PAPER-3 COLOR C0DE : PINK

24th NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS - SEPTEMBER, 2024
PAPER - 3 : ENERGY EFFICIENCY IN ELECTRICAL UTILITIES

SECTION –I : OBJECTIVE QUESTIONS Marks 50x1=50

1. What is the primary function of substations in the electrical power supply system?
   a) To generate electricity
   b) To communicate over long distances
   c) To facilitate voltage transformation
   d) None of the above

2. How does the transmission voltage level affect the efficiency of long-distance power transmission?
   a) Higher voltage levels reduce transmission losses
   b) Higher voltage levels increase transmission losses
   c) Voltage levels do not affect transmission losses
   d) None of the above

3. What is the primary purpose of using high voltage direct current (HVDC) transmission over long distances?
   a) To increase the frequency of electricity
   b) To step down the voltage for distribution
   c) To minimize transmission losses over long distances
   d) All of the above

4. What is the impact of voltage imbalance among the three phases in an electrical system?

   a) Improved motor efficiency
   b) Increased motor losses and reduced equipment life
   c) Reduced power consumption
   d) Enhanced power factor

5. How does adding capacitors to an electrical distribution system improve power factor?

   a) By providing the reactive power
   b) By increasing the active power consumption
   c) By lowering the system voltage
   d) By increasing the frequency of the system

6. A transformer has a primary voltage of 220V and a secondary voltage of 110V. If the primary current is 5A, what is the secondary current assuming no losses?

   a) 2.5A b) 5A **c) 10A** d) 20A

7. A factory consumes 500,000 kWh of electricity per month with a power factor of 0.8. How much is the reactive power (kVAR)?

   a) 400,000 kVAR
   b) 375,000 kVAR
   c) 800,000 kVAR
   d) 500,000 Kvar

8. Which of the following best describes an induction motor's operation?

   a) It uses direct current to create mechanical energy.
   b) It generates a rotating magnetic flux that induces current in the rotor.
   c) It operates synchronously with the AC supply frequency.
   d) It requires external excitation to operate.

9. How does operating a motor in star mode affect its performance?

   a) It reduces the voltage and derates the motor capacity.
   b) It increases motor speed.
   c) It improves the power factor at high loads.
   d) It eliminates the need for external capacitors.

10. In a VFD-controlled motor, what happens when the supply frequency is reduced while maintaining the same voltage?

    a) The motor speed increases.
    b) The motor efficiency improves.
    c) The motor draws higher current and may overheat.
    d) The motor torque decreases.

11. Which of the following describes the function of a soft starter in a motor system?

    a) It increases the motor's full-load speed.
    b) It converts AC power to DC power.
    c) It reduces the inrush current during motor start-up.
    d) It improves the motor's efficiency at low speeds.

12. A motor operates at 75% load with an efficiency of 88%. If the motor's rated power is 20 kW, what is the actual output power?

    a) 15 kW b) 13.2 kW c) 17.6 kW d) 14.4 kW

13. What is the main purpose of an after-cooler in a compressed air system?
    a) To remove moisture from the air by cooling it
    b) To increase the pressure of the compressed air
    c) To filter out dust and particles
    d) To lubricate the compressed air

14. How does a desiccant air dryer remove moisture from compressed air?

a) By cooling the air
b) By using adsorbents like silica gel or activated carbon
c) By increasing the pressure
d) By reducing the air flow rate

15. Which of the following is an efficient method to control the capacity of a centrifugal compressor?

a) Automatic on/off control
b) Variable inlet guide vanes
c) Load and unload control
d) Multi-step control

16. What is the effect of increasing the intake air temperature on the efficiency of an air compressor?

a) Increases efficiency by reducing power consumption
b) Decreases efficiency by increasing power consumption
c) No significant effect on efficiency
d) Increases the volumetric capacity of the compressor

17. What is the main benefit of using a variable speed drive (VSD) with a screw compressor?

a) Increases the maximum pressure capacity b) Reduces the size of the compressor
c) Eliminates unloaded running condition d) Simplifies maintenance

