Government of Karnataka
Department of Technical Education
Board of Technical Examinations, Bangalore

	Course Title: **APPLIED THERMAL ENGINEERING**		
	Scheme (L:T:P) : **4:0:0**	Total Contact Hours: **52**	Course Code: **15ME52T**
	Type of Course: **Lectures, Self Study & Quiz**	Credit **:04**	Core/ Elective: **Core**
CIE- 25 Marks			SEE- 100 Marks

Prerequisites: Knowledge of Engineering Mathematics, Applied Science and Basic Thermal Engineering

Course Objectives:

1. This course will provide the basic knowledge of thermal engineering which will function as foundation in applications in major fields of mechanical engineering and technology notably in steam and nuclear power plants.
2. This course would develop knowledge and skills related to boilers, boiler mountings and accessories, compressors, heat exchangers, steam turbines etc. This course is thus very important for mechanical engineer.

Course Outcomes:

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

Course Outcome		CL	Linked PO	Teaching Hrs
CO1	Determine steam properties and dryness fractions.	***R/U/A***	1,2	**10**
CO2	Classify and explain boilers, boiler mountings and accessories	***R/U/A***	2	**09**
CO3	Identify the elements and processes of steam condensers and cooling towers And working of steam Nozzles	***R/U/A***	1,2	**11**
CO4	Understand the working of steam Turbines	***U/A***	1,2	**10**
CO 5	Operate air compressors and observe the parameters affecting the performance	***R/U/A***	1,2	**06**
CO6	Know the mechanism of refrigeration, and its types and different air conditioning system	***R/U***	2	**06**
		Total sessions		**52**

Legend: R; Remember, U: Understand A: Application An: Analysis

COURSE-PO ATTAINMENT MATRIX

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
APPLIED THERMAL ENGINEERING	**1**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Level 3- Highly Addressed, Level 2-Moderately Addressed, Level 1-Low Addressed.

Method is to relate the level of PO with the number of hours devoted to the COs which address the given PO.

If ≥40% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 3

If 25 to 40% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 2

If 5 to 25% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 1

If < 5% of classroom sessions addressing a particular PO, it is considered that PO is considered not-addressed

COURSE CONTENT AND BLUE PRINT OF MARKS FOR SEE

Unit No	Unit Name	Hour	Questions to be set for SEE/Marks			Marks Weightage	Weightage (%)
			R	U	A		
1	**FORMATION OF STEAM**	10	**5**	**5**	**20**	**30**	**20.69**
2	**STEAM BOILERS**	10	**5**	**10**	**10**	**25**	**17.25**
3	STEAM CONDENSERS, COOLING TOWERS **AND STEAM NOZZELS**	10	**10**	**10**	**10**	**30**	**20.69**
4	**STEAM TURBINES**	10	**-**	**10**	**20**	**30**	**20.69**
5	AIR COMPRESSORS	06	**-**	**5**	**10**	**15**	**10.34**
6	**REFRIGERATION AND AIR CONDITIONING**	06	**5**	**10**	**-**	**15**	**10.34**
	Total	**52**	**25**	**50**	**70**	**145**	**100**

Legend: R; Remember, U: Understand A: Application

UNITI: FORMATION OF STEAM 10 Hrs

Concept of two phase system - Formation of steam- Definition and representation of wet steam, dry steam, saturated steam and superheated steam on T-H Diagram.

Concept and determination of dryness fraction-Degree of superheat-Latent heat-sensible heat, enthalpy-entropy-Internal energy-External work of evaporation and specific volume of steam-Use of Steam tables and Mollier chart- (Heat Entropy Chart).-Numerical examples based on above.

Steam vapour cycles-Carnot cycle- Schematic diagram –Representation on PV & T-S diagram-Rankine cycle-Schematic diagram- Representation on PV & T-S diagram-(No numerical Problems on steam vapour cycles)

Steam Calorimeters- Barrel Calorimeter, Separating Calorimeter, Throttling Calorimeter and combined Separating & Throttling calorimeters.-Limitations of Calorimeter-(No numerical Problems on Calorimeters).

UNIT II: STEAM BOILERS 10 Hrs

Steam boiler-Concept-definition-Indian Boilers Regulation (IBR)- Classification of boiler – function of boiler- Low pressure boilers- Sketch and working of Cochran boiler- Babcock and Wilcox boiler-Merits and demerits- High pressure boilers- Sketch and working of Lamont and Benson boiler- Merits and demerits- Comparison of water tube and fire tube boilers- Boiler mountings and accessories, Boiler draught system-concept and classification -steam jet draught.

