Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure/figures drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer (as long as the assumptions are not incorrect).

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept

1 A) Attempt any three of the following **12**

1 A) a) State four salient features of Energy Conservation Act 2003.

Ans:

Salient features of Energy Conservation Act 2003:

1) The Central Government to prepare a National Electricity Policy in consultation with State Governments.
2) Thrust to complete the rural electrification and provide for management of rural distribution by panchayats, Co-operative Societies, non-Government organizations, franchisees etc.
3) Provisions for license free generation and distribution in the rural areas.
4) Generation being delicensed and captive generation being freely permitted. Hydro projects need clearance from the Central Electricity Authority.
5) Transmission utility at the central as well as state level to be government company with responsibility for planned and co-ordinated development of transmission network.
6) Provision for private licensees in transmission and entry in distribution through an independent network.
7) Open access in transmission from the outset.
8) Distribution licensees would be free to undertake generation and generating companies would be free to take up distribution businesses.

1 mark for each of any four points

1 A) b) Define the following terms.

i) Colour Rendering Index ii) Luminous Efficacy iii) Luminous flux
iv) Illumination

Ans:

i) Colour Rendering Index: It is a measure of the degree to which the colors of surfaces illuminated by a given light source confirm to those of the same surfaces under a reference illuminant. Suitable allowances are made for the state of chromatic adaptation.

ii) Luminous Efficacy: This is the ratio of luminous flux (lumens) emitted by a lamp to the power (Watts) consumed by the lamp. Unit is Lumens per Watt.

iii) Luminous Flux: The luminous flux (lumens) is the total energy radiated by the light source in all direction.

iv) Illumination: It is defined as the luminous flux (lumens) falling on per unit area of the given surface on the working plane. The unit of illumination is lumens/m^2 or 1 lumens/m^2 = 1 Lux.

1 mark for each definition

1 A) c) Draw & explain power flow diagram of three phase induction motor.

Ans:

Power flow in Three Phase Induction Motor:

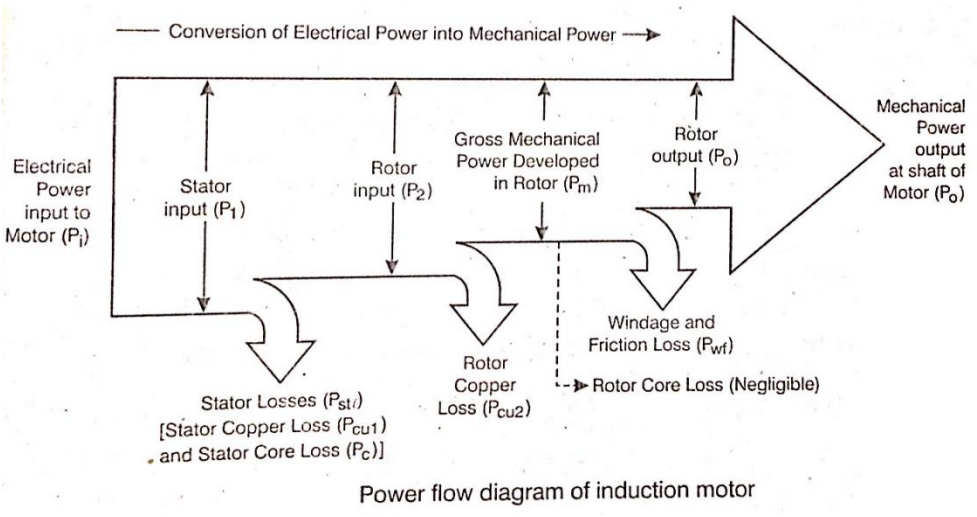
The electrical power input to the stator winding of an induction motor is transferred to rotor through the air gap between the stator and rotor by electromagnetic induction principle. This power is utilized to deliver the load at the shaft of motor and to supply I^2R loss in the rotor. Out of total power input to stator, stator Cu loss and iron loss is supplied and remaining power then transferred as power input to rotor. Since rotor rotates at speed near to synchronous speed, the rotor core is subjected to reversal of magnetic field at very low frequency. Hence rotor core loss

2 marks for explanation

is negligibly small. If the gross torque developed by rotor is T_a Nm and synchronous speed of rotating magnetic flux be N_s, then power transferred from stator to rotor $= \frac{2\pi N_s T_a}{60}$ synchronous watt.

When the rotor rotates at a speed N_a rpm, total mechanical power developed by rotor $= \frac{2\pi N_a T_a}{60}$ watt

Hence (Power transferred from stator – mechanical power developed by rotor)
= rotor I^2R loss



Power flow diagram of induction motor

2 marks for block diagram

1 A) d) Explain the following energy conservation methods of electrical motor.
i) Minimizing idle and redundant running of motor.
ii) Matching motor rating with required load

Ans:

i) Minimizing idle and redundant running of load

1) Loss of energy as the no load power drawn is approximately about 12% to 16% of rated power output in most of motors. Therefore, idle running should be avoided.
2) Unnecessary heat production at friction points such as bearings, leading to wearing of bearing.
3) Motor being highly inductive load under idle running as no real power (mechanical load) on it, the p.f. of such no-load running is low, leading to unnecessary line losses.
4) Reduction in overall system energy efficiency over period of time.

2 marks

ii) Matching motor rating with required load:

Every motor is designed to perform efficiently at certain load. If total load on the motor and the output rating of motor are identical, then this condition is called as the best matching of motor & load on it. If the load is much low or high as compared to the output rating of motor, then the motor works at lower efficiency and energy is unnecessarily wasted. Therefore, the rating of motor is chosen according to the probable load on it.

2 marks

1 B) Attempt any one of the following: 6 marks

1 B) a) State the need of energy conservation in transformer. Explain the use of Epoxy Resin Cast/ Encapsulated dry type transformer from energy conservation point of view.