18. Which of the following describes the primary function of an air receiver in a compressed air system?

a) To increase the air pressure **b) To act as a reservoir and dampen pulsations**

c) To filter out impurities d) To cool the compressed air

19. What is the primary function of the evaporator in a refrigeration cycle?

a) To compress the refrigerant **b) To absorb heat from the environment**

c) To condense the refrigerant d) To regulate the flow of refrigerant

20. In which component of an ideal refrigeration system, the refrigeration temperature will increase?

a) Compressor b) Condenser c) Evaporator d) Expansion valve

21. Which refrigerant is commonly used in vapor absorption refrigeration systems?

a) R-22 b) R-134a **c) H_2O** d) LiBr

22. What is the effect of increasing the chilled water leaving temperature on the efficiency of a centrifugal chiller?

    a) It increases the efficiency of the chiller b) It decreases the efficiency of the chiller

    c) It has no effect on efficiency d) It increases the refrigerant flow rate

23. An HVAC system operates with a COP (Coefficient of Performance) of 4. If the system provides 100 kW of cooling, what is the power input to chiller?

    a) 0.04 kW **b) 25 kW** c) 400 kW d) None of the above

24. What is the effect of decreasing the RPM of a fan by 10% on its power requirement?

    a) Decreases the power requirement by 27% b) Decreases the power requirement by 19%

    c) Increases the power requirement by 10% d) No significant effect

25. How does an increase in system resistance affect the operation of a centrifugal fan?

    a) Increases the airflow **b) Reduces the airflow**

    c) Reduces the static pressure d) No effect on fan performance

26. What is the primary purpose of trimming the impeller in a centrifugal pump?

    a) To increase the pump speed **b) To adjust the pump capacity to match system requirements**
    c) To reduce the pump speed d) To increase the NPSH required

27. How does increasing the diameter of the suction pipe affect the NPSHA in a pumping system?
    a) Reduces NPSHA **b) Increases NPSHA** c) Decreases NPSHR d) Increases NPSHR

28. A pump has a flow rate of 200 cubic meters per hour and operates against a head of 30 meters. If the pump efficiency is 70%, what is the input power required?

    a) 60.5 kW **b) 23.36 kW** c) 95.2 kW d) 100 kW

29. What is the effect of cavitation in pump?
    a) Increases efficiency
    b) Reduces noise and vibration
    c) Causes erosion of impeller surfaces
    d) Increases NPSH required

30. What is the relationship between pump speed and flow rate in a centrifugal pump according to the Affinity Laws?
    a) Flow rate is proportional to the pump speed
    b) Flow rate is proportional to the square of the pump speed
    c) Flow rate is proportional to the cube of the pump speed
    d) Flow rate is independent of pump speed

31. What is the impact of using larger diameter pipes on the system resistance in a pumping system?

    a) Reduces system resistance by lowering friction head losses
    b) Increases system resistance

c) Increases power
d) Increases static head

32. A cooling tower reduces the temperature of water from 40°C to 30°C. If the mass flow rate of water is 5 kg/s, what is the heat removed by the cooling tower?
a) 500 kW **b) 209 kW** c) 2 kW d) 5 kW

33. The approach temperature of a cooling tower is 5°C, and the range is 10°C. If the inlet water temperature is 40°C, what is the outlet water temperature?

a) 25°C
b) 30°C
c) 35°C
d) 45°C

34. How can the performance of a cooling tower be improved?
a) Proper water treatment
b) Regular maintenance
c) Optimizing air and water flow
d) All of the above

35. What is the primary function of a luminaire in a lighting system?
a) To generate light
b) To store electrical energy
c) To distribute light emitted from lamps
d) To control the voltage supply

36. Which type of lamp has the highest luminous efficacy among the following?
a) Low pressure sodium vapour lamp
b) Halogen lamp
c) LED lamp
d) Compact fluorescent lamp (CFL)

37. How does the use of high-efficiency luminaries contribute to energy conservation?
a) By decreasing the power consumption
b) By increasing the luminous efficacy
c) By improving light distribution characteristics
d) All of the above

38. How does altitude affect the performance of a DG set?
a) Increases power output
b) Reduces fuel consumption
c) Reduces power output
d) No change in fuel consumption

39. What is the Solar Heat Gain Coefficient (SHGC) used for in building energy analysis?
a) To measure light transmittance

b) To measure the heat gain through fenestration due to solar radiation
c) To measure air leakage through windows
d) To measure the thermal emittance of roofing materials

40. What is the primary function of an economizer in an HVAC system?
a) To increase indoor air pollution
b) To reduce the cost of heating equipment
c) To use outdoor air for cooling when conditions are favorable, saving energy
d) To increase the use of mechanical cooling systems

41. Energy Performance Index is the ratio of total building annual energy consumption to ------
a) Carpet area
b**) Built up area**
c) roof area
d)Windows and Walls area

