

**5-17** A 600-MW steam power plant, which is cooled by a nearby river, has a thermal efficiency of 40 percent. Determine the rate of heat transfer to the river water. Will the actual heat transfer rate be higher or lower than this value? Why?

**5-18** A steam power plant receives heat from a furnace at a rate of 280 GJ/h. Heat losses to the surrounding air from the steam as it passes through the pipes and other components are estimated to be about 8 GJ/h. If the waste heat is transferred to the cooling water at a rate of 145 GJ/h, determine (a) net power output and (b) the thermal efficiency of this power plant.

Answers: (a) 35.3 MW, (b) 45.4 percent

**5-21** An automobile engine consumes fuel at a rate of 28 L/h and delivers 60 kW of power to the wheels. If the fuel has a heating value of 44,000 kJ/kg and a density of 0.8 g/cm<sup>3</sup>, determine the efficiency of this engine. Answer: 21.9 percent

**5-34E** The steam requirements of a manufacturing facility are being met by a boiler whose rated heat input is  $3.6 \times 10^6$  Btu/h. The combustion efficiency of the boiler is measured to be 0.7 by a hand-held flue gas analyzer. After tuning up the boiler, the combustion efficiency rises to 0.8. The boiler operates 1500 hours a year intermittently. Taking the unit cost of energy to be \$4.35/10<sup>6</sup> Btu, determine the annual energy and cost savings as a result of tuning up the boiler.

**5-50** A household refrigerator with a COP of 1.5 removes heat from the refrigerated space at a rate of 60 kJ/min. Determine (a) the electric power consumed by the refrigerator and (b) the rate of heat transfer to the kitchen air.

Answers: (a) 0.67 kW, (b) 100 kJ/min

**5-51** An air conditioner removes heat steadily from a house at a rate of 750 kJ/min while drawing electric power at a rate of 6 kW. Determine (a) the COP of this air conditioner and (b) the rate of heat transfer to the outside air.

Answers: (a) 2.08, (b) 1110 kJ/min

**5-58** Determine the COP of a heat pump that supplies energy to a house at a rate of 8000 kJ/h for each kW of electric power it draws. Also, determine the rate of energy absorption from the outdoor air. *Answers: 2.22, 4400 kJ/h*

**5-59** A house that was heated by electric resistance heaters consumed 1200 kWh of electric energy in a winter month. If this house were heated instead by a heat pump that has an average COP of 2.4, determine how much money the homeowner would have saved that month. Assume a price of 8.5¢/kWh for electricity.

**5-80** A Carnot heat engine operates between a source at 1000 K and a sink at 300 K. If the heat engine is supplied with heat at a rate of 800 kJ/min, determine (a) the thermal efficiency and (b) the power output of this heat engine.

*Answers: (a) 70 percent, (b) 9.33 kW*

**5-81** A Carnot heat engine receives 650 kJ of heat from a source of unknown temperature and rejects 200 kJ of it to a sink at 17°C. Determine (a) the temperature of the source and (b) the thermal efficiency of the heat engine.

**5-115** The “Energy Guide” label of a refrigerator states that the refrigerator will consume \$74 worth of electricity per year under normal use if the cost of electricity is \$0.07/kWh. If the electricity consumed by the light bulb is negligible and the refrigerator consumes 300 W when running, determine the fraction of the time the refrigerator will run.

**5-116** The interior lighting of refrigerators is usually provided by incandescent lamps whose switches are actuated by the opening of the refrigerator door. Consider a refrigerator whose 40-W light bulb remains on about 60 h per year. It is proposed to replace the light bulb by an energy-efficient bulb that consumes only 18 W but costs \$25 to purchase and install. If the refrigerator has a coefficient of performance of 1.3 and the cost of electricity is 8 cents per kWh, determine if the energy savings of the proposed light bulb justify its cost.