UNIT III: STEAM CONDENSERS, COOLING TOWERS & NOZZELS 10Hrs

Introduction-Steam condenser-Concept-Classification-Functions- Jet condensers and surface condensers-working-merits and demerits of surface condensers over jet condensers -Cooling towers- Classification, function and working.

Steam nozzles-concept-Types-Flow of steam through convergent-divergent nozzle-Friction in a nozzle-Discharge of steam through nozzles-Critical pressure ratio (no derivation)-Methods of calculation of cross sectional areas at throat and exit for maximum discharge-Effect of friction in nozzles-Supersaturated flow through nozzle- Numerical on nozzles using Mollier Chart only.

UNIT IV: STEAM TURBINES 10 Hrs

Steam turbine –concept- classification - Working principle with line diagram of a simple De-Laval turbine – velocity diagram of impulse turbine- Expression for work done, axial thrust, tangential thrust, blade and diagram efficiency, nozzle efficiency- Compounding of steam turbine-Need for compounding- Pressure compounding.- Velocity compounding- Pressure velocity compounding. Problems on single stage impulse turbines (graphical method only) – Concept of reaction turbines – Parson's – Delaval (No numerical).

UNIT V: AIR COMPRESSOR 06 Hrs

Air compressor-concepts, functions, classification and applications- Single stage reciprocating air compressor- construction and working (with line diagram) Expression for work done and power required by single stage reciprocating compressor (without derivation), Simple problems on work done and power required.

Multi stage compression – advantages of multistage compression-Rotary Compressors - working of rotary Compressor-Difference between reciprocating and rotary compressors - concept of screw compressor (oil free).

UNIT VI: REFRIGERATION AND AIR CONDITIONING 06 Hrs

Refrigeration - Definition -Unit of refrigeration -Coefficient of performance (COP)-Vapour compression refrigeration with flow diagram-Vapour absorption refrigeration with flow diagram- Refrigerants –Types- Factors affecting the choice of refrigerants- properties of good refrigerants.

Psychrometry- definition-Psychrometric terms - dry air, saturated air, dry bulb temperature-Wet bulb temperature, dew point temperature, relative humidity, absolute humidity, specific humidity.

Air Conditioning- classification-winter Air Conditioning-Summer Air conditioning-Year round air conditioning-

REFERENCES

Sl.No.	Title of Books	Author	Publication
1.	Heat Engines	Pandya and Shah	Charotar Publishing House
2.	Thermodynamics and Heat power Engg.	Mathur and Mehta	Tata Mcgraw- Hill
3	A Text book of Thermal Engineering	R S Khurmi& J K Gupta	S Chand
4.	Thermal Engineering	P.L. Ballaney	Khanna.Publishers
5	Thermal Engineering	A. S. Sarao	SatyaPrakashan
6	Thermal Engineering	R K Rajput	Laxmi.Publications
7	Practical Thermodynamics	G D Rai	Khanna Publisher
8	Thermal Engineering	Mahesh M Rathore	Mcgraw- Hill Education
9	Basic and applied thermodynamics	P K Nag	McGraw Hill education

LIST OF SOFTWARES/ LEARNING WEBSITES:

a. http://www.nptel.iitm.ac.in/video.php?subjectId=112105123 (IIT-B Video lectures)
b. http://www.thermofluids.net/
c. http://www.learnerstv.com/Free-Engineering-Video-lectures-ltv301-Page1.htm
d. http://www.grc.nasa.gov/WWW/k-12/airplane/thermo.html
e. http://www.youtube.com/watch?v=Xb05CaG7TsQ
f. http://www.youtube.com/watch?v=aAfBSJObd6Y
g. http://www.youtube.com/watch?v=DHUwFuHuCdw
h. http://www.youtube.com/watch?v=kJlmRT4E6R0
i. http://www.youtube.com/watch?v=GKqG6n6nAmg

SUGGESTED LIST OF STUDENT ACTIVITYS

Note: the following activities or similar activities for assessing CIE (IA) for 5 marks (Any one)

- Each student should do any one of the following type activity or similar activity related to the course and before take up, get it approved from concerned Teacher and HOD.
- Each student should conduct different activity and no repeating should occur

1	Interpret steam tables, mollier chart and relationship between different thermodynamic properties.
2	Prepare Mollier charts and show different regions.
3	Visit to sugar factory / Dairy / steam power plant, Prepare Hand written Report on specifications of boiler and list of mountings and accessories with their functions, safety measured observed.
2	At least one visit of any power plant/ industry, student should observe the operational aspects, safety in handling boiler, air compressor, heat exchanger, cooling tower, condenser etc. and submit hand written report.
3	Collect/ the details and specifications of various types of Steam condensers/Cooling towers used in industry.
4	Collect/ download product catalogues with specification of various types of Air compressors used in industry.