42. In a D G set, the generator is generating 1000kVA at 0.7PF. If the specific fuel consumption of this D G set is 0.25 lits per kWh, then how much fuel in litres will be consumed while delivering generated power for one hour?
a)230
b) 250
c)175
d) 225

43. The power measured in an Induced Draft (I D) fan operating at 49 Hz is 52 kW. A Variable Frequency Drive (VFD) is installed and the fan was operated at 34 Hz, The estimated Power saving will be_________
a)35.7 kW
b)17.3 kW
c)34.6 kW
d)36 kW

44. A fan is drawing 16 kW at 800 RPM. If its speed is reduced to 600 RPM, the power drawn by the fan will be____________
a) 6.75 kW
b) 9 kW
c) 12 kW
d) None of the above

45. Harmonics generation is more in_____________
a) **Inverter Drive**
b) LED lamp
c) Transformer
d) Resistance heater

46. A 500 cfm reciprocating compressor has a loading and unloading period of 5 seconds and 20 seconds respectively during a compressor leakage test. The air leakage in the compressor air system will be ________

a)125 cfm
b**)100 cfm**
c) 200 cfm
d) none of the above

47. What is the efficiency of motor with the following nameplate details 22 kW, 415V, 42 A, 0,8 p.f, 1475 rpm?

    a)94.5% **b) 91%** c) 89.9% d) None of the above

48. A hotel building has 14 floors, each of 1000m^2 area, If the Lighting Power Density is 10.8 per m^2 the interior lighting power allowance for the hotel building is_________

    a)110800 W b) 129600 W **c)151200 W** d) 186600 W

49. A pump with 230mm diameter impeller is delivering a flow of 150 m^3/hr. If the flow is to be reduced to 110m^3 /hr by trimming the impeller, what should be the approximate size of the impeller?

    a)207mm b)175 mm **c) 169 mm** d)195 mm

50. What is the main advantage of using a rotary screw air compressor over a reciprocating compressor?

    a) Lower initial cost **b) Continuous, pulsation-free air delivery**
    c) Higher maximum pressure d) None of the above

SECTION –II : SHORT DESCRIPTIVE QUESTIONS Marks 8x5 = 40

(i) Answer all EIGHT questions
(ii) Each question carries FIVE marks

1	A 3 phase Induction motor has the following details: Name plate details: 55 kW,415 V,95 A,0.9 p.f, 50 Hz Running load details: 410 V,75 A,0.80 p.f, 48 Hz Calculate the following: a) loading percentage, b) Rated efficiency, **Ans:** Actual power drawn by the motor = 1.732 x 410 x 75 x 0.80 /1000 = 42.6 kW Rated input power = 1.732 x 415 x 95 x 0.90 /1000 = 61.5 kW Percentage loading of motor = 42.6 / 61.5 = 69.3 % Rated efficiency of motor = (55 / 61.5) x 100 = 89.4%

2	**Match the following:** Each 1 mark

Column A	Column B
1. Envelope Performance Factor (EPF)	a. Lighting System Efficiency
2. Luminous Efficacy	b. Heat Storage in Building Materials
3. Economizer	c. ECBC Compliance
4. Thermal Mass	d. Building Energy Performance Modeling
5. Energy Simulation Software	e. Outdoor Air for Free Cooling

Solution:

Column A	Column B
1. Envelope Performance Factor (EPF)	c. ECBC Compliance
2. Luminous Efficacy	a. Lighting System Efficiency
3. Economizer	e. Outdoor Air for Free Cooling
4. Thermal Mass	b. Heat Storage in Building Materials
5. Energy Simulation Software	d. Building Energy Performance Modeling

3 A cooling water pump has a positive suction head of 5 meters. The discharge pressure is 3.0 kg/cm², and the water flow rate is 150 m³/hr. Determine the pump efficiency given that the actual power input of the connected motor is 18.0 kW and the motor operates with an efficiency of 85%.

Solution:

Flow Rate: 150 m³/hr
Total Head: 30-5 = 25m
Power input to pump = 18*0.85 = 15.3 kW
Hydraulic Power = (150/3600)*25*9.81 = 10.2 kW
Pump Efficiency = 10.2/15.3 = 66.7%

4 A steel industry has 100 MW of captive power plant with 2 nos. of identical extraction condensing steam turbine. Power demand is 80 MW. The turbine specific condensing load is 3.20 kg/kWh and heat rejection in condenser is 560 kCal/kg.

