SSM INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, New Delhi / Affiliated to Anna University, Chennai / Accredited by NAAC)

Dindigul – Palani Highway, Dindigul – 624 002

DEPARTMENT OF MECHANICAL ENGINEERING

Value Added Courses Summary 2019-2020

Course Name	Heat Transfer Equipment
Course Duration	45 hours
Year offered	III year Mechanical Students
Course Instructors	Dr.M.Muthukannan & Mr.S.Srinivasan Professor/Mech. Engg, SSMIET Dindigul
Course Outcome	1. Students should be able to communicate heat transfer analyses and solutions through technical reports. 2. Students should be able to troubleshoot and address issues related to heat transfer equipment. 3. Students should be capable of understanding the environmental impact and sustainability aspects of heat transfer equipment.
Course Type	Self Framed
Assessment Mode	
Attendance	45 hours
Number of Participants	41
Scheme of Exam	Evaluation test through online mode

DEPT. OF MECHANICAL ENGG. SSMIET, DINDIGUL

Course Coordinator **HoD/Mech.Engg**

SSM Institute of Engineering and Technology DINDIGUL-624 002

Dr.D.SENTHIL KUMARAN M.E., Ph.D.,(NUS)
Principal
SSM Institute of Engineering and Technology
Kuttathupatti Village, Sindalagundu
Palani Road, Dindigul 624 002

SSM INSTITUTE OF ENGINEERING AND TECHNOLOGY

Dindigul-Palani Highway, Dindigul – 624 002, Tamilnadu

Tel. No:0451-2448800-899 (100 lines) Fax : 0451-2448855

E-mail : ssmietdgl@gmail.com

DEPARTMENT OF MECHANICAL ENGINEERING

16.12.2019

Submitted To Principal

Respected sir,

Sub: Requesting to conduct Value Added Course on "Hands on Training on Heat transfer Equipment" for third year Mechanical Students

I am writing to request your approval and support for the organization and execution of a value-added course titled "Hands-on Training on Heat Transfer Equipment."

As we are all aware, theoretical knowledge is essential, but practical application of concepts is equally crucial for a comprehensive understanding of any subject. Recognizing the significance of practical exposure, our department intends to conduct a specialized course that focuses on hands-on training in the field of heat transfer.

Thanking you

Faculty Incharge | **HoD/Mech.Engg** | **Principal**

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Department of Mechanical Engineering

Value added course On Heat Transfer Equipments Schedule

Week	Hour	Topic	Input Method
I	5,6	Introduction to Heat Transfer Equipments	Theory
	7,8	Introduction to Heat Transfer Equipments	Visit to Thermal Lab I and Thermal Lab II
II	5.6	Boiler Trial Experiments	Boiler Theory and Simulation of working of different types of Boilers
	7,8	Boiler Trial Experiments	Boiler Trial Experiments in Thermal Lab I
III	5,6	Cooling Towers	Cooling tower Theory and Working Simulation of different types of Cooling towers
	7,8	Cooling Towers experiment	Cooling Towers Experiments in Thermal Lab II
IV	5,6	Heat exchangers	Heat Exchangers Theory and Different types of Heat exchangers
	7,8	Heat exchangers Experiment	Visit to Thermal Lab II and conducting heat exchanger Experiment
V	5,6,	Application of Heat Transfer Equipments	Fins & Radiators Used in Ford Car
	7,8	Application of Heat Transfer Equipments	Refrigeration and Air conditioning Equipments
VI	5,6,7,8	Industrial Visit	Industrial Visit to SSM Mills for boiler, Milk Chilling plant (Heat Exchangers and Cooling tower)
VII	5,6,7,8	Guest Lecture	Guest Lecture From Reputed Industrial Persons and Students Feedback
VIII	5,6,7,8	Online Quiz	Online Quiz in Heat Transfer Equipments

Faculty Incharge **HoD/Mech.Engg** **Principal**

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DINDIGUL-PALANI HIGHWAY, DINDIGUL-624 002

CALENDAR for the academic year 2019-2020 even-SEM (UG - IV, VI, VIII semesters & PG - II & IV Semesters)

December 2019

DATE	DAY	SCHEDULE
1	SUN	
2	MON	
3	TUE	
4	WED	
5	THU	
6	FRI	
7	SAT	
8	SUN	
9	MON	
10	TUE	
11	WED	
12	THU	
13	FRI	
14	SAT	
15	SUN	
16	MON	College Reopens for IV Year
17	TUE	
18	WED	
19	THU	DSM-1
20	FRI	CMS for Unit I
21	SAT	
22	SUN	
23	MON	College Reopens for II and III Years
24	TUE	
25	WED	Christmas
26	THU	
27	FRI	
28	SAT	
29	SUN	
30	MON	
31	TUE	
Working Days		12
Cumulative Days		12

January 2020

DATE	DAY	SCHEDULE
1	WED	New Year
2	THU	
3	FRI	CMS for Unit II
4	SAT	VAC DAY - 1
5	SUN	
6	MON	
7	TUE	
8	WED	Unit I completion
9	THU	
10	FRI	
11	SAT	VAC DAY - 2
12	SUN	
13	MON	CCM-1
14	TUE	
15	WED	Pongal
16	THU	Pongal
17	FRI	Uzhavar Thirunal
18	SAT	
19	SUN	
20	MON	
21	TUE	
22	WED	CMS for Unit III
23	THU	DSM-2
24	FRI	Unit II completion
25	SAT	VAC DAY - 3
26	SUN	Republic Day
27	MON	IT-1
28	TUE	IT-1
29	WED	IT-1
30	THU	IT-1
31	FRI	IT-1
Working Days		22
Cumulative Days		34

February 2020

DATE	DAY	SCHEDULE
1	SAT	IT-1/VAC DAY - 4
2	SUN	
3	MON	RAW for IT-1
4	TUE	Sub. of IT-1 Marks
5	WED	
6	THU	LTP 1
7	FRI	
8	SAT	Thaipoosam
9	SUN	
10	MON	
11	TUE	
12	WED	CMS for Unit IV
13	THU	
14	FRI	Unit III completion
15	SAT	VAC DAY - 5
16	SUN	
17	MON	CCM-2
18	TUE	
19	WED	
20	THU	DSM-[illegible]
21	FRI	
22	SAT	
23	SUN	
24	MON	IT-2
25	TUE	IT-2
26	WED	IT-2
27	THU	IT-2
28	FRI	IT-2
29	SAT	IT-2 / VAC DAY - 6
Working Days		23
Cumulative Days		57

March 2020

DATE	DAY	SCHEDULE
1	SUN	
2	MON	RAW for IT-2
3	TUE	Sub. of IT-2 marks/ CMS for Unit V
4	WED	PM/LTP-2
5	THU	Unit IV completion/ DSM 4
6	FRI	
7	SAT	VAC DAY - 7
8	SUN	
9	MON	
10	TUE	
11	WED	
12	THU	
13	FRI	
14	SAT	
15	SUN	
16	MON	CCM 3
17	TUE	
18	WED	Unit V Completion
19	THU	IT-3
20	FRI	IT-3
21	SAT	VAC DAY - 8
22	SUN	
23	MON	IT-3
24	TUE	IT-3
25	WED	Telugu New Year
26	THU	IT-3/DSM 5
27	FRI	IT-3 / Last working day
28	SAT	Sub. of IT-3 marks / VAC DAY-9
29	SUN	
30	MON	UPE
31	TUE	
Working Days		21
Cumulative Days		78

April 2020

DATE	DAY	SCHEDULE
1	WED	
2	THU	
3	FRI	
4	SAT	
5	SUN	
6	MON	Mahavir Jeyanthi
7	TUE	
8	WED	
9	THU	
10	FRI	Good Friday
11	SAT	
12	SUN	
13	MON	
14	TUE	Tamil New year
15	WED	
16	THU	
17	FRI	University Theory Examinations
18	SAT	
19	SUN	
20	MON	
21	TUE	
22	WED	
23	THU	
24	FRI	
25	SAT	
26	SUN	
27	MON	
28	TUE	
29	WED	
30	THU	
Working Days		
Cumulative Days		

May 2020

DATE	DAY	SCHEDULE
1	FRI	May Day
2	SAT	
3	SUN	
4	MON	
5	TUE	
6	WED	
7	THU	
8	FRI	
9	SAT	
10	SUN	
11	MON	
12	TUE	
13	WED	
14	THU	
15	FRI	
16	SAT	
17	SUN	
18	MON	
19	TUE	
20	WED	
21	THU	
22	FRI	
23	SAT	
24	SUN	Ramzan
25	MON	
26	TUE	
27	WED	
28	THU	
29	FRI	
30	SAT	
31	SUN	
Working Days		
Cumulative Days		

VAC - Value Added Courses
DSM - Department Staff Meeting
IT - Internal Test
CMS - Course Material Submission
CCM - Class Committee Meeting

LTP - Letter to Parents
PM - Parents Meeting
RAW - Remedial Action Work

ITs are to be conducted during 3rd & 4th hour

UPE - University Practical Examinations

Total No. of working days for IV Year : 78 days

Total No. of working days for II & III Years : 72 days

Thaipoosam - District Local Holiday

Changes in the Academic schedule if any will be intimated to the students through circular.

	Holiday		Working Day

PRINCIPAL

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SSM Institute of Engineering and Technology DINDIGUL-624 002

SSM INSTITUTE OF ENGINEERING & TECHNOLOGY, Dindigul-Palani Highway, Dindigul -624 002.

Department of Mechanical Engineering

Time Table

Academic Year: 2019-2020-EVEN | Semester/Sec: IV/A | Hall.No: C - 103 | With effect from: 16.1

Day/Hour	1 9.00 to 9.50	2 09.50 to 10.40	- 10.40 to 10.55	3 10.55 to 11.45	4 11.45 to 12.35	- 12.35 to 1.20	5 01.20 to 02.05	6 02.05 to 2.50	- 02.50 to 03.05	7 03.05 to 03.50	8 03.50 to 4.35
Monday	ME8491	CE8395	Tea Break	MA8452	ME8492	Lunch	CE8381 / ME8462 - LAB		Tea Break	CE8381 / ME8462 - LAB	
Tuesday	ME8493	MA8452		HS8461 - LAB			CE8395	ME8492		ME8491	ME8451
Wednesday	ME8492	ME8491		ME8451	CE8395		MA8452 - TUT			ME8493	ME8493 - TUT
Thursday	MA8452	ME8451		ME8493	M / L		ME8492	ME8492 - TUT		CE8395	CE8395 - TUT
Friday	ME8462 / CE8381 - LAB			ME8462 / CE8381 - LAB			ME8493	ME8491		ME8451	MA8452
Saturday	ME8492 - TUT	CE8395 - TUT		ME8493 - TUT	MA8452 - TUT		VALUE ADDED COURSE			VALUE ADDED COURSE	

Details of Subjects and faculties

Sub. Code	Subject Name	Faculty Name/Design/Dept.	No. of hrs/week		Sub. Code	Subject Name	Faculty Name/Design/Dept.
MA8452	Statistics and Numerical Methods (SNM)	Dr.K.Renganathan, AP/Maths	4		MA8452	Statistics and Numerical Methods (SNM) - Tutorial	Dr.K.Renganathan, AP/Maths Prof.R.Janani, AP/Maths
ME8492	Kinematics of Machinery (KOM)	Dr.V.Kandavel, ASP/Mech	4		ME8492	Kinematics of Machinery (KOM) - Tutorial	Dr.V.Kandavel, ASP/Mech Prof.E.Sivaselvam, AP/Mech
ME8451	Manufacturing Technology (MT-II)	Prof.C.Vinoth Kumar, AP/Mech	4		CE8395	Strength of Materials for Mechanical Engineers (SOM) - Tutorial	Dr.K.A.Sundararaman, ASP/Auto Prof.M.Ramesh, ASP/Mech
ME8491	Engineering Metallurgy (EML)	Dr.R.Subhaa, AP/Mech	4		ME8493	Thermal Engineering-I (TE-I) - Tutorial	Prof.R.Rajavel, AP/Auto Prof.C.Silambarasan, AP/Mech
CE8395	Strength of Materials for Mechanical Engineers (SOM)	Dr.K.A.Sundararaman, ASP/Auto	4		ME8462	Manufacturing Technology Laboratory – II (MT LAB - II)	Prof.C.Vinoth Kumar, AP/Mech
ME8493	Thermal Engineering-I (TE-I)	Prof.R.Rajavel, AP/Auto	4		CE8381	Strength of Materials and Fluid Mechanics and Machinery Laboratory (SOM & FM LAB)	Prof.S.Srinivasan, AP/Mech
VALUE ADDED COURSE			4		HS8461	Advanced Reading and Writing (ARW)	Prof.P.Kothai Natchiar, AP/English
					M / L	Mentoring / Library	Dr.M.Sabareeswaran, ASP/Mech, Dr.R.Subhaa, AP/Mech
		Cumulative Hrs	28				Cumulative Hrs
							Total Hrs/Week

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SSM INSTITUTE OF ENGINEERING AND TECHNOLOGY, DINDIGUL - 624 002
DEPARTMENT OF MECHANICAL ENGINEERING
ANNA UNIVERSITY ATTENDANCE
VALUE ADDED COURSE: Hands on Training on 'Heat Transfer Equipments'
ATTENDANCE DETAILS (IV Year - A sec)