Ans:

Need of energy conservation in transformer:

In electrical power system, transformers are used to change the voltage levels of different sections as per the need of economic and efficient operation of the system. 2 marks

Since the transformers are integral part of power system, whether they are on load or no load, they always remain on line. The power losses: in windings (no load primary copper losses due to no load current) and magnetic core (due to rated voltage across primary) results in energy wastage. As rated voltage and no load current are there around the clock reduction in these losses in transformer, leads to large amount of energy savings over the period, which can be used for some other good reason. Therefore, there is need of energy conservation in transformer.

Epoxy Resin Cast Transformers (Dry type transformers):

i) Core used is of CRGO M4-M3 circular size, which results in minimum leakage reactance and less core losses.
ii) Winding consists of flexible rope of Cu instead of rectangular strips or rod. Therefore current carry capacity is more and better cooling effect. 2 marks
iii) Insulation consists of high quality epoxy resin which is capable of withstanding high temperature and also provides minimum clearance as per voltage requirement.
iv) As the transformer is fully encapsulated, routine maintenance is less.
v) As cooling oil is absent the total weight of transformer is less.
vi) Due to less weight loading and unloading of the transformer is easy.
vii) In the absence of oil, there is no need of regular testing the dielectric strength of oil or no filtrations of oil. 2 marks

1 B) b) An illumination on the working plane of 75 lux is required in a room 72m x 15m size. The lamps are required to be hung 4m above the work bench. Assuming a suitable space-height ratio, a utilization factor of 0.5, a lamp efficiency of 14 lumens per watt and candle power depreciation 20%. Estimate the number and rating of the lamps.

Ans:

Data Given: Illumination (E) = 75 lumen/m^2 or lux
Room Area (A) = 72m x 15m = 1080 m^2
Height of lamp (h) = 4 m
Utilization factor (η_u) = 0.5
Lamp efficiency (η_{lamp}) = 14 lumen/watt
Candle power depreciation = 20%

$\therefore$ Due to depreciation of 20 %, only 80 % of candle power is available for illumination. Hence maintenance factor (η_m) = 0.8 which results in 25% increase in lumens requirements (DF = 1/MF). 1 mark

Initially assuming space to height ratio = 1, we get space s = 4 m.

Number of lamps in one row along width = 15/4 = 3.75 assume 4 lamps. 1 mark
Hence revised space along width = 15/4 = 3.75 m.

Number of lamps in one row (space s = 4 m) along length = 72/4 = 18 lamps. 1 mark

Hence total number lamps = 4 x 18 = 72.

Total light flux to be radiated by all lamps can be obtained as,

Total Light Flux $\emptyset = \frac{E\,A}{\eta_u \eta_m} = \frac{75 \times 72 \times 15}{0.5 \times 0.8} = 202500$ lumens 1 mark

Lumen output per lamp = 202500/72 = 2812.5 lumens

Wattage of each lamp = 2812.5/14 = 200.9 W assume 200 W incandescent lamp as average efficacy of incandescent lamp = 14 lumens/watt which is given. 1 mark

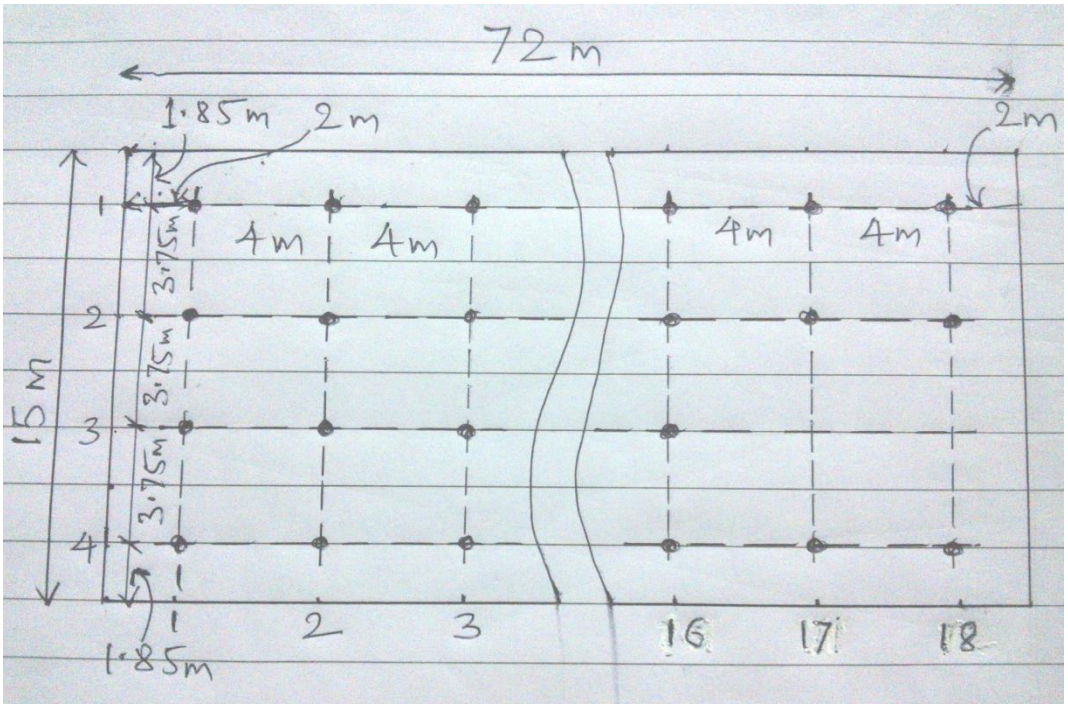


Figure of disposition of lamps: 1 mark

2 Attempt any four of the following: 16

2 a) Explain the procedure for assessing existing lighting system in a facility.

Ans:

Procedure for Lighting System Assessment:

1. Room index: Calculate the room index in order to determine no. of points and their positions where measurements are to be carried out.
   Let L_i – Length of interior,

W_i – Width of interior.
H_m – Height of the lighting fitting above the horizontal working plane.