5	Each student should prepare a detailed report showing the construction/components/Working of Domestic refrigerator or Air Conditioners

SPECIAL INSTRUCTIONAL STRATEGIES

UNIT NO	UNIT NAME	STARATEGIES
1	FORMATION OF STEAM	lectures and Power point presentations/ Video/ Video movies
2	STEAM BOILERS	Lectures/Presentations, Showing charts, Video movies, Expose to real life industries situation, industrial visits
3	STEAM CONDENSERS, COOLING TOWERS AND STEAM NOZZELS	Lectures/Presentations, Showing charts, Video movies, Expose to real life industries situation, industrial visits
4	STEAM TURBINES	Lectures/Presentations, Showing chart, Expose to real life industries situation, industrial visits.
5	AIR COMPRESSORS	Lectures/Presentations, Showing chart,
6	REFRIGERATION AND AIR CONDITIONING	Lectures/Presentations, Showing chart, Expose to real life industries situation, industrial visits

Course Assessment and Evaluation Scheme:

	What		To whom	When/Where (Frequency in the course)	Max Marks	Evidence collected	Course outcomes
Direct Assessment	CIE	IA	Students	Three IA tests (Average of three tests will be computed)	20	Blue books	1,2,3,4,5,6
				Student activities	05	Activities sheets	
	SEE	End Exam		End of the course	100	Answer scripts at BTE	1,2,3,4,5,6
Indirect Assessment	Student Feedback on course		Students	Middle of the course		Feedback forms	1,2,3 Delivery of course
	End of Course Survey			End of the course		Questionnaires	1,2,3,4,5,6 Effectiveness of Delivery of instructions & Assessment Methods

CIE- Continuous Internal Evaluation SEE- Semester End Examination

Note: I.A. test shall be conducted for 20 marks. Average marks of three tests shall be rounded off to the next higher digit.

Note to IA verifier*: *The following documents to be verified by CIE verifier at the end of semester

1. Blue books (20 marks)
2. Student suggested activities report for 5 marks evaluated through appropriate rubrics.
3. Student feedback on course regarding Effectiveness of Delivery of instructions & Assessment Methods

- **MODEL OF RUBRICS /CRITERIA FOR ASSESSING STUDENT ACTIVITY**

RUBRICS MODEL

RUBRICS FOR ACTIVITY(5 Marks)						
Dimension	**Unsatisfactory**	**Developing**	**Satisfactory**	**Good**	**Exemplary**	**Student Score**
	1	**2**	**3**	**4**	**5**	
Collection of data	Does not collect any information relating to the topic	Collects very limited information; some relate to the topic	Collect much information; but very limited relate to the topic	Collects some basic information; most refer to the topic	Collects a great deal of information; all refer to the topic	Ex: 4
Fulfill team's roles & duties	Does not perform any duties assigned to the team role	Performs very little duties but unreliable.	Performs very little duties	Performs nearly all duties	Performs all duties of assigned team roles	5
Shares work equally	Always relies on others to do the work	Rarely does the assigned work; often needs reminding	Usually does the assigned work; rarely needs reminding	Normally does the assigned work	Always does the assigned work without having to be reminded.	3
Listen to other Team mates	Is always talking; never allows anyone else to speak	Usually does most of the talking; rarely allows others to speak	Talks good; but never show interest in listening others	Listens, but sometimes talk too much	Listens and speaks a fair amount	2
Average / Total marks=(4+5+3+2)/4=14/4=3.5=4						

Note: This is only an example. Appropriate rubrics/criteria may be devised by the concerned faculty (Course Coordinator) for assessing the given activity

MODEL QUESTION PAPER (CIE)

Test/Date and Time	Semester/year	Course/Course Code	Max Marks
Ex: I test/6 th week of sem 10-11 Am	VSEM	**APPILED THERMAL ENGG.**	20
	Year: 2016-17	Course code:15ME52T	

