DIPLOMA BOARD EXAMINATION – APRIL 2024

ANSWER KEY FOR THE QUESTION CODE – 717

SUBJECT CODE / NAME: 4030630 – ENERGY CONSERVATION AND AUDIT

BRANCH: EEE SEMESTER: 6 MAXIMUM MARKS: 100

PART-A

1. What is meant by primary energy? Give an example. (3 MARKS)

- Energy captured directly from natural resources is called primary energy.
- Common primary energy sources are coal, oil, natural gas, biomass etc.
- Primary energy sources can be further classified into renewable sources and non-renewable sources.
- Examples of renewable sources are solar, wind, geo-thermal, tidal, biomass, etc.
- Examples of non-renewable sources are fossil fuels, crude oil, coal, nuclear, natural gas, etc.

2. Write short notes on MEDA. (3 MARKS)

- Government of Maharashtra has established Maharashtra Energy Development Agency (MEDA) as State Nodal Agency for promotion, propagation and development of energy sources in the State.
- MEDA is registered as Society under Societies Registration Act.
- MEDA is under the guidance of Ministry of New and Renewable Energy (MNRE), Government of India.

3. List any three points needed for energy conservation in induction motor. (ANY THREE POINTS) (3 MARKS)

- Cost of electricity is increasing, so conservation methods to motors should be provided.
- Motor must work at high efficiency, so provisions of reducing losses should be provided.
- Inefficient motors need large power for the same output. To save power, therefore energy efficient newly designed motors should be provided.
- Good quality materials for core and windings should be used by the manufacturers to improve the efficiency.

- The shape of the slots should be changed to get more efficiency.
- Operation cost can be saved by using energy efficient motors.

4.State the advantages of soft starter. (3 MARKS)

- Less mechanical stress
- Improved power factor
- Lower the maximum demand
- Less mechanical maintenance
- Low line voltage drops on motor operation
- Reduced energy loss in the lines
- System efficiency increases.
- Smooth start and stop operation

5.How to control I ^{2}R losses? (ANY THREE POINTS) (3 MARKS)

- Reduce the conductor length up to suitable length.
- Increase the conductor size.
- Install new transformers at the load centre if the distance between the substation and the load centre is large.
- Using low resistance All Aluminium Alloy Conductor (AAAC) in place of Aluminium Cored Steel Reinforced Conductor (ACS) conductor.
- Transmitting electricity at high voltage reduces the value of current and hence I^2 R losses are reduced.
- By provision of reactive power control and power factor improvement, the current reduces and hence I ^{2}R losses reduces.
- Use voltage controllers to keep the voltage constant. This control I ^{2}R losses.
- Keep as minimum as possible the distance between the consumer premises and distribution transformers.

6. Write a short note on energy efficient luminaries. (3 MARKS)

Energy conservation can be obtained by effectively installing luminaries along with lamps at proper height. The luminaries include all components such as power supply, reflector, lamp holder and electrical connection equipment's. System layout and fixing of luminaries play a major role in achieving energy efficiency.

7.What are the objectives of energy audit? (ANY THREE POINTS) (3 MARKS)

- Determine the ways to reduce energy consumption per unit product output.
- To reduce the operating cost.
- Provide a bench mark (reference point) for managing energy in the organisation.
- Provide plan for more effective use of energy throughout the organisation.
- Audit the energy consumption.
- Estimate the energy use and area of wastage.
- Identification of energy improvement opportunities and recommendations for. energy efficient measures.
- Relating the energy input and production output.
- Estimate the implementation cost with the pay back periods.

8.What are the instruments used in temperature measurements? (3 MARKS)

- Glass stem thermometer
- Contact thermometer
- Non-contact infrared thermometer

9.Give the classification of co-generation on the basis of sequence of energy use. (3 MARKS)

- Topping cycle
- Bottoming cycle

10.Write short note on peak-off day tariff. (3 MARKS)

In this type of tariff, consumers are offered electricity during peak - off period of the day. Hence generating plants working at low loads can be made to work at high loads and hence reducing the cost of generation. Consumers using energy during off peak loads can be charged at low rates. In this case, a timer switch with energy meter can be provided which will cut off the supply to the consumer during peak hours of the day.

