THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
MASTER OF TECHNOLOGY IN INDUSTRIAL ENGINEERING – LEVEL07
FINAL EXAMINATION – 2005/2006
MEX 7125 – ENERGY MANAGEMENT IN INDUSTRIES
DATE : *28 April 2006*
TIME : *0930 hrs – 1230 hrs*
DURATION : *Three (03) hours*

This paper consists of Part A and Part B . Answer one (01) question from Part A and three (03) questions from Part B.

PART A

Q.1

Assume that you are an energy management consultant, and a manufacturing organisation retained you on an assignment which is to reduce the energy cost of the organisation. Having conducted a few studies the following observations are made.

Nearly 80% of the firm's electricity is used to power the motor–driven equipment.

All motors required as new and replacement of existing ones are routinely purchased through a central purchasing office calling for competitive bids.

In the specifications drawn up for these motors, efficiency is not a criterion for the bid evaluation.

It is suspected that "Low bid prices" always offer motors of "low efficiency." Therefore you decide to investigate two typical cases of purchased motors, each having 7.5 kW power rating. The two cases are identified as A and B and each motor has efficiency, life and price as given below

Type of the motor	Efficiency	Life	Price
Standard - A	81.8%	7 years	Rs. 10,000.00
High–Efficiency - B	87.4%	10 years	Rs. 16,000.00

Assume that a motor duty cycle is 4,000 hours per year and the average cost of power (electricity plus demand charges) is Rs. 15.00 per kWh.

(i) Consider the two cases, and determine the difference in electric power demand to produce 7.5 kW? For the given duty cycle, what is the difference in electricity consumption per year in kWh?

(ii) It is also believed that a motor with a higher efficiency has a longer life. Taking this premise into account, what is the actual cost difference between motor A and B if you assume a 10% discount rate and a ten-year life for both motors?

What is the total annualized cost of owning and operating a motor of each type? Which motor do your recommend?

(iii) Because the more efficient motor reduces capacity requirements of the local utility by xkW, the incremental owning cost found in (ii) above is equivalent to an investment on the additional xkW of generating capacity. What is the corresponding capital cost per kW of this investment?

[40Marks]

Q2. The island, Oahu of Hawaii, currently obtains all its electrical energy from oil only and it is now considering three alternatives. They are wind, Ocean Thermal Energy Conversion (OTEC) and a new oil plant that has an improved efficiency.

Following information are given with reference to the existing and proposed plant.

Capital cost of new oil plant, C_o = Rs. 48,000/kW
Capital cost of OTEC plant, C_T = Rs. 300,000/ kW
Cost of oil = Rs. 2,000/barrel
Energy content in per barrel of oil = 6.12 GJ
Thermal efficiency of a new oil plant = 0.37
Thermal efficiency of an existing oil plant = 0.25
Capital cost of Wind plant, C_w to be determined

If the power generation system were only out of oil, the average load factor (ie. The amount of energy delivered divided by the energy that could theoretically be delivered if the system operated at full rating 100% of the time) is 65%. Also, to cope up with outages and emergencies, it is required that a 15% of the 'reliable' capacity be kept unused in reserve (ie. If the power generation system uses only oil and working at a rating of 1000 MW, the peak load is 850 MW).

The wind blows 50% of the time at 8 m/s and rest of the time at 4 m/s (never less than this value). Wind power is directly proportional to the cube of the wind speed. OTEC can run reliably at full load as the oil-fired plant (ie. It will supply 85% of its rated output). The wind system is also 'reliable' as the oil-fired plant, except for its unpredictable variability of output. Assume a capital recovery factor (ie. a capital charge rate) of 15% per year, and neglect inflation. Also, assume that the demand pattern does not change over the period of interest.

Answer to the following questions based on the capacity of the existing oil plant.

(i) What is the capitalized total cost of the new oil plant per kW, including fuel costs? Compare the relevant costs of the new oil plant with those of existing oil and OTEC plant.

ii) At what cost of C_w does it become economical to install wind systems?

[40Marks]

PART B

Q3. a) "Energy audit process must be carried out systematically and it needs a step by step approach." Enumerate the steps to be followed in an energy audit process and explain each step in detail.

b) "Safety is a critical part of any energy audit". Comment on this statement suggesting a safety checklist. [20 Marks]

Q4. In aiming to comply with environmental regulations, it was decided that a steam plant which was producing steam by burning fuel oil, having a sulphur content of 3 % by weight, to be converted to run on gas available from another section. The gravimetric analysis of the fuel is; CH_4 –97.85 %, H_2- 0.13%, O_2-2.02%.

a) What are the specific problems associated with the use of fuel oil?

b) What is the composition of flue gas (by volume) if 50% excess air by volume is used?

c) If the estimated fuel gas consumption is 0.5 metric tons per day, calculate the volume of any green-house gases emitted along with flue gas, per year of 365 days.

d) Suggest remedial actions to mitigate the effects due to Green House Gases (GHG's) referred to part (c) above. [20 Marks]

Q5.. A drying plant utilizes steam and air for drying wet cloths, which passes through the dryer. The feed rate of wet cloths is 11.25 kg/sec and has a moisture content of about 3% by weight. The wet cloths enter the dryer at 30°C and leaves in a completely dry state at 50°C. Air at 20°C enters via a blower which is powered by a three phase induction motor at a rate of 2700 m^3/hr and leaves the system at 70°C. Steam sent at a rate of 2.074 tons/hr, gives away latent heat and the condensate leaves the dryer. Moisture leaves the system as steam at 50° C.

a) Carry out a heat balance and determine the energy loss from the system.

b) Calculate the energy consumed by the blower motor if it draws about 24 Amperes. State any assumptions you make.

c) Suggest action to be taken to improve the energy efficiency of the overall system.

Data:

Air-Temperature	Specific heat	Density
20° C	1.005 kJ/kg°C	1.189 kg/m^3
70° C	1.009 kJ/kg°C	1.189 kg/ m^3

Steam: Inlet steam enthalpy – 2725.4 kJ/kg

Evaporated steam at 50 ^{0}C Enthalpy –2592 kJ/kg

Condensate: Enthalpy – 561.49 kJ/kg

Dry cloths: Specific heat – 1.21 kJ/kg°C

Moisture: Specific heat at 30° C – 4.2 kJ/kg°C

[20 Marks]

Q6. A process plant requires 250kg of steam and 20 kWh of electricity per day. At present it generates its own steam using coal, which produces about 5 kg of steam per kg of coal. It buys electricity from grid, which is also energized by a coal power station, which is located at considerable distance away. This causes transmission and distribution losses which accounts for 5% of energy consumed. It requires about 0.6 kg of coal to generate 1 kWh of electricity.

It is proposed to replace this plant with a cogeneration plant with a back pressure steam turbine and a steam boiler which uses coal. With cogeneration, only 10% additional coal is needed to generate the required power, when 5 kg of steam is produced per 1 kg of coal.

a) Calculate the overall savings of coal if cogeneration is used.

b) If the steam demand of the plant is increased, how would the cogeneration plant meet the additional demand.

c) What are the other benefits of cogeneration systems?

d) Explain the "topping and bottoming cycles" with reference to cogeneration systems.

[20 Marks]