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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Examination, July 2020

Programme: M.Tech-ES **Semester: II**
Course Name: Performance Analysis of Thermal Equipment
Max. Marks: 100
Course Code: EPEC8004 **Attempt Duration: 1**
No. of page/s: 03

Note:

1. Read the instruction carefully before attempting.
2. This question paper has two section, Section A and Section B.
3. Answer Sheet to be submitted within 24 hrs from the scheduled time (*exceptional provision due extraordinary circumstance due to COVID-19 and due to internet connectivity issues in the far-flung areas*).
4. No submission of Answer Sheet shall be entertained after 24 Hrs.
5. The answers should be attempted in blank white sheets (hand written) with all the details like programme, semester, course name, course code, name of the student, Sapid at the top (as in the format) and signature at the bottom (right hand side bottom corner)

Attempt all questions:

1. A typical industrial process may consist of several numbers of hot and cold process streams which may demand cooling and heating respectively. Heat exchangers can be used to recover some of the heat demand while external heaters and coolers can be used to achieve the temperature demand of the process streams. Suppose an industrial plant with hot and cold process streams as shown in Table 1. **(30 Marks)**

Table 1. Process streams in an industrial plant.

Process stream Nr / Type	Inlet Temp. [°C]	Outlet Temp. [°C]	Heat capacity rate [kW/K]	$\dot{Q}$ [kW]
1. cold	90	420	10	3300
2. cold	170	350	32	5760
3. cold	200	390	29	5510
4. hot	440	140	27	8100
5. hot	510	300	24	5040

The task is to find the optimal network of heat exchangers, external coolers and external heaters with respect to the capital and annual operating cost.
ΔT_{min} = Sum of the digit of your Roll. No – 10
Odd digit roll number: Use table method
Even digit roll number: Use composite diagram method

2. *Ultimate Analysis of Boiler (%)* ***(30 Marks)***

Carbon	= 92
Hydrogen	= 16
Nitrogen	= 0.5
Oxygen	= 1.9
Sulphur	= 1.8
Moisture	= 0.5
GCV of fuel (diesel)	= 10000 kCal/kg
Fuel firing rate	= 2637.341 kg/hr
Surface Temperature of boiler	= 82 ^{0}C
Surface area of boiler	= 90 m^2,
Humidity	= 0.015 kg/kg of dry air
Wind speed	= 3.7 m/s

Flue Gas Analysis of Boiler (%)

Flue gas temperature	= 226 ^{0}C
Ambient temperature	= 30 ^{0}C
CO2 % in flue gas by volume	= 11.4
O2 % in flue gas by volume	= 7.9

(A) Calculate efficiency of boiler using indirect method ***(Roll number 1)***

(B) Show the effect of ambient temperature on efficiency of boiler ***(Roll Number 3 and 8) – Use Excel sheet***

(C) Show the effect of flue gas temperature on efficiency of boiler ***(Roll Number 4 and 6) – Use Excel Sheet***

3. An oil-fired reheating furnace has an operating temperature of around 1340 ^{o}C. Average fuel consumption is 400 litres/hour. The flue gas exit temperature after air preheater is 750 ^{o}C. Air is preheated from ambient temperature of 40 ^{o}C to 190 ^{o}C through an air pre-heater. The furnace has 460 mm thick wall (x) on the billet extraction outlet side, which is 1 m high (D) and 1 m wide. The other data are as given below. Find out the efficiency of the furnace by indirect method. **(20 Marks)**

Flue gas temperature after air preheater	=	750^{o}C
Ambient temperature	=	40^{o}C
Preheated air temperature	=	190^{o}C
Specific gravity of oil	=	0.92
Average fuel oil consumption	=	400 Litres / hr
	=	400 x 0.92 =368 kg/hr
Calorific value of oil	=	10000 kCal/kg
Average O_2 percentage in flue gas	=	12%
Weight of stock	=	6000 kg/hr
Specific heat of Billet	=	0.12 kCal/kg/^{0}C
Surface temperature of roof and side walls	=	122 ^{o}C

Surface temperature other than heating and soaking zone = 85 ^{o}C

4. Draw layout of steam line for 200 meter using guidelines mentioned. **(20 Marks)**

Guide for proper drainage and layout of steam lines:

1. The steam mains should be run with a falling slope of not less that 125 mm for every 30 metres length in the direction of the steam flow.
2. Drain points should be provided at intervals of 30–45 metres along the main.
3. Drain points should also be provided at low points in the mains and where the steam main rises. Ideal locations are the bottom of expansion joints and before reduction and stop valves.
4. Drain points in the main lines should be through an equal tee connection only.
5. It is preferable to choose open bucket or TD traps on account of their resilience.
6. The branch lines from the mains should always be connected at the top. Otherwise, the branch line itself will act as a drain for the condensate.
7. Insecure supports as well as an alteration in level can lead to formation of water pockets in steam, leading to wet steam delivery. Providing proper vertical and support hangers helps overcome such eventualities.
8. Expansion loops are required to accommodate the expansion of steam lines while starting from cold.
9. To ensure dry steam in the process equipment and in branch lines, steam separators can be installed as required.

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