PART-B

11.(a) Explain about safety rules for working with Electrical Equipment.

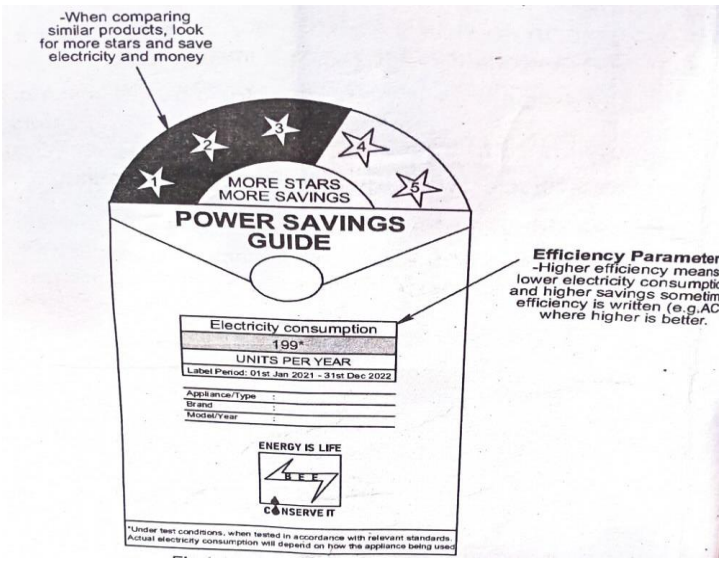
(14 MARKS)

- Avoid contact with energised electrical circuits.
- Disconnect the power source before servicing or repairing electrical equipment's.
- Use only tools and equipment's with insulating handles when working on electrical devices.
- Before replacing a blown-out fuse always put the main switch off.
- Always keep the earth connection in good condition.
- Check proper working of safety devices.
- When working on electrical equipment, be sure that the hands are dry and wear insulated gloves, protective clothes and shoes with insulated soles.
- If water or chemical is spilled on the equipment, switch off the power supply. Never try to remove water on the equipment while working.
- Enclose all electric contacts and conductors.
- Do not store highly flammable liquids near electrical equipment's.

11.(b) What is the significance of star labelling? Explain. (14 MARKS)

(Theory-7 marks,Diagram-7 marks)

- Section 14 of the Energy Conservation Act 2001, the Central Government delicate power to notify Standards and Labels for appliances in order to realise the benefits of energy efficiency through reduced energy consumption.



- Bureau of Energy Efficiency (BEE) star rating is a measure of efficiency of an electrical appliance. It is the five points scale. Higher the star rating means lower energy consumption and better savings.
- Energy labelling is one of the most cost-effective policies for improving the energy efficiency and lowering the energy cost of appliances for the consumers.

This scheme is applicable for different electrical equipment's like air conditioner, television, refrigerators, distribution transformer, industrial motors, agricultural pump sets, water heater, washing machines, LED lamps etc.

NEED OF STAR LABELLING

- Labelling of the equipment helps the consumer to know the energy level consumed by the equipment. Hence the consumer can choose the energy efficient equipment.
- Labelling encourages the consumers to buy the equipment's which are more energy efficient.
- Purchasing a labelled equipment provides better performance and reduces consumption as compared to conventional equipment.
- Demand of the labelled equipment's encourages the manufactures to produce more energy efficient equipment's in the market.

BENEFITS OF STAR LABELLING

- It helps to encourage the consumers to buy appliances and equipment's which are more energy efficient.
- If helps to provide products for customer choice.
- It helps to attract and retain the customers.
- More stars mean more saving on electricity bill.
- Demand of the labelled equipment's encourages the manufactures to produce more energy efficient equipment's in the market.

12. (a) Discuss in detail how intelligent power factor controller is adopted in energy conservation. (14 MARKS)

An intelligence power factor controller is a device used in electrical systems to optimize power factor. It continuously monitors the reactive power in an electrical circuit and automatically adjusts the connection of capacitors to maintain the power factor close to unity, thus improving energy efficiency.This controller determines the rating of capacitance connected in each step during the first hour of its operation and stores them in memory. Based on this measurement, the IPFC switch on the most appropriate steps. Thus, eliminating the hunting problems associated with the capacitor switching.

