Thermodynamics EAT 106

The Second Law of Thermodynamics

1. A steam power plant with power output of 150 MW consumes coal at a rate of 60 tons/h. If the heating value of coal is 30,000 kJ/kg, determine the thermal efficiency of this plant.

Answer: 30.0%

2. An automobile engine consumes fuel at a rate of 20 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^3, determine the efficiency of this engine.

Answer: 30.7%

3. A household refrigerator that has a power input of 450 W and a COP of 2.5 is to cool five large watermelons, 10 kg each, to 8°C. If the watermelons are initially at 20°C, determine how long it will take for the refrigerator to cool them. The watermelons can be treated as water whose specific heat is 4.2kJ/(kg.K).

Answer: 2240s

4. 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.

Answer: 2.22, 4400 kJ/h

5. 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.

Answer: 70%, 9.33 kW

6. An innovative way of power generation involves the utilization of geothermal energy – the energy of hot water that exists naturally underground as the heat source. If a supply of how water at 140°C is discovered at a location where the environmental temperature is 20°C, determine the maximum thermal efficiency a geothermal power plant built at that location have.

Answer: 29.1%

7. A refrigerator is to remove heat from the cooled space at a rate of 300 kJ/min to maintain its temperature at -8°C. If the air surrounding the refrigerator is at 25°C, determine the minimum power input required for this refrigerator.

Answer: 0.623 kW

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8. The performance of a heat pump degrades (i.e. its COP decreases) as the temperature of the heat source decreases. This makes using heat pumps at locations with severe weather conditions unattractive. Consider a house that is heated and maintained at 20°C by a heat pump during the winter. What is the maximum COP for this heat pump if heat is extracted from the out door air at (a) 10°C, (b) -5°C, and (C) -30°C.

Answer: 10 ºC, -5 ºC, -30 ºC