Refrigeration and Air Conditioning - Video course

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Mechanical Engineering

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MODULE 1: Introduction

1st Lecture

Definition of Refrigeration and Air Conditioning
History of Refrigeration and Air conditioning
History from conceptual point of view:

- Ice production by nocturnal cooling in ancient India and application of evaporative cooling in India. Use of natural ice, ice houses and ice trade.
- Vapour Compression Refrigeration Systems
- Vapour Absorption Refrigeration Systems
- Air Cycle Refrigeration Systems
- Miscellaneous Systems (Vapour Jet Refrigeration Systems, Thermoelectric systems, Vortex tube systems, Intermittent-Solar Refrigeration Systems, Combined Cycles)

2nd Lecture

History from Refrigerant development Point of View
- Early refrigerants (SO_2, CO_2, CH_3Cl, CH_4, C_2H_6 etc)
- Introduction of CFCs and HCFCs
- Ozone layer depletion
- HFCs, HCs, NH_3, CO_2, H_2O etc.

History from compressor development point of view
- Low-speed steam engine driven compressors
- High-speed electric motor driven compressors
- Rotary vane compressors
- Centrifugal compressors
- Screw compressors
- Scroll compressors

History of Air Conditioning

MODULE 2: Applications

3rd Lecture

Applications of Refrigeration and Air Conditioning

a) Comfort Air Conditioning
- Residential air conditioning
- Commercial air conditioning
- Industrial air conditioning

b) Industrial Refrigeration
- Chemical and process industries
- Dairy plants
- Petroleum refineries

c) Food processing and food chain
b) Miscellanous

MODULE 3: Methods of producing low temperatures

4th Lecture

Applications of Refrigeration and Air Conditioning

- Using enthalpy of mixing (mixing of salt with water)
- Expansion in a turbine
- Throttling
- Thermoelectric effects
- Adiabatic demagnetization

MODULE 4: Review of Fundamentals

5th Lecture

a) Thermodynamics:
- 1st law of thermodynamics for open and closed systems
- 2nd law of thermodynamics, Kelvin-Planck and Clausius statements, and Clausius inequality. 3rd law of thermodynamics.
- Heat Engines, Heat Pumps and Refrigeration Systems, Maximum COP
- Thermodynamic properties
- Thermodynamic processes
- T-s and p-h diagrams

6th Lecture

a) Fluid Mechanics:
- Continuity and Momentum equations
- Bernoulli's equation and friction factor

b) Heat Transfer:
- Modes of heat transfer
- Concept of thermal resistance and overall heat transfer coefficient
- Radiative heat transfer coefficient
- Forced Convection, Free Convection, Boiling and Condensation heat transfer coefficients

MODULE 5: Air Cycle Refrigeration Systems

7th Lecture

- Reverse Carnot Cycle and its limitations
- Bell Coleman, Joule or Reverse Brayton Cycle
- Aircraft refrigeration cycles
- Joule Thompson coefficient and Inversion Temperature
- Linde, Claude and Stirling cycles for liquefaction of air.

MODULE 6: Vapour Compression Refrigeration Systems

8th Lecture

- Comparison of Vapour Compression Cycle and Gas cycle
- Ideal refrigeration cycle – Reversed Carnot cycle and maximum COP
- Deviations of practical cycles from Carnot cycle
- Standard vapour compression refrigeration cycle (SSS cycle), Superheat horn and throttling loss for various refrigerants, efficiency

9th Lecture

- Modifications to standard cycle – liquid-suction heat exchangers
- Grindlay cycle and Lorenz cycle
- Optimum suction condition for optimum COP – Ewing's construction and Gosney's method.
- Actual cycles with pressure drops and heat transfer
- Complete Vapour Compression Refrigeration System

10th Lecture

- Multipressure, multistage systems, optimum intermediate pressure
- Two stage ammonia and halocarbon systems

11th Lecture

- Multi-evaporator systems
- Cascade systems, optimum intermediate temperature
- Manufacture of dry ice and supercritical CO2 cycle
- Autocascade cycle