S.No.	Reg.no.	Student Name	4.1.2020	11.1.2020	25.1.2020	1.2.2020	15.2.2020	29.2.2020	7.3.2020
1	922117114001	ADITHYAN B	P	P	A	P	P	P	P
2	922117114002	AFZALIBRAHIM M	P	P	P	P	P	P	P
3	922117114003	AKTHARALI S	P	P	P	P	P	P	P
4	922117114004	ANAND ALBERT RAJA A	P	A	A	P	P	P	A
5	922117114005	ANISH ROBERT J	P	P	A	A	P	P	A
6	922117114006	ARULSELVAN K	P	P	P	P	A	P	A
7	922117114007	ARUN KUMAR E	P	P	P	P	P	P	P
8	922117114008	ARUN KUMAR M	P	P	P	P	P	P	P
9	922117114009	ARUN KUMAR B	A	P	P	A	A	A	A
10	922117114010	ARUNKUMAR M	A	A	A	A	P	P	A
11	922117114011	ARUNKUMAR M	P	P	P	P	P	P	P
12	922117114013	BALASUBRAMANIAN G	P	P	P	P	P	P	P
13	922117114014	BHARATHI DASAN A	P	A	A	A	P	P	A
14	922117114016	DANNI CLEMENT S	P	P	P	P	P	P	P
15	922117114017	DEEPAK R	A	A	P	P	A	A	A
16	922117114018	DEEPAK RAJ D	A	A	A	A	A	P	A
17	922117114019	DEEPAKRAJ T	P	P	P	P	P	P	P
18	922117114020	DEEPAN CHOWDRY N	P	P	P	P	P	P	P
19	922117114021	DEVARAJAN A	P	P	P	P	P	P	P
20	922117114022	DHAYALAPRABAKAR S	P	P	A	A	P	P	A
21	922117114023	DINESH S	A	A	A	A	A	A	A
22	922117114024	DINESHKUMAR M	P	P	P	P	P	P	P
23	922117114025	DIVYA DHARSHINI K	P	P	P	P	P	P	P
24	922117114026	ESAKKI DURAI PANDI M	A	A	A	A	A	A	P
25	922117114027	ETHIRAJ YOGESH P	P	P	A	P	P	P	A
26	922117114028	GAJENDREN R	A	P	A	P	P	P	P
27	922117114029	GOUTHAM SANKAR K	A	P	A	P	P	P	A
28	922117114030	GRACE A	P	P	A	P	A	P	P
29	922117114031	GUNAKARAN C	P	P	A	P	P	P	P
30	922117114032	GUNA SEKAR S	P	P	P	P	P	P	P
31	922117114033	HARI HARAN N (01-10-1999)	P	P	P	P	P	P	P
32	922117114034	1999)	P	P	P	P	P	P	P
33	922117114035	HARIHARAN N (26-11-1999)	P	P	P	P	P	P	P
34	922117114036	04-2000)	P	P	P	A	P	P	P
35	922117114037	1999)	P	P	P	P	P	P	P
36	922117114040	JAWAHAR M	P	P	P	P	A	P	P
37	922117114041	JAYAPRATHAP K	A	P	P	A	A	P	A
38	922117114042	JAYASURYA P	P	P	P	A	A	A	A
39	922117114301	ASWATH MAGESH K	P	P	P	A	P	A	A
40	922117114302	BHARATHI K	P	A	P	P	P	P	P
41	922117114304	P KARTHIKEYAN	P	A	P	P	P	P	P

Course Coordinator
M. Muthukannan.

HoD/Mech.Engg

Principal

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Hands on Training on 'Heat Transfer Equipments'

Course Material Book

Academic Year (2019-2020) Even Semester

Department of Mechanical Engineering

SSM INSTITUTE OF ENGINEERING & TECHNOLOGY

Course Coordinators :

1.Dr.M.Muthukannan.
2.Mr.S.Srinivasan.

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SYLLABUS

Chapter – I Introduction

Heat Transfer Modes. Introduction of Heat transfer Equipments – Boiler – Heat Exchanger – Cooling Tower.

Chapter – II Boilers

Types and comparison. Mountings and Accessories. Performance calculations, Boiler trial.

Chapter – III Cooling Tower

Types and comparison. Mountings and Accessories. Heat transfer methods.

Chapter – IV Heat Exchanger

Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors - Analysis – LMTD method - NTU method.

Chapter – V Applications of Heat Transfer Equipments.

Thermal Power Plant – Milk Chilling Plant – Refrigerator – Air conditioner.

Chapter – I Introduction

BASICS OF HEAT TRANSFER

While teaching heat transfer, one of the first questions students commonly ask is the difference between *heat*and *temperature.* Another common question concerns the difference between the subjects of *heat transfer*and *thermodynamics.* Let me begin this chapter by trying to address these two questions.

1.1 Difference between heat and temperature

In heat transfer problems, we often interchangeably use the terms *heat*and *temperature.* Actually, there is a distinct difference between the two. *Temperature*is a measure of the amount of energy possessed by the molecules of a substance. It manifests itself as a degree of hotness, and can be used to predict the direction of heat transfer. The usual symbol for temperature is *T.* The scales for measuring temperature in SI units are the Celsius and Kelvin temperature scales. *Heat,* on the other hand, is energy in transit. Spontaneously, heat flows from a hotter body to a colder one. The usual symbol for heat is Q. In the SI system, common units for measuring heat are the Joule and calorie.

1.2 Difference between thermodynamics and heat transfer

Thermodynamics tells us:

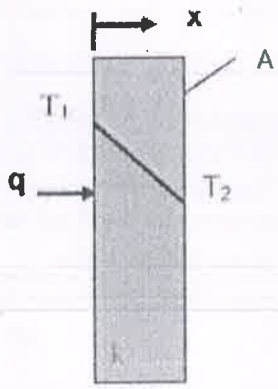
- how much heat is transferred (5Q)
- how much work is done (5W)
- final state of the system *Heat transfer*

tells us:

- how (with what modes) 5Q is transferred

1.3 Modes of Heat Transfer

- Conduction: An energy transfer across a system boundary due to a temperature difference by the mechanism of inter-molecular interactions. Conduction needs matter and does not require any bulk motion of matter.



Conduction rate equation is described by the Fourier Law:

$$q = -kAVT$$

where: q = heat flow vector, (W)
k = thermal conductivity, a thermodynamic property of the material. (W/m K)
A = Cross sectional area in direction of heat flow. (m^2)
VT = Gradient of temperature (K/m)
= 5T/5x i + 5T/5y j + 5T/&k

Note: Since this is a vector equation, it is often convenient to work with one component of the vector. For example, in the x direction:

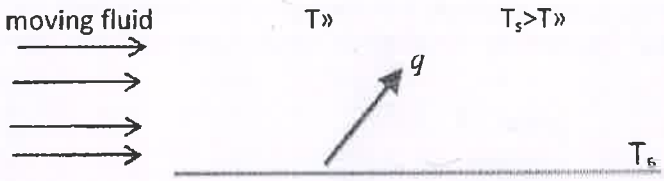
$$q_x = - k\, A_x dT/dx$$

In circular coordinates it may convenient to work in the radial direction:

$$qr = - k\, Ar\, dT/dr$$

- *Convection:* An energy transfer across a system boundary due to a temperature difference by the combined mechanisms of intermolecular interactions and bulk transport. Convection needs fluid matter.
  Newton's Law of Cooling:

$$q = h\, A_s AT$$



where: q = heat flow from surface, a scalar, (W)
h = heat transfer coefficient (which is not a thermodynamic property of the material, but may depend on geometry of surface, flow characteristics, thermodynamic properties of the fluid, etc. (W/m^2K) As = Surface area from which convection is occurring. (m^2)
AT = T_S - T_Y = Temperature Difference between surface and coolant. (K)

Convection → Free or natural convection (induced by buoyancy forces)

Forced convection (induced by external means)

May occur with phase change (boiling, condensation)

Free convection	gases: 2 – 25 liquid: 50 - 100
Forced convection	gases: 25 - 250 liquid: 50 - 20,000
Boiling/Condensation	2500 -100,000

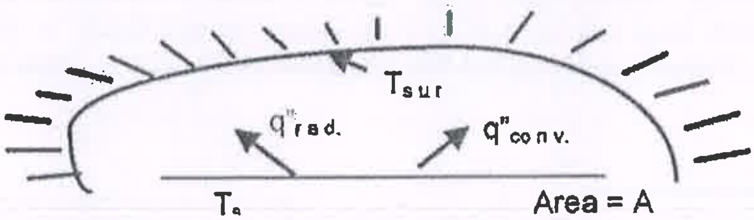
- *Radiation:* Radiation heat transfer involves the transfer of heat by electromagnetic radiation that arises due to the temperature of the body. Radiation does not need matter.

Emissive power of a surface:

$$E=asTs^4(W/\ m^2)$$

where: s = emissivity, which is a surface property (s = 1 is black body)
o = Steffan Boltzman constant = $5.67 \times 10^{-8} W/m^2K^4$.
T_s= Absolute temperature of the surface (K)

The above equation is derived from Stefan Boltzman law, which describes a gross heat emission rather than heat transfer. The expression for the actual radiation heat transfer rate between surfaces having arbitrary orientations can be quite complex, and will be dealt with in Module 9. However, the rate of radiation heat exchange between a small surface and a large surrounding is given by the following expression:



$$q = e\text{-}o\text{-}A\text{-}(Ts^4 - Tsur^4)$$

where: e = Surface Emissivity
A= Surface Area
Ts = Absolute temperature of surface. (K)
T_{sur}= Absolute temperature of surroundings.(K)

1.4 Thermal Conductivity, k

As noted previously, thermal conductivity is a thermodynamic property of a material. From the State Postulate given in thermodynamics, it may be recalled that thermodynamic properties of pure substances are functions of two independent thermodynamic intensive properties, say temperature and pressure. Thermal conductivity of real gases is largely independent of pressure and may be considered a function of temperature alone. For solids and liquids, properties are largely independent of pressure and depend on temperature alone.

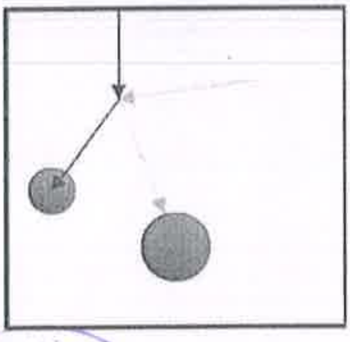
$$k = k\,(T)$$

Table 2 gives the values of thermal conductivity for a variety of materials.

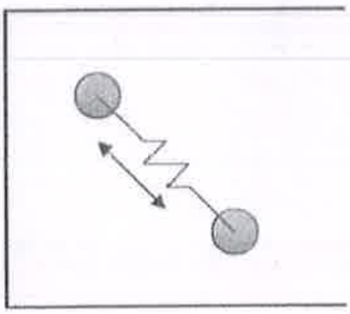
Table 2. Thermal Conductivities of Selected Materials at Room Temperature.

Material	Thermal Conductivity, W/m K
Copper	401
Silver	429
Gold	317
Aluminum	237
Steel	60.5
Limestone	2.15
Bakelite	1.4
Water	0.613
Air	0.0263

Let us try to gain an insight into the basic concept of thermal conductivity for various materials. The fundamental concept comes from the molecular or atomic scale activities. Molecules/atoms of various materials gain energy through different mechanisms. Gases, in which molecules are free to move with a mean free path sufficiently large compared to their diameters, possess energy in the form of kinetic energy of the molecules. Energy is gained or lost through collisions/interactions of gas molecules.



Kinetic energy transfer between gas molecules.



Lattice vibration may be transferred between molecules as nuclei attract/repel each other.

Solids, on the other hand, have atoms/molecules which are more closely packed which cannot move as freely as in gases. Hence, they cannot effectively transfer energy through these same mechanisms. Instead, solids may exhibit energy through vibration or rotation of the nucleus. Hence, the energy transfer is typically through lattice vibrations.

Another important mechanism in which materials maintain energy is by shifting electrons into higher orbital rings. In the case of electrical conductors the electrons are weakly bonded to the molecule and can drift from one molecule to another, transporting their energy in the process. Hence, flow of electrons, which is commonly observed in metals, is an effective transport mechanism, resulting in a correlation that materials which are excellent electrical conductors are usually excellent thermal conductors.

1.5 Boiler

A closed vessel in which steam is produced from water by combustion of fuel(Applying heat) .

1.5.1 Purpose of Boilers

- For generating power in steam engines or steam turbines .
- In textile industries for sizing and bleaching.
- For heating the buildings in cold weather and for producing hot water for hot water supply
- Primary requirements ofa boiler.
- The water must be contained safely .
- The steam must be safely delivered in desired condition (as regard its pressure, temperature, quality and required rate)

1.5.2 Applications

- Steam locomotives
- Portable engines
- Steam powered road vehicles
- Steam engine
- Power station

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1.6 Heat Exchanger

1.6.1 What are heat exchangers?

Heat exchangers are devices used to transfer heat energy from one fluid to another. Typical heat exchangers experienced by us in our daily lives include condensers and evaporators used in air conditioning units and refrigerators. Boilers and condensers in thermal power plants are examples of large industrial heat exchangers.

Chapter – II Boilers

2.1 Boiler

A closed vessel in which steam is produced from water by combustion of fuel(Applying heat) .

2.1.1 Purpose of Boilers

- For generating power in steam engines or steam turbines
- In textile industries for sizing and bleaching
- For heating the buildings in cold weather and for producing hot water for hot water supply
- Primary requirements ofa boiler
- The water must be contained safely
- The steam must be safely delivered in desired condition (as regard its pressure, temperature, quality and required rate)

2.1.2 Applications

- Steam locomotives
- Portable engines
- Steam powered road vehicles
- Steam engine
- Power station

2.2 Classification of boilers

- Fire tube and water tube
- Externally fired and internally fired
- Forced circulation and natural circulation
- High pressure and low pressure
- Stationary and portable
- Single tube and multi tube
- Natural draft,Artificial draft
- Solid fuel,liquid,nuclear energy

2.2.1 Horizontal, vertical or inclined

If the axis of the boiler is horizontal, vertical or inclined then it is called horizontal, vertical or inclined boiler respectively .

2.2.2 Fire tube and water tube

- If hot gases are inside the tube and water is outside the tube, it is called fire-tube boiler.

  Examples: Cochran, Lancashire and locomotive boilers

- If water is inside the tube and hot gases are outside the tube, it is called water-tube boiler.

