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MANIPAL INSTITUTE OF TECHNOLOGY
*A Constituent Institute of Manipal University, Manipal*

**VII SEMESTER B.TECH (MECHANICAL/IP ENGG.) END SEMESTER**

**MAKE UP EXAMINATIONS, DEC 2017**

SUBJECT: DESIGN OF THERMAL POWER PLANT SYSTEMS (P- 6) [MME 4010]

**REVISED CREDIT SYSTEM**

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

- Answer **ALL the** questions.
- Missing data may be suitably assumed.
- Use of heat exchanger data sheet, thermodynamics and heat transfer data book are permitted

**1A.** With a neat sketch explain various heat exchangers present in the steam generation process. **05**

**1B.** Find the overall heat transfer coefficient and hair pin length of the Double pipe heat exchanger with the following specifications:

| | | |
|---|---|---|
| Shell nominal diameter | : | 3″ (Schedule 40) |
| Tube nominal diameter | : | ¾″ (Schedule 80) |
| Number of tubes | : | 3 |
| Hot fluid/Cold fluid | : | Engine oil / Sea water |
| Mass flow rate | : | Hot: 8 kg/s and cold: 4.41 kg/s |
| Entry temperature | : | Hot: 140°C and cold: 40°C |
| Exit temperature of hot | : | 100°C |
| Tube material | : | Carbon steel, AISI 1010 |

Neglect fouling resistance **05**

**2A.** Explain with neat sketches the different models of film condensation in tube bundles. **05**

**2B.** Find the length of the Shell and tube heat exchanger with following specifications:

| | | | | | |
|---|---|---|---|---|---|
| Shell size | : | 12″ | Hot fluid | : | Treated water (5000 kg/h) |
| Number of pass | : | 1 | Cold fluid | : | Sea water (50000 kg/h) |
| Baffle spacing | : | 0.25 m | Entry temperature | : | Hot: 80°C / Cold: 38°C |
| | | | Exit temperature | : | Hot: 40°C / Cold: 42°C |

Tube material : Carbon steel, AISI 1010
Tube configuration : ¾″ OD on 1″ square pitch (20 BWG)

Neglect effect of property variation at shell side. Also neglect fouling resistance. **05**

**3A.** Explain different methods used to cool process fluid in industrial applications. **05**

**3B.** Flue gas at 300°C with a velocity of 20 m/s flow across a compact heat exchanger of type 9.1-0.737-S. Water at 40°C and flow rate of 40 kg/s flows through the conduit. Frontal length and height for gas flow is 0.60 m x 0.50 m. Flow length is 0.40 m. Neglect wall resistance. Find rate of heat transfer.

| | | |
|---|---|---|
| Water side c/s porosity | : | 0.15 |
| Material | : | Al alloy 195 |
| Height of the fin | : | 1.5 mm |
| Water side area of core volume | : | 150 $m^2/m^3$ |

**05**

**4A.** How tube or annulus side pressure drop can be reduced in case of double pipe heat exchangers? Explain with neat sketch. **05**

**4B.** A condenser is to be designed to condense 200 kg/h of steam at atmospheric pressure. A square array of 144, 15 mm outside diameter tubes are available for the design and the wall temperature of the tube is maintained at 96°C.

(a) Estimate the length of the tube required (by referring Nusselt relation), if the condenser is to be installed in the horizontal position.

(b) If the above condenser is by mistake installed in the vertical position, will there be any change in the condensation rate? If so find the modified value. **05**

**5A.** A furnace heater is designed for heat load of 10 MW. The process fluid has the transfer coefficient of 1000 $W/m^2K$. Tubes are 235 mm in diameter with 350 mm spacing and have the wall heat transfer coefficient of 2500 $W/m^2K$. Vertical cylinder heater have 5 rows of horizontal plain tubes each 2.5 m long in convection section. Overall efficiency of the heater is 85 %. Natural gas fuel ($CH_4$) is fired with 25 % excess air. Take the average flue gas temperature as 900 K and tube temperature as 280 K. Find the overall heat transfer coefficient of tubes in the convective section. **05**

**5B.** In a cooling tower performance test, the following readings are noted in case of Forced mode.

| | | |
|---|---|---|
| Water entry temperature | = | 45°C |
| Water exit temperature | = | 40°C |
| WBT at entry | = | 25°C |
| WBT at exit | = | 30°C |
| DBT at entry | = | 33°C |
| DBT at exit | = | 37°C |
| Water flow rate | = | 10 lpm |
| Duration of test | = | 300 s |

Find:

(a) Cooling tower duty

(b) Cooling tower efficiency

(c) Mass flow rate of air

(d) Rate of make-up water **05**