MODULE 7: Vapour Absorption Refrigeration Systems

12th Lecture

- Working principle
- Maximum COP of the ideal VARS
- Properties of Mixtures
- Simple absorption refrigeration system

13th Lecture

Lithium bromide-Water Absorption Refrigeration Systems

- Operating principles and applications
- Refrigerant-absorbent properties using tables and charts
- Performance evaluation and methods of improvement
- Practical problems – crystallization and air leakage
- Commercial systems – Single and multistage systems

14th Lecture

Aqua – Ammonia Refrigeration System

- Operating principles and applications
- Refrigerant-absorbent properties using tables and charts
- Practical problems and Principle of Rectification

15th Lecture

Aqua-ammonia Absorption Refrigeration Systems

- Analysis of Generator- Exhausting Column and Rectification column
  -Dephelgmator
- Three fluid system
- Solar energy based adsorption refrigeration systems

MODULE 8: Refrigeration system components

16th Lecture

Compressors
Reciprocating Compressors

- Constructional details – open , hermetic and semi-sealed compressors
- Performance of the ideal compressor
- Clearance volumetric efficiency Effects of evaporator and condenser pressures
- Actual volumetric efficiency
  Effects of cylinder cooling, heating and friction
  Empircial equations for actual volumetric efficiency

17th Lecture

Reciprocating Compressors (contd)

- Power requirements of ideal and actual compressors
  optimum work for given condenser and evaporator pressures, mean effective pressure,
  pull down characteristics
- Compressor discharge temperatures and need for cooling
- Capacity control

18th Lecture

Centrifugal Compressors
Basic principle of dynamic compressor

- Velocity diagrams
- Efficiency considerations
- Construction details, applications and performance characteristics
- Comparison with reciprocating compressors

19th Lecture

Screw compressors

- Basic principles- single screw and double screw compressors.
- Working principle, work requirement and performance characteristics
- Comparison with reciprocating and centrifugal compressors
- Rotary- single vane and multi-vane compressor

20th Lecture

Condensers

- Classification based on type of construction, flow direction etc.
- Condensing capacity and Heat Rejection Ratio
- Correlations for condensing heat transfer coefficients
- Thermal design of condensers
- Effects of fouling and noncondensible gases on performance

21st Lecture

Evaporators

- Classification based on type of construction, flow direction etc.
- Correlations for boiling heat transfer coefficients for various configurations
- Design and performance aspects
- Effects of pressure drops and frost formation

Use of Wilson's plots

22nd Lecture

Expansion devices

Capillary tubes

- Applications, operating characteristics and selection

Thermostatic expansion valves

- Applications and operating characteristics
- Internal vs external equalizers
- Cross charging, gas charging, liquid charging and fade out point

Automatic expansion valves

Float valves – Low side and high side float valves

Electronic expansion valves

MODULE 9: Refrigerants

23rd Lecture

- Primary and secondary refrigerants
- Designation of Refrigerants.
- Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues
- Thermodynamic properties of refrigerants
- Synthetic and natural refrigerants
- Comparison between different refrigerants vis a vis applications
- Special issues and practical implications
- Refrigerant mixtures – zeotropic and azeotropic mixtures

MODULE 10: Properties of moist air (psychrometry)

24th Lecture

- Composition of moist air
- Methods for estimating moist air properties

• Important psychrometric properties
o Dry bulb temperature
o Humidity ratio
o Relative humidity
o Degree of saturation
o Dew point temperature
o Enthalpy

25th Lecture

Psychrometry (contd.)
o Adiabatic saturation
o Thermodynamic wet bulb temperature and wet bulb thermometer
Relations between psychrometric properties
Introduction to humidity ratio vs. dry-bulb temperature psychrometric chart and ASHRAE chart.Use of psychrometric charts and moist air tables, Goff and Gratch tables