  Examples: Babcock and Wilcox, Stirling, Yarrow boiler etc .

2.2.3 Externally fired and internally fired

- The boiler is known as externally fired if the fire is outside the shell.

  Examples: Babcock and Wilcox, Stirling

- The boiler is known as internally fired if the furnace is located inside the boiler shell.

  Examples: Cochran, Lancashire.

2.2.4 Forced circulation and natural circulation

- In forced circulation type of boilers, the circulation of water is done by a forced pump

  Examples: Velox, Lamont, Benson boiler

- In natural circulation type of boilers, circulation of water in the boiler takes place due to natural convection currents produced by the application of heat

  Examples: Lancashire, Babcock and Wilcox

2.2.5 High pressure and low pressure

- The boilers which produce steam at pressures of 80 bar and above are called high pressure boilers

  Examples: Babcock and Wilcox, Velox, Lamont, Benson boilers

- The boilers which produce steam at pressure below 80 bar are called low pressure boilers

  Examples: Cochran, Cornish, Lancashire and locomotive boilers .

2.2.6 Stationary and portable

- Stationary boilers are used for power plant- steam, for central station utility power plants, for plant process steam etc

- Mobile or portable boilers include locomotive type, and other small unit for temporary use at sites .

2.2.7 Single tube and multi tube

- The fire tube boilers are classified as single tube or multi-tube boilers, depending upon whether the fire tube is one or more than one

- Examples of single tube boilers are Cornish and simple vertical boiler.

2.3 Boiler terms

- **Shell:** Consists of one or more steel plates bent into a cylindrical form and riveted or welded together. The shell ends are closed with end plates.
- **Setting**: The primary function of setting is to confine heat to the boiler and form a passage for gases. It is made of brick work and may form the wall of the furnace and combustion chamber.
- **Grate**: it is a platform in the furnace upon which fuel is burnt
- **Furnace**: it is the chamber formed by the space above the grate and below the boiler shell, in which combustion takes place.
- **Water space and steam space**: the volume of the shell that is occupied by the water is termed as water space while the entire shell volume less the water and tubes is called steam space.
- **Mountings**: The items which are used for safety of boiler are called mountings
- **Accessories**: The items which are used for increasing the boiler efficiency are called accessories
- **Water level**: The level at which water stands in the boiler is called water level
- **Refractory**: insulation material used for lining combustion chamber
- **Foaming**: Formation of steam bubbles on the surface of boiler water due to high surface tension of water.

2.4 Mountings:

- **Pressure gauge**
- **Water level indicator**
- **Safety valve** - to prevent pressure not increase above design pressure(spring controlled)
- **Fusible plug** - when shell temp. increases above particular level it melts by creating opening through which pressurized water falls on grate extinguishing fire.
- **Blow off cock** – when opened steam pushes water at bottom to remove slurries, salted contaminants, dust etc .
- **Stem stop valve** – regulate steam supply outside boiler.
- **Feed check valve** – high pressure feed water is supplied to boiler through this valve, prevent backflow of steam through the valve.

2.5 Comparison of fire tube and water tube boilers

Particulars	Fire-tube boilers	Water-tube boilers
Position of water and hot gases	**Hot gases inside the tubes and water outside the tubes**	**Water inside the tubes and hot gases outside the tubes**

Mode of firing	**Generally internally fired**	**Externally fired**
Operation pressure	**Limited to 16 bar**	**Can go up to 100 bar**
Rate of steam production	**Lower**	**Higher**
Suitability	**Not suitable for large power plants**	**Suitable for large power plants**
Risk on bursting	**Involves lesser risk of explosion due to lower pressure**	**More risk on bursting due to high pressure**
Floor area	**For a given power it occupies more floor area**	**For a given power it occupies less floor area**
Construction	**Difficult**	**Simple**
Transportation	Difficult	Simple
Shell diameter	Large for same power	Small for same power
Chances of explosion	Less	More
Treatment of water	Not so necessary	More necessary
Accessibility of various parts	Various parts not so easily accessible for cleaning, repair and inspection	More accessible

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Requirement of skill	Require less skill for efficient and economic working	Require more skill and careful attention

2.6 Boiler accessories

- **Feed pumps:** Used to deliver feed water to the boiler. It is desirable that the quantity of water supplied should be at least equal to that evaporated and supplied to the engine

  Two types of which are commonly used as feed pumps are (1) reciprocating pump (2) rotary pump.

- **Injector:** Function of injector is to feed water into the boiler .

  It is commonly employed for vertical and locomotive boilers and does not find its application in large capacity high pressure boilers.

  Also used where the space is not available for the installation of feed pump .

- **Economizer:** Is a device in which the waste heat of the flue gases is utilized for heating the feed water.

  Economizers are of two types Independent type Integral type.

- **Air Pre heater:** The function of the air pre-heater is to increase the temperature of air before it enters the furnace.
- It is placed after the economizer.
- Flue gases pass through the economizer and then to the air preheater.
- Degree of preheating depends on
  - ➢ Type of fuel
  - ➢ Type of fuel burning equipment, and
  - ➢ Rating at which the boiler and furnace are operated
- **Super heater:** The function of a super heater is to increase the temperature of the steam above its saturation point.
- The super heater is very important accessory of a boiler and can be used both on fire tube and water – tube boilers.
- **Steam separator:** The function of a steam separator is to remove the entrained water particles from the steam conveyed to the steam engine or, turbine.
- It is installed as close to the steam engine as possible on the main steam pipe from the boiler.

- According to principle of operation the steam separators are classified as follows
    - ➢ Impact or baffle type
    - ➢ Reverse current type
    - ➢ Centrifugal type

2.7 Boiler Efficiency

There are two methods to measure the boiler efficiency:

1. Direct method
2. Indirect method

Direct method: Direct method of boiler efficiency test is more usable or more common.

Boiler efficiency = power out / power in = $(Q * (H_g - H_f)) / (q * GCV) * 100\%$

Q = rate of steam flow in kg/h
H_g = enthalpy of saturated steam in kcal/kg
H_f = enthalpy of feed water in kcal/kg
q = rate of fuel use in kg/h
GCV = gross calorific value in kcal/kg (e.g. pet coke 8200 kcal/kg)

Indirect method: To measure the boiler efficiency in indirect method, we need a following parameter like:

- Ultimate analysis of fuel (H_2,S_2,S,C moisture constraint, ash constraint)
- Percentage of O_2 or CO_2 at flue gas
- Flue gas temperature at outlet
- Ambient temperature in deg c and humidity of air in kg/kg
- GCV of fuel in kcal/kg
- Ash percentage in combustible fuel
- GCV of ash in kcal/kg

Chapter – III Cooling Tower

3.1 A cooling tower is a specialized heat exchanger in which air and water are brought into direct contact with each other in order to reduce the water's temperature. As this occurs, a small volume of water is evaporated, reducing the temperature of the water being circulated through the tower.

- To reduce thermal pollution which occurs in open system
- To cool water coming out of the condenser in a closed system
- Water cooled, Air cooled cooling towers
- Uses either natural draft or mechanical draft
- Natural draft – utilizes buoyancy large space, high cost, less efficient
- Mechanical draft uses fan, requires less space, improves efficiency
- Forced draft tower: blower type fan is located at the base of the tower & forces air into the tower. Induced draft tower: fan is located at the top of the tower & pulls air through the tower.

3.2 COOLING TOWERS:

Cooling towers are heat removal devices used to transfer process waste heat to the atmosphere. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature or in the case of "Close Circuit Dry Cooling Towers" rely solely on air to cool the working fluid to near the dry-bulb air temperature. Common applications include cooling the circulating water used in oil refineries, chemical plants, power stations and building cooling. The towers vary in size from small roof-top units to very large hyperboloid structures that can be up to 200 metres tall and 100 metres in diameter, or rectangular structures that can be over 40 metres tall and 80 metres long. Smaller towers are normally factory-built, while larger ones are constructed on site. They are often associated with nuclear power plants in popular culture, although cooling towers are constructed on many types of buildings.

3.3 Types

3.3.1 Industrial cooling towers

Industrial cooling towers can be used to remove heat from various sources such as machinery or heated process material. The primary use of large, industrial cooling towers is to remove the heat absorbed in the circulating cooling water systems usedin power plants, petroleum refineries, petrochemical plants, natural gas processing plants, food processing plants, semi-conductor plants, and for other industrial facilities such as in condensers of distillation columns, for cooling liquid in crystallization, etc. The circulation rate of cooling water in a typical 700 MW coal-fired power plant with a cooling tower amounts to about 71,600 cubic metres an hour (315,000 U.S. gallons per minute) and the circulating water requires a supply water make-up rate of perhaps 5 percent (i.e., 3,600 cubic metres an hour).

If that same plant had no cooling tower and used **once-through cooling** water, it would require about 100,000 cubic metres an hour and that amount of water would have to be continuously returned to the ocean, lake or river from which it was obtained and continuously re-supplied to the plant. Furthermore, discharging large amounts of hot water may raise the temperature of the receiving river or lake to an unacceptable level for the local ecosystem. Elevated water temperatures can kill fish and other aquatic organisms. (See *thermal pollution.*) A cooling tower serves to dissipate the heat into the atmosphere instead and wind and air diffusion spreads the heat over a much larger area than hot water can distribute heat in a body of water. Some coal-fired and nuclear power plants located in coastal areas do make use of once-through ocean water. But even there, the offshore discharge water outlet requires very careful design to avoid environmental problems. Petroleum refineries also have very large cooling tower systems. A typical large refinery processing 40,000 metric tonnes of crude oil per day (300,000 barrels (48,000 m^3) per day) circulates about 80,000 cubic metres of water per hour through its cooling tower system. The world's tallest cooling tower is the 200 metre tall cooling tower of Niederaussem Power Station.

3.4 Heat transfer methods

With respect to the heat transfer mechanism employed, the main types are:

- **Wet cooling towers** or simply open circuit cooling towers operate on the principle of evaporation. The working fluid and the evaporated fluid (usually H2O) are one and the same.
- **Dry Cooling Towers** operate by heat transfer through a surface that separates the working fluid from ambient air, such as in a tube to air heat exchanger, utilizing convective heat transfer. They do not use evaporation.
- **Fluid coolers or Closed Circuit Cooling Towers** are hybrids that pass the working fluid through a tube bundle, upon which clean water is sprayed and a fan-induced draft applied. The resulting heat transfer performance is much closer to that of a wet cooling tower, with the advantage provided by a dry cooler of protecting the working fluid from environmental exposure and contamination.

- In a wet cooling tower (or Open Circuit Cooling Tower), the warm water can be cooled to a temperature lower than the ambient air dry-bulb temperature, if the air is relatively dry. (see:

dew point and psychrometrics). As ambient air is drawn past a flow of water, an small portion of the water evaporate, the energy required by that portion of the water to evaporate is taken from the remaining mass of water reducing his temperature (aproximately by 970 BTU for each pound of evaporated water). Evaporation results in saturated air conditions, lowering the temperature of the water process by the tower to a value close to wet bulb air temperature, which is lower than the ambient dry bulb air temperature, the difference determined by the humidity of the ambient air.

To achieve better performance (more cooling), a medium called fill is used to increase the surface area and the time of contact between the air and water flows. Splash fill consists of material placed to interrupt the water flow causing splashing. Film fill is composed of thin sheets of material (usually PVC) upon which the water flows. Both methods create increased surface area and time of contact between the fluid (water) and the gas (air).

3.5 Air flow generation methods

With respect to drawing air through the tower, there are three types of cooling towers:

Natural draft, which utilizes buoyancy via a tall chimney. Warm, moist air naturally rises due to the density differential to the dry, cooler outside air. Warm moist air is less dense than drier air at the same pressure. This moist air buoyancy produces a current of air through the tower.

Mechanical draft, which uses power driven fan motors to force or draw air through the tower.

Induced draft: A mechanical draft tower with a fan at the discharge which pulls air through tower. The fan induces hot moist air out the discharge. This produces low entering and high exiting air velocities, reducing the possibility of recirculation in which discharged air flows back into the air intake. This fan/fin arrangement is also known as draw-through.

Forced draft: A mechanical draft tower with a blower type fan at the intake. The fan forces air into the tower, creating high entering and low exiting air velocities. The low exiting velocity is much more susceptible to recirculation. With the fan on the air intake, the fan is more susceptible to complications due to freezing conditions. Another disadvantage is that a forced draft design typically requires more motor horsepower than an equivalent induced draft design. The forced draft benefit is its ability to work with high static pressure. They can be installed in more confined spaces and even in some indoor situations. This fan/fill geometry is also known as blow-through.

Fan assisted natural draft. A hybrid type that appears like a natural draft though airflow is assisted by a fan.

Hyperboloid (a.k.a. hyperbolic) cooling towers (Image 1) have become the design standard for all natural-draft cooling towers because of their structural strength and minimum usage of material. The hyperboloid shape also aids in accelerating the upward convective air flow, improving cooling efficiency. They are popularly associated with nuclear power plants. However, this association is misleading, as the same kind of cooling towers are often used at large coal-fired power plants as well. Similarly, not all nuclear power plants have cooling towers, instead cooling their heat exchangers with lake, river or ocean water.

3.6 Categorization by air-to-water flow Crossflow

Crossflow is a design in which the air flow is directed perpendicular to the water flow (see diagram below). Air flow enters one or more vertical faces of the cooling tower to meet the fill material. Water flows (perpendicular to the air) through the fill by gravity. The air continues through the fill and thus past the water flow into an open plenum area. A *distribution* or *hot water basin* consisting of a deep pan with holes or *nozzles* in the bottom is utilized in a crossflow tower. Gravity distributes the water through the nozzles uniformly across the fill material.

Counterflow

In a counterflow design the air flow is directly opposite to the water flow (see diagram below). Air flow first enters an open area beneath the fill media and is then drawn up vertically. The water is sprayed through pressurized nozzles and flows downward through the fill, opposite to the air flow.