The room index is calculated as

$$RI = \frac{L_i \times W_i}{H_m(L_i + W_i)}$$

1 mark for each point = 4 marks maximum

2. Finding out the installed load efficacies
   Step1: Measurement of the floor area of interior, Area = ---------- m^2
   Step 2: Determine Room index
   Step 3: Measure the total circuit watts of the lighting installation using power meter
   Step 4: (Value obtained in step 3) / (Value obtained in step 1)
   Total circuit watts / floor area = ---------- w / m^2
   Step 5: Find out the average maintained illuminance using Lux meter.
   Step 6: (Value obtained in step 5) / (Value obtained in step 4)
   Step 7: Get target Lux/w/m^2 according to the type of interior or application and RI obtained in step in step 2
   Target Lux/w/m^2 = ----------
   Step 8: Installed Load Efficacy Ratio (ILER)
   = (Value obtained in step 6) / (Value obtained in step 7)
   ILER = ------

3. Target Lux/w/m^2 for various premises :- The amount of light required is an important factor to perform a particular task or to illuminate the workspace. The most effective lighting with respect to performance and cost needs to have detail knowledge of the premises or application for which it is to be installed. The primary requirement of lighting as well as quality and amount of illumination depend upon,
   1. Nature of industry
   2. Its ocular needs & personnel

4. Assessment of ILER using indicators of performances :- Annual energy wastage is possible to calculate after deriving the actual ILER as:
   Annual energy wastage (kwh)
   = (1- ILER) * Total load (kw)* annual operating hours (h)

   Efficiency of the new lighting installations or replacement can also be assessed by comparison of ILE with target value for RI and type. In this case if the calculated ILE is found less than the target value, it is suggested to diagnose the reasons.

2 b) Explain the energy conservation techniques in lighting system by installation of separate transformer / servo stabilizer of lighting.

Ans:

Energy conservation techniques by installation of separate transformer / servo stabilizer:

The luminous efficiency of lamps depends upon the voltage applied across the terminals. It gives its best output at rated voltage. Small reduction in applied

voltage greatly reduces its luminous output. 2 marks for transformer

Therefore, it is necessary that the voltage applied across them is properly maintained constant. This can be achieved by installing a transformer substitution near the load so that variation in voltage will be negligible. However, to such sub-station, different categories of loads are connected, which may act in such a way that there may be sudden voltage drop. When such loads are made off, it may result in sudden rise of voltage, which certainly affects the luminous efficiency of the lamps.

To obtain constant luminous output in particular installation it is necessary to stabilize the voltage. Hence for such purposes, servo stabilizers are connected in the system of such premises, which will maintain the voltage constant in that installation for giving best luminous efficiency of lamps. 2 marks for servo stabilizers

2 c) Write any four comparisons between energy efficient motor with conventional induction motor.

Ans:

Comparison between Energy Efficient Motor with Conventional Induction Motor:

1 mark for each of any four points = 4 marks maximum

Particulars	**Energy efficient motor**	**Conventional induction motor**
1. Material used	They are manufactured with higher quality conducting, electromagnetic & insulating material & technique	They are manufactured with lower quality conducting, electromagnetic & insulating material & technique.
2. Losses	They usually have higher service factors & bearing lives, less waste heat output all of which increase reliability	High
3. Starting torque	Good optimum value with soft starter	Depends on starting method
4. Speed	Smooth speed over a required range & less vibrations	Speed may not be so smooth, jerks, vibrations may be involved
5. Maintenance	Negligible maintenance, longer warranties, low failure rates	More maintenance, less warranty, High failure rates
6. Operating temperature	Can withstand high temperature without any problem	At high temperature some problems may arise in the operation

2 d) State and explain any two energy conservation measures for T and D system related to administrative loss.

Ans:

Energy conservation measures for T and D system related to administrative loss:-

1. **Mitigation of Power Theft:-** Power theft being the most important issue which all of the services providing utilities face. It necessitates some strong steps towards mitigation of power theft. State government can contribute in this by forming strict rules and laws.
2. **Meter Seal :-** CT/PT terminals at meter terminal box should be provided with proper seal management in order to prevent power theft. Severe penalties should be imposed for meter tampering.
3. **Vigilance Squad:-** Areas of power theft should be identified and vigilance squad needs to be formed for power theft checking in order to speed up mitigation
4. **Installation of MVD : -** In areas sensitive to power theft, installation of medium voltage distribution is an option. Under this scheme each consumer can be directly connected to low voltage terminal of the supply transformer, immediate action should be taken to stop the unmetered supply.
5. **Faulty meter replacement :-**
   Replacement: Distribution agency should pay attention to faulty or sluggish meters. It should be replaced by newer & advanced meters.
   Checking: Meter should not only be installed but also it is necessary to check periodically for the purpose of knowing accuracy.
   Advanced Meters: Old inaccurate electromechanical meters should be replaced with latest microprocessor based digital meters so that energy consumption can be accurately measured.
   Prepaid Metering: Prepaid metering encourages efficient use of power especially for agricultural sector. Prepaid meters may prove effective measures against unauthorized abstraction of energy.
6. **Bill collection facility:**
   Payment cells:- No. of payment cells for paying electricity bill should be increased with the development of the areas.
   E-payment facility :- Option for E-payment is suitable for both consumer as well as utility. With this facility consumer get more relief as it avoids long, time consuming ques for bill payment. This encourages consumer for regular payment for the usage.
7. **Reduce Debits:** Consumer having old debits should be legally communicated and necessary judicial action should be taken against them in order to recover the same. Police can be taken along to disconnect the supply if recovery is not being done.
8. **Energy audit schemes:** Big industries and utilities should be mandated to carry out an energy audit as it identifies the areas of losses and measures to reduce. Incentives should be awarded to utilities as well as consumers who are being able to keep T & D losses in prefixed limits. Assessment of the whole system considering the T & D losses depends upon calculation of the sample size. For a realistic and quick estimate of the losses, proper size of

2 marks for each of any two measures

the sample system chosen is an important factor.