Cold cooling water temperature: 32.0 ^{0}C
Hot cooling water temperature 39.2 ^{0}C

Calculate the following:

a) The Cooling Water circulation flow (m^3/hr) through both condensers, If only one cooling tower supplies water to condenser of both the steam turbines.
b) Make-up water flow rate (kg/hr) to basin, assuming blowdown loss is 1.0 % of circulation flow.

<u>Solution:</u>

	Condenser heat load = (3.2*80000*560/1000000) = 143.36 MkCal/hr Circulated cooling water flow = (143.36*1000000/7.2/1000) = 19911m^3/hr Evaporation losses = 0.00085*1.8*19911*7.2= 219.3 m^3/hr Blowdown loss = 19911*0.01 = 199 m^3/hr Water makeup to cooling tower = 219.3+199 = 418.4 m^3/hr = 418400 kg/hr
5.	A process engineer develops a scheme to put 500 TR absorption-based refrigeration system to bring down process fluid temperature from 34 ^{0}C to 26 ^{0}C and this will result in higher production by 10%. 5 TPH excess steam is available in the plant and this new scheme utilizes this excess steam. COP of refrigeration system is 0.65 and available latent of steam for refrigeration system is 540 kcal/kg. A)Estimate excess steam utilization for absorption- based refrigeration system in TPH. ……………………………..3 Marks b) Estimate required Cooling water (m^3/hr), if available approach in condenser is 10 ^{0}C. ……………………………..2 Marks **Solution:** Energy required for refrigeration system 500*3024/0.65 = 2326153.8 kcal/hr Steam needed for refrigeration system = 4.3 TPH 2326153.8/540 Steam utilization for VAM = 4.3 TPH Required condenser duty = 3838153.8 kcal/hr 2326153.8+(500*3024) Required Cooling water = 383.8 m^3/hr 3838153.8/10

6	A process plant continuously operates a furnace oil operated DG set of capacity 3.0 MW to avoid any process safety incident in case of tripping of critical equipment on power failure. Total critical load on DG set is 2.5 MW and exhaust flue gas at 430 deg.C is vented as original design intent was to operate DG set intermittently only during power failure. Since it is being operated continuously, the process team developed a scheme to generate saturated steam at 5 bar(g) using the waste heat boiler. Other operating parameters are given below: Specific heat of flue gas 0.24 kcal/kg-Deg.C Final stack temperature to avoid Sulphur dewing 210.0 Deg.C Flue gas flow 17.5 TPH Sat. temp. of steam at 5 barg 159.0 Deg.C Latent heat at 5 barg 498.0 kcal/kg Feed water temperature 130.0 Deg.C Calculate the quantity of steam generated from waste heat boiler in TPH. Solution: Heat available for steam generation= 17500*0.24*(430-210) = 924000 Kcal/hr Steam Generation= 924000/(498+(159-130)) = 1753.3 kg/hr = 1.75 TPH
7	List five energy efficiency measures in Compressed air system. Solution: Book 3, Refer Page 101
8	Analyse the following data collected for a water pump. If the operating head is 16m explain what will happen to other parameters. **Design Parameters** — **Values** Flow (Q) — 40 lps Head (H) — 20 m Power(P) — 15 kW Efficiency — 51% Solution : 1. If the operating head is 16m instead of 20 m, the operating flow will be higher than the rated flow. 2. Since the operating point has deviated from the BEP, the operating efficiency will be less than design efficiency. 3. Since, the flow has increased and pump efficiency decreased than rated, the operating power demand will be more than the rated power.

SECTION –III : LONG DESCRIPTIVE QUESTIONS Marks 6 x 10 = 60

L1

A 20 MW co-generation plant operates at a daily load factor of 85% and 8% auxiliary power consumption. The power is generated at 11 kV. Out of the total energy generated, 45% is exported to the grid through a 15 MVA transformer with 99% efficiency. Additionally, 35% of the generated energy is supplied to mill motors at 600 Volts through an 8 MVA step-down transformer with 98.5% efficiency. The remaining energy is used for other LT loads and auxiliaries at 415 Volts through a 4 MVA transformer with 98.2% efficiency. Calculate the following:

1. Daily energy generation in MWh.
2. Daily energy exported in MWh to the grid at 33 kV.
3. Daily mill motors consumption in MWh at 600 V.
4. Daily LT loads and auxiliary consumption in MWh at 415 V.
5. Daily transformer losses in kWh and % transformer losses.