Common to both designs:

The interaction of the air and water flow allow a partial equalization and evaporation of water.

The air, now saturated with water vapor, is discharged from the cooling tower.

A *collection* or *cold water basin* is used to contain the water after its interaction with the air flow.

Both crossflow and counterflow designs can be used in natural draft and mechanical draft cooling towers.

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Chapter – IV Heat Exchanger

4 Introduction

Heat exchangers are widely used in various thermal and thermal related industries for the purpose of maintaining a desired temperature in the system. Heat transfer occurs in many forms, one of this is convection, which is also known as convective heat transfer. This type of heat transfer is widely used in all types of heat exchangers.Among various types of heat exchangers, shell and tube type heat exchangers are widely used because of this simple construction and less maintenance. This type of heat exchangers run under parallel and counter flow modes.

In this project, a shell and tube heat exchanger is taken for analysis purpose. The model of the heat exchanger is done using solid works software and for future CFD analysis, the same package will be used, because this package is capable of integrating the model between the modeling and simulation. The datas for the simulation will be collected from a nearer diary factory, as they use heat exchangers for maintaining the temperature in their system. Initially the existing setup will be subjected to CFD analysis and then the results are noted. Then, the working fluid is replaced from ammonia to titanium oxide hence attempting to increase the heat transfer from gas to liquid. Then the CFD results are tabulated and compared accordingly.

4.1 Heat Transfer

Heat transfer is the exchange of thermal energy between physical systems, depending on the temperature and pressure, by dissipating heat. The fundamental modes of heat transfer are conduction or diffusion, convection and radiation.

Heat transfer always occurs from a region of high temperature to another region of lower temperature. Heat transfer changes the internal energy of both systems involved according to the First Law of Thermodynamics. The Second Law of Thermodynamics defines the concept of thermodynamic entropy, by measurable heat transfer.

Thermal equilibrium is reached when all involved bodies and the surroundings reach the same temperature. Thermal expansion is the tendency of matter to change in volume in response to a change in temperature.

The fundamental modes of heat transfer are:

ADVECTION

Advection is the transport mechanism of a fluid substance or conserved property from one location to another, depending on motion and momentum.

CONDUCTION OR DIFFUSION

The transfer of energy between objects that are in physical contact. Thermal conductivity is the property of a material to conduct heat and evaluated primarily in terms of Fourier's Law for heat conduction.

CONVECTION

The transfer of energy between an object and its environment, due to fluid motion. The average temperature, is a reference for evaluating properties related to convective heat transfer.

RADIATION

The transfer of energy from the movement of charged particles within atoms is converted to electromagnetic radiation.

4.2 Convective Heat Transfer

Convective heat transfer, often referred to simply as convection, is the transfer of heat from one place to another by the movement of fluids. Convection is usually the dominant form of heat transfer in liquids and gases. Although often discussed as a distinct method of heat transfer, convective heat transfer involves the combined processes of conduction (heat diffusion) and advection (heat transfer by bulk fluid flow). Free, or natural, convection occurs when bulk fluid motions (streams and currents) are caused by buoyancy forces that result from density variations due to variations of temperature in the fluid. Forced convection is a term used when the streams and currents in the fluid are induced by external means—such as fans, stirrers, and pumps—creating an artificially induced convection current.

4.3 Devices

Heat engine is a system that performs the conversion of heat or thermal energy to mechanical energy which can then be used to do mechanical work.

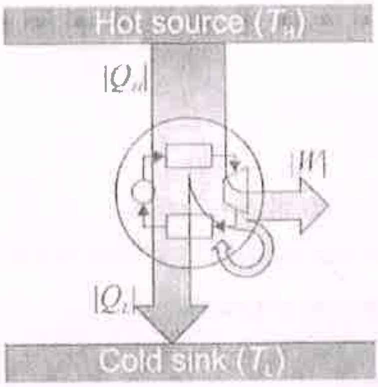


Figure 1.1 Heat Engine

Thermocouple is a temperature-measuring device and widely used type of temperature sensor for measurement and control, and can also be used to convert heat into electric power.

Thermoelectric cooler is a solid state electronic device that pumps (transfers) heat from one side of the device to the other when electric current is passed through it. It is based on the Peltier effect.

Thermal diode or thermal rectifier is a device that causes heat to flow preferentially in one direction.

4.4 Heat Exchangers

A heat exchanger is a device used to transfer heat between one or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air.

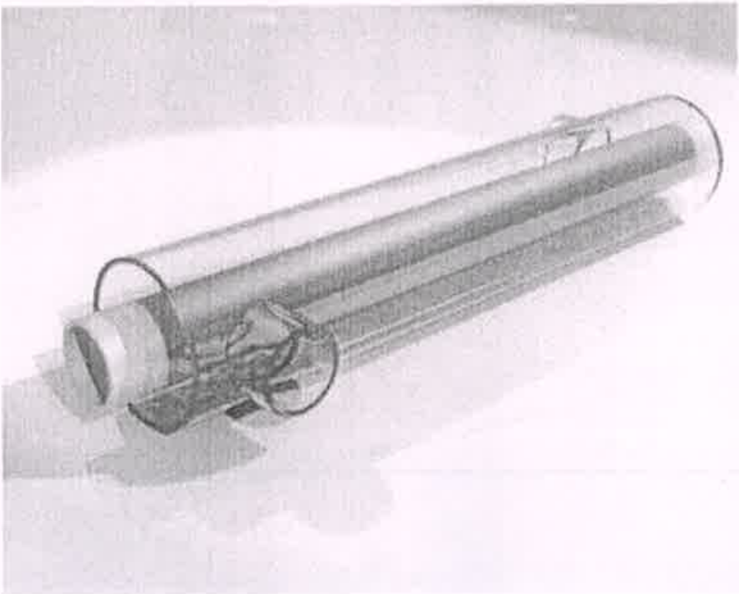


Figure 1.2 Tubular heat exchanger

4.4.1 Flow Arrangement

There are three primary classifications of heat exchangers according to their flow arrangement. In parallel-flow heat exchangers, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side. In counter-flow heat exchangers the fluids enter the exchanger from opposite ends.

The counter current design is the most efficient, in that it can transfer the most heat from the heat (transfer) medium per unit mass due to the fact that the average temperature difference along any unit length is higher. See countercurrent exchange. In a cross-flow heat exchanger, the fluids travel roughly perpendicular to one another through the exchanger.

For efficiency, heat exchangers are designed to maximize the surface area of the wall between the two fluids, while minimizing resistance to fluid flow through the exchanger. The exchanger's performance can also be affected by the addition of fins or corrugations in one or both directions, which increase surface area and may channel fluid flow or induce turbulence.

The driving temperature across the heat transfer surface varies with position, but an appropriate mean temperature can be defined. In most simple systems this is the "log mean temperature difference" (LMTD). Sometimes direct knowledge of the LMTD is not available and the NTU method is used.

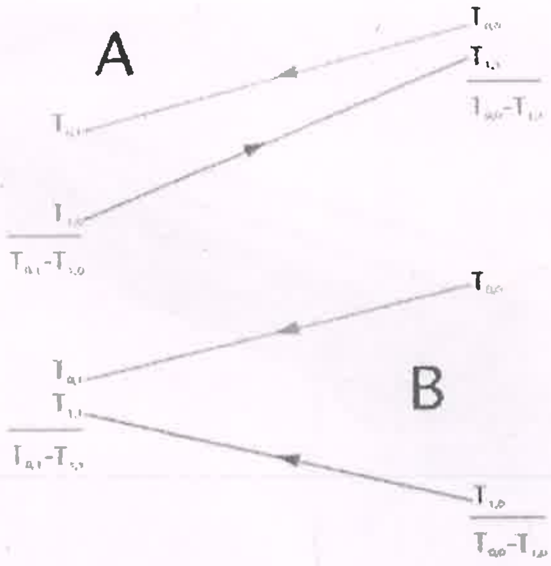


Figure 1.3Countercurrent (A) and parallel (B) flows

4.4.2 Types Of Heat Exchangers

Double pipe heat exchangers are the simplest exchangers used in industries. On one hand, these heat exchangers are cheap for both design and maintenance, making them a good choice for small industries. On the other hand, their low efficiency coupled with the high space occupied in large scales, has led modern industries to use more efficient heat exchangers like shell and tube or plate. However, since double pipe heat exchangers are simple, they are used to teach heat exchanger design basics to students as the fundamental rules for all heat exchangers are the same. To start the design of a double pipe heat exchanger, the first step is to calculate the heat duty of the heat exchanger. It must be noted that for easier design, it's better to ignore heat loss to the environment for initial design. The mail types of heat exchangers are,

- Shell and tube heat exchanger
- Plate heat exchangers
- Plate and shell heat exchanger
- Adiabatic wheel heat exchanger

- Plate fin heat exchanger
- Pillow plate heat exchanger
- Fluid heat exchangers
- Waste heat recovery units
- Dynamic scraped surface heat exchanger
- Phase-change heat exchangers
- Direct contact heat exchangers
- Microchannel heat exchangers

4.5 Shell And Tube Heat Exchanger

A shell and tube heat exchanger is a class of heat exchanger designs. It is the most common type of heat exchanger in oil refineries and other large chemical processes, and is suited for higher-pressure applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. The set of tubes is called a tube bundle, and may be composed of several types of tubes: plain, longitudinally finned, etc.

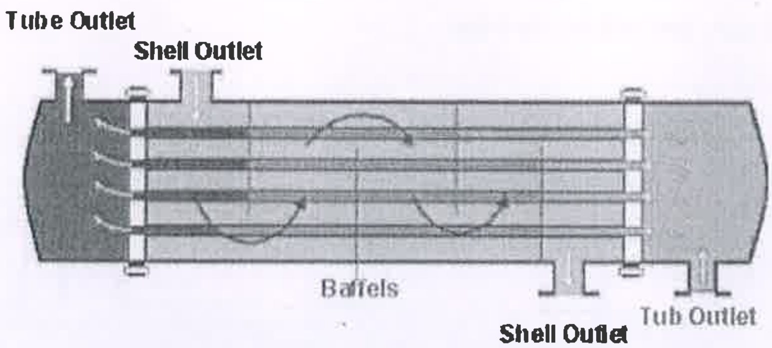


Figure 1.4 Typical Shell and tube Heat exchanger

4.5.1 Shell And Tube Heat Exchanger Design

There can be many variations on the shell and tube design. Typically, the ends of each tube are connected to plenums (sometimes called water boxes) through holes in tubesheets. The tubes may be straight or bent in the shape of a U, called U-tubes.

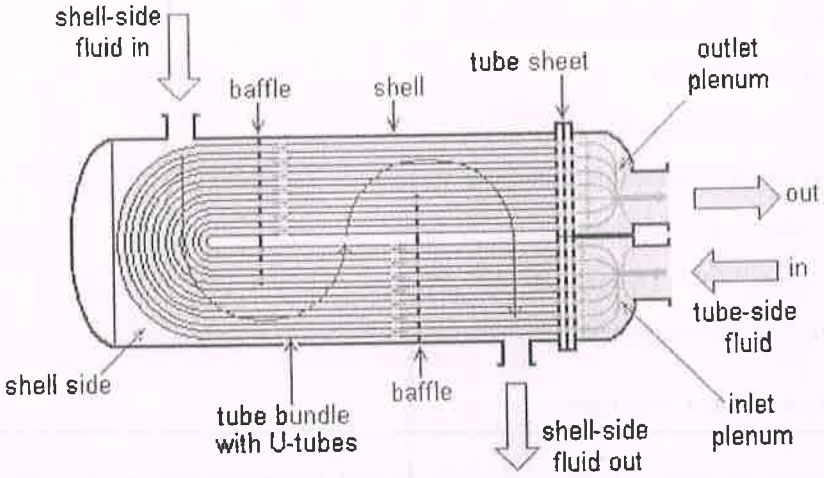


Figure 1.5 U tube heat exchanger

In nuclear power plants called pressurized water reactors, large heat exchangers called steam generators are two-phase, shell-and-tube heat exchangers which typically have U-tubes. They are used to boil water recycled from a surface condenser into steam to drive a turbine to produce power. Most shell-and-tube heat exchangers are either 1, 2, or 4 pass designs on the tube side. This refers to the number of times the fluid in the tubes passes through the fluid in the shell. In a single pass heat exchanger, the fluid goes in one end of each tube and out the other.

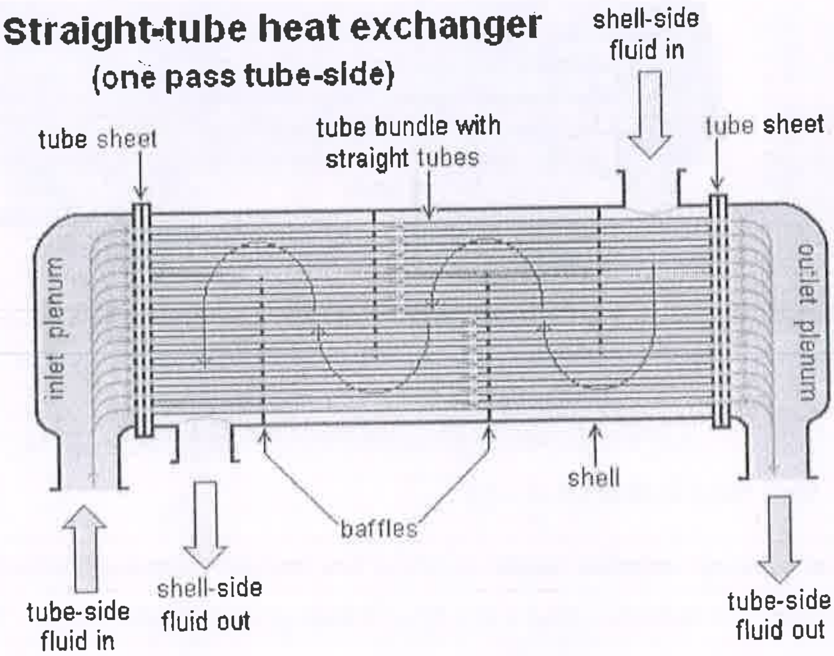


Figure 1.6 Straighttube heat exchanger

Surface condensers in power plants are often 1-pass straight-tube heat exchangers (see Surface condenser for diagram). Two and four pass designs are common because the fluid can enter and exit on the same side. This makes construction much simpler.