Name of Course coordinator : Units:1,2 Co: 1,2

Note: Answer all questions

Question no	Question	MARKS	CL	CO	PO
1	Explain Barrel type Steam Calorimeters with a neat sketch. OR Explain Separating type Steam Calorimeters with a neat sketch	5	U	2	2
2	Make use of the given data find the quantity of heat required to produce 1kg of steam at a pressure of 6 bar at a temperature of 25^0C, under the following conditions. a)When the steam is wet having a dryness fraction 0.9, b)when the steam is dry saturated, c)when it is superheated at a constant pressure at 250^0C assuming the mean specific heat of superheated steam to be 2.3 kJ/kg^{0}K.	5	A	1	2
3	Choose the different system of producing draught in a boiler and mention their advantages and disadvantages	5	A	2	2
4	Explain the various types of draughts used in usual practice. OR Compare the advantages of high pressure boiler over low pressure boiler.	5	U	2	2

MODEL QUESTION PAPER (SEE)

V- Semester Diploma Examination

Course Title: **APPILED THERMAL ENGINEERING**

Time: **3 Hours**] [Max Marks**:** **100**

Note: Answer any **SIX from PartA** and any **SEVEN from Part B**

PART-A 6x5=30 marks

1. List the advantages of superheated steam
2. Explain Barrel type Steam Calorimeters with a neat sketch
3. List the various types of draughts used in usual practice.
4. List the different types of steam - condensers.
5. List the function of cooling tower in a modem condensing plant
6. Explain the Working of simple De-Laval turbine with line diagram
7. Summarise the advantages and disadvantages of velocity compounded impulse turbines.
8. List the desirable properties of a secondary refrigerant.
9. Explain Single stage reciprocating air compressor with line diagram

PART-B 7x10=70 marks

1. Steam at 18 bar and dryness 0.9 is heated at constant pressure until dry and saturated. Find the increase in volume, heat supplied and work done per kg of steam. If the volume is now kept constant, find how much heat must be extracted to reduce the pressure to 14 bar.
2. Make use of the steam table,find the following : (i) Enthalpy and volume of 1 kg of steam at 12. 1 bar and dryness fraction 0.9, and (ii) Enthalpy and volume of 1 kg of steam at 12. 1 bar and 225'C. Take the specific heat at constant pressure for superheated steam as 2.1 kJ/kg K.
3. i) Compare high pressure boiler and low pressure boiler
   ii) Explain the function of the safety valve
4. Outline the sketch and explain the working of a La-mount boiler
5. Outline the sketch and explain counter-flow low level jet condenser and list the advantages.
6. A convergent-divergent nozzle is required to discharge 2 kg of steam per second. The nozzle is supplied with steam at 7 bar and 180^0C and discharge takes place against the back pressure of 1 bar. The expansion up to throat is isentropic and the frictional resistance between throat and exit is equivalent to 63 kJ/kg of steam. The approach velocity to the nozzle is 75 m/s and throat pressure is 4 bar. Estimate (a) Suitable areas of throat and exit, (b) Overall efficiency of the nozzle based on enthalpy drop between inlet pressure, temperature and exit pressure.
7. An impulse turbine with a single row wheel is to develop 99.3 kW, the blade speed being 150 m/sec. A mass of 2 kg of steam per second is to flow from the nozzles at a speed of 350 m/sec. The velocity coefficient of the blades may be assumed to be 0.8 while the steam is to flow axially after passing through the blades ring. Determine the

nozzle angle, and the blade angles at inlet and exit assuming no shock. Estimate also the diagram efficiency of the blading.

8. The steam leaves the nozzle of a single-stage impulse wheel turbine at 900 m/sec. The nozzle angle is 20°, the blade angles are 30° at inlet and outlet, and friction factor is 0.8. Calculate : (a) the blade velocity, and (b) the steam flow in kg per hour if the power developed by the turbine is 257'kW.

9. a) Explain winter Air Conditioning with neat sketch.
   b) Explain Summer Air conditioning with neat sketch

10. It is desired to compress 17m^3 of air per minute from 1 bar (100 kN/m2) and 21'C to a delivery pressure of 7 bar (700 kN/m^2) in a single-stage, single-acting air compressor. Calculate the power required to drive the compressor and the heat rejected duhng compression to cooling water if the compression is (a) Isentropic (y = 1.4 for air), and (b) Isothermal.

MODEL QUESTION BANK

Diploma in Mechanical Engineering

V Semester

Course title: APPILED THERMAL ENGINEERING

Note: ***The paper setter is of liberty to set the questions on his/her desecration based on cognitive levels notified for that unit. They has to follow only blue print of SEE question paper format. The model question bank is only for reference to students/course coordinator to initiate the process of teaching-learning only.***

CO-1: Determine steam properties and dryness fractions.

REMEMBER

1. What is meant by saturation temperature and saturation pressure?
2. Define the following terms : (i) Saturated steam, (ii) Dry saturated steam, (Hi) Wet steam, (iv) superheated steam, (v) Dryness fraction of steam, (vi) Specific volume of steam, and (vii) Saturated water.
3. List the advantages of superheated steam
4. Define Internal energy of steam.

