Vidya Jyothi Institute of Technology

(Accredited by NBA, Approved by AICTE New Delhi)
Aziz nagar Gate, C.B. Post, Hyderabad-500 075

DEPARTMENT OF MECHANICAL ENGINEERING

REGULATION : R18

BATCH : 2018-2022

ACADEMIC YEAR : 2020-21

PROGRAM : B.TECH (MECHANICAL ENGINEERING)

YEAR/SEM : III/II

COURSE NAME : REFRIGERATION AND AIRCONDITIONING

COURSE CODE : A26324

NAME OF THE FACULTY: **SHAIK ISMAIL**

DESIGNATION: **ASSISTANT PROFESSOR**

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DEPARTMENT OF MECHANICAL ENGINEERING

REGULATION	:	R15
BATCH	:	2017-2021
ACADEMIC YEAR	:	2019-20
PROGRAM	:	B.TECH (MECHANICAL ENGINEERING)
YEAR/SEM	:	III/II
COURSE NAME	:	REFRIGERATION AND AIRCONDITIONING
COURSE CODE	:	A16329

NAME OF THE FACULTY: **SHAIK ISMAIL**

DESIGNATION: **ASSISTANT PROFESSOR**

COURSE FILE INDEX

1. SYLLABUS

REFRIGERATION AND AIR CONDITIONING

B.TECH III Year II Semester
A26324

L	T	P	C
3	0	0	3

Course Outcomes

1. Distinguish various types of refrigeration system.
2. Apply the principles of thermodynamics to refrigeration systems.
3. Thermodynamically analyze refrigeration and air conditioning systems.
4. Evaluate the performance parameters while designing the refrigeration and air conditioning system.

UNIT – I

Introduction to Refrigeration: Necessity and applications - Unit of refrigeration and C.O.P. Mechanical Refrigeration, Ideal cycle of refrigeration.

Air Refrigeration: Bell Coleman cycle Brayton Cycle Open and Dense air refrigerationcycle -Air craft cooling systems.

UNIT – II

Vapour Compression Refrigeration: Introduction Working of simple VCR cycle Representation of cycle on T-S and p-h charts -Effect of sub cooling and super heating Actual VCR cycle Problems.

System Components: Compressors - General classification working principles **Condensers** classification Working Principles, **Evaporators** classification Working Principles, **Expansion Devices** Types Working Principles.

Refrigerants: Classification Desirable properties commonly used refrigerants Nomenclature.

UNIT III:

Vapor Absorption System: Introduction Description and working of N ter system, Calculation of Maximum COP Water Li-Br absorption system T uid absorption system.

Steam Jet Refrigeration System: Introduction Working Advanta nd Disadvantages.

UNIT IV:

Psychometric: Introduction Psychometric terms Psychometric processes.

Inside and Outside Design Conditions: Introduction - Selection of ins design conditions Selection of outside design conditions.

UNIT – V:

Psychometric of Air Conditioning Systems: Introduction- Summer Air c tioning system winter Air conditioning system- All year air conditioning system.

Unitary refrigerant based systems.

Cooling Load Calculations: Introduction- Estimation of required cooling ca

TEXT BOOKS:

1. Refrigeration and Air Conditioning, CP Arora, TMH.

2. TEXT BOOKS & OTHER REFERENCES

S. NO.	TITLES
1	Refrigeration and Air Conditioning / CP Arora / TMH.
2	A Course in Refrigeration and Air Conditioning / SC Arora & Domkundwar / Dhanpatrai.
3	Refrigeration and Air Conditioning / Manohar Prasad / New Age.
References:	
1	Principles of Refrigeartion / Dossat / Pearson Education.
2	Refrigeration and Air Conditioning-P.L.Bellaney.
3	Basic Refrigeration and Air Conditioning / Ananthanarayanan / TMH.
4	Refrigeration and Air Conditioning – R.S. Khurmi & J.K. Gupta – S. Chand –Eurisia Publishing House(P) Ltd.
	Web References: • http://nptel.ac.in/courses/ • https://ocw.mit.edu/courses

3. TIME TABLE

VIDYA JYOTHI INSTITUTE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

ACADEMIC YEAR 2020-21 B.TECH III-II SEM

TIME TABLE FOR ONLINE CLASSES--SECTION A

DAY	TIMINGS	COURSE NAME	FACULTY NAME
MON	9:30-10:30AM	Design of Machine Members-II	Dr.VV Satyanarayana
	10:45-11:45 AM	Heat Trasfer	Mr.Chirra Ravi
	12:00-1:00 PM	Finite Element Method	Dr.G. Sreeram Reddy
	2.00-3.00 PM	Refrigeration And Air Conditioning	Mr.Ismael
TUE	9:30-10:30AM	Metrology & Machine Tools	Dr.V.Phanindra
	10:45-11:45 AM	Finite Element Method	Dr.G. Sreeram Reddy
	12:00-1:00 PM	**** OPEN ELECTIVE ****	
	2.00-3.00 PM	Personality Development And Behavioral skills	Dr.Padma venkat
WED	9:30-10:30AM	Production Planning & Control	Mr.S.Ramakrishna
	10:45-11:45 AM	Refrigeration And Air Conditioning	Mr.Ismael
	12:00-1:00 PM	**** OPEN ELECTIVE ****	
	2.00-3.00 PM	Metrology & Machine Tools	Dr.V.Phanindra
THU	9:30-10:30AM	Design of Machine Members-II	Dr.VV Satyanarayana
	10:45-11:45 AM	Heat Trasfer	Mr.Chirra Ravi
	12:00-1:00 PM	**** OPEN ELECTIVE ****	
	2.00-3.00 PM	Finite Element Method	Dr.G. Sreeram Reddy
FRI	9:30-10:30AM	Production Planning & Control	Mr.S.Ramakrishna
	10:45-11:45 AM	Metrology & Machine Tools	Dr.V.Phanindra
	12:00-1:00 PM	Heat Trasfer	Mr.Chirra Ravi
	2.00-3.00 PM	Design of Machine Members-II	Dr.VV Satyanarayana
SAT	9:30-10:30AM	Refrigeration And Air Conditioning	Mr.Ismael
	10:45-11:45 AM	Heat Trasfer	Mr.Chirra Ravi
	12:00-1:00 PM	Personality Development And Behavioral skills	Dr.Padma venkat
	2.00-3.00 PM	Production Planning & Control	Mr.S.Ramakrishna
		HT LAB	C.L.Sindhuja/Dr. Dareddy Ramana Reddy
		MMT LAB	Dr.V.Phanindra/Mr.Ismael

HOD

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(Aziz Nagar, C.B.Post, Hyderabad -500075)

DEPARTMENT OF MECHANICAL ENGINERRING

TIMETABLE

A.Y- 2019-20

III B.Tech II Sem

w.e.f. 09/12/2019

SECTION-A

TIME/ DAY	9.00- 9.55	9.55-10.50	10.50.11-45	11.45-12.30	12.30-1.25	1.25-2.20	2.20-3.15	3.15-4.05
MON	RAC	HT	PLMH	LUNCH BREAK	DMM-II	FEM	PPC	MEFA
TUE	HT	OE			RAC	HT LAB		
WED	FEM	OE			HT	AECS LAB		
THU	DMM-II	FEM	FEM		PPC	PLMH	MEFA	HT
FRI	MEFA	DMM-II	PPC		RAC	HT	QMLR	PLMH
SAT	PLMH	QMLR	RAC		FEM	MEFA	DMM-II	PPC

SL.NO	SUBJECT CODE	SUBJECT	FACULTY
1	A16327	DESIGN OF MACHINE MEMBERS-II	Mr.G.RAJESH BABU/Mr.J.V.Subramaniyam(OU)
2	A16328	HEAT TRANSFER	Mrs.J.EMEEMA
3	A16329	FINITE ELEMENT METHODS	Dr.G.SREERAM REDDY
4	A16330	REFRIGERATION & AIR CONDITIOING	Mr.K.RAVI KUMAR
5	A16019	MANAGERIAL ECONOMICS AND FANANCIAL ANALYSIS	Mr.ARJUN GOUD
6		QUANTITATIVE METHODS & LOGICAL REASONING	Mr.VIJAY BABU
7	A18345	PRODUCTION PLANNING AND CONTROL	Mr.RAGHURAM REDDY
8	A18346	PLANT LAYOUT AND MATERIAL HANDLING	Dr.B.SUDHA BINDU
9	A16388	HEAT TRANSFER LAB	Mrs.J.EMEEMA/Mr.RAMAKANTH Mr.K.RAVI KUMAR/Mr.IMAM SAHEB
10	A16090	ADVANCED ENGLISH COMMUNICATION SKILLS	Mr.PETER

H.O.D

VIDYA JYOTHI INSTITUTE OF TECHNOLOGY
MECHANICAL ENGINEERING DEPARTMENT
TIMETABLE 2018-19 **w.e.f. 17/12/18**

III B.Tech II Sem **SECTION-A**

TIME/ DAY	9.00- 10.00	10.00- 11.00	11.00- 12.00	12.00- 1.00		01.45- 02.45	02.45- 03.45
MON	HT	FEM	AECS			DMM-II	MEFA
TUE	RAC	HT	OE		LUNCH BREAK	HTLAB	
WED	MEFA	RAC	OE			FEM	DMM-II
THU	DMM-II	FEM	RAC	QMLR		MEFA	HT
FRI	QMLR	MEFA	DMM-II	FEM		HT	RAC

SL.NO	SUBJECT		FACULTY
1	FINITE ELEMENT METHODS		Mr.M.Naveen Kumar
2	HEAT TRANSFER		Mr.Ravi chirra
3	REFRIGERATION AND AIR CONDITIONING		Mr.K.Srinivas Rao
4	DESIGN OF MACHINE MEMBER-II		Dr.N.Ravinder Reddy
5	MEFA		Mrs. Srujana
6	QMLR		Mr.Vijay kumar
7	HEAT TRASNFER LAB	Mr.Ravichirra/ Mr.Ashok chary	Mr.K.SrinivasRao/ Dr.B.Ramesh Babu
8	AECS LAB		Mr.Surendar

H.O.D

4. PROGRAM OUTCOMES(PO'S) & PROGRAM SPECIFIC OUTCOMES(PSO'S)

PROGRAM OUTCOMES

Engineering Graduates will be able to:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

After completion of the Program (B.Tech), graduates will be able to:

PSO1. Analyze and solve problems of thermal and manufacturing in the comprehensive design of mechanical engineering components.

PSO2. An ability to design, develop and implement mechanical engineering solutions keeping in view the sustainability and environmental issues with social responsibility.

5. COURSE OBJECTIVES & COURSE OUTCOMES (CO'S)

Course Objectives:

The objective of the course is to:

1	Understand the fundamentals of Refrigeration and working of air refrigeration cycles
2	Understand the Working principles and analysis of VCR, VAR, Steam jet refrigeration systems and non conventional methods of producing cooling effect.
3	Understand the various psychometric properties and processes commonly used in the field of Air conditioning
4	Estimate cooling load calculations and understand the working principles of different air conditioning systems

Course Outcomes:

At the end of the course, the students should be able to:

CO1 Unit1	Understand the basic concepts of refrigeration and thermodynamically analyze air refrigeration systems.
CO2 Unit2	Appreciate the working principle and thermodynamically analyze vapor compression refrigeration system.
CO3 Unit3	Classify basic components of vapor compression refrigeration system according to different criteria and understand their working. Identify the different refrigerants used in the field of refrigeration and air conditioning, and understand their desirable properties and nomenclature.
CO4 Unit4	Understand the working principles and thermodynamically analyze vapor absorption refrigeration system, steam jet refrigeration system and different non conventional methods of producing cooling effect.
CO5 Unit5	Estimate the air conditioning load for comfort and industrial applications by applying the principles of psychrometry. Appreciate the working of different air conditioning systems, their components, heat pump and different heat pump circuits.

