ME(M) Thermal Sem II (R)

Cryogenics

Con. 3473-09. BB-5769

(4 Hours) [Total Marks : 100

N.B. : (1) Question No. **1** is **compulsory**.
(2) Answer any **four** questions out of remaining **six** questions.
(3) Answers to **all parts** of a question should be written **together** and **one** below the **other**.
(4) Assume any **suitable data** wherever **required** but **justify** the **same**.
(5) **Use of T-s charts, h-c charts are permitted**.

ME(M) Thermal Sem II Rev Cryogenics.

1. (a) 1 kg of air at 1 atmosphere pressure and 300K is to be liquefied. Find the amount of work input required if this has to be done using a reversed Carnot cycle. Why Carnot cycle is not the ideal cycle for liquefaction ? 5

(b) Derive an expression for ideal work of liquefaction and find the minimum work requirement to liquefy air that is at 1 atm and 300K. Comment on the pressure levels involved. 5

(c) A simple Linde Hampson cycle operates between the pressure levels of 1 atm. and 100 atm., with isothermal compression at 300K. Find heat exchanger effectiveness when yield is 70% of the maximum. Show schematic diagram and trace the cycle on T-s chart and derive all equations used. 10

2. (a) Explain the working of the pre cooled Linde Hampson cycle. Is there a restriction on increase of refrigerant flow rate ? 6

(b) An air liquefaction system operates on pre cooled L-H cycle with pre cooling of air at – 40°C by using an ammonia vapor compression system with specific power consumption of 8540 kJ/kWh. The pressure levels of the main system are 1 atm. and 200 atm. respectively. Temperature of isothermal compression is 305 K. Heat gain into storage vessel is 8.8 kJ/kg. Determine the flow rate of air to be compressed to obtain 50 kg/h of liquid air. Also determine power required for the same. 14

3. (a) List various insulations used in cryogenic systems in order of increasing performance and describe them in detail. 10

(b) With a neat sketch describe the elements of a Dewar vessel clearly outlining the function of each of the elements. 10

4. (a) A mixture consisting of 73% nitrogen, 18% oxygen and 9% argon by volume is to be separated into their pure constituents. The work required is 125 kJ/kg mixture. Find figure of merit of the system. Derive any formula used. 10

(b) A rectification column is to be used to separate a feed stream of saturated liquid of composition 79% nitrogen and 21% oxygen into two streams. The top product being saturated liquid containing 98% nitrogen and bottom product saturated liquid with 95% oxygen. Derive the equation of the operating lines of the column and hence explain the McCabe Thiele method to find the number of plates needed for this duty. 10

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5. (a) Derive an expression for the thermodynamically ideal isobaric-source system and show that it reduces to the expression of the Carnot refrigerator when T_2/T_1 approaches unity. 8

   (b) Describe working of Philips cryocooler stating the importance of regenerator effectiveness. 12

6. (a) Define Murphree efficiency and discuss the factors that lead to high values of Murphree efficiencies. 10

   (b) Describe temperature measurement at cryogenic temperature levels. 10

7. Write short notes on any **four** of the following :— 20
   (a) Linde double column separation system
   (b) Cryogenic applications in space technology
   (c) Cryopumping
   (d) Simon helium liquefaction system
   (e) Ortho-para conversion of Hydrogen.

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