UNDERSTAND

1. Explain the process of formation of steam at a constant pressure from water.
2. Explain how the wet steam, dry saturated steam and superheated steam is produced.
3. Explain T-H diagram during steam formation.
4. Explain steam tables and their uses.
5. Explain Carnot cycle with Sketch
6. Explain with sketch Rankine cycle
7. Explain Barrel type Steam Calorimeters with a neat sketch.
8. Explain Separating type Steam Calorimeters with a neat sketch
9. Explain Throttling type Steam Calorimeters with a neat sketch
10. Explain combined Separating & Throttling type Steam Calorimeters with a neat sketch
11. Compare enthalpy and internal energy of steam
12. Outline the Limitations of Calorimeter.
13. Explain the following terms : (i) Saturated steam, (ii) Dry saturated steam, (Hi) Wet steam, (iv) superheated steam, (v) Dryness fraction of steam, (vi) Specific volume of steam, and (vii) Saturated water.
14. Explain the following terms as referred to steam : (i) Enthalpy of water, (ii) Enthalpy of evaporation, (iii) Superheat, (iv) Specific volume, and (v) Enthalpy of dry saturated steam.
15. Compare saturated steam and dry saturated steam.

APPLICATION

1. Make use of the given data find the quantity of heat required to produce 1kg of steam at a pressure of 6 bar at a temperature of 25^0C, under the following conditions.
   a)When the steam is wet having a dryness fraction 0.9, b)when the steam is dry saturated, c)when it is superheated at a constant pressure at 250^0C assuming the mean specific heat of superheated steam to be 2.3 kJ/kg^{0}K.
2. Steam enters an engine at a pressure of 12bar with 67^0C of superheat. It is exhausted at a pressure of 0.15bar and 0.95dry. Find the drop in enthalpy of steam.

3. Make use of the given data find the internal energy of 1kg of superheated steam at a pressure of 10bar and 280^0C.
   If this steam be expanded to a pressure of 1.6bar and 0.8dry, determine the change in internal energy. Assume specific heat of superheated steam as 2.3 kJ/kg^{0}K.
4. A vessel contains 20kg of steam at a pressure of 8 bar. Find the amount of heat, which must be rejected, so as to reduce the quality of steam in the vessel to be 70%.
5. Steam at 18 bar and dryness 0.9 is heated at constant pressure until dry and saturated. Find the increase in volume, heat supplied and work done per kg of steam. If the volume is now kept constant, Analyze how much heat must be extracted to reduce the pressure to 14 bar.
6. Analyze how much heat is needed to convert 5 kg of water at 40'C into 90 per cent dry (or 10 per cent wet) steam at 5 bar (500 kPa) ? Take specific heat of water as 4. 187 kJ/kg K.
7. Analyze how much heat is needed to convert 4 kg of water at 20'C into steam at 8 bar (800 kPa) and 200'C. Take kp of superheated steam as 2.1 kJ/kg K and specific heat of water as 4.187 kJ/kg K.
8. Make use of the given data ,Find the volume of one kilogram of steam at a pressure of 15 bar (15 MPa) in each of the following cases : (i) when steam is dry saturated, (ii) when steam is wet having dryness fraction of 0.9, and (iii) when steam is superheated, the degree of superheat being 40'C.
9. Analyze the condition of steam in each of the following cases : (i) at a pressure of 10 bar and temperature 200'C, (ii) at a pressure of 8 bar and volume 0.22 m /kg, and (iii) at a pressure of 12 bar, if 2,688 kJ/kg are required to produce it from water at 0 'C.
10. Utilize steam table,and find (i) Enthalpy and volume of 1 kg of steam at 12. 1 bar and dryness fraction 0.9, and (ii) Enthalpy and volume of 1 kg of steam at 12. 1 bar and 225'C. Take the specific heat at constant pressure for superheated steam as 2.1 kJ/kg K.
11. Wet steam of mass 25 kg and occupying a volume of 0.49 m at 75 bar has a total heat (enthalpy) increase of 1,500 kJ when superheated at constant pressure. Determine : (i) Initial quality of steam, (ii) Final quality (degree of superheat) of steam, and (HI) Increase in volume of steam after superheating. Assume kp for the superheated steam to be 2-1 kJ/kg K.
12. Steam enters a steam engine at a pressure of 12 bar with 67'C of superheat and is exhausted at 0.15 bar and 094 dry. Calculate the drop in enthalpy from admission to exhaust, and volume of 1 kg of steam at admission and exhaust conditions. Take kp of superheated steam as 2.1 kJ/kg K.
13. Make use of the given data, find the external work done during evaporation, internal latent enthalpy and internal energy per kg of steam at a pressure of 15 bar (1,500 kPa) when the steam is (i) 09 dry, and (ii) dcy saturated.
14. 0.025 m3 of steam at 3.5 bar and dryness fraction 08 is converted into dry saturated steam at 11 bar. By how much are the enthalpy and internal energy changed ?
15. The internal energy of 1 kg of steam at a pressure of 14 bar (1.4 MPa) is 2,420 kJ. Calculate the dryness fraction of this steam. Find the increase in internal energy if this steam is superheated at constant pressure to a temperature of 295'C. Take kp of superheated steam as 2.3 kJ/kg K.
16. Inspect at what fraction of enthalpy of 1 kg of steam at 10 bar and 0.9 dry represents the internal energy ? What is the change in internal energy when the pressure and temperature of this steam is raised to 13 bar and 250'C ? Take kp of superheated steam as 2.1 kJ/kg K.