2 e) State the opportunities for energy conservation techniques in transformer.

Ans:

Opportunities of energy conservation technique in transformer:

Energy conservation in transformer obviously will be step forward when attempts to reduce energy losses related with transformer operation in electrical power system are made. Transformers especially in distribution network actually make up near about 40% of energy loss. All the electrical power which consumer receives is through transformer. In some cases it may have to undergo numerous stages of transformations, hence called numerous transformers. If these losses are given attention, it will considerably reduce greenhouse emission. A modern distribution transformer operates at high efficiency in the range of 98.99 %. However, the total no. of transformers used in transmission and distribution system supplying power to all class of consumer: industrial, commercial, domestic, and rural is very large. Thus even small positive changes in transformer efficiency will lead to remarkable reduction in generation capacity requirement and hence greenhouse gases emission. 1 mark

Reduction of copper losses: by using good quality thicker low resistance conductors for windings. 1 mark

Reduction in iron losses: by using good quality electromagnetic cores having low eddy current and hysteresis losses at rated voltage. 1 mark

Operating the transformers at designed voltage value and rated full load conditions for as high efficiency conditions as possible. Or using properly rated transformers that are matching to load requirements. 1 mark

2 f) Define both laws of illumination.

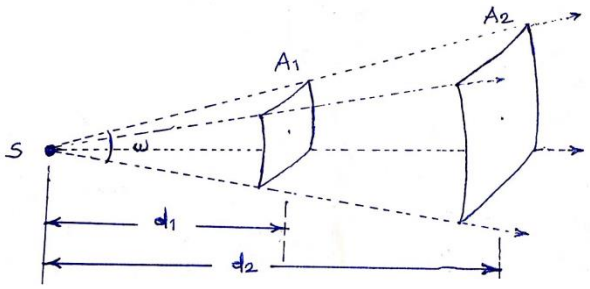
Ans:

Laws of Illumination:

The illumination of a surface due to point sources are governed by the following two laws of illumination

1) Inverse square Law
2) Lambert's cosine law or $\cos^3\theta$ law

1) Inverse Square Law : - 2 marks for each law



Consider a point source of light "S" and areas A_1 and A_2 placed at distances d_1 & d_2 make same solid angle ω with point source "S"

Let I be the luminous intensity of the point source expressed as lumen/steradian.

Total flux (∅) falling on area A_1 and A_2 is given by,

$\emptyset = I\omega$ lumen……(i)

from the definition of solid angle, ω= Area / distance^2

For area A_1, $\omega = A_1/(d_1)^2$ …… (ii)

For area A_2, $\omega = A_2/(d_2)^2$ ……(iii)

Total flux for area A_1 from equation (i) & (ii)

$\emptyset = \frac{IA_1}{(d_1)^2}$……(iv)

Total flux on area A_2 from equation (i) & (iii)

$\emptyset = \frac{IA_2}{(d_2)^2}$ ……..(v)

Illumination of area $A_1 = \frac{IA_1}{(d_1)^2} \times \frac{1}{A_1} = \frac{I}{(d_1)^2}$ ……(vi)

Similarly, illumination of area $A_2 = \frac{IA_2}{(d_2)^2} \times \frac{1}{A_2} = \frac{I}{(d_2)^2}$ ……..(vii)

From equation (vi) and (vii), it is seen that illumination at a point due to point source is inversely proportional to the square of distance of the point from the source. Hence, it is termed as an inverse square law of illumination. Also, the illumination is directly proportional to intensity of illumination (I).

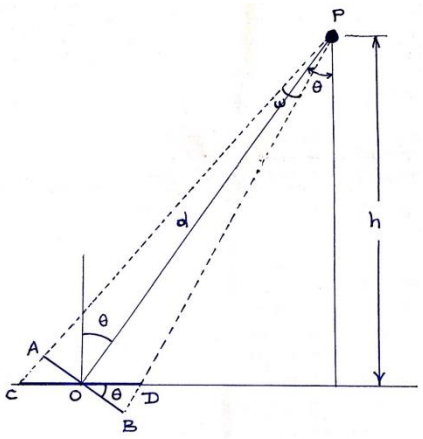
2) Lambert's Cosine law:

Let P be the point source at height h from the plane containing the surface CD.

Let O be the centre point of the surface CD which subtends solid angle ω at the source of light.

Let AB be the surface perpendicular to OP

∴ AB = CD cosθ



Illumination of area AB,

$$E_{AB} = \frac{I\omega}{Area\ AB} = \frac{I}{\left(\frac{Area\ AB}{\omega}\right)} = \frac{I}{d^2}$$

Illumination of area CD,

$$E_{CD} = \frac{I\omega}{Area\ CD} = \frac{I\omega}{\left(\frac{Area\ AB}{cos\theta}\right)} = \frac{I}{d^2} cos\theta = E_{AB} cos\theta$$

Thus the illumination at a point on a surface is proportional to cosine of the angle

which ray makes with the normal to the surface at that point.

Since $cos\theta = \frac{h}{d}$ we can write $d = \frac{h}{cos\theta}$

$\therefore E_{CD} = \frac{I}{d^2} cos\theta = \frac{I}{(\frac{h}{cos\theta})^2} cos\theta = \frac{I}{h^2} cos^3\theta$

3 Attempt any four of the following: 16

3 a) State any four objectives of tariff system.

Ans:

The objectives of tariff:

1) Recover capital investment made
2) Cost of operation, supplies, maintenance and losses must be recovered.
3) The cost recovered must be distributed amongest the consumers.
4) Cost of metering , billing, collection and miscellaneous services must be recovered.
5) Should have a provision of penalty for low power factor.
6) Gain suitable profit on capital investment
7) Discourage users from drawing higher loads than contracted.