(NOTE: Any Diagram related to Automatic Power Factor Controller)

1.Input Section:

- Voltage Sensor: Measures the voltage of the electrical system.
- Current Sensor: Measures the current flowing through the system.
- Power Factor Sensor: Measures the power factor of the system.

2.Control Logic:

- Microcontroller or Digital Signal Processor (DSP): Processes input signals and calculates the required correction.

3.Compensation Section:

- Capacitor Bank: This includes multiple capacitors that can be switched on or off to provide reactive power compensation.

4.Output Section:

- Switching Device: Controls the connection of capacitors based on signals from the control logic.
- Protection Circuitry: Ensures safe operation of the controller and electrical system by monitoring voltage, current, and temperature.

5.Communication Interface (Optional):

- Ethernet, RS-485, or other communication protocols: Allows for remote monitoring and control of the IPFC.

12.(b) Explain the following energy conservation methods of electrical motor:

(i) Rewinding of motor (ii) Energy efficient motor

REWINDING OF MOTOR (7 MARKS)

- Generally, in industries rewind the burn out motors and reuse them. Hence the cost of new motor purchase is saved. Careful rewinding of motors sometimes maintains the motor efficiency at previous levels.
- But in most cases efficiency will be reduced. The efficiency of rewinding motor will be reduced due to the factors such as winding and slot design, winding material, insulation performance and operating temperature.
- However, if proper precautions are taken, the motor efficiency can be maintained and, in some cases, increased after rewinding. Efficiency can be improved by changing the winding design.
- By using greater cross - section of wires and slot size, the stator losses are reduced. Hence the efficiency will be increased.
- The efficiency and power factor of the rewinding motor can be easily assessed if the no load losses of motor are known before and after rewinding.
- If maintaining the record of no-load losses and no-load speed from the time of purchase of each motor will help to assess the efficiency and power factor of rewinding motor.
- By using larger cross section area of conductors and better insulation the copper losses can be minimised. Extension of coils beyond the slot must be minimised to reduce the amount of copper. This leads to reduction of copper loss.

Energy efficient motor (7MARKS)

- Energy efficient motors operate with efficiencies 3 to 4% more than the standard motors.
- According to BIS, energy efficient motors are designed to operate without loss in efficiency at loads between 75% and 100% of rated capacity.
- This may result in major benefits in varying load application. The power factor is same or may be higher than the standard motors. in energy efficient motors, design improvements are incorporated specifically to increase the operating efficiency than the standard motors design.

- The design improvements for reducing the losses of the motor is by using low loss silicon steel, longer core, thick wire to reduce resistance, thinner laminations, smaller air gap between stator and rotor, copper instead of aluminium bars in the rotor, superior bearing and smaller tan etc.
- Replacing of standard motors with energy efficient motors will give energy saving and long operating life.
- This energy conservation technique producing less carbon emission and hence less global warming and protection to the environment.

13. (a) Discuss in detail about cascade efficiency and Aggregated Technical and Commercial (ATC) Losses. (14 marks)

- In earlier days because of absence of feeder metering the major portion of the transmission and distribution losses was due to electricity theft.
- Transmission and distribution losses were calculated
- by the electricity bill issued to consumers instead of the amount paid by the consumers. This method did not determine the actual value of theft.
- To overcome this drawback the concept of Aggregate Technical and Commercial loss was introduced (ATC).

AT and C losses mainly comprise of two kinds of losses.

(1) Technical loss

(2) Commercial loss

ATC loss is the difference between energy input units into the system and the units for which the payment is collected.

ATC Loss (%)=(Energy input - Energy realised/ Energy input) × 100

where,

Energy Realised = Energy Billed × collection efficiency

TECHNICAL LOSSES

- The technical losses are developed due to energy dissipated in conductors used for transmission and distribution lines and also the equipment used for transformation, transmission, distribution of power etc.
- Technical losses are calculated as given below,
- Technical losses = Line losses in HT lines + line losses in LT lines + losses in transformers.
- The line losses occur in the lines or cables. These line losses present in HT and LT lines are called copper losses. It can be calculated by using the formula I R.
- The losses that occur in the core of the transformer is
- called as core losses. Different levels of distribution system needed different rating of transformer. Hence these transformers have different core losses.