6. MAPPING OF CO'S WITH PO'S & PSO'S

		PO 1	P O2	PO 3	PO4	PO 5	P O 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
Refrigeration and Air Conditioning/ A16330	**CO1**	3	3	3	3	-	3	3	2	-	3	-	3	-	3
	CO2	3	3	3	3	-	2	-	2	-	-	-	2	-	3
	CO3	3	3	3	3	-	3	-	-	-	-	-	2	-	2
	CO4	3	3	3	3	-	3	3	2	-	3	-	1	-	2
	CO5	3	3	3	3	-	3	3	2	-		-	2	-	2
	Avg	**3**	**3**	**3**	**3**	-	**2.8**	**3**	**2**	-	**3**	-	**2**	-	**2.4**

Note: Low-1, Medium-2, High-3

7. ACADEMIC CALENDAR

II SEMESTER

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B.Tech II & III Year Revised Academic Calendar for the Academic Year 2020-21

SECOND SEMESTER		Commencement of Class Work 30.03.2021	
I Spell of Instructions	30.03.2021	12.06.2021	11 WEEKS
I Mid Examinations	14.06.2021	22.06.2021	8 DAYS
II Spell of Instructions	23.06.2021	14.08.2021	8 WEEKS
II Mid Examinations	16.08.2021	19.08.2021	4 DAYS
Practical Examinations	20.08.2021	24.08.2021	4 DAYS
Betterment Examinations	25.08.2021	28.08.2021	4 DAYS
End Semester Examinations	30.08.2021	18.09.2021	3 WEEKS
Commencement of class work for B. Tech., III & IV Year I Semester will be from 20.09.2021			

II SEMESTER

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II/III/IV B.Tech I & II Semester Academic Calendar for the Academic Year 2019-20

II/III/IV YEAR I SEMESTER		Commencement of Class Work 17.06.2019	
	From	To	Duration
I Spell of Instruction	17.06.2019	10.08.2019	8 WEEKS
I Mid Examinations	13.08.2019	17.08.2019	4 DAYS
II Spell of Instruction	19.08.2019	05.10.2019	7 WEEKS
Dussehra Holidays	07.10.2019	12.10.2019	1 WEEK
II Spell of Instruction Continuation	14.10.2019	19.10.2019	1 WEEK
II Mid Examinations	21.10.2019	24.10.2019	4 DAYS
Practical Examinations	25.10.2019	29.10.2019	4 DAYS
Betterment Examinations	30.10.2019	01.11.2019	3 DAYS
End Semester Examinations	02.11.2019	18.11.2019	2 WEEKS
Supplementary Examinations	19.11.2019	04.12.2019	2 WEEKS
II/III/IV YEAR II SEMESTER		**Commencement of Class Work 02.12.2019**	
I Spell of Instruction	02.12.2019	10.01.2020	6 WEEKS
Pongal Holidays	11.01.2020	15.01.2020	5 DAYS
Technical/Sports fest	16.01.2020	18.01.2020	3 DAYS
I Spell of Instruction Continuation	20.01.2020	01.02.2020	2 WEEKS
I Mid Examinations	03.02.2020	08.02.2020	1 WEEK
II Spell of Instruction	10.02.2020	04.04.2020	8 WEEKS
II Mid Examinations	06.04.2020	09.04.2020	4 DAYS
Practical Examinations	13.04.2020	17.04.2020	4 DAYS
Betterment Examinations	18.04.2020	22.04.2020	4 DAYS
End Semester Examinations	23.04.2020	08.05.2020	2 WEEKS
Supplementary Examinations	11.05.2020	23.05.2020	2 WEEKS
Commencement of classes will be from			

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II SEMESTER

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II/III/IV B.Tech I & II Semester Academic Calendar for the Academic Year 2018-2019

II/III/IV YEAR I SEMESTER		Commencement of Class Work 02.07.2018	
	From	To	Duration
I Spell of Instruction	02-07-2018	28-08-2018	8 Weeks
I Mid Examinations	29-08-2018	01-09-2018	4 Days
II Spell of Instruction	03-09-2018	12-10-2018	6 Weeks
Dussehra Holidays	13-10-2018	21-10-2018	9 Days
II Spell of Instruction Continuation	22-10-2018	03-11-2018	2 Weeks
II Mid Examinations	05-11-2018	10-11-2018	4 Days
Preparation & Practical Examinations	12-11-2018	21-11-2018	1 Week
End Semester Examinations	22-11-2018	10-12-2018	2 Weeks
Supplementary/ Semester Break	11.12.2018	16.12.2018	1 Week
II/III/IV YEAR II SEMESTER		**Commencement of Class Work 17.12.2018**	
I Spell of Instruction	17.12.2018	12.02.2019	8 Weeks
I Mid Examinations	13.02.2019	16.02.2019	4 Days
II Spell of Instruction	18.02.2019	13.04.2019	8 Weeks
II Mid Examinations	15.04.2019	18.04.2019	4 Days
Preparation & Practical Examinations	20.04.2019	27.04.2019	1 Week
End Semester Examinations	29.04.2019	15.05.2019	2 Weeks
Supplementary/ Summer Vacation	16.05.2019	30.06.2019	6 Weeks
Commencement of classes will be from 01.07.2019			

DIRECTOR

8. TEACHING SCHEDULE

UNIT	TOPICS	Total No. of Hours
I	**INTRODUCTION TO REFRIGERATION:** Necessity and applications – Unit of refrigeration and C.O.P. – Mechanical Refrigeration – Types of Ideal cycle of refrigeration. **AIR REFRIGERATION:** Bell Coleman cycle and Brayton Cycle, Open and Dense air systems – Actual air refrigeration system – Refrigeration needs of Air crafts- Air systems – Actual Air refrigeration system – Refrigeration needs of Air crafts – Application of Air Refrigeration, Justification – Types of systems – Problems.	13
II	**VAPOUR COMPRESSION REFRIGERATION**: Working principle and essential components of the plant – Simple Vapour compression refrigeration cycle – COP – Representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – Actual cycle Influence of various parameters on system performance – Use of p-h charts – Problems.	8
III	**SYSTEM COMPONENTS:** Compressors – General classification – comparison – Advantages and Disadvantages. Condensers – classification – Working Principles Evaporators – classification – Working Principles Expansion devices – Types – Working Principles Refrigerants – Desirable properties – common refrigerants used – Nomenclature – Ozone Depletion – Global Warming – Azeotropes and Zeotropes	16
IV	**VAPOR ABSORPTION SYSTEM:** Calculation of max COP – description and working of NH3 – water system – Li – Br system. Principle of operation Three Fluid absorption system, salient features. **STEAM JET REFRIGERATION SYSTEM:** Working Principle and Basic Components, Principle and operation of (i) Thermoelectric refrigerator (ii) Vortex tube or Hilsch tube.	8
V	**INTRODUCTION TO AIR CONDITIONING:** Psychometric Properties & Processes – Sensible and latent heat loads – Characterization – Need for Ventilation, Consideration of Infiltration – Load concepts of RSHF, ASHF, ESHF and ADP. **CONCEPT OF HUMAN COMFORT AND EFFECTIVE TEMPERATURE:** Comfort Air conditioning – Industrial air conditioning and Requirements – Air conditioning Load Calculations. **AIR CONDITIONING SYSTEMS**: Classification of equipment, cooling, heating humidification and dehumidification, filters, grills and registers, deodorants, fans and blowers. Heat Pump – Heat sources – different heat pump circuits – Applications.	20
	TOTAL HOURS	65

COURSE PRE-REQUISITES: Thermodynamics, Applied Thermodynamics -II

9. ASSIGNMENT QUESTIONS

ASSIGNMENT **A.Y: 2020-21**

Q.No	Question	Bloom's Taxonomy Level	Course Outcomes
1	A dense air refrigeration cycle operates between pressures of 4 bar and 16 bar. The air temperature after heat rejection to the surroundings is 37°C. The isentropic efficiencies of turbine and compressor are 0.85 and 0.8 respectively. Determine compressor and turbine work per TR; C.O.P; and power per TR.	L3	CO 1 Unit1
2	A regenerative air cooling system for an aeroplane is designed to take a load of 30TR. The atmospheric temperature and pressure conditions are 5°C and 0.85 bar. The pressure of air is increased from 0.85 bar to 1.2 bar due to ramming action. The pressure of air leaving the main compressor is 4.8 bar. 60% of the total heat of air leaving the main compressor is removed in the heat exchanger and then it is passed through the cooling turbine. The temperature of rammed air which is used for cooling purposes in the heat exchanger is reduced by 50°C by mixing the air coming out from the cooling turbine, and in the process, the cooling air from the turbine gets heated to 100°C before it is discharged. The isentropic efficiencies of the compressor and turbine are 90% and 80% respectively. The pressure and temperature required in the cabin are 1 bar and 25°C respectively. Assuming isentropic ramming and mass of cooled air passing through the heat exchanger equal to the mass of cooling air, find: 1. The ratio of by-passed air to ram air used for cooling purposes; and 2. Power required for maintaining the cabin at required condition.	L3	CO 1 Unit 1
3	In a vapour compression refrigeration system using R-12, the evaporator pressure is 1.4 bar and condenser pressure is 8 bar. The refrigerant leaves the condenser sub cooled to	L3	CO 2 Unit2

ASSIGNMENT II **A.Y: 2020-21**

Q.No	Question	Bloom's Taxonomy Level	Course Outcomes
1	Explain the working principle of thermostatic expansion valve with a neat sketch.	L3	CO 3 Unit3
2	Obtain an expression for maximum C.O.P. of an ideal vapour absorption refrigeration system.	L4	CO 4 Unit4
3	Explain the working operation of vortex tube. Also discuss its applications.	L2	CO 4 Unit4
4	A small office hall of 25 persons seating capacity is provided with summer air conditioning with the following data: Outside conditions: 34°C DBT and 28°C WBT Inside conditions: 24°C and 50% RH Volume of air supplied: 0.4 m^3/min/person Sensible heat load in the room: 125600 kJ/h Latent heat load in the room: 42000 kJ/h. Find the sensible heat factor of the plant.	L3	CO 5 Unit5
5	An air conditioned auditorium is to be maintained at 27°C DBT and 60% RH. The ambient condition is 40°C DBT and 30°C WBT. The total sensible heat load is 100000 kJ/h and the total latent heat load is 40000 kJ/h. 60% of the return air is recirculated and mixed with 40% of makeup air after the cooling coil. The condition of air leaving the cooling coil is 18°C. Determine i. RSHF ii. Condition of air entering the auditorium iii. Amount of makeup air iv. ADP v. BPF of the cooling coil. Sketch the processes on psychrometric chart.	L3	CO 5 Unit5

10. MID QUESTION PAPERS I & II

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III Year B.Tech II Semester I Mid Examination

Branch: ME	Duration: 90Min
Sub: Refr eration and Air Conditioning	Marks: 20
Date:	Session:

Course Outc nes:

1. Distinguish ious types of refrigeration systems.
2. Apply the p ciples of thermodynamics to refrigeration systems.
3. Thermodyn mically analyze refrigeration and air conditioning systems.
4. Evaluate p formance parameters while designing the refrigeration and air conditioning systems.

Bloom's Level:

Remember	I
Understand	II
Apply	III
Analyze	IV
Evaluate	V
Create	VI

PART-A (3Q×2M =6Marks) ANSWER ALL THE QUESTIONS		Course Outcomes CO	Course Outcomes PO	Bloom Le	Marks
1.i)	1. Explain the difference between refrigerator and a heat pump.	1	1,2,3,4,6, 7,8,10	II	2
	[OR]				
ii)	Mention the advantages of air being used as refrigerant in aircraft cooling systems.	1	1,2,3,4,6, 7,8,10	II	2
2.i)	Define refrigerant. Classify refrigerants.	2	1,2,3,4,6, 7,8	II	2
	[OR]				
ii)	What is the effect of suction and discharge pressure on the performance of simple VCR system?	2	1,2,3,4,6, 7,8	III	2
3.i)	State the fundamental differences between VCR and VAR system.	3	1,2,3,4,6, 7,8,10	II	2
	[OR]				
ii)	State the working principle of VAR system.	3	1,2,3,4,6, 7,8,10	I	2

PART-B (5+5+4= 14 Marks) ANSWER ALL THE QUESTIONS		Course Outcomes CO	Course Outcomes PO	Bloom Le	Marks
4.i.	A dense air refrigeration cycle operates between pressures of 4 bar and 16 bar. The air temperature after heat rejection to the surroundings is 37°C and air temperature at the exit of refrigerator is 7°C. The isentropic efficiencies of turbine and compressor are 0.85 and 0.8 respectively. Determine compressor and turbine work per TR; C.O.P; and power per TR.	1	1,2,3,4,6, 7,8,10	IV	5
	[OR]				
ii.	Describe regenerative air cooling system with a neat sketch.	1	1,2,3,4,6, 7,8,10	III	5

5. i.	Describe the working of evaporative condenser with a neat sketch. Mention its advantages, disadvantages and applications.	2	1,2,3,4,6, 7,8	III	5
	[OR]				
ii.	Explain the working of flooded evaporator with a neat sketch.	2	1,2,3,4,6, 7,8	III	5
6.i.	Obtain the expression for maximum C.O.P of an ideal VAR system.	3	1,2,3,4,6, 7,8,10	III	4
	[OR]				
ii.	Explain practical VAR system with a neat sketch.	3	1,2,3,4,6, 7,8,10	III	4

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(Accredited by NAAC & NBA, Approved By A.I.C.T.E., New Delhi, Permanently Affiliated to JNTU, Hyderabad) (Aziz Nagar, C.B.Post, Hyderabad -500075)

III Year B.Tech II Semester II MidExamination

Branch: ME	Duration: 90Min
Sub:Refrigeration and Air Conditioning	Marks: 20
Date:	Session:

Course Outcomes:

1. Distinguish various types of refrigeration systems.
2. Apply the principles of thermodynamics to refrigeration systems.
3. Thermodynamically analyze refrigeration and air conditioning systems.
4. Evaluate the performance parameters while designing the refrigeration and air conditioning systems.