1 mark for each of any four

3 b) State any four causes of technical losses in transmission and distribution system. Also state techniques to reduce it.

Ans:

Causes of technical losses in transmission and distribution system:

1) Leakage current
2) Open circuit loss
3) Dielectric loss
4) Corona loss
5) Heating due to current
6) Losses in contact resistance.

½ mark for each of any four causes = 2 marks

Techniques of Reducing Technical Losses:

1) Find out the weakest area of more technical loss in the distribution system.
2) Locate distribution transformer near to the load centre.
3) Use proper capacity distribution transformer.
4) Use energy efficient transformers.
5) Use shunt capacitors for reactive power management.
6) Use HVDC system for long distance bulk power transmission.
7) Use ACSR or bundled conductors instead of solid conductors.
8) Reduce overloads on distribution transformer.
9) Use reactive power compensation techniques.
10) Use power factor controlling devices or techniques.
11) Minimize I^2R losses.
12) Balance the load currents.
13) Regulate the system voltages.

½ mark for each of any four techniques = 2 marks

3 c) With an example, explain how energy flow diagram helps in energy audit procedure.

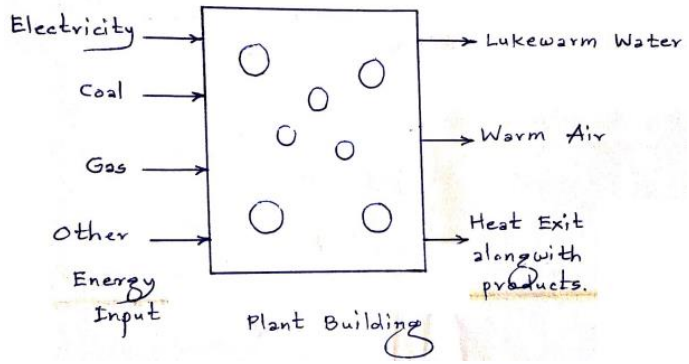
Ans:

1) High value energy is in the form of electricity, petroleum products, coal and

other combustible materials enter the plant.

2) The machines, drives, and other equipment and processes within the plant are the energy consumers.
3) All the energy contained in the input materials can not be utillised fully.
4) Some low value energy in the form of warm air, lukewarm,water etc. is the waste energy and leaves the plant in one form or the other.
5) The aim of energy audit is to improve energy utillisation so that the extent of waste energy is reduced and energy input per unit finished product is kept to minimum to ensure overall economy.
6) To measure and record the quantity and quality of energy input. The word quality is important because the cost of energy depends on energy quality.
7) To determine and record all energy losses in the plant. These losses occur in various combustion processes, energy distribution etc.

Any four 1 mark each.



3 d) Explain energy conservation technique in induction motor by operating I.M. in star mode.

Ans:

Energy conservation technique in induction motor by in star mode: 1 mark for each point

In star mode operation of induction motors, energy is conserved as follows:-

1) Lesser than 30% of rated load means torque required by load is less than 30%
2) When connected in star the phase voltage reduces to $(1/\sqrt{3})$ times that in delta mode. As the torque generated by motor is directly proportional to the (Applied Voltage per phase)^2 the torque produced falls 1/3 compared to delta mode
3) Due to decreased phase voltage the iron losses decrease to nearly 1/3
4) Due to reduction in phase voltage, the current drawn in the lines are reduced which further reduces copper losses in motor and decreases line losses.

3 e) Explain the need of co-generation plants helps for energy conservation.

Ans:

Need of Co-generation:

1) In conventional power plant efficiency is only 35% and remaining 65% of energy is lost.
2) The conventional system uses energy of fuel to produce electrical energy or thermal energy whereas co-generation system produces both electrical and thermal energy from both fuels.
3) The overall efficiency of energy use in co-generation can be up to 85% or

Broadly points covered 1 mark each any four or

above. other similar valid points = 4 marks

4) Lower volume of CO_2 compared to the conventional system where separate production of electricity and heat.
5) In Co-generation system, heat generated is byproduct in electricity generation process.
6) Limited need of cooling water in co-generation system, therefore reduces thermal pollution.

4 A) Attempt any three of the following: 12

4 A) a) State any four merits of co-generation.

Ans:

Merits of co-generation: 1 mark for each of any four merits = 4 marks

1) Co-generation can meet both power & heat needs.
2) A much more efficient use of primary energy can be achieved as compared to separate production of electricity and heat.
3) Many times it is implemented in a very cost effective manner.
4) Increases overall efficiency of system
5) Reduction in emission of pollutants due to reduced fuel consumption.
6) Helps to maintain grid stability.
7) In co-generation heat is byproduct of electricity generation process.
8) Due to decentralization of electricity, it avoids transmission losses and makes system more flexible.

4 A) b) What is ABC analysis? State its three advantages referred to energy audit projects.

Ans:

ABC Analysis :

ABC analysis is used to identify components of project that have major and minor influence on the cost. The major and minor influential components are classified in to items of List A,B,C 1 mark

List A :- Contains the items that account for approximately 70% of total Cost

List B:- Contains the items that account for approximately 20-25% of total cost. 1 mark

List C :- Contains items that account for approximately 5 to 10 % of total Cost.

Advantages :

1) The audit helps to identify items and cost involved.
2) Optimize the expenses on energy required
3) Maximize the savings.
4) Reduce energy losses.

1 to 2 advantages =1 mark; 3 advantages =2 marks

4 a) c) Why soft starter used for motor? State its two advantages.

Ans:

Necessity of Soft-starters:

The AC motor draws a heavy current at start with normal voltage applied to it resulting in high line voltage drops that affects the other machines used and energy losses in line conductors. Also the torque produced at start is also larger than required value at full speed. 2 marks

Thus if starting current is maintained at the normal value, the additional line drops

and energy losses are avoided leading to saving in energy.
A soft starter is such a device which is used to apply the supply voltage to the motor in such a manner that the current never shoots up to create additional drops of voltage and power in the lines and unnecessary torque. It provides a step-less acceleration or deceleration leading to increase in motor life.