COMMERCIAL LOSSES

- Commercial losses are also called non-technical losses. Generally, these losses are higher than the technical losses but are difficult to detect.
- This loss does not take place in transmission and distribution lines. As this loss directly affect a revenue or commercial cost, they are called as commercial losses.
- Commercial loss can be represented as follows,
- Theft of energy, meter bypass, detective meter, meter stopped, wrong reading, reduced collection efficiency, burning of meter etc.
- Commercial losses can be calculated by,
- Commercial Losses = ATC losses - Technical losses

(OR)

- Energy input in the distribution system - Sales at consumer end - technical losses

13.(b) Explain the working principle and operation of APFC. (14 marks)

Majority of the loads in the industries are highly inductive in nature such as induction motors, welding machines, arc furnaces etc. This will lead to poor lagging power factor. If this poor power factor is lent uncorrected, the maximum demand of the industry will increase. Hence the electricity bill will be high. Also, the industry will pay penalty for the poor power factor. Low power factor will lead to increase current and hence increase losses. Hence to improve the power factor of the load, Automatic Power Factor Controllers are used.

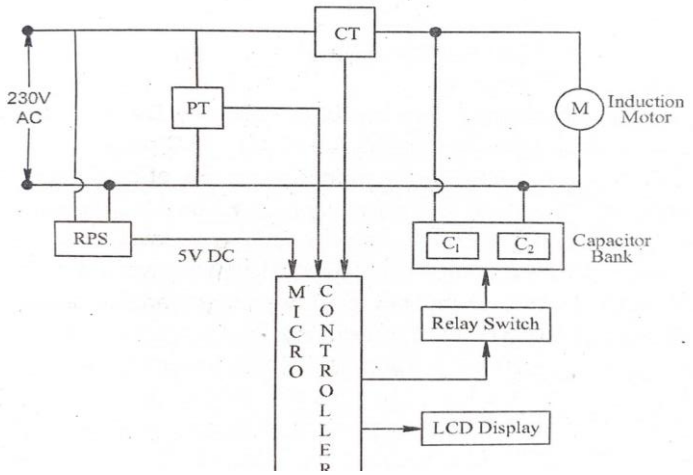


Figure shows the Automatic Power Factor Controller.

It consists Of,

1. Regulated Power supply Unit

2. Microcontroller

3. LCD Display

4. Potential Transformer

5. Current Transformer

6. Capacitor Bank

The Regulated Power Supply Unit converts 230 V AC into 5V DC. The 5-volt DC supply is given to the microcontroller. The load voltage and load current are sensed by PT and CT. This sensed voltage and current are given 10 the microcontroller. The inbuilt comparator of the microcontroller acts as zero crossing detector and determines the power factor of the

load and the power factor is displayed on the LOD display. For the given load if the power factor is less than the desired power factor, capacitor bank 1 (C_1) is switched on.

If the desired power factor is not achieved after switching on capacitor bank (C1), capacitor bank (C2) is switched by using micro controller to get desired power factor.

14.(a) Draw and explain the Sankey diagram for

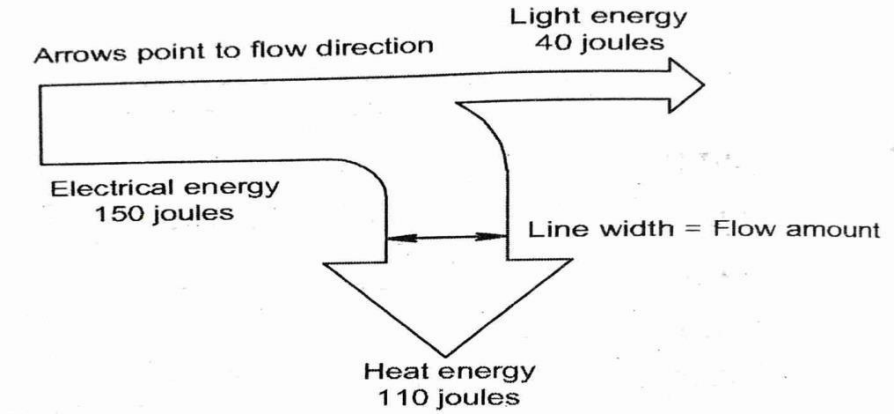
(i) Converting electrical energy to Heat to Light. (7 MARKS)