Bloom'sLevel:

Remember	I
Understand	II
Apply	II I
Analyze	I V
Evaluate	V
Create	V I

PART-A (3Q×2M=6Marks)		Outcomes		Bloom's Level	Marks
ANSWERALLTHEQUESTIONS		CO	PO		
1.i)	State the working principle of Steam jet Refrigeration System.	CO3	1,2,4,5,6,7,9,10	I	2
[OR]					
ii)	Discuss the applications of Steam jet Refrigeration System.	CO3	1,3,5,7,8,9,10,11	II	2
2.i)	Write a short note on Bypass factor of the coil.	CO4	1,2,4,5,6,7,9,10,11	II	2
[OR]					
ii)	Write a short note on Mixing of Air-streams.	CO4	1,3,5,7,8,9,10.11	III	2
3.i)	Define sensible heat ratio.	CO5	1,2,4,5,67,8,9,10	I	2
[OR]					
ii)	What is the purpose of ventilation?	CO5	1,2,4,5,6,7,9,10	II	2

PART-B(4+5+5=14Marks)		Outcomes		Bloom'sLevel	Marks
ANSWERALLTHEQUESTIONS		CO	PO		
4.a)	Explain the working of Steam jet Refrigeration system	CO3	1,2,3,4,5,6,7,8,9,10	III	4

	with a neat sketch.				
	[OR]				
b)	Discuss the advantages and disadvantages of Steam jet Refrigeration System.	CO3	1,3,5,7,8,9,10.11	III	4
5.i)	Discuss the factors affecting thermal comfort. Mention the indices for thermal comfort.	CO4	1,2,4,5,6,7,9,10	II	5
	[OR]				
ii.	A class room of 60 seating capacity is air conditioned. The outdoor conditions are 32°C DBT and 22°C WBT and required comfort conditions are 22°C and 55% R.H. The quantity of outdoor air supplied is 0.5m^3/min/student. The comfort conditions are achieved first by chemical dehumidification and then cooling by cooling coil. Find a. DBT of air leaving the dehumidifier b. Capacity of the dehumidifier c. Capacity of cooling coil in TR. d. If the bypass factor of the cooling coil is 0.3, find the surface temperature of the cooling coil.	CO4	1,3,5,6,8,9,10,11	III	5
6.i) a)	Describe the working of winter air conditioning system with the help of schematic	CO5	1,2,3,4,5,67,8,9,10	III	5
	[OR]				
ii) a)	Describe the working of All Year air conditioning system with the help of schematic.	CO5	1,2,3,4,5,67,8,9,10	III	5

11. RUBRICS FOR MID-EVALUATION

Criteria of Evaluation	Poor (1)	Satisfactory (2)	Good (3)	Very Good (4)	Excellent (5)
Interpretation	Answer reflects that the question was not understood at all	Answer reflects that the question was somewhat understood	Answer reflects that the Question was understood to a reasonable	Answer reflects that the Question was understood to an	Answer reflects that the Question was completely understood
Presentation	No proper presentation	Presentation was marginal with issues in legibility and grammar	Presentation was clear but with grammatical errors	Presentation was explicitly good and clear with minor grammatical	Presentation was excellent and clear with no grammatical errors
Solution	Solution has more errors	Solution has moderate amount of errors	Solution was complete but with minor errors	Solution was complete but with no clear mention of entire procedure	Solution was accurate/ complete with clear mention of the entire

12. LECTURE NOTES

REFRIGERATION AND AIR CONDITIONING

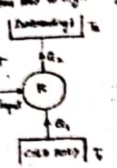
Introduction to refrigeration:

Definition: Refrigeration is the science of providing and maintaining temperature below that of surrounding (ambient) temperature.

Continuous extraction or removal of heat from a body.

Removal of heat from a body which is already kept at lower temperature than its surroundings is possible only with the aid of external agency according to "2nd law of T.D".

Heat cannot be completely converted from low to high temp without any external agent.



The machine 'R' (refrigerator) extracts heat "Q_1" from a cold body at temperature "T_1" with the help of work input.

Here $T_2 > T_1$ & $Q_2 = Q_1 + W$

ie $W = Q_2 - Q_1$

Unit of refrigeration:

The practical unit of refrigeration is expressed in terms of "Tonne of refrigeration".

A Tonne of refrigeration is defined as the amount of refrigeration effect (heat removal) produced for melting of one tonne (1000 kg) of ice from and at 0°C in 24 hours.

Basic units:
1) Work – Joules
2) Energy – Joules
3) Heat – Joules
4) Pressure – N/m^2 or bar
5) Power – Watt or J/sec

Latent heat of ice is 335 KJ/kg (change in phase without change in temp (L.H)).

Heat = mass × latent heat

∴ 1 TR = 1000 × 335 KJ in 24 hours – KJ/day

$= \frac{1000 \times 335}{24 \times 60} = 232.6$ KJ/min

In actual practice, one tonne of refg is equivalent to 210 KJ/min

or $\frac{210}{60}$ KJ/sec = 3.5 KW

∴ 1 TR = 210 KJ/min
= 3.5 KJ/sec
= 3.5 KW

Coefficient of Performance of refrigerator: (C.O.P)

The efficiency of a refrigerator is determined by C.O.P.

It is defined as the ratio of heat extracted (refrigerating effect) to the work done on the refrigerant.

Theoretical C.O.P = $\frac{\text{Refg. effect}}{\text{work done}}$ = $\frac{\text{heat extracted}}{\text{amount of work done}}$

→ $C.O.P = \frac{Q}{W}$

Relative C.O.P = $\frac{\text{actual C.O.P}}{\text{theoretical C.O.P}}$

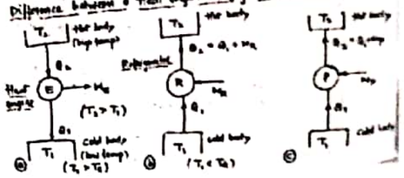
In engines, we consider efficiency, and in refrigerators we consider (C.O.P).

Ex: Find the C.O.P of a refrigeration system if the work input is 80 KJ/kg and refrigeration effect produced is 160 KJ/kg of refrigerant flowing.

$W = 80$ KJ/kg $Q = 160$ KJ/kg

$\therefore C.O.P = \frac{Q}{W} = \frac{160}{80} = 2$

Difference between a Heat engine, refrigerator and heat pump:



Heat engine: The heat supplied (Q_2) to the engine is converted into useful work (W_E), and the rest is heat rejected (Q_1) (losses).

$Q_2 = W_E + Q_1$

→ $W_E = Q_2 - Q_1$

∴ The performance of heat engine is expressed by its efficiency.

We know efficiency in engine

η_E or efficiency = $\frac{O/P}{I/P}$ = $\frac{\text{work done}}{\text{heat supplied}}$

→ $\eta_E = \frac{W_E}{Q_2} = \frac{Q_2 - Q_1}{Q_2}$

$\eta_E = 1 - \frac{Q_1}{Q_2}$

Refrigerator: W_R is required on the system.

$W_R = Q_2 - Q_1$

Here C.O.P is expressed as the ratio of amount of heat taken from a cold body (Q_1) to the amount of work required to be done on the system (W_R).

$(C.O.P)_R = \frac{Q_1}{W}$ (refg. effect / work done)

$(C.O.P)_R = \frac{Q_1}{Q_2 - Q_1}$

Heat pump: ratio of the amount of heat delivered to the hot body (Q_2) to the amount of work required to be done on the system (W_P). $W_P = Q_2 - Q_1$

$(C.O.P)_P = \frac{Q_2}{W}$ $\frac{\text{(heating effect)}}{\text{(work input)}}$ = $\frac{Q_2}{Q_2 - Q_1}$

Note: $(C.O.P)_{HP} = (C.O.P)_R + 1$

Proof: $(C.O.P)_{HP} = \frac{Q_1}{Q_2 - Q_1} + 1$

$= \frac{Q_1 + Q_2 - Q_1}{Q_2 - Q_1}$

$(C.O.P)_{HP} = \frac{Q_2}{Q_2 - Q_1}$

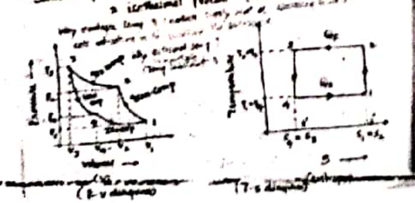
Applications of refrigeration:

Industrial purpose: (10TR – 1000TR)
1) Restaurants
2) Hotels
3) Chemical industry
4) Food industry.

Domestic: (1TR – 5TR)
(i) Living rooms
(ii) Halls
(iii) Residential purposes
(iv) Computer functioning (1TR – 3TR)

Air refrigerator working on Reversed Carnot cycle: (ideal) (Reversed Carnot cycle is used for comparing the real cycles with ideal cycles)

- Consists of all reversible cycles (reversible process)
- efficiency η = 100%
- Consists of 2 isentropic process ($PV^\gamma = C$)
  2 isothermal process ($PV = C$)



1) **Isentropic Compression process:** (1–2) (no heat added or removed)
The air is compressed isentropically from 1 → 2 in P-V & T-S. During this process, the pressure of air increases from P_1 to P_2. Sp. volume decreases from V_1 to V_2 and temperature increases from T_1 to T_2. (P↑, V↓, T↑, S = C, $Q_A = 0$, $Q_R = 0$)

2) **Isothermal compression process:** (T = C) (2–3)
Here air is now compressed isothermally (T = C) i.e ($T_2 = T_3$). During this process, the pressure of air increases from P_2 to P_3 and sp. vol decreases from V_2 to V_3, and here heat is rejected at high temperature (P↑, V↓, T = C, S↓)

∴ Heat rejected during the process

Q_R = area 2-3-3'-2'

$= T_2(S_2 - S_3)$

→ $Q_R = q_{2-3} = T_2(S_2 - S_3)$

$ds = \frac{dQ}{T}$

3) **Isentropic expansion process:** ($Q_R = 0$, $Q_A = 0$) (3–4)
The air is now expanded isentropically on curve 3–4. The pressure of air decreases from P_3 to P_4, sp. volume increases from V_3 to V_4 and temp decreases from T_3 to T_4.
(P↓, V↑, T↓, S = C, $Q_A = 0$, $Q_R = 0$)

4) **Isothermal expansion process:** (4–1) (T = C)
Now the air is expanded isothermally ($T_4 = T_1$). The pressure of air decreases from P_4 to P_1, sp vol increases from V_4 to V_1. Thus heat is absorbed (extracted) by the air during the process.