MODULE 11: Psychrometric Processes

26th Lecture

• Sensible cooling and heating, RSH
• Humidification and dehumidification, RLH
• Combined heat and mass transfer processes, RTH, RSHF,
o Straight line law – coil bypass factor and ADP
o Cooling and dehumidification
o Heating and humidification
o Psychrometric calculations for simple airconditioning system and for
return air systems with bypass factor. RSHF, GSHF and ESHF

27th Lecture

Psychrometric processes (contd.)
o Cooling and humidification (evaporative cooling)
o Adiabatic mixing
o Spray washers and cooling towers

MODULE 12: Air conditioning systems for comfort

28th Lecture

• Thermal comfort. Heat transfer from human body by sensible and latent heat transfer. Metabolic heat generation, steady state and unsteady state model for heat transfer, effect of clothing and definition of effective temperatures. PMV and PPD. ASHRAE comfort chart.
• Inside and Outside design conditions
• Summer air conditioning systems
• Winter air conditioning systems
• All year air conditioning systems

MODULE 13: Infiltration and IAQ

29th Lecture

Infiltration
o Infiltration and ventilation
o Infiltration due to stack effect, temperature difference and wind velocity
o Air change and crack length methods for estimating infiltration
o Infiltration due to door openings

Indoor Air Quality (IAQ)
o Sources of indoor air pollution
o Methods of control of IAQ
o Fresh air requirements for ventilation and IAQ

MODULE 14: Heating and Cooling load calculations

30th Lecture

Heating and Cooling load calculations
• Differences between winter and summer load calculations

• Solar radiation
  o Distribution of solar radiation
  o Direct and diffuse solar radiation
  o Earth sun angles and their relationship

31st Lecture

• Solar radiation (contd.)
  o Solar radiation on horizontal, vertical and inclined surfaces
  o Solar radiation through glass, SHGF and shading coefficients
  o Effects of internal and external shading devices

32nd Lecture

Heat transfer through building structure
• Thermal resistance of various building materials
• Periodic heat transfer through walls and roof
  o Governing equations
  o Methods of solution
  o Decrement factor and Time lag method
  o Equivalent Temperature difference Method

33rd Lecture

Winter heating load calculations
• Heat losses through the structure
• Heat losses due to infiltration
• Effects of solar radiation and internal heat sources on heating loads
• Degree day and BIN methods for estimating energy requirements for heating

34th Lecture

Summer cooling load calculations
• Heat gain through walls and roof
• Heat gain through glazings
  o Cooling Load Factors (CLF)
• Heat gain through doors, floor, partition etc.
• Internal heat gains
• Infiltration and ventilation heat gains
• System heat gains (ducts, fans, blowers etc)

35th Lecture

Fixing of supply air conditions for summer air conditioning
  o Supply air temperatures and air quantity, RSHF
  o Outdoor air quantity
  o Bypass factor and coil condition line
  o Cooling load on the room and cooling load on the coil, GSHF
  o High latent heat load applications
  o Use of reheat coils

MODULE 15: Air conditioning Systems

36th Lecture

a) All air systems
b) All water systems
c) Air water systems
d) Unitary systems
  • Window air conditioners

MODULE 16: Fan and Duct Systems

37th Lecture

• Frictional pressure drops in straight ducts of circular and rectangular crosssection, equivalent diameter for rectangular duct.

- Pressure losses in fittings, due to sudden enlargements, contractions etc.
- Sizing of ducts
  - o Velocity Reduction method
  - o Equal friction method
  - o Static Regain method

38th Lecture

- Selection of fans
  - o Fan laws and fan characteristic curves
- Air distribution in rooms
- Selection and location of supply and return grills, diffusers etc.

MODULE 17: Transport air conditioning Systems

39th Lecture

- Air conditioning systems for automobiles (cars, buses etc.)
- Air conditioning systems for trains
- Air conditioning systems for ships

MODULE 18: Control systems for Refrigeration and Air conditioning applications

40th Lecture

- Closed loop and open loop control systems
- Choice of control systems
- Types of control action
- Energy sources, controllers and controlled devices
- Control based on space temperature
- Control based on outside temperature
- Control based on heating and cooling medium
- Control of humidity
- Complete control systems