UNIVERSITY OF RUHUNA

Faculty of Engineering

End - Semester 8 Examination in Engineering: August 2022

Module Number: ME 8211 **Module Name: Energy Management**

[Three Hours]

[Answer **all questions**, each question carries **10** marks]

Note: Clearly state any assumptions you made in answering the questions.

Q1. a) State **three** options available to an **Energy Manager** when optimizing energy usage in the industry. Briefly discuss each.

[3 Marks]

b) "**The key to a successful energy management program is the dedication and commitment from the top management**". Discuss the significance of this statement and state **three** methods that you will use to get the attention and support of the top management in a given organisation.

[2 Marks]

c) Discuss in brief what the **ISO 50001 Energy Management System** enables organizations to do.

[2 Marks]

d) Explain how the **PDCA Process** is implemented in ISO 50001 (Hint: you may consider the **Energy Management System Model** in answering).

[3 Marks]

Q2. a) How would **an industry, the nation and the globe** benefit from energy efficiency programs?

[2 Marks]

b) What are the factors to be considered before procuring fuels in the context of energy efficiency and economics?

[2 Marks]

c) Distinguish between "**Preliminary Energy Audit**" and "**Detailed Energy Audit**".

[2 Marks]

d) List steps involved in a "**Detailed Energy Audit**".

[4 Marks]

Q3. a) Give **five** examples of environmental issues of a global significance.

[2.5 Marks]

b) What is the "**Ozone Layer Depletion**"?

[1.5 Marks]

c) What are the impacts of the "**Ozone Layer Depletion**"?

[2.0 Marks]

Q3 is continued to next page...

... Q3 is continued from previous page

d) What are the impacts of "**Global Warming**"?

[1 Mark]

e) What are the implications of "**Global Warming**"?

[3 Marks]

Q4. a) In a manufacturing plant, a steam boiler feeds 10 bar g steam to the main steam line, which delivers 7 and 5 bar steam to two production lines of the plant. The 7 bar steam line is composed of a large heating oven while the 5 bar steam line is composed of three small-size heating ovens. Both oven types have copper coils as heating elements. Particularly the small ovens need to be supplied with dry steam free of solid impurities. Also, to improve the heating performance when production starts on each day, de-aeration must be arranged specially in the large oven. Furthermore, condensate from each oven has to be separately drained to the common condensate line. Also, it is found that the oven lines are about 150 m away from the boiler. Considering this case, draw a schematic diagram of the steam distribution network, complying with all the specifications mentioned above. In the diagram, make sure to include essential standard steam circuit components and name them clearly.

[5 Marks]

b) In the production plant mentioned in Q4 (a), it has been planned to introduce co-generation and tri-generation as two consecutive upgrades. Explain both concepts with clear schematic diagrams and discuss their advantages over conventional isolated systems.

[5 Marks]

Q5. For a given steam boiler, an air preheater is to be designed as a waste heat recovery option to extract heat from the hot flue gas flowing out of its chimney. This air preheater is to heat up the primary combustion air of the boiler and will be constructed using 50 circular thin pipes arranged in a square array as given in the Figure Q5 (not all pipes are shown there). Answer the following questions using the data and key formula given in the Table Q5, where symbols have their usual meaning. Clearly state any assumptions made.

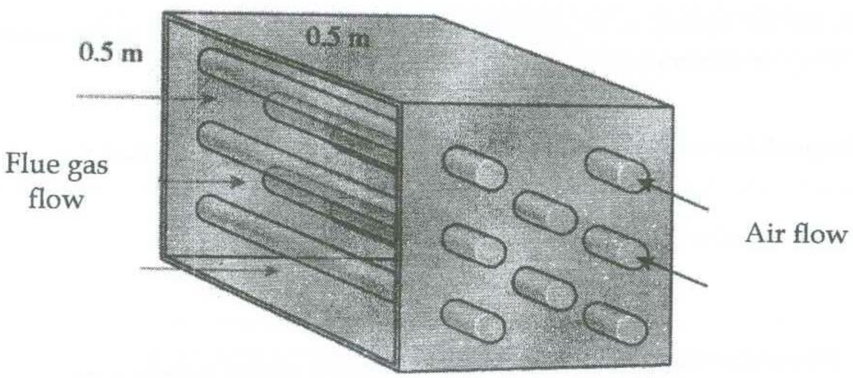

Figure Q5. Tube arrangement in the air preheater

Q5 is continued to next page...

... Q5 is continued from previous page

Table Q5: Data and key formula which may be used for calculations

Air side data	Inlet air temperature	30 °C
	Average diameter of a given pipe	25 mm
	Number of pipes used	50
	Average air velocity inside of a given pipe	20 ms^{-1}
	Specific heat of air at the average temperature of the air flow	1007 $Jkg^{-1}K^{-1}$
	Kinematic viscosity of air at the average temperature of the air flow	0.0000160 m^2s^{-1}
	Prandtl number of air at the average temperature of the air flow	0.69
	Thermal Conductivity of air at the average temperature of the air flow	0.03
	Density of air at the average temperature of the air flow	1.127 kgm^{-3}
Flue gas side data	Inlet flue gas temperature to the air preheater	300 °C
	Flue gas velocity	7 ms^{-1}
	Length of one side of the square cross section of the chimney (= hydraulic diameter)	0.5 m
	Kinematic viscosity of flue gas at the average temperature of the flue gas flow	0.0000157 m^2s^{-1}
	Prandtl number of flue gas at the average temperature of the flue gas flow	0.72
	Thermal Conductivity of flue gas at the average temperature of the flue gas flow	0.026 $Wm^{-1}K^{-1}$
	Density of flue gas at the average temperature of the air flow	0.617 kgm^{-3}
Other data	Corrected logarithmic mean temperature difference of the air preheater	254 °C
Key formula	Reynolds number (Re): $Re = \frac{VD}{v}$ Nusselt number for turbulent flow (Nu): $Nu = 0.023\, Re^{0.8} Pr^{0.4}$ Convection coefficient (h): $h = \frac{k}{D} Nu$ Overall heat transfer coefficient (U) for thin pipes: $\frac{1}{U} \approx \frac{1}{h_i} + \frac{1}{h_o}$ Rate of heat transfer ($\dot{Q}$): $\dot{Q} = UA(\Delta T_{lm})$	

(a) Convection coefficient of the inner surface of any given pipe of the air preheater.

[2.5 Marks]

(b) Convection coefficient of the outer surface of any given pipe of the air preheater.

[2.5 Mark]

(c) Overall heat transfer coefficient of any pipe of the air preheater.

[1.0 Mark]

(d) Total rate of heat transfer through the air preheater.

[2.0 Marks]

(e) Outlet air temperature of the air preheater.

[2.0 Marks]