Heat absorbed q_{4-1}

Q_A = area 4-1-2'-3'

$= T_4(S_1 - S_4) = T_1(S_2 - S_3)$

$Q_A = T_1(S_2 - S_3)$

∴ work done during the cycle per kg of air

W.D = heat rejected – heat absorbed

$= Q_R - Q_A$

$= T_2(S_2 - S_3) - T_1(S_2 - S_3)$

$W.D = (T_2 - T_1)(S_2 - S_3)$

∴ (C.O.P) of refrigeration system working on Reversed Carnot cycle

C.O.P = $\frac{\text{heat absorbed (refg. effect)}}{\text{work done}}$

$= \frac{Q_A}{W.D}$

$= \frac{T_1(S_2 - S_3)}{(T_2 - T_1)(S_2 - S_3)}$

$(C.O.P)_R = \frac{T_1}{T_2 - T_1}$ ($T_2 > T_1$)

∴ $(C.O.P)_P = (C.O.P)_R + 1$

$= \frac{T_1}{T_2 - T_1} + 1$

$= \frac{T_1 + T_2 - T_1}{T_2 - T_1}$

$(C.O.P)_P = \frac{T_2}{T_2 - T_1}$

$(C.O.P)_E = \frac{1}{(C.O.P)_P}$

Note: for carnot cycle

$(COP)_R = \frac{Q_1}{Q_2 - Q_1} = \frac{T_1}{T_2 - T_1}$

$(COP)_{HP} = \frac{Q_2}{Q_2 - Q_1} = \frac{T_2}{T_2 - T_1}$

$\eta_E = \frac{T_2 - T_1}{T_2} = \frac{Q_2 - Q_1}{Q_2}$

$\because R = C_p - C_v$

$= C_v\left[\frac{C_p}{C_v} - 1\right] \quad \left[\frac{C_p}{C_v} = \gamma\right]$

$\rightarrow R = C_v(\gamma - 1)$

$\rightarrow$ $C.O.P = \dfrac{C_p(T_1 - T_4)}{\frac{n}{n-1} \times C_v(\gamma-1)\left[(T_2 - T_1) - (T_3 - T_4)\right]}$

$= \dfrac{\gamma(T_1 - T_4)}{\frac{n}{n-1}(\gamma-1)\left[(T_2 - T_1) - (T_3 - T_4)\right]}$

$$\boxed{C.O.P = \frac{T_1 - T_4}{\frac{n}{n-1} \times \frac{(\gamma-1)}{\gamma}\left[(T_2 - T_3) - (T_1 - T_4)\right]}}$$

If $n = \gamma$

$$\boxed{C.O.P = \frac{T_1 - T_4}{(T_2 - T_3) - (T_1 - T_4)}}$$ Same as (x) previous

obtain T_2 and T_4 from the following relations

$$\left[\frac{T_2}{T_1}\right] = \left[\frac{P_2}{P_1}\right]^{\frac{n-1}{n}} \quad \& \quad \left[\frac{T_3}{T_4}\right] = \left[\frac{P_3}{P_4}\right]^{\frac{n-1}{n}}$$

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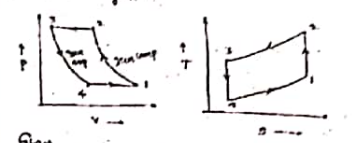
Problems:

1) In a refrigeration plant working at Bell Coleman cycle, air is compressed to 5 bar from 1 bar. its initial temperature is 10°c. after compression, the air is cooled upto 20°c in a cooler before expanding back to a pressure of 1 bar. determine the C.O.P of the plant and net refrigeration effect. $C_p = 1.005$ KJ/kg-K, $C_v = 0.718$ KJ/kg-K ?



Given $P_2 = 5$ bar $= P_3$

$P_1 = 1$ bar $= P_4$

$T_1 = 10°c = 283K$ (Initial temp)

$T_3 = 20°c$ (before expansion) $= 293K$

$T_2 = ?$

$\gamma = \frac{C_p}{C_v} = \frac{1.005}{0.718}$, $\boxed{\gamma = 1.4}$

$$\boxed{C.O.P = \frac{T_4}{T_3 - T_4}}$$

$\because \frac{T_3}{T_4} = \left[\frac{P_3}{P_4}\right]^{\frac{\gamma-1}{\gamma}}$

$\frac{293}{T_4} = \left[\frac{P_2}{P_1}\right]^{\frac{1.4-1}{1.4}}$

$\rightarrow \frac{293}{T_4} = \left(\frac{5}{1}\right)^{\frac{0.4}{1.4}} \rightarrow \boxed{T_4 = 185K}$

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$\therefore C.O.P = \frac{T_4}{T_3 - T_4} = \frac{185}{293 - 185} = 1.713$

Refrigeration effect : (process 4-1)

$Q_A = C_p(T_1 - T_4)$

$= 1.005(283 - 185)$

$Q_A = 98.5$ KJ/kg = Ref. effect

2) A refrigerator working on Bell-Coleman cycle operates between pressure limits of 1.05 bar and 8.5 bar. air is drawn from the cold chamber at 10°c. compressed and then it is cooled to 30°c before entering the expansion cylinder. the expansion and compression follows the law $PV^{1.3} = C$. determine the theoretical C.O.P of the system ?

$P_1 = 1.05$ bar $= P_4$

$P_2 = 8.5$ bar $= P_3$

$T_1 = 10°c = 283K$

$T_3 = 30°c = 303K$

$n = 1.3$

$\frac{T_2}{T_1} = \left[\frac{P_2}{P_1}\right]^{\frac{n-1}{n}}$

$\frac{T_2}{T_1} = \left[\frac{8.5}{1.05}\right]^{\frac{1.3-1}{1.3}}$

$\rightarrow T_2 = 283 \times 1.62$

$\boxed{T_2 = 458.5K}$

also $\frac{T_3}{T_4} = \left[\frac{P_3}{P_4}\right]^{\frac{n-1}{n}}$ (Same diagrams to be drawn)

$\frac{303}{T_4} = \left[\frac{8.5}{1.05}\right]^{\frac{1.3-1}{1.3}}$

$\rightarrow \boxed{T_4 = 187K}$

$\therefore C.O.P = \dfrac{T_1 - T_4}{\frac{n}{n-1} \cdot \frac{\gamma-1}{\gamma}\left[(T_2 - T_3) - (T_1 - T_4)\right]}$

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$= \dfrac{283 - 187}{\frac{1.3}{1.3-1} \times \frac{1.4-1}{1.4}\left[(458.5 - 303) - (283 - 187)\right]}$

$\therefore \boxed{C.O.P = 1.3}$ (See note into problem in the beginning on notes) (Eric Cycle)

Air refrigeration Systems :

→ Air is used as a refrigerant (easily available, non-toxic)

→ Bell Coleman cycle works on ARS

→ aircraft uses ARS (Low C.O.P)

Classification :

1) Simple air refrigeration System. (air cooling & evaporative)

2) Boot strap ARS (air cooling)

3) Regenerative ARS

4) Reduced ambient ARS

5) Boot strap air evaporative cooling System

Need of ARS :

• Air craft travels at 950 km/hr. so air comes in contact with the body of air craft and friction is developed and ramming takes place

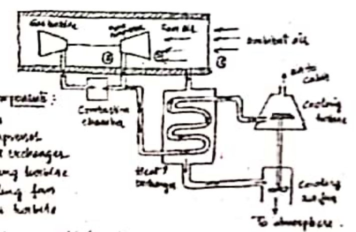
• Human body also develops heat (releases 400J)

• machinery also releases large amount of heat.

① Simple air cooling System : (for aircraft)

the main components of this system are. 1) main compressor driven by a gas turbine 2) heat exchanger. 3) cooling turbine and 4) a cooling air fan.

The air required for refrigeration system is bled of from the main compressor. This high pressure and high temp air is cooled initially in the heat exchanger where ram air is used for cooling. It is further cooled in the cooling turbine by the process of expansion. The work of this turbine is to drive the cooling fan which draws cooling air through the heat exchanger and used for low speed flight.



Main Components :

1) Ram

2) Compressor

3) Heat exchanger

4) Cooling turbine

5) Cooling fan

6) Gas turbine

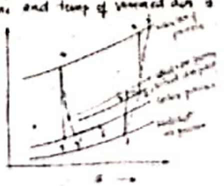
Ramming process : (1-2)

without any work done on/by the system the pressure energy of air is increased and here kinetic energy is converted to pressure energy.

the ambient air is rammed isentropically from P_1, T_1 to P_2 & T_2. the ideal ramming is shown by vertical line 1-2 but in actual practice because of internal friction, the temp of rammed air is more than T_2. Thus the actual ramming process is shown by curve 1-2' which is adiabatic not isentropic due to friction. the pressure and temp of rammed air is now P_2' and T_2' resp.

Ram efficiency :

$\eta_R = \dfrac{\text{Actual rise in pressure}}{\text{Isentropic rise in pressure}}$



$\frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^{\frac{\gamma}{\gamma-1}}$

(formula used)

also $T_2 = T_1 + \frac{V^2}{2000\,C_p}$

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2) Compression process : (2'-3)

The isentropic compression of air in the main compressor is represented by the line 2'-3. In actual practice, because of internal friction due to irreversibilities the actual compression is represented by curve 2'-3'.

The work done during the compression is

$\boxed{W_C = m_a C_p(T_3' - T_2')}$ m_a = mass of air bled from the main compressor

3) Cooling process : (3'-4)

the compressed air is cooled by the ram air in the heat exchanger. this process is shown by the curve 3'-4. In actual practice, because there is a pressure drop in the heat exchanger which is not shown in diagram.

The temp of air decreases from T_3' to T_4

the heat rejected in the heat exchanger during the cooling process is $Q_R = m_a C_p(T_3' - T_4)$

4) Expansion process : (4-5')

the cooled air is now expanded isentropically in the cooling turbine shown by 4-5. In actual practice because of internal friction due to irreversibilities the actual expansion in the cooling turbine is shown by 4-5'.

the work done by the cooling turbine during the expansion process is $W_T = m_a C_p(T_4 - T_5')$

5) Refrigeration process : (5'-6')

the air from the cooling turbine (after expansion) is sent to the cabin where it is heated by the heat of equipment and occupancy.

the refrigeration effect produced or heat absorbed is given by $\boxed{R_E = Q_A = m_a C_p(T_6 - T_5')}$

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2) Process 2'-3 represents isentropic compression of air in the main compressor and 2'-3' represents the actual compression of air due to internal friction due to irreversibilities.

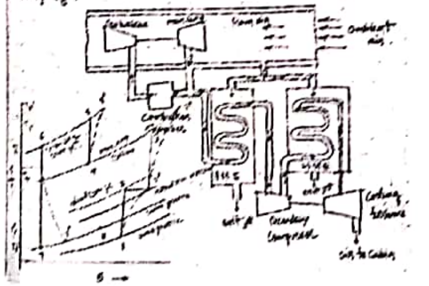
3) Process 3'-4 represents the cooling by ram air in the first heat exchanger. The pressure drop in HE is neglected.

4) Process 4-5 represents isentropic compression of cooled air in secondary compressor. The process 4-5' represents the actual compression process.

5) Process 5'-6 represents the cooling by ram air in second heat exchanger. Pressure drop is neglected.

6) Process 6-7 represents isentropic expansion of cooled air in the cooling turbine upto the cabin pressure. The process 6-7' represents actual expansion of the cooled air in the cooling turbine.

7) Process 7'-8 represents the heating of air upto the cabin temp T_8.