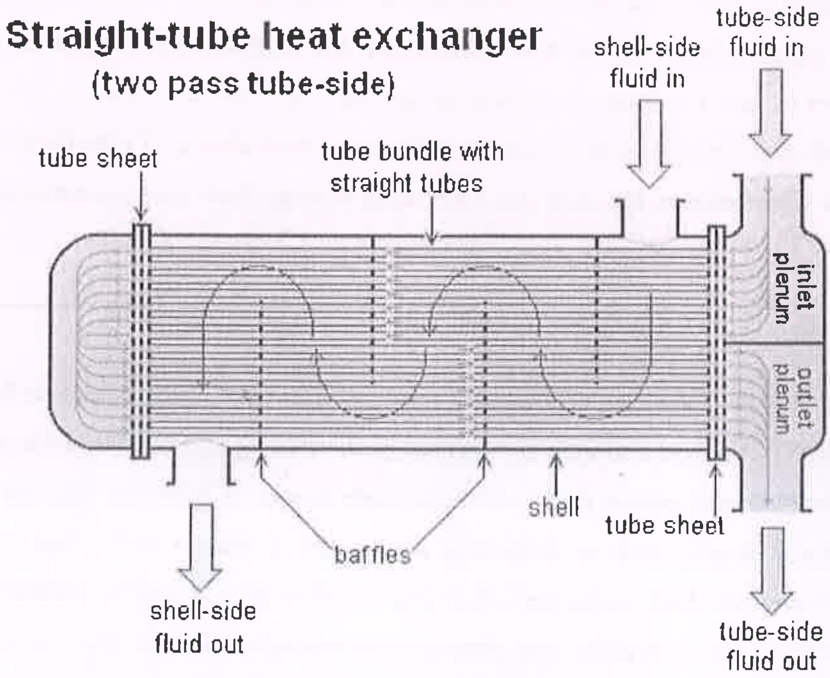


Figure 1.7 Straight tube heat exchanger _ two pass tube side

There are often baffles directing flow through the shell side so the fluid does not take a short cut through the shell side leaving ineffective low flow volumes. These are generally attached to the tube bundle rather than the shell in order that the bundle is still removable for maintenance.

Counter current heat exchangers are most efficient because they allow the highest log mean temperature difference between the hot and cold streams. Many companies however do not use single pass heat exchangers because they can break easily in addition to being more expensive to build. Often multiple heat exchangers can be used to simulate the counter current flow of a single large exchanger.

4.5.2 Selection Of Tube Material

To be able to transfer heat well, the tube material should have good thermal conductivity. Because heat is transferred from a hot to a cold side through the tubes, there is a temperature difference through the width of the tubes. Because of the tendency of the tube material to thermally expand differently at various temperatures, thermal stresses occur during operation. This is in addition to any stress from high pressures from the fluids themselves.

The tube material also should be compatible with both the shell and tube side fluids for long periods under the operating conditions (temperatures, pressures, pH, etc.) to minimize deterioration such as corrosion. All of these requirements call for careful selection of strong, thermally-conductive, corrosion-resistant, high quality tube materials, typically metals, including copper alloy, stainless steel, carbon steel, non-ferrous copper alloy, Inconel, nickel, Hastelloy and titanium. Fluoropolymers such as Perfluoroalkoxy alkane (PFA) and Fluorinated ethylene propylene (FEP) are also used to produce the tubing material due to their high resistance to extreme temperatures. Poor choice of tube material could result in a leak through a tube between the shell and tube sides causing fluid cross-contamination and possibly loss of pressure.

4.5.3 Applications And Uses

The simple design of a shell and tube heat exchanger makes it an ideal cooling solution for a wide variety of applications. One of the most common applications is the cooling of hydraulic fluid and oil in engines, transmissions and hydraulic power packs. With the right choice of materials they can also be used to cool or heat other mediums, such as swimming pool water or charge air.[5] One of the big advantages of using a shell and tube heat exchanger is that they are often easy to service, particularly with models where a floating tube bundle (where the tube plates are not welded to the outer shell) is available.

4.5.4 Design And Construction Standards

- Standards of the Tubular Exchange Manufacturers Association (TEMA), 9th edition, 2009
- EN 13445-3 "Unfired Pressure Vessels - Part 3: Design", Section 13 (2012)
- ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Part UHX

4.6 Heat-Transfer Fluid

Heat transfer fluids are those, which supports the occurrence of heat transfer in a system. This type of fluids are generally called as coolants.

A coolant is a fluid which flows through or around a device to prevent its overheating, transferring the heat produced by the device to other devices that use or dissipate it. An ideal coolant has high thermal capacity, low viscosity, is low-cost, non-toxic, and chemically inert, neither causing nor promoting corrosion of the cooling system. Some applications also require the coolant to be an electrical insulator.

While the term coolant is commonly used in automotive and HVAC applications, in industrial processing, heat transfer fluid is one technical term more often used, in high temperature as well as low temperature manufacturing applications. Another industrial sense of the word covers cutting fluids.

The coolant can either keep its phase and stay liquid or gaseous, or can undergo a phase transition, with the latent heat adding to the cooling efficiency. The latter, when used to achieve low temperatures, is more commonly known as refrigerant.

4.6.1 Types

The following are the main types of heat transfer fluids available as well as used in industry.

- Gases
- Liquids
- Molten metals and salts
- Liquid gases
- Nano-fluids
- Solids

4.7 LMTD

The **LMTD** is a logarithmic average of the temperature difference between the hot and cold streams at each end of the exchanger. The larger the **LMTD**, the more heat is transferred. The use of the **LMTD** arises, straightforwardly, from the analysis of a heat exchanger with constant flow rate and fluid thermal properties.

4.7.1 Purposes of LMTD

LMTD is the logarithmic mean of temperature difference of the fluids at both the ends of the heat exchangers. The **LMTD** is the driving force for the heat exchange between the two fluids in a single pass heat exchanger. The **LMTD** value is also used for calculating the heat duty of the heat exchanger.

4.8 NTU

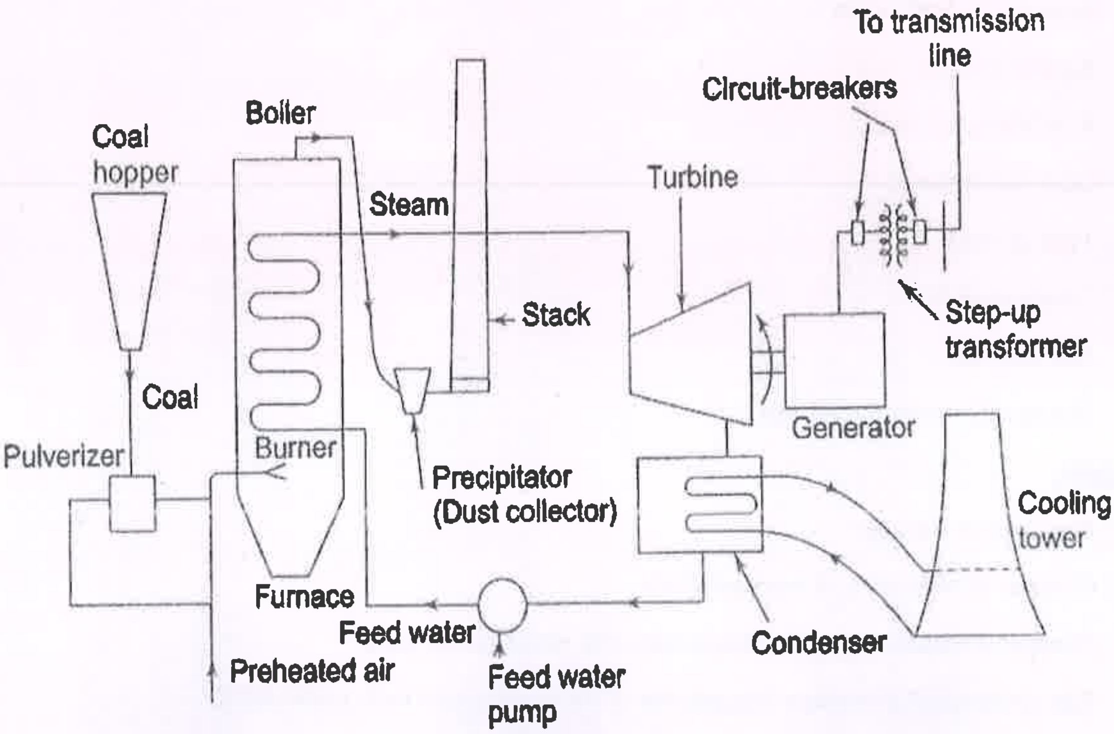
The Effectiveness – Number of Transfer Units (ε-**NTU**) methods. The **LMTD** method is convenient for determining the overall heat transfer coefficient based on the measured inlet and outlet fluid temperatures.

4.9 Fouling Factor

The fouling factor represents the theoretical resistance to heat flow due to a build-up of a layer of dirt or other fouling substance on the tube surfaces of the heat exchanger, but they are often overstated by the end user in an attempt to minimise the frequency of cleaning.

Chapter – V Applications of Heat Transfer Equipments.

5.1 Thermal Power plant



Schematic diagram of Coal Fired Power Plant

The water is boiled and made into **steam**. The pressure exerted by the **steam** on the turbine rotates the turbine. ... The steam, after expanding is cooled down at a constant pressure to water and then pumped back into the boiler for use again.

5.1.1 Thermal Power Stations

- Coal Fired
  - Turbo alternators driven by steam turbine
- Oil Fired
  - Crude oil OR Residual oil
- Gas Fired
  - Fastest growing primary fuel, worldwide
  - Combined cycle

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- First stage - Gas turbine & Second stage - Steam Turbine

- Diesel Fired
  - IC Engine as prime mover
  - Standby power plants

5.2 Selection of site Selection of site

- Nearness to load center
- Supply of water
- Availability of coal
- Land requirement
- Type of land
- Labour supplies
- Ash disposal
- Distance from populated area

5.3 Merits:

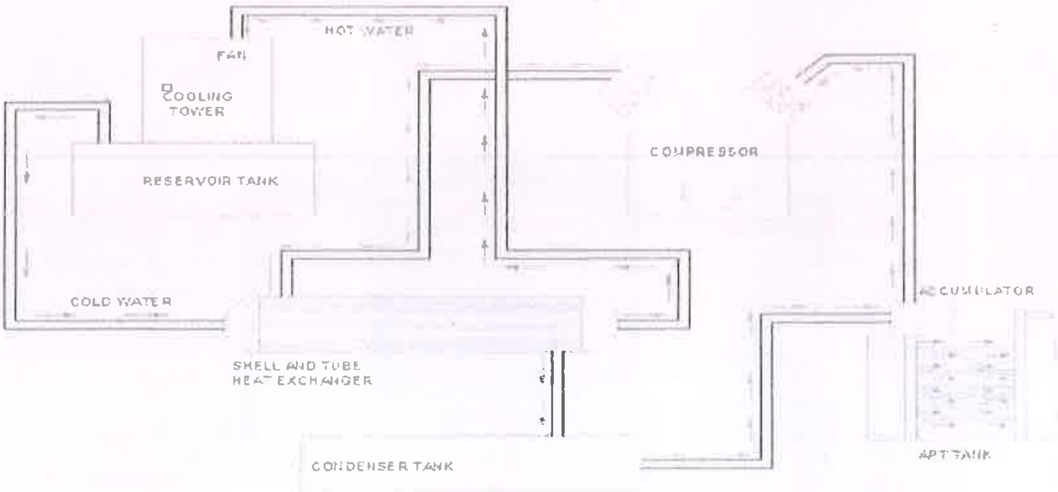
- Fuel used is cheaper
- Cheaper installation cost comparatively
- Cheaper production cost in comparison with diesel power plant
- Can be installed at ay place irrespective of the existence of fuels unlike HEPP
- Can be located near to load center unlike HEPP
- Able to respond rapidly changing loads without difficulty
- Steam engines and turbine can work under under 25% of over load continuously
- Portion of steam raised can be used as process steam in various industries (paper mills, textile mills etc)

5.4 Demerits:

- High maintenance and operating cost.
- Pollution.
- Requirement of water in huge quantity.
- Handling of coal and ash is quite difficult
- The plant cost increases with the increases in the operating temperature and pressure.

- Require long time for erection and put into action.
- Efficiency fall rapidly below 75% of full load.

5.4 Milk chilling plant



layout of the plant

In the above layout, the water from the reservoir enters the shell and tube heat exchanger as a cold water. Meanwhile in the other hand, a compressor sucks the ammonia from the accumulator and passes it through the pipes under constant pressure. Since the ammonia gets pressurised, it attains some thermal heat and passes through the pipes and reaches the shell and tube heat exchanger.

Here, the cold water mixes with the hot fluid and as a result, heat transfer occurs. As a result, the water gets heated and sent to reservoir through pipes. During the travel, the water gets its work done here and there. On the other hand, the ammonia which was cooled, gets condensed and collected in the condenser tank, here the ammonia will be in liquid state and again pumped to accumulator unit where it gets ready to compress again by compressor, and this cycle repeats.

During this process, the heat transfer which occurs inside the exchanger is said to be not much efficient and not all the condensed ammonia is not collected at the tank. Some stay on the bottom layers of the shell. This in turn makes the shell corroded and makes the system failure.

