GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch: Cryogenic Engineering

Subject Code : ME02074011

Course / Subject Name : Cryogenic Systems

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	PCC

Prerequisite:	Fundamental knowledge of physics and thermodynamics
Rationale:	The course is formulated to impart detailed study of cryogenic systems which can be utilized for different cryogenic applications.

Course Outcome:

On successful completion of the course, the students will be able to

No	Course Outcomes	RBT level
1	Develop cryogenic refrigerators above 2 K	R/U/A
2	Develop cryogenic refrigerators using solid as working medium	R/U/A
3	Compare various gas liquefaction systems	R/U
4	Develop gas separation system using adsorbents.	R/U/A

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA/CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Cryogenic Refrigeration System:** Ideal refrigeration systems, Joule Thomson system, cascade / pre-cooled joule–Thomson \refrigeration systems, expansion engine and cold gas refrigeration systems, Philips refrigerators, Importance of regenerator effectiveness for the Philips refrigerators, Gifford-McMohan refrigerator, Gifford double volume refrigerators analysis, COP, FOM,	16	35

	regenerators, pulse tube refrigerators, various types of pulse tube refrigerator, Vuilleumier refrigerator, Solvay refrigerator		
2	**Refrigerators for temperatures below 2K:** Magnetic refrigeration system, Thermal valves, Dilution refrigeration system	5	10
3	**Gas liquefaction systems:** Thermodynamically ideal system and performance parameters, Joule Thomson effect and adiabatic expansion, liquefaction systems such as Linde Hampton, precooled Linde Hampson, Linde dual pressure, cascade system, Claude, Kapitza and Heyland systems, liquefaction systems using expanders, liquefaction systems for LNG, comparison of liquefaction systems. Liquefaction systems for neon, hydrogen and helium – Pre cooled Linde-Hampson system for neon and hydrogen, Claude system for hydrogen liquefaction system, Ortho-para- hydrogen conversion in liquefier, Collins and Simon helium liquefaction system	16	35
4	**Separation of gases using Adsorbents:** Principles of adsorption, various adsorbents, salient features – properties, determination of mass of absorbents for the adsorption of gases, Brunauer–Emmett–Teller (BET) equation for single and multiple layers, use of sorption process in cryogenics. Static and dynamic arrangement for the sorption processes, Adsorption columns, PSA and VSA adsorption systems, isotherms	8	20
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
30	**40**	**30**	**0**	**0**	**0**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy

References/Suggested Learning Resources:

(a) Books:

1. Cryogenic Systems, Barron, McGraw Hill Book Co.

2. Theory and design of cryogenic systems : A.Arkherov
3. Cryogenic process engineering Timmerchand & Flynn
4. "Theory and design of cryogenic systems", Mikulin, MIR Publication, 2002

(b) Open-source software and website:

1. Cryogenic Engineering by M D Atrey (NPTEL)
nptel.ac.in/courses/112/101/112101004/

Suggested Course Practical List:

1. Study and analysis of cryo refrigeration system. – isothermal source system, isobaric source system.
2. Study and analysis of Philips refrigeration system.
3. Study and analysis of precooked cycle of refrigeration
4. Study and analysis of GM refrigerator.
5. Study and analysis of Vuilleumier and Solvay refrigerators.
6. Study and analysis of magnetic refrigerator and thermal valves.
7. Study and analysis of dilution refrigerator.
8. Study of ideal liquefaction system.
9. Study of Linde dual pressure system.
10. Study of hydrogen liquefaction system.
11. Study of pulse tube refrigeration system.

List of Laboratory/Learning Resources Required:

Liquid nitrogen plant, pulse tube cryocoolers, GM cryocoolers, Stirling cryocooler

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