Process 4-5:

$$\frac{T_5}{T_4} = \left(\frac{P_5}{P_4}\right)^{\frac{\gamma-1}{\gamma}} \rightarrow T_5 = 360.85 \left(\frac{4}{3}\right)^{\frac{1.4-1}{1.4}}$$

$\rightarrow \boxed{T_5 = 391.5K}$

$$\eta_{c_2} = \frac{T_5 - T_4}{T_5' - T_4} \rightarrow 0.8 = \frac{391.5 - 360.85}{T_5' - 360.85}$$

$\rightarrow \boxed{T_5' = 399.16K} = 126.16°C$

30% of enthalpy is discharged in 2nd HE

$\rightarrow T_6 = 0.7 \times 126.16$

$= 88.3°C$

$\rightarrow \boxed{T_6 = 361.3K}$

Process 6-7:

$$\frac{T_7}{T_6} = \left(\frac{P_7}{P_6}\right)^{\frac{\gamma-1}{\gamma}}$$

$\rightarrow T_7 = 361.3 \left(\frac{0.9}{4}\right)^{\frac{1.4-1}{1.4}} \rightarrow \boxed{T_7 = 236K}$

Turbine efficiency (expansion)

$$\eta_T = \frac{\text{actual increase in temp}}{\text{Isentropic increase in temp}} = \frac{T_6 - T_7'}{T_6 - T_7}$$

$$\rightarrow 0.8 = \frac{361.3 - T_7'}{361.3 - 236}$$

$\rightarrow \boxed{T_7' = 254.8K} = -18.2°C$

If Q tonnes of refrigeration is the cooling load of the cabin, then the quantity of air required for the refrigeration system

$$m_a = \frac{210Q}{C_p(T_8 - T_7')} \text{ kg/min}$$

Power required for the refrigeration system

$$P = \frac{m_a C_p (T_5' - T_3')}{60} \text{ kW}$$

C.O.P of refrigeration system

$$C.O.P = \frac{210Q}{m_a C_p (T_5' - T_3')} = \frac{210Q}{P \times 60}$$

Problems:

1. A boot-strap cooling system of 10TR capacity is used in an aeroplane. The ambient air temp and pressure are 20°C and 0.85 bar resp. The pressure of air increases from 0.85 bar to 1 bar due to ramming action of air. The pressure of air discharged from the main compressor is 3 bar. The discharge pressure of air from the auxiliary compressor is 4 bar. The isentropic efficiency of each of the compressors is 80% while that of turbine is 85%. 50% of the enthalpy of air discharged from the main compressor is removed in the first heat exchanger and 30% of the enthalpy of air discharged from the auxiliary compressor is removed in the secondary heat exchanger using rammed air. Assuming ramming action to be isentropic, the required cabin pressure is 0.9 bar and temp of air leaving to cabin not more than 20°C. Find 1) power required to operate the system 2) C.O.P of the system. Take $\gamma = 1.4$, $C_p = 1.005$ kJ/kg-K.

Power required to operate the system

$$m_a = \frac{210Q}{C_p(T_8 - T_7')} = \frac{210 \times 10}{1(293 - 254.8)}$$

$\rightarrow \boxed{m_a = 55 \text{ kg/min}}$

$$\therefore P = \frac{m_a C_p (T_5' - T_3')}{60} = \frac{55 \times 1 (448.7 - 366.8)}{60}$$

$\boxed{\therefore P = 130KW}$

$$C.O.P = \frac{210Q}{m_a C_p (T_5' - T_3')} = \frac{210 \times 10}{55 \times 1 \times (448.7 - 366.8)}$$

$\rightarrow \boxed{C.O.P = 0.27}$

Given

Q = 10TR

$T_1 = 20°C = 293K$

$P_1 = 0.85$ bar

$P_2 = 1$ bar

$P_3 = P_3' = P_4 = 3$ bar

$P_5 = P_5' = P_6 = 4$ bar

$\eta_{c_1} = \eta_{c_2} = 80\% = 0.8$

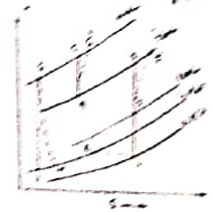
$\eta_T = 85\% = 0.85$

$P_7 = P_7' = P_8 = 0.9$ bar

$T_8 = 20°C = 293K$

$\gamma = 1.4$

$C_p = 1.005$ kJ/kg-K



Process 1-2:

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} \rightarrow T_2 = (293)\left(\frac{1}{0.85}\right)^{\frac{1.4-1}{1.4}} \rightarrow \boxed{T_2 = 306.8K}$$

Process 2-3:

$$\frac{T_3}{T_2} = \left(\frac{P_3}{P_2}\right)^{\frac{\gamma-1}{\gamma}} \rightarrow T_3 = (306.8)\left(\frac{3}{1}\right)^{\frac{1.4-1}{1.4}} \rightarrow \boxed{T_3 = 420.K}$$

$$\eta_{c_1} = \frac{\text{Isentropic increase in Temp}}{\text{Actual increase in Temp}} = \frac{T_3 - T_2}{T_3' - T_2}$$

$$\rightarrow 0.8 = \frac{420 - 306.8}{T_3' - 306.8} \rightarrow \boxed{T_3' = 448.7K}$$

$= 175.7°C$

50% of enthalpy is removed in 1st heat exchanger during 3'-4 process

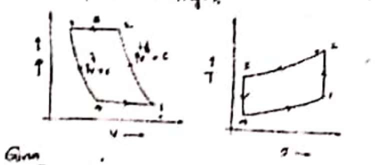
$\therefore T_4 = 0.5 \times 175.7 = 87.85°C$

$\rightarrow \boxed{T_4 = 360.85K}$

2. A refrigerating machine of 6 tonnes capacity working on Bell-Coleman cycle has an upper limit of pressure 5.2 bar. The pressure and temperature at the start of compression are 1 bar and 16°C respectively. The compressed air is cooled at constant pressure to a temperature of 41°C, enters the expansion cylinder. Assuming both expansion and compression processes to be isentropic with $\gamma = 1.4$.

Calculate 1) C.O.P 2) Quantity of air circulated per min 3) piston displacement of compressor and expander 4) Bore of compressor and expansion cylinder. The unit runs at 240 rpm and is double acting. Stroke length is 200 mm. 5) power required to drive the unit.

Take $C_p = 1.003$ kJ/kg-K.



Given

Q = 6TR

$= 6 \times 210$ kJ/min

Q = 1260 kJ/min

$P_2 = P_3 = 5.2$ bar

$P_1 = P_4 = 1$ bar

$T_1 = 16°C = 289K$

$T_3 = 41°C = 314K$

$\gamma = 1.4$

$C_p = 1.003$ kJ/kg-K

1) $C.O.P = \frac{T_4}{T_1 - T_4}$ — Try consider small formulas of C.O.P ? m' (Unit-1) (... not given ...) — You can also use any formulas.

$\because \frac{T_1}{T_4} = \left[\frac{P_1}{P_4}\right]^{\frac{\gamma-1}{\gamma}}$

$\rightarrow \frac{T_1}{T_4} = \left[\frac{5.2}{1}\right]^{\frac{1.4-1}{1.4}}$

$\rightarrow \frac{310}{T_4} = (5.2)^{\frac{0.4}{1.4}}$

$\rightarrow \boxed{T_4 = 196.25\ K}$

$\therefore C.O.P = \frac{196.25}{314 - 196.25}$

$\rightarrow \boxed{C.O.P = 1.674}$

2) Quantity of air in circulation per minute:

let m_a = mass of air in circulation in kg per minute

$\therefore m_a = \frac{\text{refrigeration capacity of the machine}}{\text{refrigeration effect produced (heat extracted)}}$

Ref capacity $= 6TR = 6 \times 210$
$= 1260\ KJ/min$

Ref effect $= C_p(T_1 - T_4) = 1.007(289 - 196.25)$
$= 93\ KJ/kg$

$\therefore m_a = \frac{1260}{93} = 13.548\ kg/min$

3) Piston (vol) displacement of compressor and expander:

V_1 & V_4 are piston displacement per min of compressor & expander. $R = 287\ J/kg\text{-}K$

We know for process 4-1, (constant pressure process)

(2) $\frac{V_4}{T_4} = \frac{V_1}{T_1}$ (P=C)

(1) $P_1V_1 = mRT_1$

$V_1 = \frac{(13.548)(287)(289)}{1 \times 10^5}$

$\boxed{V_1 = 11.273\ m^3/min}$

$\Rightarrow V_4 = \frac{11.273 \times 196.25}{289}$

$\rightarrow \boxed{V_4 = 7.65\ m^3/min}$

9

4) Size of compressor and expansion cylinder:

N.D = Bore of compressor
d = Bore of expansion cylinder
N = 240 rpm
L = 200 mm = 0.2 m.

for double acting

Piston displacement of compressor

$V_1 = \left[\frac{\pi}{4} D^2 \times L\right] \times 2 \times N$ (double acting)

$\rightarrow 11.273 = \frac{\pi}{4} D^2 \times 0.2 \times 2 \times 240$

$\Rightarrow D = 0.386\ m$

$\Rightarrow \boxed{D = 386\ mm}$

//ly expansion

$V_4 = \frac{\pi}{4} d^2 \times L \times 2 \times N$

$7.65 = \frac{\pi}{4} \times d^2 \times 0.2 \times 2 \times 240$

$\rightarrow d = 0.318\ m$

$\boxed{d = 318\ mm}$

5) Power required to drive the unit:

Power required = W.D/min $\left[\because C.O.P = \frac{Q_a}{W.D}\right]$

$W.D/min = \frac{\text{Heat absorbed}}{C.O.P}$

$= \frac{m_a C_p (T_1 - T_4)}{1.674}$

$= \frac{13.54 \times 1.003(289 - 196.25)}{1.674}$

$\Rightarrow$ Power $= 752.7\ KJ/min$

Refrigerants: 19

The refrigerant is a heat carrying medium in the refrigeration system absorbs heat from a low temperature system and discards the heat so absorbed to a high temperature system.

classification:

1) Primary 2) secondary refrigerants

1) Primary refrigerant:

The refrigerants which directly take part in the refrigeration system are called primary
- a) Halo-carbon (organic)
- b) Azeotrope refrigerant.
- c) Inorganic ref
- d) Hydro-carbon ref

2) Secondary refrigerant:

The refrigerants which are first cooled by primary refrigerants and then used for cooling purpose are known as secondary refrigerant. (ie as ex:-) (brine sol?)

desirable properties of an ideal refrigerant:

Thermodynamic properties:
1) Low boiling point
2) low freezing point
3) High sat. temp
4) High latent heat of vap

chemical properties:
1) non-toxicity
2) non-flamable
3) non-explosive
4) non-corrosive.

other properties:
1) Ease of handling
2) High c.o.p
3) Availability & low cost
4) low power consumption per TR.

Alternative refrigerants to reduce ozone depletion and global warming:
1) Ammonia
2) Air
3) Carbon dioxide
4) sulphur dioxide
5) water.

designation system for refrigerants: (R) symbol.

the general chemical formula for the refrigerant, either for methane or ethane base is $C_mH_nCl_pF_q$ in which $n+p+q = 2m+2$

m → no. of carbon atoms
n → no of Hydrogen atoms
p → no. of chlorine atoms
q → no. of fluorine atoms.

the no. of refrigerant is given by $R(m-1)(n+1)(q)$

ex: 1) dichloro - difluoro - methane (CCl_2F_2)

Here $p = 2$
$q = 2$
$n = 0$

(one C_1 – methane, C_2 – ethane)

$\because n+p+q = 2m+2$
$0+2+2 = 2m+2$.
$\rightarrow m = 1$.
$\rightarrow$ no. of carbon atoms = 1.

$\therefore R(1-1)(0+1)(2)$

$= R_{012} = R12\ (CCl_2F_2)$

2) dichloro - tetrafluoro - ethane ($C_2Cl_2F_4$).

$p = 2$
$q = 4$
$n = 0$

$n+p+q = 2m+2$
$0+2+4 = 2m+2$
$\rightarrow m = 2$ (no. of carbon atoms)

$\therefore R_{(2-1)(0+1)(4)} = R\text{-}114\ (C_2Cl_2F_4)$

Green house effect: 10.

Rise in earth's temperature or drastic change in earth's temperature

The green house effect increases the temperature of earth by trapping heat in our atmosphere. This keeps the temp of the earth higher than it would be if direct heating by the Sun. The green house effect is caused by the interaction of the sun's energy with green house gases such as CO_2, nitrous oxide, fluorinated gases. The ability of these gases to trap heat is what causes the green house effect.

Gases like carbon dioxide are causing global warming. CO_2 is produced when petrol is burned in car engine, or when coal and gas are burned at power stations to make electricity. CO_2 causes global warming.

Global warming is referred as climate change.

Increase of air temperature near the earth surface is called global warming.

Ozone depletion: (Ozone layer or ozone shield)

Ozone depletion is a region of earth's stratosphere that absorbs most of the sun's UV radiation.

due to liberation of chlorine & fluorine gases (CFC). The acidic structure of these gases makes holes on the ozone shield, now the UV rays directly falls on the earth surface which causes ozone depletion.

Unit-5 (Theory)

Air-conditioning systems

Types of air-conditioning systems:

1) Acc to the purpose
- a) Comfort air conditioning system (homes, office, hospitals etc)
- b) Industrial " " " (lab's, mills, Textiles, plants etc)

2) Acc to season of the year
- a) winter a/c system
- b) Summer a/c system
- c) year-round a/c system

3) Acc to the arrangement of equipments
- a) unitary a/c system
- b) central a/c system.

Winter A/c System: In this system air is heated by humidification process.

