GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Mechanical, Energy Engineering)
Subject Code: 3733905
Semester – III
Subject Name: Solar Refrigeration and Air-Conditioning

Type of course: Program elective

Prerequisite: Solar Energy, Thermodynamics, Refrigeration and Air-conditioning, psychometric

Rationale: The course intends to provide knowledge of refrigeration and air-conditioning system operated on solar energy, non-conventional cooling system, performance analysis and applications to graduate students.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Solar Energy – A potential for cooling system:** Introduction to solar energy used for cooling, Potential and scope of solar cooling, Types of solar cooling systems **Solar Collection System:** Performance analysis of solar flat plate collector, cylindrical parabolic collector, compound parabolic collector, Flat plate collector with phase changing fluid, Evacuated collector for the solar refrigeration and air-conditioning, Thermal storage systems and its performance analysis.	**8**
2	**Conventional and Non-Conventional Compression Solar Refrigeration System** **Conventional Compression:** Conventional Vapour compression (V-C) refrigeration, Cycle analysis, Selection criteria of refrigerants, Performance evaluation of V-C System. **Non-Conventional Compression:** Solar thermal conversion based V-C system, Conventional Rankine cycle, Cycle analysis, Rankine cycle solar cooling system and modeling, Selection criteria of refrigerants for Rankin cycle, Jet ejector compression solar cooling, Modeling and performance evaluation, Gas compression cycle solar cooling system.	**10**
3	**Thermodynamics of Vapour Absorption Cooling System (VACS):** Principle and working of conventional VAC System, Basic processes and working of VACS components, Performance evaluation parameters of ideal and non-ideal VACS, Selection criteria of refrigerant, P-T-X measurement. **Solar Absorption Cooling System:** Types of VAC system – Closed, Intermittent and open cycle system, Working and modeling of solar operated LiBr- H_2O and NH_3-H_2O VACS, Performance enhancement of VACS, Principle, working and performance evaluation of solar intermittent VAC system, Modeling of solar open cycle VACS, Performance analysis of open and closed VACS, Solar absorption space conditioning system with internal storage – working and modeling.	**12**

4	**Solar Vapour Adsorption/ Desiccant Cooling System:** Introduction, Difference between desiccant cooling and conventional cooling, Desiccant Materials, Selection criteria, Solar solid desiccant cooing system – open and closed cycle, Solar liquid desiccant cooing system, Desiccant regenerator system – working, analysis and performance evaluation.	**7**
5	**Non-Conventional Solar Cooling System:** Solar thermoelectric refrigeration and air-conditioning – theoretical analysis, design and performance evaluation. Selection of thermoelectric materials, Solar thermo acoustic cooling – working, solar economics of cooling systems	**5**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**20**	**20**	**20**	**20**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1) Solar air conditioning and refrigeration, A. A. M. Sayigh and J. C. McVeigh, Pergamon Press.
2) Solar Refrigeration and Space conditioning, S. C. Kaushik, Divya Jyoti Publication
3) Solar cooling and Heating Volumes- I, II, III, T. Nejat Veziroglu.
4) Advances in solar heating and cooling, R. Z. Wang and T.S. Ge, Woodhead Publishing.
5) Desiccant Assisted Cooling Fundamentals and Applications, Carlos Eduardo Leme No'brega, Nisio Carralho, Lobo Brum, Springer
6) A Liquid Desiccant Air Conditioning System, Thosapon Katejanekam, Lambert Acedemic Publishing
7) Emerging Technologies in Air-conditioning and Refrigeration, R. S. Agrawal, P. L. Dhar, M. M. Pande, Sanjeev Jain, ASHRAE, ISHRAE, Allied Publishers Limited
8) Solar-assisted air conditioning in buildings, Hans-Martin Henning, Springer

Course Outcomes:

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	To discuss the concept of solar cooling opportunities, solar collectors and thermal storage for the cooling system.	**20%**
CO-2	To analyze the solar operated compression cooling system.	**25%**
CO-3	To analyze the solar operated absorption cooling system.	**30%**
CO-4	To appraise to desiccant cooling systems and its applications.	**15%**
CO-4	To discuss the non-conventional solar refrigeration and air conditioning.	**10%**

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List of Experiments:

1) To study and Performance evaluation of liquid flat plate solar collector, concentrating collector for solar refrigeration and air-conditioning system.
2) To study and performance of Sensible and latent heat thermal storage devices for solar refrigeration and air-conditioning system.
3) To Study and Performance evaluation of Rankine Cycle Solar Cooling system.
4) To Study and Performance evaluation of Jet Ejector Cooling System.
5) To Study and Performance evaluation of LiBr - H2O Vapour absorption system integrated with solar collectors.
6) To Study and Performance evaluation of Aqua Ammonia Vapour absorption system integrated with solar collectors.
7) To study and performance evaluation of Intermittent and Open cycle absorption solar cooling system.
8) To Study and Performance evaluation of Solar Absorption Space Conditioning System with Integral Refrigerant Storage.
9) To Study and Performance evaluation of solar assisted Solid and Liquid desiccant cooling system.
10) To Study and Performance Evaluation of Solar Thermoelectric Cooling system.

Major Equipment:

Solar flat plate collector, Cylindrical Parabolic Collector, Compound Parabolic Collector, Sensible and Latent heat storage device, Rankin cooling system, Jet ejector cooling system, Libr-H_2O and Aqua – Ammonia VARS integrated with collector, Solar Vapour Absorption space conditioning system, Solar assisted Solid and Liquid desiccant cooling system, Thermoelectric cooling system.

Requirement: Solar Refrigeration and Air conditioning data book containing correlations and refrigerant property tables are required for examinations.

List of Open Source Software/learning website:

1) http://ocw.mit.edu/courses/energy-courses/