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UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: B tech (ET+IPR) | **Semester – VII**
Subject (Course): Thermal Utilities | **Max. Marks : 100**
Course Code : PSEG337 | **Duration : 3 Hrs**
No. of pages: 3

Section-A (All Questions are Compulsory) (4×5= 20)

1. Enumerate and explain five characteristics of a good fuel and in that context explain the disadvantages of solid fuels. **[CO3]**

2. Enlist and explain the criteria for selection of burners. In the same context explain the phenomena known as "back fire." **[CO4]**

3. When a gas is forced through a duct system, a loss in pressure occurs. In this context explain what is meant by system resistance and how it affects fluid flow? **[CO2]**

4. Enlist the characteristics of an "Emerging Technology." **[CO5]**

Section-B (All Questions are Compulsory) (5×8= 40)

5. An induced draft system consists of the steam generator, air heater, electrostatic precipitator, wet scrubber, chimney, and the interconnecting ductwork. Flue gas from the steam generator leaves the common air heater outlet plenum and flows to two parallel electrostatic precipitators and four parallel wet scrubber modules.

Component	Flue gas flow rate, 1,000 lb/h	Total pressure loss, in. wg
Steam generator	5,000	8
Air heater	5,000	6
Precipitator, each	2,500	2
Wet scrubber, per module	1,750	5
Chimney	5,000	2
		Total 23

How does this total system resistance change if one precipitator and one scrubber module are removed from service and the total system flow at 5,000,000 lb/h is held constant? **[CO2]**

6. How is the Hydrogen and Fuel Cell infrastructure expected to dominate most aspects of the world energy needs? Present your points with suitable real time examples.

A domestic fuel cell system in a rural area is to be fed by butane. This gas is to be steam reformed and the resulting carbon monoxide is to be shifted to hydrogen. Assuming no losses, how many kg of hydrogen can be extracted from each kg of butane?
Also calculate percentage yield for hydrogen. **[CO4]**

7. A boiler is provided with a chimney of 26m height. The boiler house temperature is 30°C and temperature of flue gases leaving chimney is 300°C. If air supplied to the boiler is 20kg/kg of fuel. Estimate: **[CO3]**

(i) Draught in mm of water,

(ii) Velocity of gases passing through chimney with 50% loss of draught in Chimney.

8. Explain the working of **ORSAT apparatus** with the help of a neat diagram; also explain why it is a useful tool for flue gas analysis. **[CO3]**

9. Two broad categories of co-generation are (i) the topping cycle, and (ii) the bottoming cycle; in that context enumerate the **four designs** for the Topping cycle. **[CO5]**

Based on the above arrangements suggest the suitability of these designs to meet electricity and heat demand.

Section-C (All Questions are Compulsory) (2×20= 40)

10. Convert model fan (b) performance to that of a full-size fan (a) with different speed and operating temperature as indicated below. Assume that the inlet pressure and gas molecular weight are the same for the model and full size fan. **[CO3]**

Parameter	Model Fan (b)	Full size Fan (a)
Diameter, inches	20	80
RPM	1200	900
Temperature	60°F (520°R)	320°F (780°R)

The model fan performance data is given as:

Flow (acfm)	ΔP, in w.g.	bhp
3000	9	7
6000	10	16
12000	8.6	25
18000	5.2	28
24000	3.1	30

11. A company is considering replacing an oil-fired boiler of 10 tons per hour with a coal-fired boiler of the same capacity. **[CO1]**

The following data is given:

Heat content of steam	**660 kCal /kg**
Feed water inlet temperature	**60^0 C**
Daily operating hours	**24**
Number of days / year	**300**
Efficiency of oil-fired boiler	**82%**
Efficiency of coal-fired boiler	**72%**

With the help of the data provided, calculate the following:

a. Annual oil consumption in tons per year
b. Annual coal consumption in tons per year
c. Annual fuel cost savings in million US$