CO-2: Classify and explain boilers, boiler mountings and accessories

REMEMBERING

1. Define steam boiler and list its function.
2. List the types of boilers according to various factors
3. List the advantages of a Lancashire boiler
4. List the advantages of Cochran boilers
5. List the advantages and disadvantages of a locomotive boiler.
6. List the advantages and disadvantages of water-tube boilers.
7. List the advantages of water-tube boilers over fire-tube boilers and tank boilers.
8. List the boiler mountings.
9. List the different mountings and accessories with which the Babcock and Wilcox water-tube boiler is fitted
10. List the various types of draughts used in usual practice.

UNDERSTANDING

1. Explain the following terms used in boiler practice : (a) Boiler shell, (b) Fire grate, (c) Furnace, (f) Mountings, (g) Blowing-off
2. Expline the method of obtaining draught in the boiler.
3. Compare ‘water-tube’ and Fire-tube' boilers.
4. Explain the function of the safety valve .
5. Explain the function of the Fusible plug.
6. Outline the neat sketch of the Babcock and Wilcox water tube boiler.
7. Compare Natural draught and artificial draught.
8. Compare Forced draught and induced draught.
9. Compare how an artificial draught is considered advantageous over a natural draught
10. Explain the terms mechanical draught and balanced draught.
11. Explain the working principle of the steam jet draught.
12. Compare the advantages of high pressure boiler over low pressure boiler.
13. Compare high pressure boiler and low pressure boiler.

APPLICATION

1. Construct neat sketch and explain the Lancashire boiler.
2. Construct neat sketch and explain the Co-chran boiler
3. Construct neat sketch and explain the locomotive boiler.
4. Choose the different system of producing draught in a boiler and mention their advantages and disadvantages.
5. Construct neat sketch and explain the La-mount boiler.
6. Construct neat sketch and explain the working of a Benson boiler

CO-3: identify the elements and processes of steam condensers and cooling towers and working of steam nozzles.

REMEMBERING

1. List the function of a condenser in a modem steam condensing power plant.
2. list the different types of steam - condensers.
3. List the function of cooling tower in a modem condensing plant.
4. Define the term 'Nozzle efficiency.

UNDERSTANDING

1. Outline the Sketch and explain the working of Surface Condenser
2. Outline the Sketch and explain the working of Jet Condenser
3. Construct neat sketch of a barometric jet condenser and explain its working
4. Compare the merits and demerits of surface condensers over jet condensers
5. Construct neat sketch of a counter-flow low level jet condenser and explain its working.
6. Construct neat sketch and explain the operation of an evaporative condenser
7. Construct neat sketch and explain the working of any one type of cooling tower.
8. Explain the function of a steam nozzle. Explain the types of nozzles with sketch.
9. Explain the term critical pressure as applied to steam nozzles.
10. Explain the term "critical pressure" as applied to steam nozzles. Why are the turbine nozzles made divergent after the throat.
11. Explain he causes of supersaturated flow in nozzles.
12. Explain the supersaturated expansion of steam and give some idea of the limits within which this condition is possible.
13. Explain the Types of steam nozzles with neat sketches
14. Explain the Effect of friction on the flow of steam through convergent-divergent steam nozzles.
15. Explain the Effect of supersaturated flow in steam nozzles.