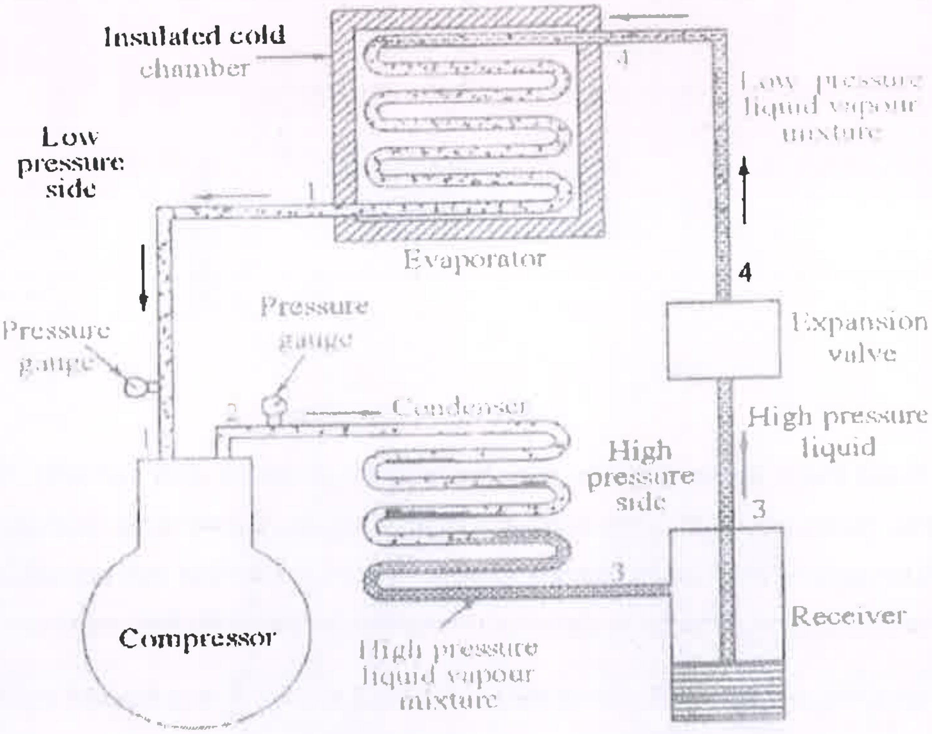
5.5 **Refregerator**

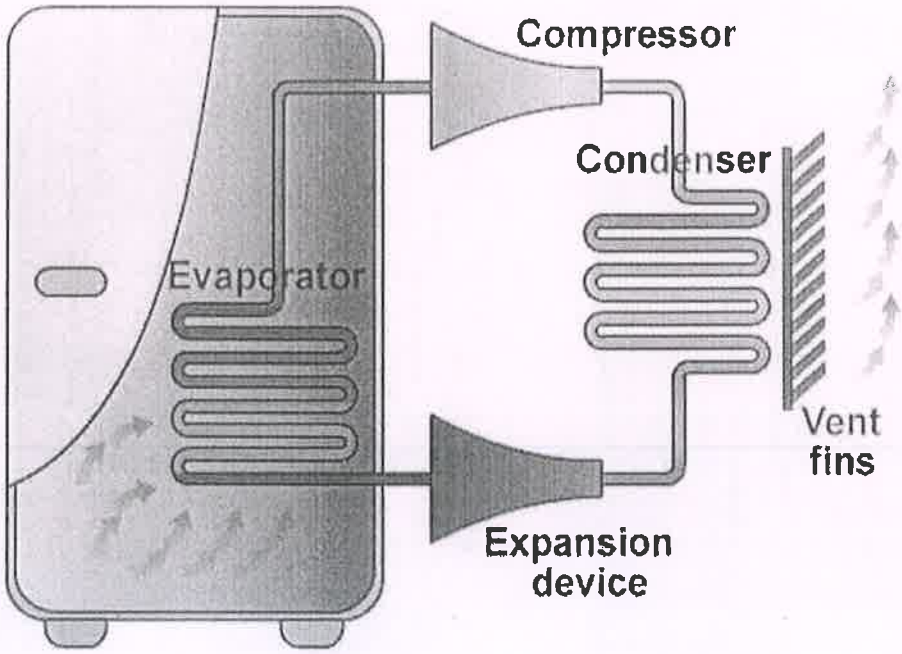
5.5.1 **Refrigeration**

5.5.2 **Refrigerator**

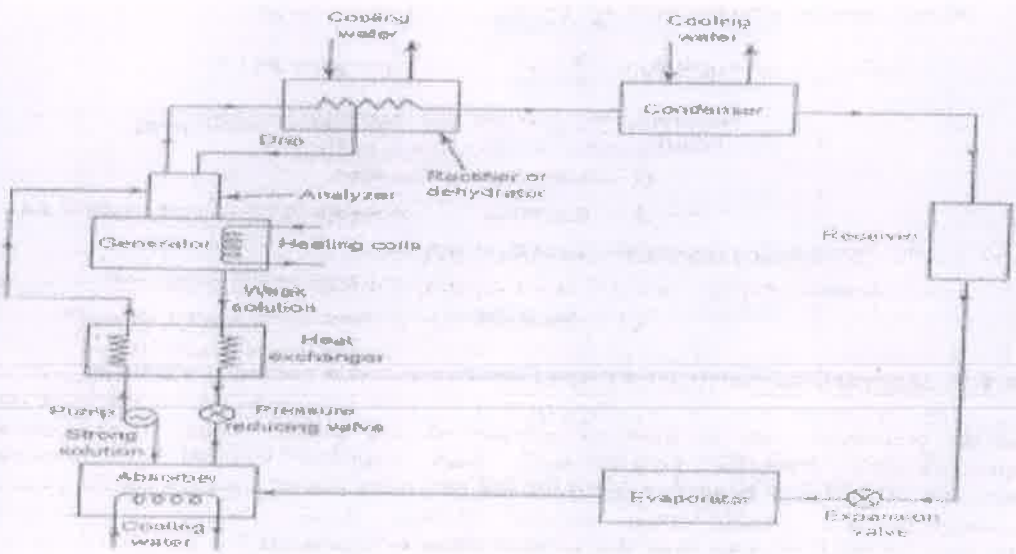
5.5.3 **Types**

1. **Vapour Compression Refrigeration (VCR)**

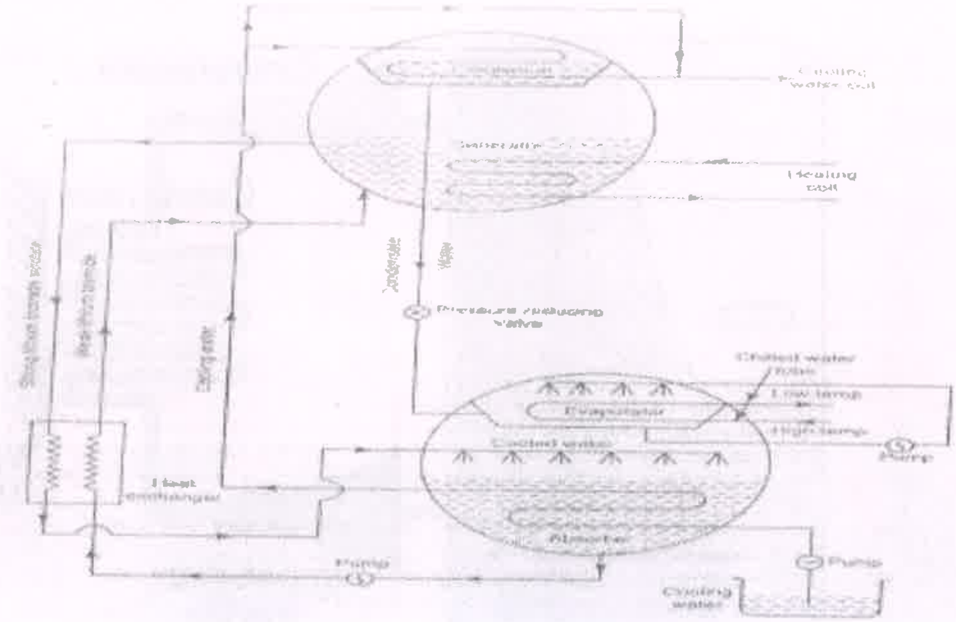




2. **Vapour Absorption Refrigeration system (VAR)**



i) Ammonia water vapour compression system



ii) Lithium bromide - water vapour compression system

5.6 Air conditioning

5.6.1 Air conditioning process

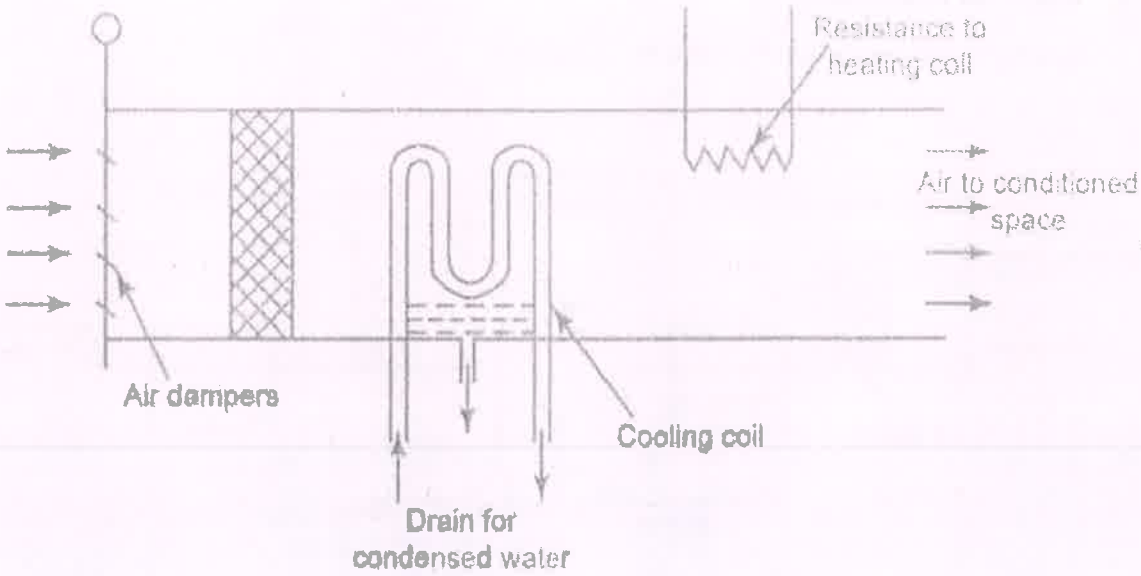
- Sensible heating process
- Sensible cooling process
- Humidification process
- Dehumidification process
- Heating and humidification process
- Cooling and dehumidification process
- Adiabatic mixing air streams process
- Evaporative cooling process.

5.7 Types

1. **Summer air conditioning system for hot and wet weather**

   Air contains more quantity of water vapour than the requirement.

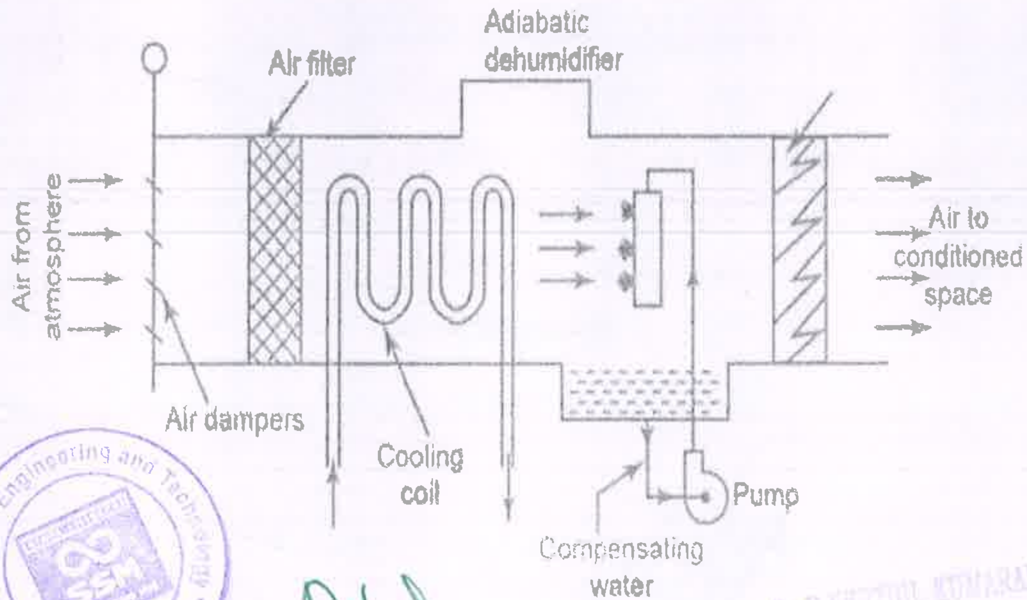
   Cooling and removing of water vapour by dehumidification is required .