Cost of oil	**US$ 300/ton**
Cost of coal	**US$ 45/ton**
GCV of oil	**10,000 kCal/kg**
GCV of coal	**4,200 kCal/kg**

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Section-A (All Questions are Compulsory) (4×5= 20)

1. What is meant by artificial draught? With the help of a neat flow diagram explain the working of Induced Draught systems. **[CO3]**

2. Enlist the advantages of Gaseous fuels and explain what you mean by "Principle of Combustion." **[CO2]**

3. What are the advantages of mechanical draught over natural draught? Present your views for what can be some disadvantages with artificial draught systems. **[CO3]**

4. What are the various types of DSM measures? In that context explain DSM applied to Boilers. **[CO5]**

Section-B (All Questions are Compulsory) (5×8= 40)

5. Explain the working of Gas Liquid Chromatography (GLC) with the help of a conceptual diagram.
How is the aforementioned process different from flue gas analysis using Infrared (IR) analyzer? **[CO2]**

6. A practical OTTO cycle engine has an efficiency of 20%, while a practical methanol fuel cell may have an efficiency of 60% (this is the efficiency of the practical cell compared with that of the ideal cell). If methanol fueled IC car has highway performance of 10 km per liter, what is the performance of the fuel cell car assuming that all the other characteristics of the cars are identical? **[CO4]**
Assume unit yield from methanol is 21.2 MJ of energy/ kg of fuel consumed.

7. For the solution from Question Number 6, assume that if you drive 2000 km per month and a gallon of methanol costs $2.40, how much do you save in fuel per year when you use the fuel cell version compared with the IC version? (Given: 1 Gallon = 3.78 Liters)
Can you think of other savings besides that in the fuel? **[CO4]**

8. Draught produced by chimney is 2 cm of water column. Temperature of flue gas is 300°C and ambient temperature is 33°C. The flue gas formed per kg of fuel burnt is 24 kg. Neglect the losses and take the diameter of chimney as 1.75 m.
Calculate: **[CO3]**

a. Height of Chimney in meters.
b. Mass of flue gas flowing through the chimney in kg/min.

Density of flue gases is given by: $\rho_g = \left\{\frac{m_a+1}{m_a}\right\}\frac{353}{T_g}$

9. What do you understand by **Energy Storage**? Contrast and compare Battery Storage with Compressed Air Energy Storage (CAER). **[CO4]**

The Alabama Electric Corporation has a 100 MW CAER plant, present a conceptual flowsheet with explanations for how the system works.

Section-C (All Questions are Compulsory) (2×20= 40)

10. A combustion air system consists of the following equipment, each component operating at its respective temperatures and pressure drops with a forced draft (FD) fan flow of 500,000 acfm:

Parameter	Entering Temp. (°F)	Leaving Temp. (°F)	ΔP , in. wg
FD fan inlet silencer	100	100	0.5
Ducts to air heater	110	110	0.5
Air heater	110	700	5.0
Ducts to wind box	700	700	1.0
Wind box dampers	700	700	2.0
Burners	700	700	4.0
			(Total) 13.0

How does this system resistance change with a 60° F ambient temperature reduction?

In the above context, explain the terms: (i) **Air Horse Power** (ii) **Break Horse Power.**

How can you relate **AHP** and **BHP** with the efficiency of a Fan?

Now that you have established the efficiency of the fan, describe the following laws and their significance to fan performance: **[CO3]**

a. **Law of Fan Flow.**
b. **Law of Fan Pressure.**
c. **Law of Fan Power.**

11. The four critical parameters for the success of any emerging technology are:

a. Energy Benefits.
b. Operating stability.
c. Environmental impact.
d. Economics. **[CO5]**

In the above context, explain how the following technologies can be a part of the foreseeable future?

(i) Coal fired Magneto-hydrodynamics (MHD) Systems
(ii) Microbial Fuel Cells.
(iii) Solar Towers (Central Receiver Systems).