Advantages :

1) Very low line voltage drops on motor operation
2) Reduced energy losses in the lines
3) System efficiency increases
4) Improves power factor
5) Very smooth starting & operation
6) As current is limited, the maximum demand is controlled
7) Starting torque is low
8) Prevents damage to motor through mechanical stress

1 mark for each of any two

4 a) d) State the incentives and penalty related with P.F. tariff.

Ans:

Concept of incentive:

When the value of consumer's power factor increases above the value of reference power factor then the incentive is given to the consumer and electricity bill amount is reduced in proportion to the difference in power factor value above reference. 2 marks

Concept of Penalty:

When value of consumer's power factor decreases below the value of reference power factor then the penalty is applied to the consumer and electricity bill amount is increased in proportion to the difference in power factor value below reference. 2 marks

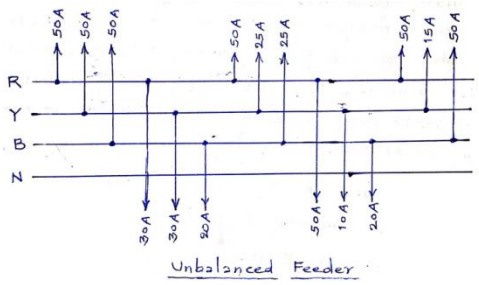
4 B) Attempt any one of the following: 6

4 B) a) What is phase balancing system? Explain in detail how it is used to conserve energy in distribution system.

Ans:

Phase balancing System :

1) In India for distribution of electrical power, three-phase, 4 wire system is used.
2) By using this system, three phase as well as single phase loads are supplied.
3) Most of the three phase load is balanced but the single phase load will cause unbalance, depending upon the load used by consumer.
4) Due to which there is a need of balancing single phase system and it is called as phase balancing system. 2 marks



Unbalanced Feeder

2 marks

1) Figure shows single phase loads on three phase feeder at different points. A balanced load of 50 A is taken on each phase at the starting end of feeder. 1 mark
2) But at other points, the load is not balanced on all three phases.
3) R phase is supplying 230 A, Y phase is supplying 125 A while B phase is supplying 165 A.
4) Thus, the system is unbalanced in supplying loads on each phase.
5) Due to which losses are increased. 1 mark
6) If proper care is taken to supply different phases such that equal or nearly equal load current is supplied by each phase, then the distribution system will be balanced and no additional losses will take place due to unbalance currents. To achieve this manually is difficult, therefore an appropriate optimization technique should be used.

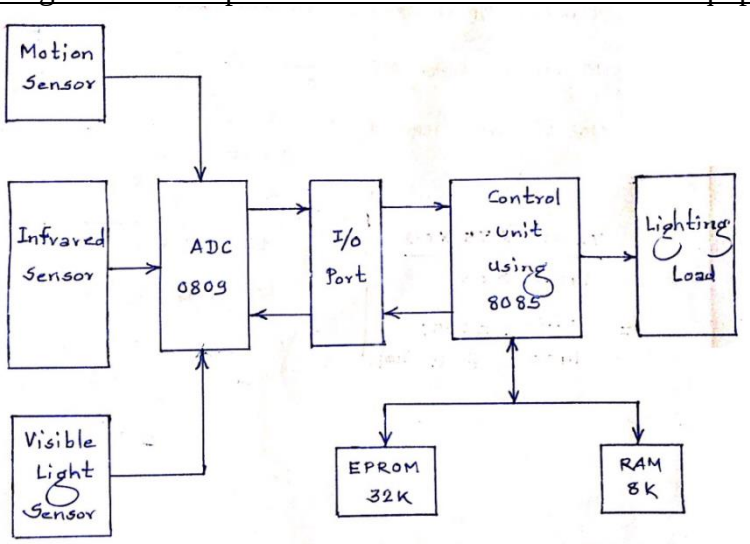
4 B) b) Define energy conservation equipment. Draw block diagram of microprocessor based centralized control equipment of energy conservation and explain it in detail.

Ans:

Energy Conservation Equipment:

The devices/equipment which save energy by optimally controlling the usage of the power equipment in the system is called as Energy Conservation Equipment. 2 marks

Block diagram of Microprocessor based centralized control equipment



2 marks for block diagram

1) Microprocessor based systems are increasingly used as a solution to manual systems
2) A microprocessor based centralized lighting control system is nothing but a microprocessor based centralized load controller.
3) It is used for lighting should be ON only if persons are in the room.
4) Automatic ON / OFF control is programmed.
5) Motion sensors are used to detect presence of person in the room
6) Central processing unit reads only digital signal hence analog output of the sensors are converted in to digital by using ADC (Analog to Digital Converter)
7) The data obtained from occupancy sensor is compared with reference value.

2 marks for explanation

8) When compared value is greater than reference value then it indicates person present in the room and lights are turned ON
9) Desired value of illumination is 135 to 300 Lux.

5 Attempt any four of the following: 16 Marks

5 a) Explain the working principle of automatic power factor controller.

Ans:

Automatic power factor controller:

Majority of the loads in the industries are highly inductive in nature such as induction motors, AC/DC drives, welding machines, arc furnaces, fluorescent Lightings, electronic controls and computers. There may be a few resistive loads for heaters and incandescent bulbs. Very rarely industries may have capacitive loads such as synchronous motors.Net industrial load is highly inductive causing a very poor lagging power factor. If this poor power factor is left uncorrected, the industry will require a high maximum demand from Electricity Board and also will suffer a penalty for poor power factor. 2 marks

Standard practice is used to connect power capacitors or automatic power factor controllers in the power system at appropriate places to compensate the inductive nature of the load. It has an individual starter control for the capacitors. In many industries a centralized compensation is employed. The capacitor banks are at the incoming distribution boards and these are sub divided into the steps. Automatic control system switches these subdivided capacitor units in steps to maintain the power factor to a reference margin. 2 marks

5 b) Explain energy conservation technique in induction motor by improving power quality method.