Solution

1. Daily Energy Generation Calculation

Gross energy generated=Plant capacity×Load factor×Hours per day Gross energy generated

=20 MW×0.85×24 hours Gross energy generated=408 MWh per day

Net energy available after auxiliary consumption:

Net energy available=Gross energy generated×(1−Auxiliary power consumption)

=408 MWh×0.92 = 375.36 MWh

2. Energy Exported to the Grid

Energy available for exported =Net energy available×45% =375.36 MWh×0.45 =168.912 MWh

Energy exported to the grid after transformation loss=168.912 MWh×0.99 =167.223 MWh

3. Daily Mill Motors Consumption

Energy available for mill motors =Net energy available×35% =375.36 MWh×0.35 =131.376 MWh

Energy supplied to mill motors after transformation loss = 131.376 MWh×0.985 =129.278 MWh

4. Daily LT Loads and Auxiliary Consumption

Energy available to LT loads and auxiliaries = =375.36 MWh×0.20 =75.072 MWh

Energy supplied to LT loads and auxiliaries after transformation loss = 75.072×0.982 =73.78 MWh

	5. Calculate Daily Transformer Losses in kWh and % Transformer Losses **Total Transformer Losses:** Grid Transformer Losses+Mill Motors Transformer Losses+LT Transformer Losses Total l osses= =(168.912-167.223)+(131.376-129.278)+(75.072-73.78) 1,689 kWh+2,098 kWh+1,292 kWh Total losses=5,079 kWh **Percentage of Transformer Losses from Net Generation:** 5079/408000 = 1.24%
L2.	As part of a management initiative to advance green energy in a new process plant, a process engineer is assessing the economic viability of a 650 TR chiller. She is considering proposals for both LiBr-based vapor absorption chillers and vapor compression refrigeration systems. While power is sourced from renewable energy, the steam required is partially generated from excess process heat and additionally from firing furnace oil. COP of advance Vapor Absorption Chiller : 1.3 COP of Vapor Compression Chiller : 4.50 Net steam price including excess steam and from boiler : 1500.00 INR/MT Net Power cost from green source : 7.20 INR/kWh Price of Cooling water : 3.00 INR/M3 Cooling water range : 8^0C Specific steam heat available for chiller : 490.0 kcal/kg Evaluate both the offers and find out the offer which is economical in terms of operating cost. **Solution:** Vapor Absorption chiller Chilling capacity 650.0 TR Required heat duty 1965600 kcal/hr Heat equivalent input to VAM = 1965600/1.3 = 1512000 Required Steam flow = 1512000/490 = 3084 kG/hr Condenser heat duty = (650*3024) + (3084* 490) = 3476760 kcal/hr Required Cooling Water = 434.6 M3/hr Operating cost of Vapor Absorption Chiller =(3084*1.5)+(434.6*3) = 5930 INR/hr Vapor Compression chiller Chilling capacity 650.0 TR Required heat duty 1965600 kcal/hr Required Power consumption 508 kW Condenser heat duty = (650*3024)+(508*860)=2402480kcal/hr Required Cooling Water =300 M3/hr

	Operating cost of Vapor Absorption Chiller = (508*7.2)+(300*3) = 4558 INR/hr Hence, operating vapor compression chiller is economical.
L3	a) Match the following: (4 Marks)

1	Prescriptive Approach	1. Exterior façade
2	Whole Building Performance Approach	2. Trade-Off option
3	Building envelope	3. light admitting potential
4	Effective Aperture	4. Uses simulation to show compliance for the entire building

b. Fill in the following blank statements:

1. The Effective Aperture (EA) or light admitting potential of a glazing system is determined by multiplying the Visible Light Transmittance (VLT) of the glazing by the ______________ of the building.
2. Thermal emittance is the relative ability of a material to ___________the absorbed heat.
3. If a window has a SHGC of 0.25 and the total incident solar radiation is 600 W/m², the solar heat gain through the window is __________
4. The emissivity of a material is the ratio of energy radiated by a particular material to energy radiated by a ___________ at the same temperature.
5. As per ECBC the unit of Energy Performance Index (EPI) ___________
6. Fenestration surface having a slope of less than **60** degrees from the horizontal plane is termed ___________________

Solution:

a)

1. Prescriptive Approach – b
2. Whole Building Performance Approach – d
3. Building envelope – a
4. Effective Aperture – c

b)