The outside air flows through a damper and mixes up with the recirculated air (obtained from the conditioned space). The mixed air passes through a filter to remove dirt, dust and other impurities. The air now passes through a preheat coil in order to prevent the possible freezing of water and to control the evaporation of water in humidifier.

After that, the air is made to pass through a reheat coil to bring the air to the design D.B.T.

Now the air is supplied to the conditioned space by a fan. From the conditioned space, a part of used air is exhausted to the atmosphere by the exhaust fan and the remaining air is recirculated.

13. PPT'S MATERIAL

Evaporators

geration & Air Conditioning)

Evaporator

Definition :

➢The evaporator is a heat transfer system, and is that part of a refrigeration cycle in which liquid refrigerant is evaporated for the purpose of removing heat from the refrigerated space or product.

➢Responsible for ...g heat into the refrigeration system
➢The evaporator ...tained at a temperature that is lower than the medium being co...
➢The capacity ... evaporator or cooling coil is the rate at which heat will pass through the ...orator walls from the refrigerated space to the vaporizing liquid
➢Removes both ...t and sensible heat from the air in the refrigerated bo...
➢Latent heat is in the form of moisture
➢Sensible heat reduces air and product temperature.

Types Of Evaporators

Based on their construction the various types of evaporators are:

1. Bare Tube Evaporators :

a)The bare tube evaporators are made up of copper tubing or steel pipes

b)The copper tubing is used for small evaporators where the refrigerant other than ammonia is used

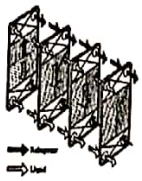
c)the steel pipes are used with the large evaporators where ammonia is used as the refrigerant.

d)the atmospheric air flows over the bare tube evaporator and the chilled air leaving it used for the cooling purposes..

e)The bare tube evaporators are usually used for liquid chilling

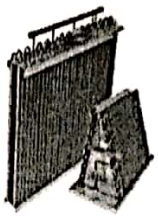
2) Plate Type of Evaporators

a) the coil usually made up of copper or aluminum is embedded in the plate so as so to form a flat looking surface.
b) the plate type of evaporator looks like a single plate, but inside it there are several turns of the metal tubing through which the refrigerant flows.
c) advantage of the plate type of evaporators is that they are more rigid as the external plate provides lots of safety.
d) This type of evaporator is widely used in domestic refrigeration.
e) The plates can also be welded together forming the bank of the plate type of evaporators that can be used the larger evaporators of higher capacities.



3) Finned Evaporators

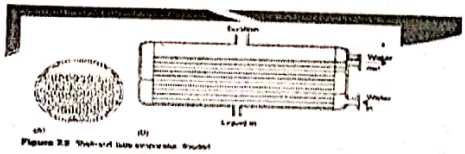
a) Are the bare tube type of evaporators covered with the fins
b) he fluid tends to move between the open spaces of the tubing and does not come in contact with the surface of the coil, thus the bare tube evaporators are less effective,
c) the finned evaporators are more effective than the bare tube evaporators.
d) are most commonly used in the air conditioners of almost all types like window, split, packaged and the central air conditioning systems.

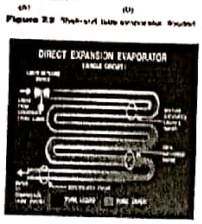


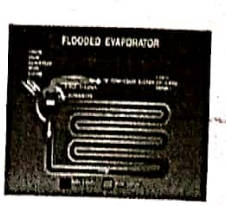
4) Shell and Tube types of Evaporators

a) Are used in the large refrigeration and central air conditioning systems.
b) comprise of large number of the tubes that are inserted inside the drum or the shell.
c) Depending on the direction of the flow of the refrigerant in the shell and tube type of evaporator, they are classified into two types: dry expansion type and flooded type of evaporator.

1. **Dry expansion evaporator**: In dry expansion evaporators the refrigerant flows along the tube side and the fluid to be chilled flows along the shell side.
2. **Flooded evaporator :** In case of the flooded type of evaporators the refrigerant flows along the shell side and fluid to be chilled flows along the tube.







14. END SEMESTER EXAMINATION QUESTION PAPERS

	lya Jyothi Institute of Technology (Autonomous) (Accredited by NAAC & NBA, Approved By A.I.C.T.E., New Delhi, Permanently Affiliated to JNTU, Hyderabad) (Aziz Nagar, C.B.Post, Hyderabad -500075) **Subject Code: A16329**	**R15**

B.Tech. III [illegible] II Semester Regular/Supply Examinations, OCTOBER/NOVEMBER-2020

SUBJECT : REFRIGERATION & AIR CONDITIONING BRANCH : ME

Time: 3 Hours **Max. Marks:75**

Note: This question paper contains EIGHT questions and answer any FIVE questions. Each question carries 15 marks.

Bloom's Level:

Remember	L1
Understand	L2
Apply	L3
Analyze	L4
Evaluate	L5
Create	L6

	ANSWER ANY FIVE QUESTIONS 5QX15M = 75M	Bloom's Level	Marks
1	Derive the expression for C.O.P. of an Air Refrigerator working on Bell-Coleman cycle.	L3	15M
2	A regenerative air cooling system is used for an aeroplane to take 20TR load. The ambient air at 0.8 bar pressure and 10°C temperature is rammed isentropically till the pressure rises to 1.2 bar. The air bled off the main compressor at 4.5 bar is cooled by the ram air in the heat exchanger whose effectiveness is 60%. The air from the heat exchanger is further cooled to 60°C in regenerative heat exchanger with a portion of air bled after expansion in the cooling turbine. The cabin is to be maintained at 25°C temperature and 1 bar pressure. If the isentropic efficiencies of compressor and turbine are 90% and 80% respectively. Find 1) Mass of air bled from cooling turbine for regenerative cooling. 2) Power required for maintaining the cabin at the required condition. 3) C.O.P of the system. Assume temperature of air leaving to the atmosphere from the regenerative heat exchanger as 100°C.	L4	15M
3	In a Vapour Compression Refrigeration system using R-12, the evaporator pressure is 1.4 bar and condenser pressure is 8 bar. The refrigerant leaves the condenser sub cooled to 30°C. The vapour leaving the evaporator is dry and saturated. The compression process is isentropic. The amount of heat rejected in the condenser is 13.42 MJ/min. Determine i) Refrigerating effect in kJ/kg ii) Refrigeration load in TR iii) Compressor input in kW iv) COP of the refrigerator using P-h chart.	L4	15M
4	Explain the working of simple vapour compression refrigeration system with a neat schematic diagram.	L2	15M
5	Explain the working of sealed compressor. Mention its advantages, disadvantages and applications.	L2	15M
6	Obtain the expression for volumetric efficiency of reciprocating compressor. Explain the factors affecting the volumetric efficiency of a reciprocating compressor?	L3	15M
7	Derive the expression for maximum C.O.P of an ideal Vapour Absorption Refrigeration system.	L3	15M
8	Explain the use of heat pump for heating and cooling cycle with a neat diagram.	L3	15M

VJIT(A)

Vidya Jyothi Institute of Technology (Autonomous)

(Accredited by NAAC & NBA, Approved By A.I.C.T.E., New Delhi, Permanently Affiliated to JNTU, Hyderabad)

(Aziz Nagar, C.B.Post, Hyderabad -500075) **Subject code: A16329**

III B. Tech II SEM REGULAR EXAMINATION - MAY 2018
REFRIGERATION AND AIR CONDITIONING
(FOR MECH)

Time: 3hrs **Max.Marks:75**

Note: This question paper contains two PARTS A and B.
PART A is compulsory which carries 25 marks. Answer all the questions.
PART B consists of 5 questions. Answer all the questions.

PART-A

ANSWER ALL THE QUESTIONS **25M**

1. Define Tonne of refrigeration and express its value in kJ/min 2M
2. What is the necessity of air craft refrigeration 3M
3. What are the effects of discharge pressure in a vapour compression refrigeration system. 2M
4. The C.O.P of vapour compression refrigeration system with super heating is very low, but still the super heated refrigerant is allowed into compressor. State the reasons. 3M
5. What is hermetically sealed compressor ? 2M
6. Define refrigerant and write classification of various refrigerants. 3M
7. How water vapor is removed in vapor absorption refrigeration system? 2M
8. What is Peltier effect? 3M
9. Explain the term By-pass factor 2M
10. List various industrial applications of air conditioning system. 3M

PART B

ANSWER ALL THE QUESTIONS **5X10M=50M**

11 (i) The atmospheric air at pressure 1 bar and temperature -5 °C is drawn in the cylinder of a Bell-Coleman refrigerating machine. It is compressed isentropically to a pressure of 5 bar. In the cooler the compressed air is cooled to 15 °C, the pressure remaining the same. It is then expanded to a pressure of 1 bar in an expansion cylinder, from where it is passed to the cold chamber. Find (1) work done per kg of air and (2) C.O.P of the plant. For air assume low for expansion $pv^{1.2}$ = constant law for compression $pv^{1.4}$ = constant. 10M

OR

(ii) (a) Explain with a neat sketch a Bootstrap cycle of air refrigeration system 5M
(b) Differentiate between open and closed air refrigeration systems. 5M

12 (i) (a) Explain the working principle of vapor compression refrigeration system with the help of neat sketch and obtain the expression for C.O.P. 5M
(b) Establish how an actual cycle differs from a theoretical vapour compression cycle. 5M
(ii) A refrigerator works between -7°C and 27°C. The vapor is dry at the end of adiabatic compression. There is under cooling and the evaporation is by throttle valve. Determine a) C.O.P (b) Power of the compressor to remove 180kJ/min. The properties of refrigerant are as follows 10M

Temp °C	Enthalpy		Entropy	
	Liquid(kJ/kg)	Latent(kJ/kg)	Liquid(kJ/kg K)	Vapor(kJ/kg K)
-7	-30	1298	-0.108	4.75
27	115	1173	4.27	4.33

P.T.O

15. SAMPLE COPIES OF ASSIGNMENTS

* Refrigeration & Air Conditioning Assignment - I

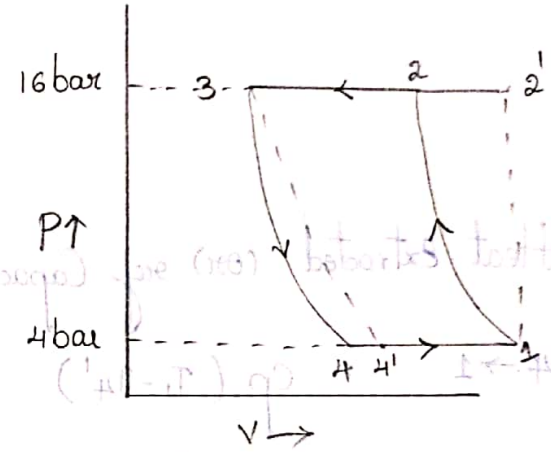
P. GIRIJA
15911A03E3

1) A dense air refrigeration cycle operates between pressure 4bar and 16bar. Air temp of heat rej to surrounding is 37°C & air temp at exit of refrigerator is 7°C. Isentropic η of turbine & compressor are 0.85 & 0.8 resp. Det compressor & turbine work per tonne of refrigeration, COP & power per ton of refrigeration?

