67. A 110 hp internal combustion engine burns propane at a rate of 0.01 lbm/sec when mixed with theoretical air. The engine takes in air and fuel at 77°F and 1 atm. The air-fuel mixture burns completely and leaves the engine at 1240°F. The rate of heat transfer from the engine and exhaust is most nearly

(A) −140 Btu/sec

(B) −93 Btu/sec

(C) −68 Btu/sec

(D) 33 Btu/sec

68. Octane is burned completely with theoretical air at atmospheric pressure. The dew point of the products is most nearly

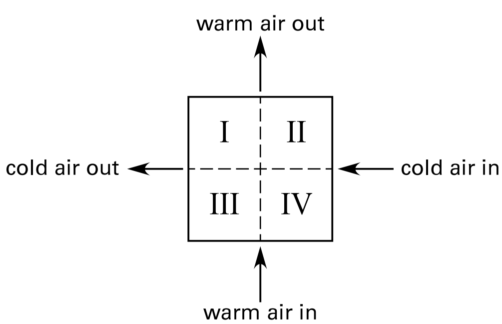
(A) 130°F

(B) 150°F

(C) 200°F

(D) 210°F

69. A schematic diagram of a crossflow, air-to-air, flat plate heat exchanger is shown. This type of heat exchanger will transfer heat between a cold airstream and a warm airstream. Quadrants of the heat exchanger plate are indicated.



Which quadrant has the LOWEST rate of heat transfer?

(A) I

(B) II

(C) III

(D) IV

70. An engineering consulting company is considering a $100,000 investment in new computers and software. The software and equipment have only a five-year lifetime. The expected annual operating costs will be $20,000/yr for the first two years and $25,000/yr for the remaining period. The company would like to get a 15% return on its investment. Most nearly, the additional annual profit needed to realize this goal is

(A) $37,000

(B) $42,000

(C) $47,000

(D) $52,000

71. A fan blows 30,000 cfm of air into a 24 in × 36 in duct. Most nearly, the 100% effective duct length for this duct is

(A) 5.4 ft

(B) 8.6 ft

(C) 11 ft

(D) 14 ft

72. An air compressor takes in atmospheric air at 0 psig and 60°F. The compressor compresses the air into a tank that is at 150 psig. The compression temperature is 300°F. Most nearly, the polytropic index for this process is

(A) 0.83

(B) 0.99

(C) 1.2

(D) 1.4

73. Steam at ~~400~~°F and 2000 psia enters a steam turbine and is expanded to 200 psia. The turbine has an isentropic efficiency of 75%. Most nearly, the enthalpy of the steam as it exits the turbine is

(A) 980 Btu/lbm

(B) 1100 Btu/lbm

(C) 1300 Btu/lbm

(D) 1500 Btu/lbm

74. A simple gas turbine cycle on the front half of a combined cycle intakes atmospheric air at 60°F and 14.7 psia. The pressure ratio is 5:1 and the air-fuel ratio is 150. The heating value of the fuel is 20,000 Btu/lbm, and the combustion efficiency is 80%. Most nearly, the enthalpy of the air as it enters the turbine is

(A) 330 Btu/lbm

(B) 360 Btu/lbm

(C) 390 Btu/lbm

(D) 430 Btu/lbm

Substitute values and solve for the polytropic index, n.

$$\frac{164.7\ \frac{\text{lbf}}{\text{in}^2}}{14.7\ \frac{\text{lbf}}{\text{in}^2}} = \left(\frac{760°\text{R}}{520°\text{R}}\right)^{n/(n-1)}$$

$$11.2 = (1.46)^{n/(n-1)}$$

$$\ln 11.2 = \ln(1.46)^{n/(n-1)}$$

$$= \frac{n}{n-1}\ln 1.46$$

$$\frac{n}{n-1} = 6.38$$

$$n = \frac{6.38}{6.38-1} = 1.186 \quad (1.2)$$

The answer is (C).

73. Use the Mollier diagram in MERM App. "Enthalpy-Entropy (Mollier) Diagram for Steam (customary U.S. units)." For steam at 2000 psia and 400°F, the enthalpy and entropy of the steam at the entrance to the turbine are

$$h_{\text{in}} = 1500\ \text{Btu/lbm}$$

$$s_{\text{in}} = 1.57\ \text{Btu/lbm-°R}$$

For an ideal isentropic efficiency of 100%, the steam would have the same entropy at the exit as at the entrance. From the Mollier diagram, for steam with the same entropy and a pressure of 200 psia, the exit enthalpy is

$$h_{\text{out,ideal}} = 1225\ \text{Btu/lbm}$$

The actual isentropic efficiency is

$$\eta = 0.75 = \frac{h_{\text{in}} - h_{\text{out,actual}}}{h_{\text{in}} - h_{\text{out,ideal}}}$$

The actual exit enthalpy is

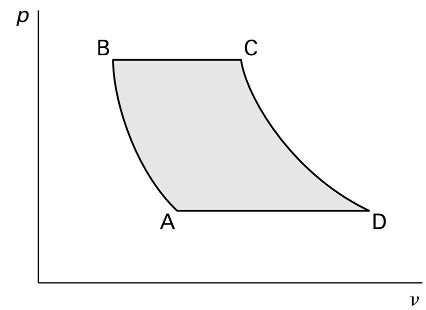
$$h_{\text{out,actual}} = h_{\text{in}} - 0.75(h_{\text{in}} - h_{\text{out,ideal}})$$

$$= 1500\ \frac{\text{Btu}}{\text{lbm}} - (0.75)\left(1500\ \frac{\text{Btu}}{\text{lbm}} - 1225\ \frac{\text{Btu}}{\text{lbm}}\right)$$

$$= 1294\ \text{Btu/lbm} \quad (1300\ \text{Btu/lbm})$$

The answer is (C).

74. A pressure-specific volume diagram for a gas turbine cycle is shown. From A to B is isenthropic compression, from B to C is heating, and from C to D is isentropic expansion through the turbine.



The absolute temperature at state A is $60°\text{F} + 460° = 520°\text{R}$. From MERM App. "Properties of Low-Pressure Air (customary U.S. units)," the reduced pressure, p_r, and specific enthalpy, h, at this temperature are

$$p_{r,\text{A}} = 1.2147$$

$$h_{\text{A}} = 124.27\ \text{Btu/lbm}$$

The reduced pressure at state B is

$$p_{r,\text{B}} = \left(\frac{p_{\text{B}}}{p_{\text{A}}}\right)p_{r,\text{A}} = (5)(1.2147)$$

$$= 6.074$$

The pressure at state B is

$$p_{\text{B}} = 5p_{\text{A}} = (5)\left(14.7\ \frac{\text{lbf}}{\text{in}^2}\right)$$

$$= 73.5\ \text{lbf/in}^2$$

Based on MERM App. "Properties of Low-Pressure Air (customary U.S. units)" and a reduced pressure of 6.074, the specific enthalpy at state B is

$$h_{\text{B}} = 196.7\ \text{Btu/lbm}$$

To find the specific enthalpy at state C, calculate the heat of combustion from the heating value of the fuel and the air-to-fuel ratio.

$$q_{\text{combustion}} = \frac{\text{HV}}{\text{AFR}} = \frac{20{,}000\ \frac{\text{Btu}}{\text{lbm}}}{150}$$

$$= 133.3\ \text{Btu/lbm}$$