1. The Effective Aperture (EA) or light admitting potential of a glazing system is determined by multiplying the Visible Light Transmittance (VLT) of the glazing by the **Window-Wall Ratio (WWR)** of the building.
2. Thermal emittance is the relative ability of a material to **radiate** the absorbed heat.
3. If a window has a SHGC of 0.25 and the total incident solar radiation is 600 W/m², the solar heat gain through the window is **150 W/m².**
4. The emissivity of a material is the ratio of energy radiated by a particular material to energy radiated by a **black body** at the same temperature.
5. As per ECBC the unit of Energy Performance Index (EPI) **kWh/Sq.mt/year**
6. Fenestration surface having a slope of less than **60** degrees from the horizontal plane

<table>
<tr><td></td><td>is termed <u>Skylight</u>. (6 Marks)</td></tr>
<tr><td>L4</td><td>
1. The lumen (lm) is the photometric equivalent of the Watt, weighted to match the eye response of the "standard observer," with blue light receiving the greatest weight - False.
2. The CRI of a lamp is 100 if it renders the color of the chips identical to the reference light source, indicating perfect color rendering. - True.
3. A commercial building with a high window-to-wall ratio (WWR) and low SHGC glazing will experience higher cooling loads, as more solar heat will be transmitted through the windows - False.
4. Rotary screw compressors are preferable for fluctuating air demand- False.
5. Operating compressors at lower delivery pressures always results in higher energy efficiency- True.
6. Heat of compression dryers have higher operating costs compared to heatless purge dryers- False
7. Using variable speed drives in compressors can eliminate unloaded running conditions and save energy-True
8. Motor efficiency generally increases as the motor's rated capacity increases. True
9. The power factor of an induction motor improves as the load on the motor decreases. False
10. A decrease in supply voltage by 10% will decrease the torque of the motor by approximately 19% - False
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<tr><td>L5</td><td>
A 2-stage reciprocating compressor is supplying nitrogen from low pressure header to high pressure vessel. This high-pressure nitrogen is only used during any process upset. Compressor is cut-off, once vessel pressure reaches 45 barg, and started, when vessel pressure comes down to 35 barg. During energy audit, it was observed that compressor is started at gap of every 36 hrs when there is no intended consumption. Other data is given below:

Vol. of high pressure N2 vessel 11.5 m^3
Vessel temperature 35.0 Deg.C
Initial gas density 50.3 kg/m3
End gas density 39.4 kg/m3
Compressor load kW drawn 30.0 kW
Compressor capacity at constant suction pressure 250.0 kg/hr

i. Estimate the leak rate (kg/hr).
ii. Estimate the energy saving potential (kWh/Annum), if all leaks are attended. Consider operating time of 8760 hrs/annum.

Solution:

Initial Vessel Pressure 45.0 barg
End vessel pressure 35.0 barg
Initial gas density 50.3 kg/m3
End gas density 39.4 kg/m3
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	Change in gas quantity in 36 hrs 125.7 kg N2 leakage rate 3.5 kg/hr Time needed for compressor run 0.51 hrs or 30.6 min % time of compressor running 1.40 % Running time of compressor per annum 122.3 hrs Power consumption per annum due to air leakage 3670.0 kWh/Annum Energy Saving Potential 3670.00 kWh/Annum
L6	a) During performance guarantee test of an induced draft cooling tower, it was found that design approach of cooling tower is not achieved. As one of the probable causes, the team decided to check the efficiency of cooling tower fan. If design static efficiency is 70%, estimate the operating static efficiency using following parameters: Pitot tube coefficient 0.9 Velocity pressure 49.0 mmWC Air Density at operating condition 1.129 kg/m3 Duct diameter 2.1 m Differential pressure across fan 130.0 mmWC Motor shaft Power 190.0 kW Motor Efficiency 95.0 % Gear Box Efficiency 96.0 % b) A centrifugal fan drawing 54 kW and operating at 1440 rpm is delivering air at 30,000 m^3 /hr. The head developed by the fan is 400 mm WC. If the speed is decreased by 200 rpm, calculate the following: 1. Air flow in m^3 / hr 2. Static pressure in mm WC 3. Power drawn in kW **Solution**: a) Air Velocity = 26.3 m/sec Duct Area = 3.5 m^2 Vol. flowrate = 92.0 m^3/sec Air kW transferred = 92*130/102 = 117.25 kW Power input to fan = 190*0.95*0.96 = 182.4 kW Static Efficiency = 117.25 / 182.4 x100 = 64.28% b) 1. Airflow in m^3 / hr = (1240/1440) x 30000 = 25833 m^3 /hr 2. Static pressure in mm WC = $(1240 /1440)^2$ x 400 = 296.6 mm WC 3. Power drawn in kW = $(1240 /1440)^3$ x54= 34.48 kW