(ii) Electrical to Mechanical conversion. (7 MARKS)

(i) Converting electrical energy - > Heat - > Light.

[Theory - 3 Marks & Diagram – 4 Marks]

- An Irish man, Captain Mathew Sankey used a flow chart to show the energy efficiency of the steam engine. It is now referred as sankey diagram. Sankey diagram is a specific type of flow diagram in which width of arrow is proportional to the quantity of flow.
- Sankey diagram represents the energy flow visually by identifying the energy input, energy transfers and points where energy is wasted. Usually energy flows are represented by arrows. Sankey diagram is used to investigate the energy efficiency of the system. This diagram helps the energy manager for finding the energy saving improvements in priority manner.



- Figure shows the Sankey diagram. Quantity of energy is represented by width of arrows and their direction indicates where the energy flows. In fig. the arrow to the right represents useful energy output i.e., light energy (40 Joules) and the downward arrow represents the wasted output energy (110 Joules). The figure shows an input of 150 Joules results in a total output of (40J + 110J).

(ii)Energy Flow Diagram, Electrical to Mechanical Conversion

(Taking a Case of Water Pump)

[Theory - 3 Marks & Diagram – 4 Marks]

In such electrical to mechanical conversion, there are various stages where power is lost (losses).

Losses

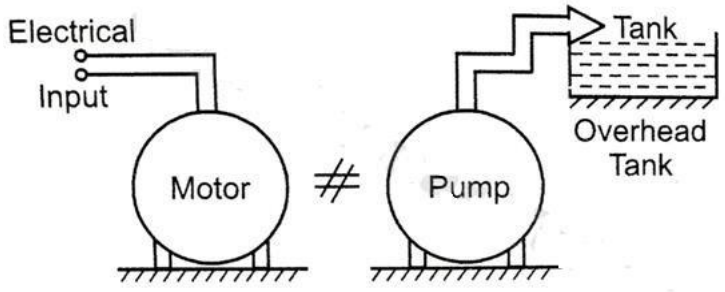
Motor lossessay10 % Coupling losses say 1% Pump losses say 24%
Valve losses say 8%
Pipe losses say 12 %

Summing up **Input 100% - losses 55% = useful output only 45%.**
Input - Losses = Useful output 100% - 55% =45%

- From such Sankey diagram, internal distribution of energy to final consumption can be easily understood and can be studied.
- From such diagrams, experts can decide the priorities to be given for improvement findings.

Such diagrams should be drawn in proportion it for losses in the above diagram shall be shown by proper thickness (portions) small strip shows 1%, medium sized strip shows 8% like this.

By studying this diagram, the inefficiency present in the pump and loss-reduction methods can be employed to increase



Sankey Diagram

14,(b) Write in short about the following instruments

(i) Load and power factor measuring equipment. (4 MARKS) (ANY FOUR)

1.Ammeter (AC and DC)

Ammeters are used to measure the current in the electrical circuit. Clamp on ammeters is used to measure the currents in different sections or branches of the electrical system.

2. Voltmeter

AC and DC voltmeters are used for measuring the voltages at different points in electric system.

3. Trivector meters

Trivector meters is used to measure the multiple quantities such as KW, KVAR, KVA.

4. Energy meters

It is used to measure the electrical energy supplied to load.

5. Power factor meter

Power factor meter measures the power factor of the electric load. It also determines the type of load used in the system. (Resistive, inductive, capacitive)

6. Multi meter

It is a testing instrument used to measure two more electrical quantities. Voltage (AC and DC), current (AC and DC) Resistance (R).

7. Frequency meter

It is used to measure the frequency (Hertz) of the AC supply.