2. **Summer air conditioning system for hot and dry weather**

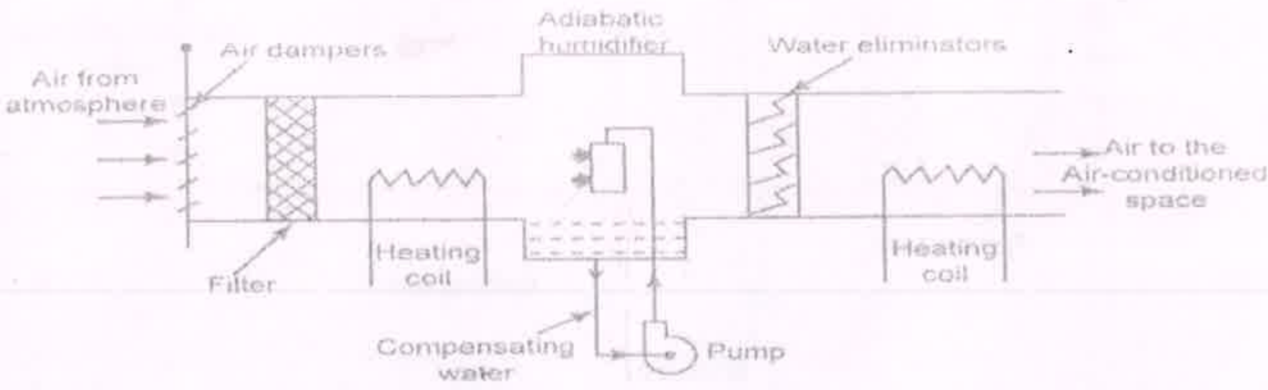
Air at low relative humidity

Cooling and humidification is required



3. Winter air conditioning

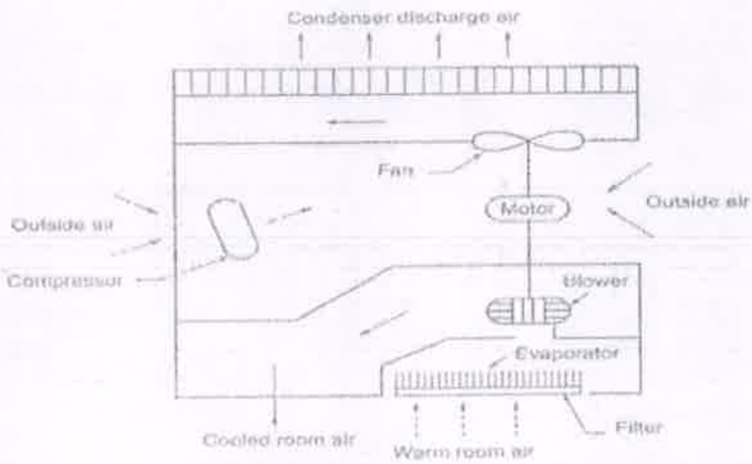
Heating and increasing relative humidity is required.



4. Room air conditioner

Components of the system

1. Refrigeration system
2. Control system
3. Electrical circuit system
4. Air circulation system
5. Exhaust system



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Hands on training on Heat Transfer Equipment

Total points 100/100

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Department of Mechanical Engineering

Value Added Course 2019-2020 Even Semester

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Course Coordinators: Dr.M.Muthukannan and Prof.S.Srinivasan

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1. What is the primary purpose of a heat exchanger? * 5/5

- A)Cooling
- B) Heating
- C) Both A and B
- D) None of the above

2. Which of the following is a type of heat transfer equipment commonly used in industrial applications? * 5/5

- A) Refrigerator
- B) Microwave
- C) Heat Exchanger
- D) Heater

3. In a shell-and-tube heat exchanger, what is the role of the shell? * 5/5

- A) Containing the fluid
- B) Facilitating heat transfer
- C) Insulating the tubes
- D) None of the above

4. What is the function of a condenser in a refrigeration system? * 5/5

- A) Evaporating refrigerant
- B) Cooling compressed refrigerant ✓
- C) Heating the working fluid
- D) None of the above

5. Which of the following materials is commonly used for the tubes in a heat exchanger? * 5/5

- A) Plastic
- B) Copper ✓
- C) Glass
- D) Wood

6.What is the purpose of fins in a heat exchanger? * 5/5

- A) Increasing surface area ✓
- B) Decreasing surface area
- C) Insulating the system
- D) None of the above

✓ 7.What is the unit of heat transfer rate? * 5/5

- (●) A) Watts ✓
- ( ) B) Joules
- ( ) C) BTU
- ( ) D) Kelvin

✓ 8. In which type of heat exchanger do the hot and cold fluids flow parallel to each other? * 5/5

- (●) A) Parallel-flow ✓
- ( ) B) Counterflow
- ( ) C) Crossflow
- ( ) D) None of the above

✓ 9.What is the purpose of a baffle in a shell-and-tube heat exchanger? * 5/5

- (●) A) Enhancing turbulence ✓
- ( ) B) Insulating the system
- ( ) C) Regulating pressure
- ( ) D) None of the above

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✓ 10.Which heat transfer method relies on the movement of fluid due to temperature differences? *5/5

- A) Conduction
- B) Convection ✓
- C) Radiation
- D) Insulation

✓ 11.What is the role of a pump in a liquid-based heat transfer system? * 5/5

- A) Heating
- B) Circulating the fluid ✓
- C) Cooling
- D) Insulating the system

✓ 12.Which material is commonly used as insulation in heat transfer systems? *5/5

- A) Aluminum
- B) Rubber
- C) Fiberglass ✓
- D) Steel

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13.What is the main purpose of a cooling tower in a heat transfer system? *5/5

- A) Heating
- B) Increasing pressure
- C) Cooling hot water
- D) None of the above

14.Which factor affects the thermal conductivity of a material? * 5/5

- A) Color
- B) Density
- C) Viscosity
- D) Sound

15. What is the typical range of Reynolds number for laminar flow? * 5/5

- A) < 2000
- B) 2000-4000
- C) 4000-8000
- D) > 8000

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16.Which law describes the relationship between heat transfer rate, surface area, and temperature difference? *5/5

- A) Boyle's Law
- B) Newton's Law of Cooling
- C) Ohm's Law
- D) Kepler's Law

17.What is the function of a thermostat in a heating system? * 5/5

- A) Controlling temperature
- B) Increasing pressure
- C) Circulating fluid
- D) None of the above

18.Which type of heat exchanger is commonly used in household air conditioning systems? *5/5

- A) Shell-and-tube
- B) Plate
- C) Finned-tube
- D) Double-pipe

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Hands on training on Heat Transfer Equipment

Total points 75/100

MCQ Test for Value Added Course

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Course Name : Hands on training on Heat Transfer Equipments **28.03.2020**
Course Coordinators: Dr.M.Muthukannan and Prof.S.Srinivasan

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3. In a shell-and-tube heat exchanger, what is the role of the shell? * 0/5

- A) Containing the fluid
- B) Facilitating heat transfer
- C) Insulating the tubes
- D) None of the above

Correct answer

- B) Facilitating heat transfer

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× 4. What is the function of a condenser in a refrigeration system? * 0/5

- (●) A) Evaporating refrigerant ×
- ( ) B) Cooling compressed refrigerant
- ( ) C) Heating the working fluid
- ( ) D) None of the above

Correct answer

- (●) B) Cooling compressed refrigerant

× 5. Which of the following materials is commonly used for the tubes in a heat exchanger? * 0/5

- ( ) A) Plastic
- ( ) B) Copper
- (●) C) Glass ×
- ( ) D) Wood

Correct answer

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6.What is the purpose of fins in a heat exchanger? * 5/5

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- B) Decreasing surface area
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7.What is the unit of heat transfer rate? * 5/5

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9.What is the purpose of a baffle in a shell-and-tube heat exchanger? * 0/5

- A) Enhancing turbulence
- B) Insulating the system
- C) Regulating pressure
- D) None of the above

Correct answer

- A) Enhancing turbulence

10.Which heat transfer method relies on the movement of fluid due to temperature differences? * 5/5

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- B) Convection
- C) Radiation
- D) Insulation

11.What is the role of a pump in a liquid-based heat transfer system? * 5/5

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✓ 18.Which type of heat exchanger is commonly used in household air conditioning systems? *5/5

- A) Shell-and-tube
- B) Plate
- C) Finned-tube ✓
- D) Double-pipe

✗ 19.What is the purpose of a safety relief valve in a heat transfer system? * 0/5

- A) Controlling temperature
- B) Preventing overpressure
- C) Enhancing heat transfer ✗
- D) None of the above

Correct answer

- B) Preventing overpressure

✓ 20.Which heat transfer method does not require a medium for energy transfer? *5/5

- A) Conduction
- B) Convection
- C) Radiation ✓
- D) None of the above

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Department of Mechanical Engineering

Value Added Course 2019-2020 Even Semester

Course Name : Hands on training on Heat Transfer Equipments **28.03.2020**

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- ○ C) Insulating the tubes
- ○ D) None of the above

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4. What is the function of a condenser in a refrigeration system? * 0/5

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× 12.Which material is commonly used as insulation in heat transfer systems? *0/5

- A) Aluminum
- B) Rubber ×
- C) Fiberglass
- D) Steel

Correct answer

- C) Fiberglass

Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
Principal
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Kuttathupatti Village Sindalagundu (Po),
Palani Road, Dindigul - 624 002.

SSM Institute of Engineering and Technology DINDIGUL-624 002

✓ 13.What is the main purpose of a cooling tower in a heat transfer system? *5/5

- A) Heating
- B) Increasing pressure
- C) Cooling hot water ✓
- D) None of the above

✓ 14.Which factor affects the thermal conductivity of a material? * 5/5

- A) Color
- B) Density ✓
- C) Viscosity
- D) Sound

✓ 15. What is the typical range of Reynolds number for laminar flow? * 5/5

- A) < 2000 ✓
- B) 2000-4000
- C) 4000-8000
- D) > 8000

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Principal
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- B) Newton's Law of Cooling ✓
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✓ 17.What is the function of a thermostat in a heating system? * 5/5

- A) Controlling temperature ✓
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- D) None of the above

✗ 18.Which type of heat exchanger is commonly used in household air conditioning systems? *0/5

- A) Shell-and-tube ✗
- B) Plate
- C) Finned-tube
- D) Double-pipe

Correct answer

- C) Finned-tube

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SSM Institute of Engineering and Technology
Kuttathupatti Village Sindalagundu (Po),
Palani Road, Dindigul - 624 002.

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- A) Controlling temperature
- B) Preventing overpressure ✓
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- D) None of the above

✗ 20.Which heat transfer method does not require a medium for energy transfer? * 0/5

- A) Conduction
- B) Convection ✗
- C) Radiation
- D) None of the above

Correct answer

- C) Radiation

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Hands on training on Heat Transfer Equipment

Total points 90/100

MCQ Test for Value Added Course

Online Test for Value Added Course in " **Hands on training on Heat Transfer Equipment**"

SSM INSTITUTE OF ENGINEERING AND TECHNOLOGY

Dindigul- Palani Highway, Dindigul – 624 002.

Department of Mechanical Engineering

Value Added Course 2019-2020 Even Semester

Course Name : Hands on training on Heat Transfer Equipments **28.03.2020**

Course Coordinators: Dr.M.Muthukannan and Prof.S.Srinivasan

Name of the Student *

GRACE A

Register Number of the Student *

922117114030

Year & Section *

III & A

SSM Institute of Engineering and Technology, Dindigul

Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
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Palani Road, Dindigul - 624 002

✓ 1. What is the primary purpose of a heat exchanger? * 5/5

- A)Cooling
- B) Heating
- C) Both A and B ✓
- D) None of the above

✓ 2. Which of the following is a type of heat transfer equipment commonly used in industrial applications? * 5/5

- A) Refrigerator
- B) Microwave
- C) Heat Exchanger ✓
- D) Heater

✓ 3. In a shell-and-tube heat exchanger, what is the role of the shell? * 5/5

- A) Containing the fluid
- B) Facilitating heat transfer ✓
- C) Insulating the tubes
- D) None of the above

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Principal
SSM Institute of Engineering and Technology

✕ 4. What is the function of a condenser in a refrigeration system? * 0/5

- (●) A) Evaporating refrigerant ✕
- ( ) B) Cooling compressed refrigerant
- ( ) C) Heating the working fluid
- ( ) D) None of the above

Correct answer

- (●) B) Cooling compressed refrigerant

✓ 5. Which of the following materials is commonly used for the tubes in a heat exchanger? * 5/5

- ( ) A) Plastic
- (●) B) Copper ✓
- ( ) C) Glass
- ( ) D) Wood

✓ 6.What is the purpose of fins in a heat exchanger? * 5/5

- (●) A) Increasing surface area ✓
- ( ) B) Decreasing surface area
- ( ) C) Insulating the system
- ( ) D) None of the above

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Palani Road, Dindigul - 624 002

✓ 7.What is the unit of heat transfer rate? * 5/5

- (●) A) Watts ✓
- ( ) B) Joules
- ( ) C) BTU
- ( ) D) Kelvin

✓ 8. In which type of heat exchanger do the hot and cold fluids flow parallel to each other? * 5/5

- (●) A) Parallel-flow ✓
- ( ) B) Counterflow
- ( ) C) Crossflow
- ( ) D) None of the above

✓ 9.What is the purpose of a baffle in a shell-and-tube heat exchanger? * 5/5

- (●) A) Enhancing turbulence ✓
- ( ) B) Insulating the system
- ( ) C) Regulating pressure
- ( ) D) None of the above

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Dr. D. SENTH...
SSM Institute of En... ...nology
Kuttathupatti Village, ...agnandu (Po),
Palani Road, Dindigul - 624 002.

✓ 10.Which heat transfer method relies on the movement of fluid due to temperature differences? *5/5

- A) Conduction
- B) Convection ✓
- C) Radiation
- D) Insulation

✓ 11.What is the role of a pump in a liquid-based heat transfer system? * 5/5

- A) Heating
- B) Circulating the fluid ✓
- C) Cooling
- D) Insulating the system

✗ 12.Which material is commonly used as insulation in heat transfer systems? *0/5

- A) Aluminum
- B) Rubber ✗
- C) Fiberglass
- D) Steel

Correct answer

- C) Fiberglass

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✓ 14.Which factor affects the thermal conductivity of a material? * 5/5

- A) Color
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- C) Viscosity
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✓ 15. What is the typical range of Reynolds number for laminar flow? * 5/5

- A) < 2000 ✓
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Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
Principal
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- A) Controlling temperature ✓
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- D) None of the above

✓ 18.Which type of heat exchanger is commonly used in household air conditioning systems? *5/5

- A) Shell-and-tube
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- C) Finned-tube ✓
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Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
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SSM Institute of Engineering and Technology
Kuttathupatti Village, Sindalagundu (Po)
Palani Road, Dindigul

✓ 19.What is the purpose of a safety relief valve in a heat transfer system? * 5/5

- A) Controlling temperature
- B) Preventing overpressure ✓
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- D) None of the above

✓ 20.Which heat transfer method does not require a medium for energy transfer? * 5/5

- A) Conduction
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Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
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Palani Road, Dindigul - 624 002.