APPLICATION

1. A nozzle is to be designed to expand steam at the rate of 0.10kg/s from 500kpa, 210^0C to 100kpa. Neglect inlet velocity of steam. For a nozzle efficiency of 0.9, determine the exit area of the nozzle.
2. Steam enters a convergent – divergent nozzle at 2 MPa and 400^0C with a negligible velocity and mass flow rate of 2.5 kg/s and it exists at a pressure of 300 kPa. The flow is isentropic between the nozzle entrance and throat and overall nozzle efficiency is 93 percent. Determine (a) throat, and (b) exit areas.
3. In a convergent-divergent nozzle, the steam enters at 15 bar and 300^0C and leaves at a pressure of 2 bar. The inlet velocity to the nozzle is 150 m/s. Find the required throat and exit areas for mass-flow rate of 1 kg/s. Assume nozzle efficiency to be 90 percent and C_{ps}= 2.4 kJ/kgK
4. Determine the throat and exit diameters of a convergent-divergent nozzle, which will discharge 820 kg of steam per hour at a pressure of 8 bar superheated to 220 ^{0}C into a chamber having a pressure of 1.5 bar. The friction loss in the divergent portion of the nozzle may be taken as 0.15 of the isentropic enthalpy drop.
5. A convergent-divergent nozzle is required to discharge 2 kg of steam per second. The nozzle is supplied with steam at 7 bar and 180^0C and discharge takes place against the back pressure of 1 bar. The expansion up to throat is isentropic and the frictional

resistance between throat and exit is equivalent to 63 kJ/kg of steam. The approach velocity to the nozzle is 75 m/s and throat pressure is 4 bar. Estimate (a) Suitable areas of throat and exit, (b) Overall efficiency of the nozzle based on enthalpy drop between inlet pressure, temperature and exit pressure.

6. A turbine having a set of 16 nozzles receives steam at 20 bar and 400 ^{0}C. The pressure of steam at the nozzle exit is 12 bar. If the discharge rate is 260 kg/min and the nozzle efficiency is 90 %, calculate the cross-sectional area at the nozzle exit. If the steam has a velocity of 80 m/s at entry to the nozzle, find the percentage increase in discharge.
7. The steam is supplied to a nozzle at a rate of 1 kg/s from an inlet condition of 10 bar, dry saturated and exit at 1 bar pressure. The efficiency of the nozzle for the convergent portion is 95 percent and that of the divergent portion is 90 percent. Determine (a) throat and exit diameters of nozzle (b) length of nozzle, if divergent cone angle of the nozzle is 14^0. (c) The power in kW correspondence to exit velocity of the steam
8. A convergent-divergent nozzle is required to discharge 350 kg of steam per hour. The nozzle is supplied with steam at 8.5 bar and 90% dry and discharges against a back pressure of 0.4 bar. Neglecting the effect of friction, find the throat and exit diameters.

CO-4: Understand the working of steam Turbines

UNDERSTANDING

1. Compare Impulse and reaction turbines.
2. Explain the principle of working of impulse turbine.
3. Explain the Working of simple De-Laval turbine with line diagram
4. Outline the velocity diagram of a impulse turbine blades.
5. Explain the need for compounding.
6. Explain Blade efficiency and diagram efficiency.
7. Explain why steam turbines are compounded
8. Explain the Pressure compounding with diagrams
9. Explain the Velocity compounding with diagrams
10. Explain the Pressure-Velocity compounding with diagrams.
11. Explain the working of an Impulse reaction turbine.
12. Summarise the advantages and disadvantages of velocity compounded impulse turbines.
13. Explain Parson's reaction turbine.

APPLICATION

1. Steam issues from the nozzle of a simple impulse turbine with a velocity of 900 m/sec. The nozzle angle is 20°, the mean diameter of the blades is 25 cm and the speed of rotation is 20,000 r.p.m. m The mass flow through the turbine nozzles and blading is 0.18 kg of steam per sec. Draw the velocity diagram and derive or calculate the following : (a) Tangential force on blades, (b) Axial force on blades, (c) Power developed by the turbine wheel, (d) Efficiency of the blading, and (e) Inlet angles of

2. The rotor of an impulse turbine is 60 cm diameter and runs at 9,600 r.p.m. The nozzles are at 20° to the plane, of the wheel, and the steam leaves them at 600 m/sec. The blades outlet angle are 30° and the friction factor is 0.8. Calculate the power developed per kg of steam per second and the diagram efficiency.

3. An impulse turbine with a single row wheel is to develop 99.3 kW, the blade speed being 150 m/sec. A mass of 2 kg of steam per second is to flow from the nozzles at a speed of 350 m/sec. The velocity coefficient of the blades may be assumed to be 0.8 while the steam is to flow axially after passing through the blades ring. Determine the nozzle angle, and the blade angles at inlet and exit assuming no shock. Estimate also the diagram efficiency of the blading.