8. Power Analyser.

An on-line power analyser gives a continuous measurement and record of real power (Kl), apparent power (KVA), voltage, current and power factor.

9. Synergy meter:

This instrument measures and records current, voltage, power factor, frequency, kWh and KVAh.

10. ph meter

It is used to measure the pH value of solutions to give the idea of their corrosions, pollution capacity etc.

(ii) Wattmeter (3 MARKS)

A wattmeter is an electrical instrument used to measure the electrical power in watts consumed by an electrical circuit or produced by a generator. It typically consists of a current coil and a voltage coil, which together measure both the current flowing through the circuit and the voltage across it to calculate power.

(iii) Flue Gas Analysis (3 MARKS)

- Combustion gas analyser is used to measure various combustion gases such as CO_2, O_2, CO_2, NO_2, SO_2, etc. This analyser has in-built chemical cells which measure the combustion gases.
- Specific sensors sealed inside the equipment can be changed to measure the different components in the gas. But only two or three parameters can be measured at one time because a maximum of two sensors can be connected to it.

(iv) Temperature and Thermal loss measurements. (4 MARKS)

- Thermal loss is the decrease of heat existing in space, resulting from heat transfer. Through roof, walls and windows.
- There are four types of heat losses within any building. These include thermal radiation, conduction, convection and air infiltration.
- The factors affecting thermal losses include wind speed, wind direction and ambient temperature**.**

Heat loss formula is expressed by

$$Q = (U \times A) \times \Delta t$$

Where,

Q = total heat loss through the building in Btu/hr.

U = Overall coefficient of heat transmission through the building.

A = The area in square ft of the building

Δt = Temperature difference between inside and outside.

15. (a) Explain about the bottoming cycle of co-generation system using neat sketches. (14 MARKS)

(Diagram-7&Theory-7)

- In this system, high temperature heat energy is produced using primary fuels (coal, oil, natural gas, nuclear).
- This heat is mainly used for other processes except generation of electricity. The waste or rejected heat from the process is used to generate electricity. The waste heat is applied to a recovery boiler and it is then applied to the steam turbine to generate electricity. For manufacturing process of some products, high temperature heat is required in furnaces.
- After the manufacturing process, the rejected heat is also high temperature which cannot be neglected. If it is neglected it will reduce the overall efficiency of the system.
- Bottoming cycles of co-generation is used in cement, steel, ceramic, gas and petrochemical industries.

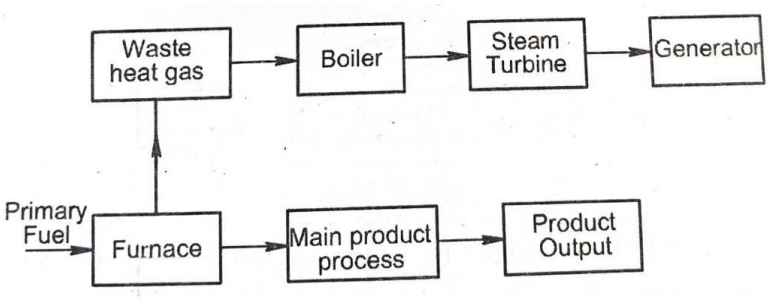


Fig. Block diagram of bottoming cycle co-generation

15. (b) Explain the guidelines for writing Energy Audit report. (14 MARKS)

1. Grammar and style

The report should be grammatically correct. The language should be clear, simple and understandable by all the readers.

2. Documentation

All numbers related to the results should be supported with suitable proof.

3. Mathematical Accuracy

All calculations should be checked for mathematical accuracy.

4. Logical consistency

The results should be logically consistent. For example, separate summaries in the report may use different bases for calculating energy savings. One summary may be based on energy savings related to the recommended measures. While a secondary summary may be based on energy savings related to both recommended and non-recommended measures. In such cases the auditor should explain in note for the two references.

5. Illustrations

Graphs and charts may be used to spark interest in the report and implementation of the recommendations

Prepared by,

Mrs. Indhumathi N

Lecturer (Consolidated)/EEE,

149, Government Polytechnic College,

Vanavasi,Salem-636457.