Problem Sheet No 01

1. A 100-watt light bulb is on for 2 hours a day. (a) What is the energy in watt-hour (Wh) it consumes per day? (b) What is the energy it consumes per year? Give your answer in watt-hour and in kilowatt-hour (1 kilowatt = 1000 watts) (c) What is the energy it consumes in BTUs per day and per year? (d) What is the energy it consumes in joules per day and per year?

2. Assume a 1000 MW (megawatt) nuclear power plant operates 7,000 hours in one year. (Hint: One megawatt is one million watts or one thousand kilowatts.) (a) Calculate the energy produced by this power plant in: i. megawatt-hours (MWh) per year ii. kilowatt-hours (kWh) per year, (b) Calculate the energy in joules. (Hint: 1 kWh = 3.6 million joules) c) Calculate the energy in BTU.

3. A sample of bituminous coal gave the following ultimate analysis by mass: C 81.9%; H 4.9%; O 6%; N 2.3%; ash 4.9%, calculate: (a) The stoichiometric A/F ratio; (b) The analysis of the wet and dry products of combustion

4. A boiler generates 5000 kg of steam per hour at 1.8 MN/m^2. The steam temperature is 325 ^oC and the feedwater temperature is 49.4 ^oC. The efficiency of the boiler plant is 80% when using oil of calorific value 45,500 kJ/kg. The steam generated is supplied to a turbine which develops 500 kW and exhausts at 0.18 MN/m^2, the dryness fraction of the steam is 0.98. Estimate the mass of oil used per hour and the fraction of the enthalpy drop through the turbine that is converted into useful work.

5. A boiler delivers 5400 kg of steam per hour at a pressure of 750 kN/m^2 and with a dryness fraction of 0.98. The feedwater to the boiler is supplied at a temperature of 41.5 ^oC. The coal used for firing the boiler has a calorific value of 31000 kJ/kg and is used at the rate of 670 kg/h. Determine the thermal efficiency of the boiler.

6. During a test a unit was operated at its rated load of 100,000 kW for 12 hours. The coal consumption was 429 tons, with a heating value of 12,670 Btu per lb. Find gross station heat rate (heat required per kWh of electricity production. The cost of coal for this power plant is 1200 PKR per ton delivered to the plant, what is the unit fuel cost (cost of fuel per unit of electricity).

7. A simple Brayton cycle using air as the working fluid has a pressure ratio of 8. The minimum and maximum temperatures in the cycle are 310 and 1160 K. Assuming isentropic compression and expansion process, determine (a) the air temperature at the turbine exit, (b) the net-work output, and (c) the thermal efficiency.

8. A 1320 MW coal fired power plant is being installed at Sahiwal, go through the literature and extract required data to do an estimate about annual fuel consumption, cost of electricity per kWh. Do an estimate for emission as well. Make suitable assumptions (like, ηth=40%, ηgen=0.95, $\eta boiler$=0.80 and so on) and do mention them in your solution. Consider the same power plant once again and consider operation with natural gas and gasoline, redo the same calculations with these two fuel variants.

9. Consider a steam power plant that operates on a simple ideal Rankine cycle and has a net power output of 45 MW. Steam enters the turbine at 7 MPa and 500°C and is cooled in the condenser at a pressure of 10 kPa by running cooling water from a lake through the tubes of the condenser at a rate of 2000 kg/s. Show the cycle on a T-s diagram with respect to saturation lines, and determine (a) the thermal efficiency of the cycle, (b) the mass flow rate of the steam, and (c) the temperature rise of the cooling water.