Sol:- Given :-

$T_3 = 37°C$; $T_1 = 7°C$

$T_3 = 310K$, $T_1 = 280K$



$P_1 = P_4 = 4 bar$; $P_2 = P_3 = 16 bar$

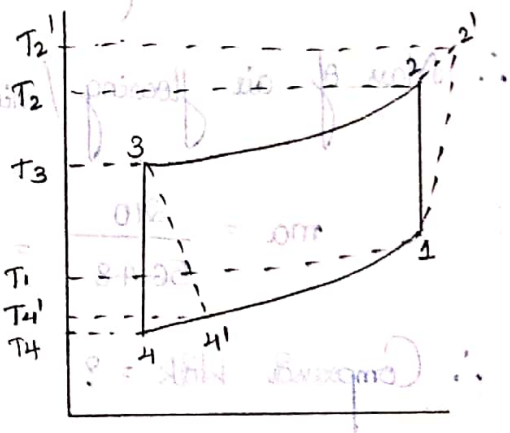
$\eta_C = 0.85$; $\eta_T = 0.80$

For process 1 → 2

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\frac{T_2}{280} = \left(\frac{16}{4}\right)^{\frac{1.4-1}{1.4}}$$

$T_2 = 411.6K$



$$\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{\frac{1.4-1}{1.4}} = T_4 = 208.6K$$

$\eta_C = 0.85$

Isentropic η of compressor = $\frac{\text{Isentropic Rise}}{\text{Actual Rise}}$

$$\eta_C = \frac{T_2 - T_1}{T_2' - T_1} = 0.8 = \frac{414.16 - 280}{T_2' - 280}$$

$$T_2' = 450K$$

$$\eta \text{ of turbine} = \frac{\text{Actual Work}}{\text{Isentropic work}} = \frac{T_3 - T_4'}{T_3 - T_4}$$

$$0.85 \rightarrow \frac{310 - T_4'}{310 - 208.6}$$

$$T_4' = 223.81$$

Heat extracted (or) ref Capacity :-

$$4 \rightarrow 1 = C_p (T_1 - T_4')$$

$$= 1.005 (280 - 223.81) = 56.48$$

∴ Mass of air flowing /min/ Tonne of ref is :- $m_a = \frac{210}{\text{Heat Extracted}}$

$$m_a = \frac{210}{56.48} = 3.72 \text{ kg/min}$$

∴ Compressor Wdk = ?

process (1-2') Steady flow device

$$W_c = m_a C_p (T_2' - T_1)$$

$$= 3.72 \times 1.005 (450 - 280)$$

$$W_c = 635.6 \text{ kJ/min}$$

W_T = ?

WT/Ton of ref ⇒ $m_a c_p (T_3 - T_4)$

⇒ $3.72 \times 1.005 (310 - 208.6)$

⇒ $W_T = 322.3$ KJ/min

Network ⇒ $W_C - W_T$

$= 635.6 - 322.3$

⇒ 313.3 KJ/min

$$COP = \frac{210}{313.3} = 0.67$$

(2) Power Req/ton = ?

$$P = \frac{W_{net}}{60} = \frac{313.3}{60} = 5.22 \text{ watts}$$

---

(2) * Actual Vapour Compression Refrigeration Cycle :-

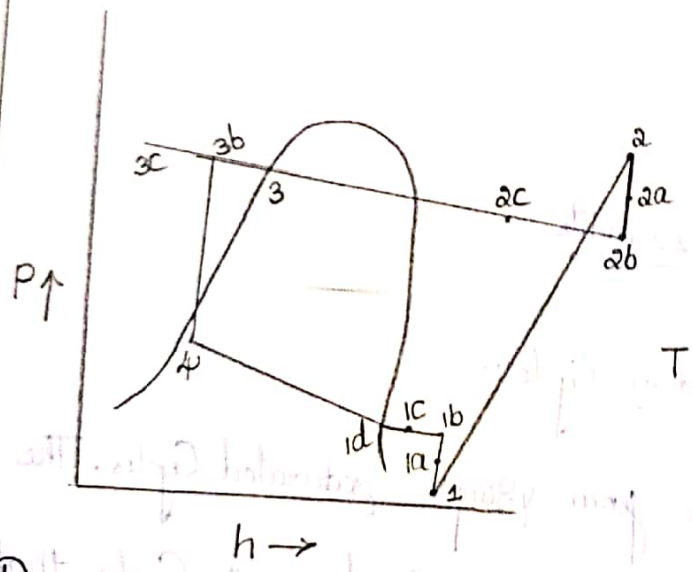
Actual Cycles deviates some what from Simple saturated Cycles. The Reason is certain assumptions are made for Simple sat Cycles that don't hold to for actual Cycles.

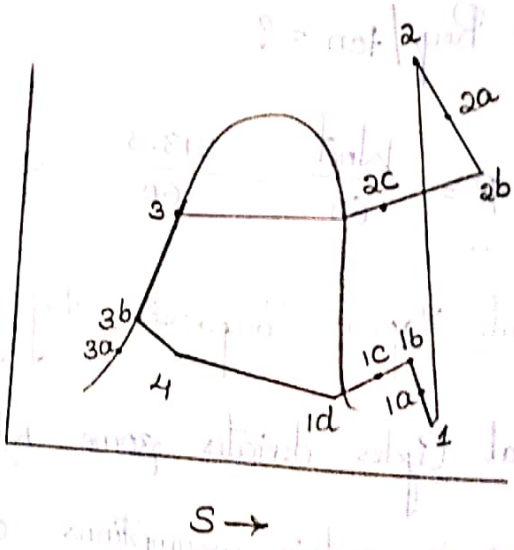
Ex :- The drop in pressure in pipelines, Evaporater, Condensex resulting from the flow of refrigerant through these parts are Neglected. For that. Superheating of Suction Vap & subcooling of Liq refrigerant are

nit considered. Also, Compression in the Compressor is assumed Isentropic Compression.

The following are main deviations between theoretical & Actual Cy

1) The Vapour refrigerant Leaves the Evaporator in Superheated state.
2) Compression of refrigerant is n't Isentropic due to frictional effi
3) Also, their is pr drop across the Suction & discharge walls of Compr
4) The Liquid ref Leaves the condenser in Sub-cooled state.
5) Their are pr drops in Evaporator, Condenser, as well as in all the Connecting pipelines.





Processes :-

4 - 1d ⇒ pressure drop in Evaporator

1d - 1c ⇒ Superheat of Vapour in Evaporator

c - 1b ⇒ Superheated Vap in Suction Line (or) useless Superheat.

x-1a ⇒ pr drop in suction valve (or) Line.

1a-1 ⇒ pr drop across suction Valve of Compressor

1-2 ⇒ Actual Compression is n't Isentropic may (or) can be polytropic process.

2-2a ⇒ pr drop across delivery valve of Compressor.

2a-2b ⇒ pr drop across in discharge line.

2b-2c ⇒ desuperheating of vap compression in discharge line.

2b-3 ⇒ Condenser pr drop

3-3a ⇒ Sub-cooling of Liquid refrigerant in Condenser (ref effect ↑)

3a-3b ⇒ change in temperature (Heat gain in Liq Line)

3b-4 ⇒ Expansion process by throttling (or) Isenthalpic Expansion & pr drop in Expansion wall.

---

3) Write a short Note on a) Sealed b) Evaporative Condensers

a) Sealed ~~Condenser~~ Compressors :-

Sealed Condensers is also called as Hermetic Sealed Condensers.

→ When the compressor & motor operate on same shaft and are enclosed in a common casing, they are known as Sealed Condensers.

→ These type of compressors eliminate the use of crankshaft seal which is necessary in ordinary compressions in order to prevent

evaporated coil. The feeler bulb is partly filled with the

the Leakage of Refrigerant.

These compressors may operate on either reciprocating or principle may be mounted with shaft in either vertical (or) Horizontal position.

→ The welded shell has connection for refrigerant inlet & Outlet for power o/p socket.

→ In open type compressor, compressors & motors reject surroundings. But in hermetic cold suction gas is flow over before entering the Compressor.

→ The cooling rate depends on flow rate of refrigerant.

Advantages :-

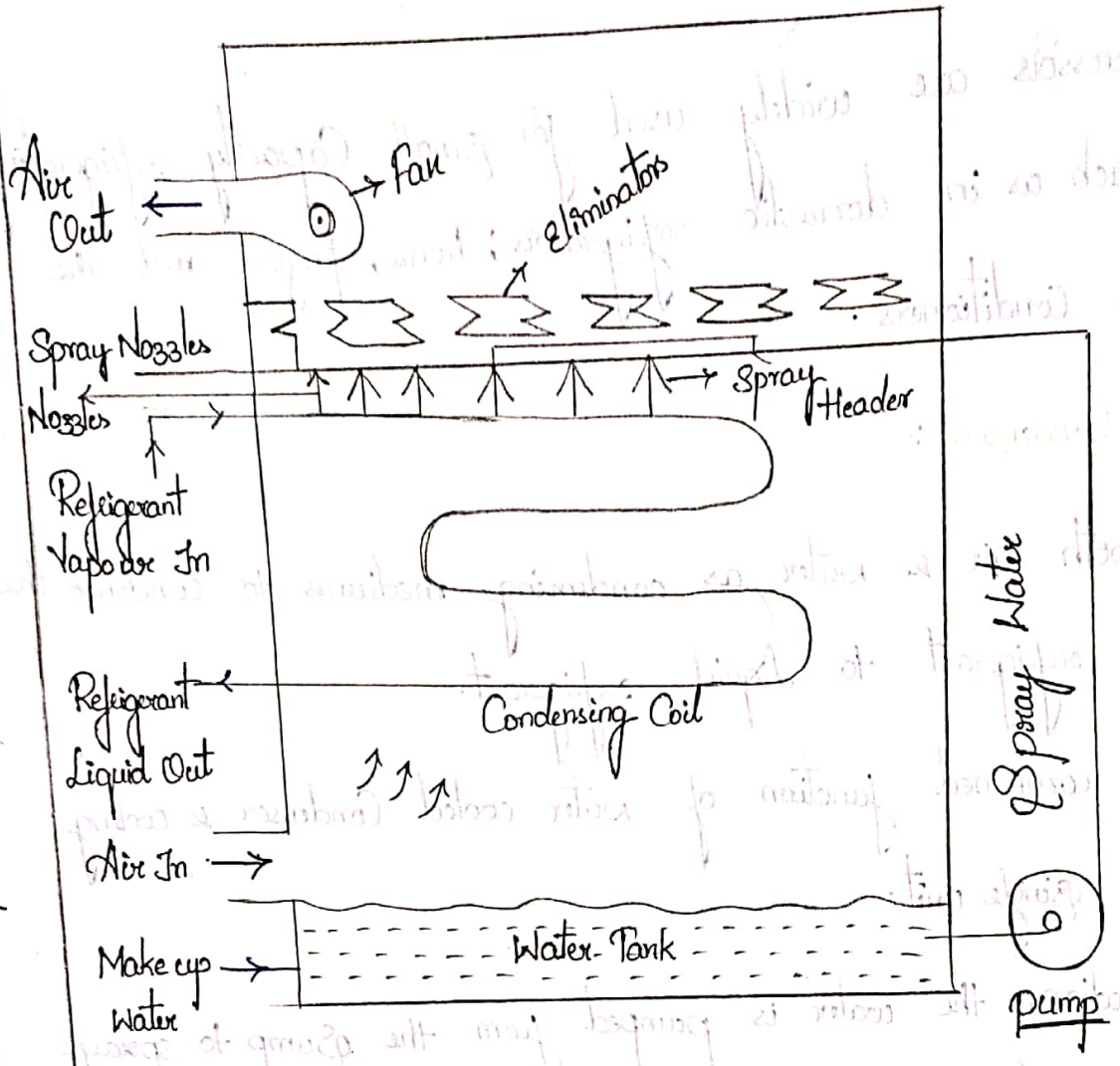
1) Leakage is eliminated.
2) Occupies Less Space.
3) Makes Less Noise.

Limitations :-

1) The Maintainance is n't easy because the moving parts are Inaccessible.
2) A Seperate pump is required for evacuation & charging of the refrigerant.
3) They are n't Servicable.
4) Low COP : A part of cooling effect is Lost in cooling motor & Compressr.

Applications :-

These compr... System...



(b) Evaporative Condensers

→ These Evaporative Condensers are used where water is scarce.

→ Water Consumption is typically very low about 5% of an Equivalent Water cooled Condenser with a Cooling water.

Regenerative air cooling system for an aeroplane is designed to take a load of 30TR. The atmospheric temperature & pr Cond^{n}s are 5°C & 0.85 bar. The pr of air is increased from 0.85 bar to 1.2 bar due to ramming action. The pressure of air leaving the main compressor is removed in heat Exchanger & then it passed through cooling turbine. The temperature of rammed air which is used for cooling purposes in heat exchanger is reduced by 50°C by mixing the air coming out from the cooling turbine, and in process, the cooling air from the turbine gets heated to 100°C before it is discharged. The Isentropic efficiencies of compressor & turbines are 90% & 80% respectively. The pr & temp req in the cabin are 1 bar & 25°C respectively. Assuming Isentropic Ramming & Mass of cooled air passing through Heat Exchanger Equal to mass of cooling air. find: 1) The Ratio of by-passed air to ram air used for cooling purposes. & 2) power req for the maintaining cabin at req condition.