Hands on training on Heat Transfer Equipment

Total points 85/100

MCQ Test for Value Added Course

Online Test for Value Added Course in " **Hands on training on Heat Transfer Equipment**"

SSM INSTITUTE OF ENGINEERING AND TECHNOLOGY

Dindigul- Palani Highway, Dindigul – 624 002.

Department of Mechanical Engineering

Value Added Course 2019-2020 Even Semester

Course Name : Hands on training on Heat Transfer Equipments **28.03.2020**

Course Coordinators: Dr.M.Muthukannan and Prof.S.Srinivasan

Name of the Student *

HARI HARAN S K (04-10-1999)

Register Number of the Student *

922117114034

Year & Section *

III & A

SSM Institute of Engineering and Technology * DINDIGUL-624 002

Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
Principal
SSM Institute of Engineering and Technology
Kuttathupatti Village, Sindalagundu (Po),
Palani Road, Dindigul - 624 002.

1. What is the primary purpose of a heat exchanger? * 5/5

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- A) Refrigerator
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- A) Containing the fluid
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SSM Institute of Engineering and Technology DINDIGUL-624 002

Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
Principal
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Kuttathupatti Village, Sindalagundu (Po),
Palani Road, Dindigul - 624 002.

4. What is the function of a condenser in a refrigeration system? * 5/5

- A) Evaporating refrigerant
- B) Cooling compressed refrigerant
- C) Heating the working fluid
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5. Which of the following materials is commonly used for the tubes in a heat exchanger? * 5/5

- A) Plastic
- B) Copper
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Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
Principal,
SSM Institute of Engineering and Technology
Kuttathupatti Village, ...
Palani Road, Dindigul...

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Dr.D.SENTHIL KUMARAN. M.E., Ph.D., (NUS)
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Kuttathupatti Village, ...
Palani Road, Dindigul - 624 002.

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Correct answer

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- C) Fiberglass ✓
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Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
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- D) Double-pipe

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Dr.D.SENTHIL KUMARAN. M.E., Ph.D., (NUS)
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SSM INSTITUTE OF ENGINEERING AND TECHNOLOGY

Dindigul- Palani Highway, Dindigul – 624 002.

Department of Mechanical Engineering

Value Added Course (2019-2020) Even Semester

Course Name : Hands on training on Heat Transfer Equipments

Course Coordinators: Dr.M.Muthukannan and Prof.S.Srinivasan

MARKS STATEMENT FOR VALUE ADDED COURSE

S.No	Reg.No	Name of the Student	Marks Scored
1	922117114001	ADITHYAN B	100
2	922117114002	AFZALIBRAHIM M	75
3	922117114003	AKTHARALI S	85
4	922117114004	ANAND ALBERT RAJA A	80
5	922117114005	ANISH ROBERT J	75
6	922117114006	ARULSELVAN K	85
7	922117114007	ARUN KUMAR E	85
8	922117114008	ARUN KUMAR M	90
9	922117114009	ARUN KUMAR B	85
10	922117114010	ARUNKUMAR M	75
11	922117114011	ARUNKUMAR M	85
12	922117114013	BALASUBRAMANIAN G	90
13	922117114014	BHARATHI DASAN A	80
14	922117114016	DANNI CLEMENT S	80
15	922117114017	DEEPAK R	85
16	922117114018	DEEPAK RAJ D	85
17	922117114019	DEEPAKRAJ T	80
18	922117114021	DEVARAJAN A	85
19	922117114022	DHAYALAPRABAKAR S	75
20	922117114023	DINESH S	75
21	922117114024	DINESHKUMAR M	85
22	922117114025	DIVYA DHARSHINI K	90

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SSM Institute of Engineering and Technology
Kuttathupatti Village, Sindalagundu
Palani Road, Dindigul

23	922117114026	ESAKKI DURAI PANDI M	90
24	922117114027	ETHIRAJ YOGESH P	90
25	922117114028	GAJENDREN R	85
26	922117114029	GOUTHAM SANKAR K	90
27	922117114030	GRACE A	90
28	922117114031	GUNAKARAN C	85
29	922117114032	GUNA SEKAR S	85
30	922117114033	HARI HARAN N (01-10-99)	85
31	922117114034	HARI HARAN S K (04-10-1999)	85
32	922117114035	HARIHARAN N (26-11-1999)	75
33	922117114036	HARI HARA SUDHAN G (11-04-2000)	85
34	922117114037	HARI KRISHNAN S (27-09-1999)	85
35	922117114041	JAYAPRATHAP N	80
36	922117114301	ASWATH MAGESH R	80
37	922117114302	BHARATHI K	80
38	922117114304	KARTHIKEYAN P	75

Faculty Incharge **HoD/Mech.Engg** **Principal**

Dr.D.SENTHIL KUMARAN M.E.,Ph.D.,(NUS)
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Palani Road, Dindigul - 624 002.

SSM Institute of Engineering and Technology
DINDIGUL-624 002

Hands on training on Heat Transfer Equipments (III year - A)

40 responses

Register Number of the student

40 responses

922117114002

922117114003

922117114004

922117114005

922117114006

922117114007

922117114008

922117114009

922117114010

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SSM Institute of Engineering and Technology
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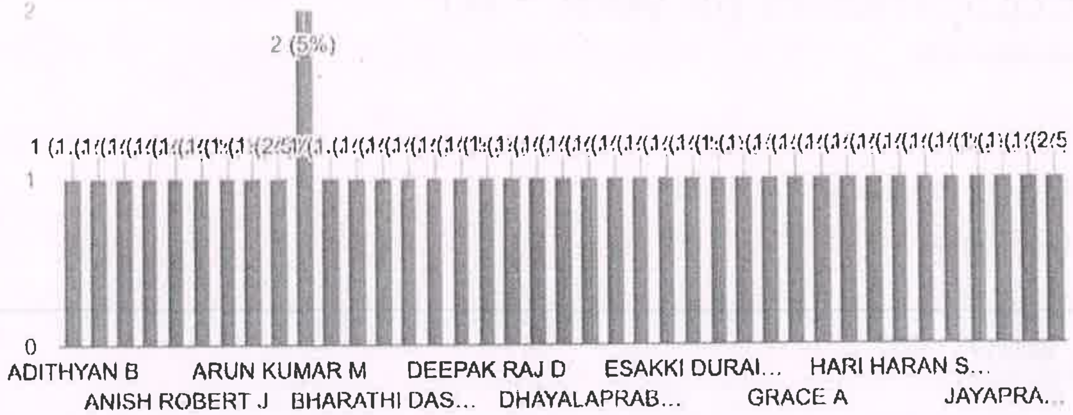
Palani Road, Dindigul - 624 002.

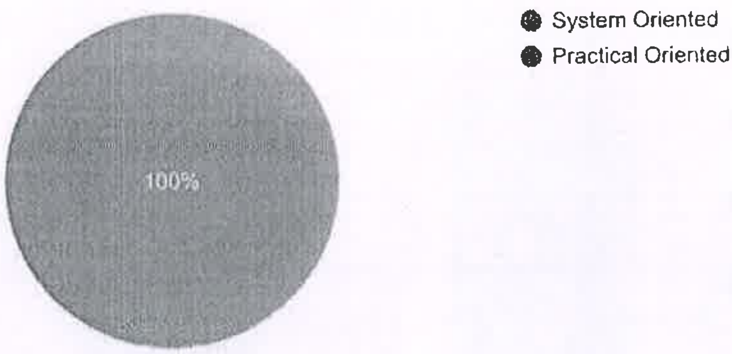
Name of the Student

40 responses



Type of Course

40 responses



Dr.P. SENTHIL KUMARAN, M.E., Ph.D., (NUS)
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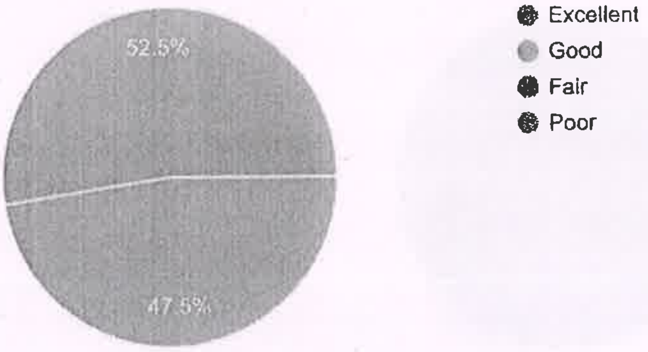
SSM Institute of Engineering and Technology
Kuttathupatti Village, Sindalagundu (Po),
Palani Road, Dindigul - 624 002.

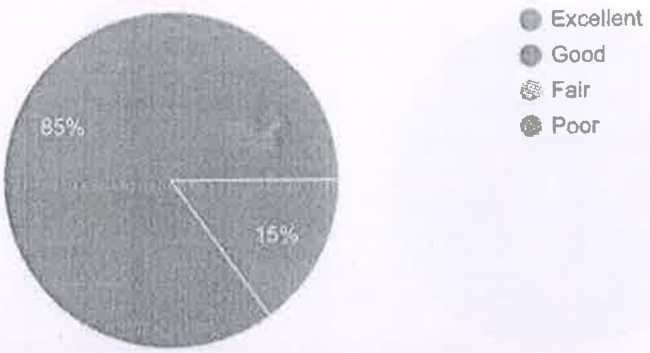
Course Content

40 responses



Level of Preparation

40 responses



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Kuttathupatti Village, Sindalagundu (Po),
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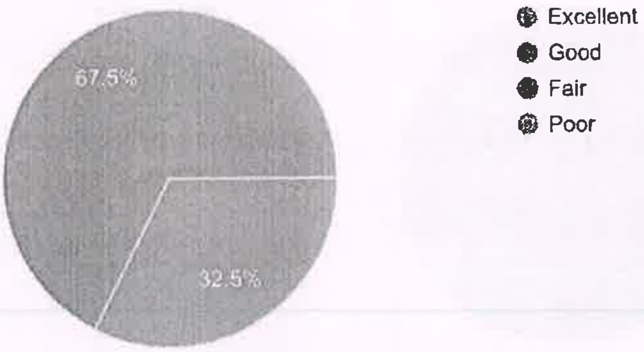
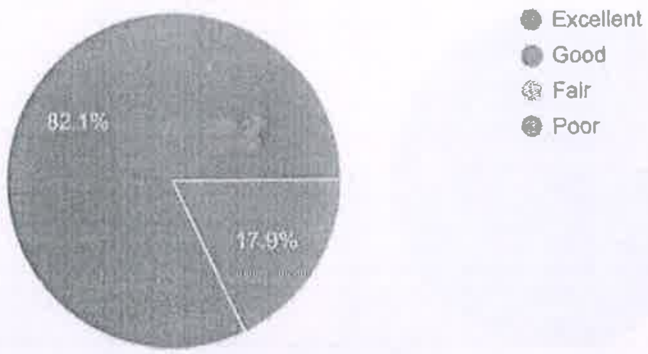
Clarity of Delievery

40 responses



Level of Inetraction with students

39 responses



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SSM Institute of Engineering and Technology
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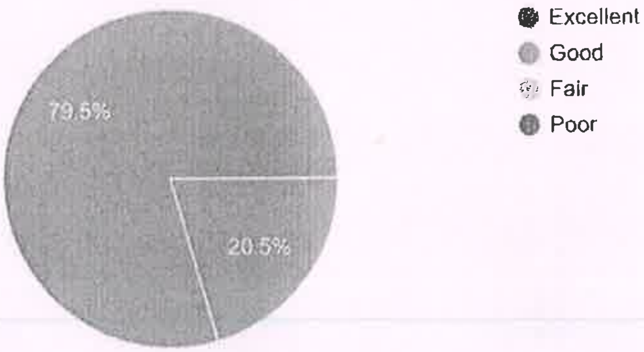
Palani Road, Dindigul - 624 002.

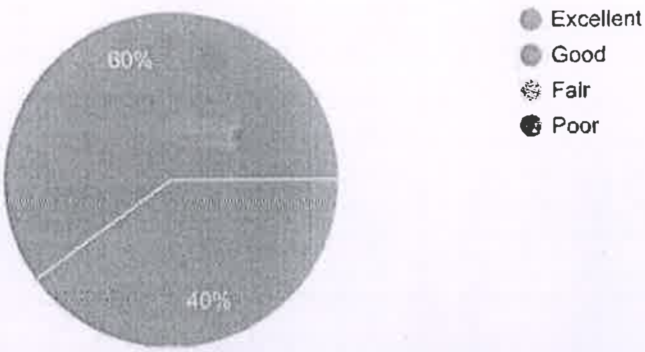
Clarity of Demonstration

39 responses



Quality of Course Material

40 responses



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Kuttathupatti Village, Sindalagundu (Po),
Palani Road, Dindigul - 624 002

SSM INSTITUTE OF ENGINEERING AND TECHNOLOGY

Approved by AICTE, New Delhi | Affiliated to Anna University, Chennai. Accredited by NACC
Dindigul – Palani Highway, Dindigul -624 002

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE COMPLETION CERTIFICATE

This is to certify that

ADHITHYAN B (922117114001)

has completed value added course in "Hands on Training on Heat Transfer Equipment" in the year of 2019-2020 Even Semester

Coordinator(s)	Convener	Principal
Dr.M.Muthukannan	Dr.G.Sankaranarayanan	Dr.D.Senthil Kumaran
Mr.S.Srinivasan	Professor and Head / Mech	SSMIET
ASP / Mech		

E-CERTFICATE DOES NOT REQUIRE SIGNATURE

Made for free with Certify'em

SSM Institute of Engineering and Technology • DINDIGUL-624 002

Dr.D.SENTHIL KUMARAN, M.E., Ph.D., (NUS)
Principal
SSM Institute of Engineering and Technology
[illegible] Village, [illegible] (Po),
[illegible] Road, Dindigul - 624 002.