4. The steam leaves the nozzle of a single-stage impulse wheel turbine at 900 m/sec. The nozzle angle is 20°, the blade angles are 30° at inlet and outlet, and friction factor is 0.8. Calculate : (a) the blade velocity, and (b) the steam flow in kg per hour if the power developed by the turbine is 257'kW.

5. The outlet area of the nozzles in a simple impulse turbine is 15-5 err? and the steam leaves them 0.91 dry at 1.4 bar and at 920 m/sec. The blade angles are 30° at inlet and exit, and the blade velocity is 0.25 of the steam velocity at the exit from the nozzle. The friction factor is 0.8. Find : (a) the nozzle angle, (b) the power developed, (c) the diagram efficiency, and (d) the axial thrust on the blading.

6. A single stage impulse rotor has a blade ring diameter of 57.5 cm and rotates at a speed of 10,000 r.p.m. The nozzles are inclined at 20^0 to the direction of motion of the blades and the velocity of the issuing steam is 1050 m/sec. Determine the inlet blade angle in order that the steam shall enter the blades passage without shock. Assume a friction coefficient of the blading equal to 0.85 and that the inlet and outlet angles are equal. Find also: (a) the power developed at the blades for a steam supply of 1,350 kg per hour, (b) the diagram efficiency, and (c) the loss of kinetic energy due to blade friction.

CO5: Operate air compressors and observe the parameters affecting the performance

REMEMBERING

1. List the types of air compressors.
2. List the applications of the air compressor.
3. List the advantages of multi stage reciprocating air compressor.

UNDERSTANDING

1. Explain the uses of compressed air.
2. Classify the air compressor.
3. Explain Single stage reciprocating air compressor with line diagram.
4. Explain multi stage compression with line diagram.
5. Compare Reciprocating compressor with Rotary compressors.
6. Explain with Sketch the operation of a single-stage centrifugal compressor
7. Explain with Sketch the operation of a Screw compressor(oil free).

APPLICATION

1. A single-cylinder, single-acting reciprocating air compressor has a cylinder of 24 cm diameter and linear piston speed of 100 metres per minute. It takes in air at 100 kPa (100 kN/m2) and delivers at 1 MPa (1 MN/rrP), Determine the indicated power of the

compressor. Assume the law of compression to be $pv^{1.25}$ = constant ture of air at inlet is 288 K. Neglect clearance effect.

2. A single-acting, single-stage air compressor developing indicated power of 11 kW, runs at 200 r.p.m. and has a linear piston speed of 100 metres per min. If the suction pressure and temperature are 100 kPa and 15‘C respectively and delivery pressure is 1,000 kPa, calculate the dimensions of the compressor cylinder. Assume the law of compression to be $pv^{1.25}$ = constant. Neglect clearance effects.
3. A single-acting, single-stage air compressor is belt driven from an electric motor at 300 r.p.m. The cylinder diameter is 20 cm and the stroke is 24 cm. The air is compressed from one atmosphere to 8 atmospheres and the law of compression is $pv^{1.25}$ = constant. Find the power of the electric motor if the transmission efficiency is 96 per cent and the mechanical efficiency of the compressor is 85 per cent Neglect clearance effect.
4. It is desired to compress 17m^3 of air per minute from 1 bar (100 kN/m2) and 21'C to a delivery pressure of 7 bar (700 kN/m^2) in a single-stage, single-acting air compressor. Calculate the power required to drive the compressor and the heat rejected duhng compression to cooling water if the compression is (a) Isentropic (y = 1.4 for air), and (b) Isothermal.

CO6: Know the mechanism of refrigeration, and its types and different air conditioning system

REMEMBER

1. Define Refrigeration, Refrigerating effect, Tonne of refrigeration and COP.
2. Name the common refrigerants in use.
3. List the desirable properties of a secondary refrigerant.
4. Define Air Conditioning and list the types of air conditioning.
5. Define: Dry air, Saturated air, Dry bulb temperature, Wet bulb temperature, Dew point temperature, Relative humidity, Absolute humidity, Specific humidity.

UNDERSTANDING

1. Explain Vapour compression refrigeration with flow diagram.
2. Explain Vapour absorption refrigeration with flow diagram.
3. Explain the factors affecting the choice of refrigerants commonly used in refrigerating machines.
4. Explain winter Air Conditioning with neat sketch.
5. Explain Summer Air conditioning with neat sketch.
6. Explain Year round air conditioning with neat sketch.