Given:-

$Q = 30TR$

$T_1 = 5°C$; $P_1 = 0.85 bar$

$P_2 = 1.2 bar$; $P_3 = P_3' = P_4 = P_5 = 4.8 bar$

$0.6 h_3 = h_5$; $0.6\ T_3 = T_5$

$T_4 = 50^\circ C = 323 K$; $\eta_C = 90\%$; $\eta_T = 80\%$

$P_6 = P_6' = P_7 = 1 bar$

$T_7 = 25^\circ C = 298 K$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$T_2' = T_2 = 278 \left(\frac{1.2}{0.85}\right)^{\frac{0.4}{1.4}} = 306.78 K$$

$$\frac{T_3}{T_2} = \left(\frac{P_3}{P_2}\right)^{\frac{\gamma-1}{\gamma}}$$

$$T_3 = T_2 \left(\frac{4.8}{1.2}\right)^{\frac{0.4}{1.4}}$$

$$\Rightarrow 306.7 \left(\frac{4.8}{1.2}\right)^{0.4/1.4}$$

$T_3 = 455.87 K$

$T_4 = 50 + 273 = 323 K$

$T_5 = 0.6\ (455.87) = 273.52$

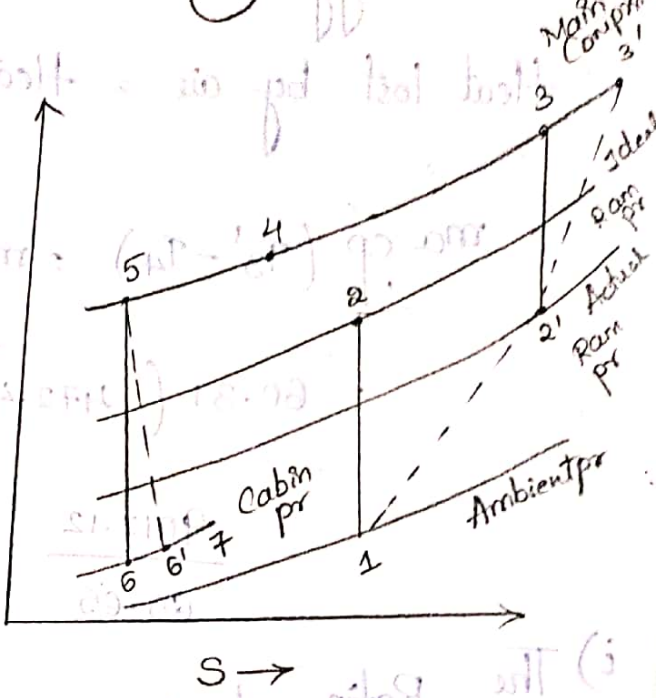
$$\frac{T_5}{T_6} = \left(\frac{P_5}{P_6}\right)^{\frac{\gamma-1}{\gamma}} = \frac{273.52}{T_6} = \left(\frac{4.8}{1}\right)^{0.4/1.4}$$

$T_6 \Rightarrow 174.72 K$

$$\eta_c = \frac{T_3 - T_2}{T_3' - T_2}$$

$$\Rightarrow 0.9 = \frac{455.87 - 306.78}{T_3' - 306.78}$$

$$T_3' = 472.43$$



$$\eta_T = \frac{T_5 - T_6'}{T_5 - T_6}$$

$$0.8 = \frac{583.91 - T_6'}{583.91 - 174.2} \qquad T_6' = 194.06$$

$$T_7 = 298K$$

$$m_a = \frac{210Q}{C_p(T_7 - T_6')} = \frac{210 \times 30}{C_p(298 - 194.06)}$$

$$\Rightarrow 60.31 \text{ kg/min}$$

$$m_2 = \frac{m_1(T_4 - T_5)}{T_8 - T_6'} = m_1 \frac{(323 - 273.52)}{(373 - 194.06)} \qquad m_2 = 0.27 m_1$$

$$m_a = m_1 - m_2 \; ; \; m_a = 0.73 m_1$$

$$m_1 = \frac{60.31}{0.73}$$

$$\boxed{m_1 = 82.14} \qquad \boxed{m_2 = 22.19}$$

16. ASSESSMENT SHEET – CO WISE (DIRECT ATTAINMENT)

R&AC

CO Attainment for 2016-2020 batch

CO	Method	Value	Average	Attainment Level (Internal)	Attainment Level (External)	CO Direct Attainment (25%Int+75%Ext)
CO1	M1_D_Q1	3	2.00	2.33	2.00	2.08
	M1_D_Q4	0				
	M1_A_Q1	3				
	M1_A_Q2	2				
CO2	M1_D_Q2	3	1.75			
	M1_D_Q5	0				
	M1_A_Q3	3				
	M1_A_Q4	1				
CO3	M1_D_Q3	3	2.67			
	M1_D_Q6	3				
	M1_A_Q5	3				
	M2_D_Q1	3				
	M2_D_Q4	1				
	M2_A_Q1	3				
CO4	M2_D_Q2	3	2.50			
	M2_D_Q5	1				
	M2_A_Q2	3				
	M2_A_Q3	3				
CO5	M2_D_Q3	3	2.75			
	M2_D_Q6	3				
	M2_A_Q4	2				
	M2_A_Q5	3				

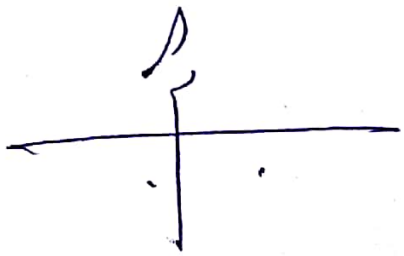
Direct CO Attainment	2.08
Indirect CO Attainment	2.63
Overall CO Attainment (0.8 * Direct Attainment+ 0.2 * Indirect Attainment)	2.19

R&AC

CO Attainment for 2017-2021 batch

CO	Method	Value	Average	Attainment Level (Internal)	Attainment Level (External)	CO Direct Attainment (25%Int+75%Ext)
CO1	M1_D_Q1	3	2.75	2.75	2.00	2.19
	M1_D_Q4	2				
	M1_A_Q1	3				
	M1_A_Q2	3				
CO2	M1_D_Q2	3	2.25			
	M1_D_Q5	2				
	M1_A_Q3	3				
	M1_A_Q4	1				
CO3	M1_D_Q3	3	3.00			
	M1_D_Q6	3				
	M1_A_Q5	3				
	M2_D_Q1	3				
	M2_D_Q4	3				
	M2_A_Q1	3				
CO4	M2_D_Q2	3	3.00			
	M2_D_Q5	3				
	M2_A_Q2	3				
	M2_A_Q3	3				
CO5	M2_D_Q3	3	2.75			
	M2_D_Q6	3				
	M2_A_Q4	2				
	M2_A_Q5	3				

Direct CO Attainment	2.19
Indirect CO Attainment	2.14
Overall CO Attainment (0.8 * Direct Attainment+ 0.2 * Indirect Attainment)	2.18



17. COURSE END SURVEY FORM

COURSE (OUTCOME) END SURVEY FORM (THEORY/ LABORATORY)

Faculty Name:		Designation / Department	
Course Code:		Course Name:	
Student Name (Optional):		Roll No./Reg. No. (Optional):	
Programme:		Semester:	
Academic Year:		Batch:	

[Please tick (√) appropriately]				
CO's	**To what extent do you have learnt and will be able to do the following (which of the CO's of the course)**	**Poor**	**Average**	**Good**
		1	**3**	**5**
CO 1				
CO 2				
CO 3				
CO 4				
CO 5				

Any other feed back / suggestions:

CALCULATION OF INDIRECT ATTAINMENT

Average of indirect CO attainment from course end survey of all the students for RAC =

18. TOPICS COVERED UNDER CONTENT BEYOND SYLLABUS (GAP ANALYSIS)

CONTENT BEYOND SYLLABUS

COURSE: REFRI RATION AND AIRCONDITIONING

TOPIC:INVERTER CHNOLOGY IN AIR CONDITIONERS

An inverter is a de for converting frequency. The technology is used in many home appliances and cont electric voltage, current and frequency. Inverter air-conditioners vary their cooling/heating pacity by adjusting the power supply frequency of their compressors.

An inver er type air- nditioner adjusts the speed of the compressor to control the refrigerant (gas) flo v rate, there consuming less current and power. An inverter has precise temperature control and as the temperature is attained, the unit adjusts its capacity to eliminate any temperature fluctu s.

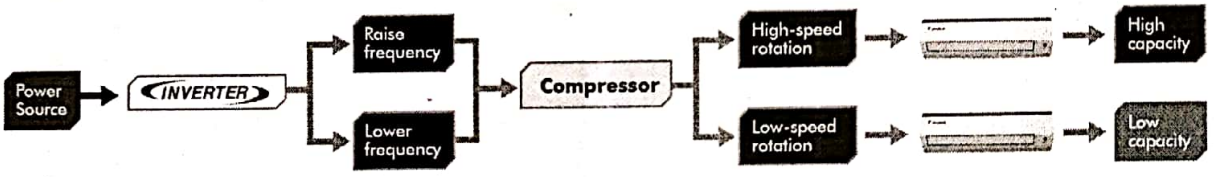
In contrast, non-in er air conditioners have a fixed cooling/ heating capacity and can only control the indoor temperature by starting or stopping their compressors.

Non-inverter air-conditioners stops and starts repeatedly. The power consumption and current goes down when the operation stops, but it goes up sharply at the time of restart and thus it has high average power consumption and temperature variations. As a result, inverter air conditioners are more energy-saving and comfortable than non-inverter air-conditioners.

Let's take an example of 1.5 Ton AC. Inverter AC can work from. 3 to 1.7 ton based on cooling requirement. Non-inverter AC can work at 1.5 ton only (fixed capacity).

Variable capacity operation

Inverter power control



Non-inverter type air-conditioner

Inverter air-conditioners are able to vary their operating capacity. Non-inverter air-conditioners can only operate at a fixed capacity.

19. INNOVATIONS IN TEACHING

The commonly practiced methods are:

1. Interactive Learning
2. Collaborative Learning

(a) Stump your partner

(b) Fishbowl debate

3. Flipped Classroom
4. Project Based Learning
5. Case studies and Problem based Learning
6. ICT

Some other aids like

1. Seminar by students for specific topic
2. Creating Research groups and Clubs
3. NPTEL Lectures and other Video

20. COURSE CLOSURE REPORT

Regulation: R18

Academic Year: 2020 - 2021

Program: B.Tech (Mechanical Engineering)

Year/Sem: III / II

Course Name: Refrigeration and Air conditioning

Course Code: A26324

Contact Hours: 4Lectures/1Tutorial/4Credits

No. of Students:

No. of lecture classes taken	59
No. of tutorial classes taken	10
Course delivery modes	Lectures, Demonstration
Technology utilization	Power Point / OHP Slides
Assessment Tools	Internal Mid Examinations, Assignments, End Exam

OVERALL ATTAINMENT (80% DIRECT + 20% INDIRECT)	
DIRECT	
INDIRECT	
OVERALL ATTAINMENT	

Regulation: R15

Academic Year: 2019 - 2020

Program: B.Tech (Mechanical Engineering)

Year/Sem: III / II

Course Name: Refrigeration and Air conditioning

Course Code: A16329

Contact Hours: 4Lectures/1Tutorial/4Credits

No. of Students: 249

No. of lecture classes taken	**59**
No. of tutorial classes taken	**10**
Course delivery modes	Lectures, Demonstration
Technology utilization	Power Point / OHP Slides
Assessment Tools	Internal Mid Examinations, Assignments, End Exam

OVERALL ATTAINMENT (80% DIRECT + 20% INDIRECT)	
DIRECT	2.19
INDIRECT	2.14
OVERALL ATTAINMENT	2.18

Regulation: R15

Academic Year: 2018 - 2019

Program: B.Tech (Mechanical Engineering)

Year/Sem: III / II

Course Name: Refrigeration and Air conditioning

Course Code: A16329

Contact Hours: 4Lectures/1Tutorial/4Credits

No. of Students: 254

No. of lecture classes taken	**59**
No. of tutorial classes taken	**10**
Course delivery modes	Lectures, Demonstration
Technology utilization	Power Point / OHP Slides
Assessment Tools	Internal Mid Examinations, Assignments, End Exam

OVERALL ATTAINMENT (80% DIRECT + 20% INDIRECT)	
DIRECT	2.08
INDIRECT	2.63
OVERALL ATTAINMENT	2.19