Ans:

Energy conservation technique in induction motor by improving power quality method:

Electrical energy can be conserved by improving the power quality. It can be achieved by avoiding voltage unbalance, maintaining voltage & frequency value, and avoiding harmonic distortion.

i) Voltage unbalance:

Three phase induction motors are designed to operate on a balanced three phase A.C. Supply. In unbalanced condition the voltages in three phases are unequal which may cause a significant problem to motor such as excessive heating and vibrations. Excessive heating in the motor caused due to the unbalance or neagative sequence current because of the unbalanced voltages. This condition leads to increase in the I^2R loss in motor. 2 marks

Voltage unbalance can be minimized by equal distribution of single phase loads on all three phases and by identifying or taking aside the loads which are disturbing the voltage balance.

ii) Harmonic distortion :

Increased use of the power electronics devices in the system leads to add the harmonics in a supply frequency. Undesirable effect of these higher frequencies related to the harmonic voltage distortion causes in iron and copper losses in 1 mark

motor. These losses can be minimized by using harmonic filter thus reducing the harmonics in the system.

iii) Maintaining the frequency and the required form factor of 1.11 (sine wave) minimizes the harmonics, and iron / mechanical losses as the speed is maintained at specified value. — 1 mark

5 c) Explain energy conservation in transmission and distribution system by using compensating reactive power. How?

Ans:

- The reactive power drawn through lines due to heavy reactive loads or conditions leads to increase in the kVA and higher current in lines.
- This current leads to higher line heating losses, heavy line voltage drops and fall in line efficiency.
- If this reactive power is compensated near the load ends, the current gets reduced thus decreasing the line losses and lowering the line voltage drops.
- The compensation also helps to supply higher loads as per the system capacity.
- There are reactive power compensation devices as capacitor banks and static VAR compensators that are used to carry out the compensation. Both lagging and leading reactive powers are compensated.

1 mark for each of any four points

Thus the energy is saved / conserved.

5 d) Define the following terms:

i) Electricity tax ii) Electricity duty iii) Connected load iv) Load factor tariff.

Ans:

i) Electricity tax:

In some states tax is charged on the transaction of electricity. This tax is charged in percentage of total amount of bill. This tax amount is received to the state government and not to the utility.

ii) Connected load :

It is the total wattage of all appliances which are used by the consumer on his sanctioned connection. Each consumer is having a different value of wattage of connected load.

iii) Electricity Duty:

In some states apply duty on the supply of electricity. This duty is charged in additional cost per unit or it may also be in percentage. This amount is received to the state government and not to the utility

iv) Load factor tariff :

Load factor is the ratio of energy used during a certain period to the maximum demand multiplied by number of hours for same period. For a proper use of plant capacity, consumers have to use energy at high load factors. The Load factor tariff may be formed in such a way that consumers using power at high load factors are charged at low rates or get intensives as compared to the consumers using power at low load power factors.

1 mark for each definition

5 e) List name of eight industries suitable for cogeneration.

Ans:

Following are the suitable industries for the cogeneration:

1. Aluminum industries
2. Cement industries
3. Paper and Pulp industries
4. Rice mills
5. Distilleries
6. Petrochemical sector
7. Sugar mills
8. Steel manufacturing plants
9. Ceramic industries
10. Gas Plants

½ mark for each of any eight other valid also to be considered

5 f) Explain following energy audit instrument and their use
i) Lux meter ii) Tri vector meter.
Ans:

i) Lux meter:
Lux meter consist of a photo cell which senses the light input and converts into an electrical impulses which can be calibrated as lux. Lux meter is used for measuring the illumination level. — 2 marks

ii) Tri Vector meter:
It is a multipurpose meter. It is having several functions. It can be used for unidirectional and bidirectional metering, Energy management and TOD (Time of Day) metering purpose. Some of the tri-vector meters are having an ability to display 350 parameters like RMS values of voltage, current, kVA, kVAr, kWh, kVAh, Power factor, kW, frequency, phase sequence, maximum demand etc. — 2 marks

6 Attempt any four of the following: 16

6 a) Draw layout of steam turbine cogeneration system and label it. — Any one diagram
Ans:
Steam turbine cogeneration system:

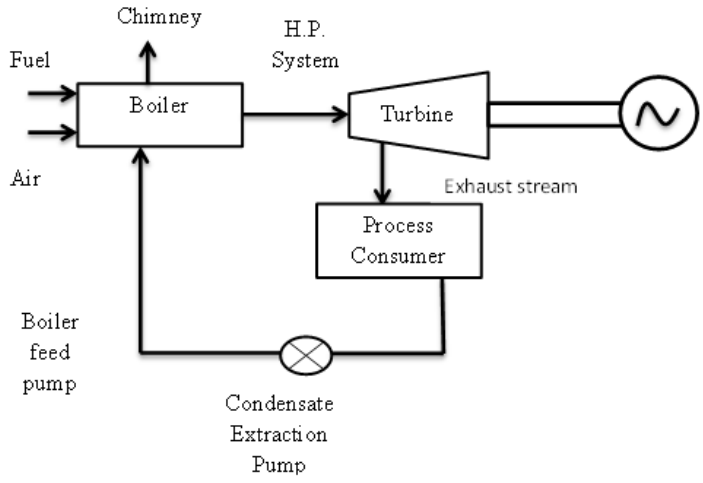


Fig: Back pressure steam turbine cogeneration

Labeled diagram 4 marks

Partially labeled diagram 3 marks

Unlabeled diagram 1 marks

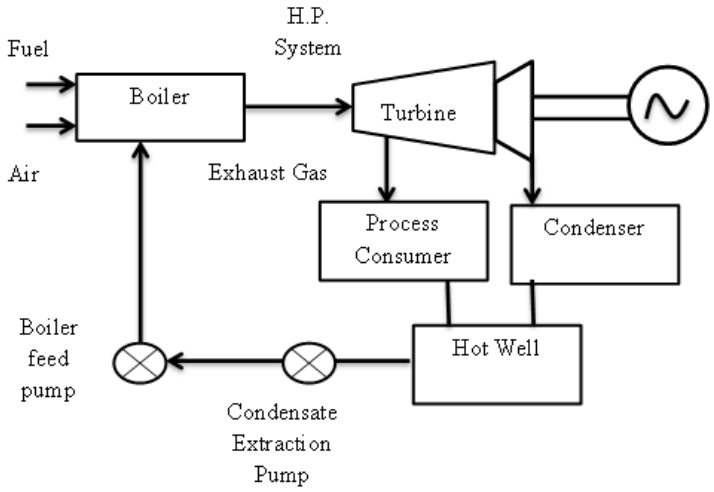


Fig:- Extraction condensing turbine Cogeneration

6 b) A consumer requires $50X10^6$ kWh per annum. The tariff is Rs. 100/kW of maximum demand per year plus 20 paise per unit. Calculate the annual cost of supply at load factor 50%. Also estimate the saving in annual cost its load factor is improved to 100%.

Ans:

1) Annual bill when load factor = 50%

Unit consumed annually = Maximum demand x Total hours x Load factor

$50 \times 10^6 = (M.D.) \times (365 \times 24) \times 0.5$

$$\text{Maximum Demand} = \frac{50 \times 10^6}{365 \times 24 \times 0.5}$$

Maximum demand = 11415.52 kW.

$$\text{Annual bill} = (11415.52 \times 100) + \left[(50 \times 10^6) \times \left(\frac{20}{100}\right)\right]$$

= Rs. 1,11,41,552/- 2 marks

2) Annual bill when load factor = 100%

Unit consumed annually = Maximum demand x Total hours x Load factor

$50 \times 10^6 = (M.D.) \times (365 \times 24) \times 1$

$$\text{Maximum Demand} = \frac{50 \times 10^6}{365 \times 24 \times 1}$$

Maximum demand = 5707.76 kW.

$$\text{Annual bill} = (5707.76 \times 100) + \left[(50 \times 10^6) \times \left(\frac{20}{100}\right)\right]$$

= Rs. 1,05,70,776/-

Annual saving = 1,11,41,552 - 1,05,70,776 2 marks

= Rs. 05,70,776/-

6 c) State any four advantages of energy audit.

Ans:

Advantages of energy audit:

The energy audit helps us to identify energy losses that can be minimized by various means to achieve the following:

1 mark for each advantage Any four = 4 marks

- Reduced expenditure on energy; e.g., by reducing consumption or changing tariff or fuel type.
- Reduced maintenance cost; e.g., following improved utilization of plant and optimization in operation.
- Saving in other costs; e.g., water charges, where demand is reduced.
- Reduced capital expenditure; e.g., where increased efficiency avoids the need for additional plant or supply capacity or makes possible accurate sizing of any replacement plant.
- More productive use of labour where measures release staff for other duties; e.g., automated control systems.
- Increased productivity where working conditions are improved; e.g., improved temperature levels, airflow, etc
- Hedging against forecast increases in energy and water costs with the introduction of the carbon emissions trading scheme.

OR

1. Energy audits will evaluate the facility "as a whole", their goal is not to evaluate single measures but to consider a wide range of available alternatives (Electrical, Mechanical, Envelope and Water).
2. The audit identifies opportunities and provides financial analysis. This will enable prioritization based on financial benefit and return on investment.
3. Suggest technical information regarding the proposed energy conservation measures.
4. Provide emissions analysis to understand the benefits of decisions from an environmental standpoint.
5. Understand where energy is used and which areas are worth focusing on the most (energy hogs).
6. Provide benchmark information to understand the energy use performance compared to others in similar area.

OR

1. We can organize the correct energy efficient program.
2. It identifies where energy is being consumed & assesses energy saving opportunities.
3. It gauges energy efficiency of the plant against best practice.
   During annual evaluation of factory performance energy audit assesses money saved through energy conservation techniques.

6 d) State two benefits and two applications of variable frequency drives

Ans:

a) Benefits of Variable frequency Drives:

1. Energy saving.
2. Better process control.
3. Cost saving.

1 mark for each of any two

4. Less maintenance cost.
5. Large life for bearing & motors.
6. Improved power quality.
7. Smooth starting.
8. Improved power factor

benefits

b) Applications of variable frequency drives:

1. For conveyers, Machine tools and other production line equipment machine Starting and controlling
2. Tunnel boring, mining and oil drilling platform machines staring and controlling
3. For controlling motor driven centrifugal pumps, fans and blowers.

1 mark for each of any two applications

6 e) Explain two part tariff with its advantages and disadvantages.

Ans:

In this type of tariff energy bill is split into two parts:

1. Fixed Charge 2. Variable Charge.

1. Fixed Charge:

The fixed charge is set according to the maximum demand. It includes, interest and depreciation on the capital investment in infrastructure and capital investment in equipment. Also it includes taxes and insurance charges. — 1 mark

2. Variable Charge:

Variable Charge recovers running cost or operating cost. The operating cost depends upon total energy consumed and varies with energy supplied to the consumer. — 1 mark

Total charges = Rs. (b*kw +c*Kwh)

Where, b = charge per kW of maximum demand.

c = charge per Kwh of energy demand.

Advantages:

1. Easy to understand. — 1 mark for advantage

Disadvantages:-

1. Consumer has to pay a fixed amount even though he has consumed a zero units
2. There is always error in assessing the maximum demand of consumer.

1 mark for disadvantages