(d) $COP = \frac{Q_{41}}{W_{12}} = \frac{8.72}{1.9}$

$= 4.59$ — (1)