GOVERNMENT COLLEGE OF ENGINEERING,KALAHANDI

DEPARTMENT OF ELECTRICAL ENGINEERING

Lecture notes on Electrical Energy Conservation and Auditing

Submitted By

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5Th Semester

Electrical Energy Conservation and Auditing

Module I: **(12 Hours)**

Electrical energy conservation: Energy economics- discount rate, payback period, internal rate of return, net present value, and life cycle cost. Energy generation, energy distribution, energy usage by processes, technical and economic evaluation, understanding energy costs, classification of energy conservation measures, plant energy performance, benchmarking and energy performance, matching energy usage to requirement, maximizing energy system efficiency, optimizing the input energy requirements, fuel and energy substitution, and energy balancing.

EB billing- HT and LT supply, transformers, electric motors- motor efficiency computation, energy efficient motors, pumps, fans, blowers, compressed air systems, refrigeration and air conditioning systems, cooling towers, electric heaters (space and liquid), DG-sets, illuminating devices, power factor improvement, and harmonics.

Module II: **(12 Hours)**

Electrical energy audit: Energy consumption pattern and scenario of any region; Energy auditing: Need, types, methodology and approaches; Preliminary energy audit methodology (initial site visit and preparation required for detailed auditing, detailed energy audit activities, information and data collection, process flow diagram and process steps); Procedure and techniques: Data gathering, evaluation of saving opportunities, and energy audit reporting; and Energy audit instruments.

Module III: **(06 Hours)**

Illumination: Illumination, luminous flux, lumen, luminous intensity, candela power, brightness, glare, types of lighting (incandescent, CFL, and LED), requirements of lux for various purposes, determine the method of lighting, select the lighting equipments, and calculate the lighting parameters.

Text Books:

[1] Callaghn, P. W." Design and Management for Energy Conservation", Pergamon Press, Oxford, 1981.

[2] Dryden. I. G. C.," The Efficient Use of Energy", Butterworths, London, 1982.

[3] Energy Economics -A. V. Desai (Wiley Eastern).

[4] Handbook of Energy Efficiency - CRC Press

Reference Books:

[1] Energy Technology, OP Gupta, Khanna Book Publishing

[2] Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 2009.

[3] Handbook on Energy Audit and Environment Management, Y P Abbi and Shashank Jain, TERI, 2006.

Electrical Energy Conservation & Auditing

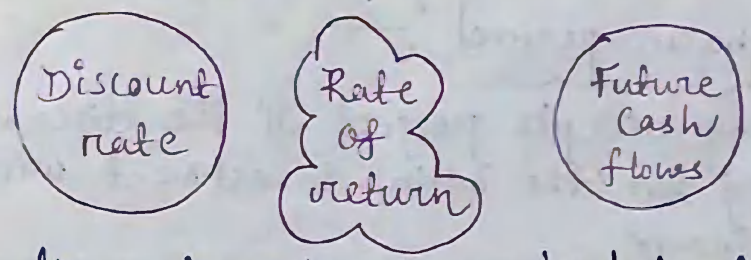
Energy Economics :—

(i) To minimize the greenhouse gas emission all reducing electrical energy cost.

(ii) It involves to identify the optimal combination of energy resources, technology & policy manner to meet the specific energy related objectives.

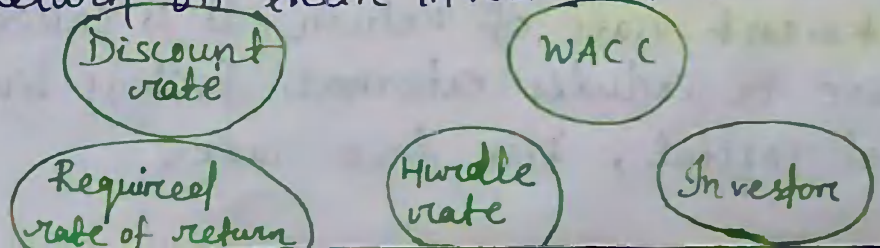
Discount rate ? —

(1) Discount rate is the rate of return used to discount future cash flows when calculating an investment's present value.



(2) A discount rate is applied to future cash flows because money earned in the future is less valuable than money earn today.

(3) The discount rate is used when computing a Company's weighted Average cost of capital (WACC). & is used as a "required rate of return" or the hurdle rate that companies & investors expect as a return on their investment.



Payback period :—

To calculate the length of time required to recover the initial cost of project.

$$\frac{\text{Investment}}{\text{Annual inflow}}$$

or

$$\frac{\text{Initial outflow}}{\text{Annual inflow}}$$

It is the no. of years required to recover the original cash outlay invested in a project.

Payback period > Target period = reject proposal

Payback period < Target period = accept proposal

Project with a shorter payback period will be less risky.

Discount payback period :—

A company accepts project if the discounted cash flows pay for the initial investment within a specific time frame.

Discount payback period

↓

Time value of money

The number of period taken in recovering the investment outlay on the present value basis.

Internal Rate of Return :— (IRR)

It is a method of calculating & investment rate of return. It is called internal because it excludes external factors like inflation, cost of capital, Risk free rate.

IRR considers what discount rate will be needed to produce an NPV of 0 for the project.

It is the rate of return at which the net present value (NPV) of a project becomes zero. i.e. PVCOF is equal to PVCIF.

'Internal' because it does not take any external factor into consideration.

The project with the highest IRR will be selected

Net Present Value (NPV) :—

This method considered the Time value of money.

NPV is the difference between present value of cash in flow & present value of cash out flows over a period of time.

NPV is used in capital budgeting & investment planning to analyse the profitability of a project as Projected investment.

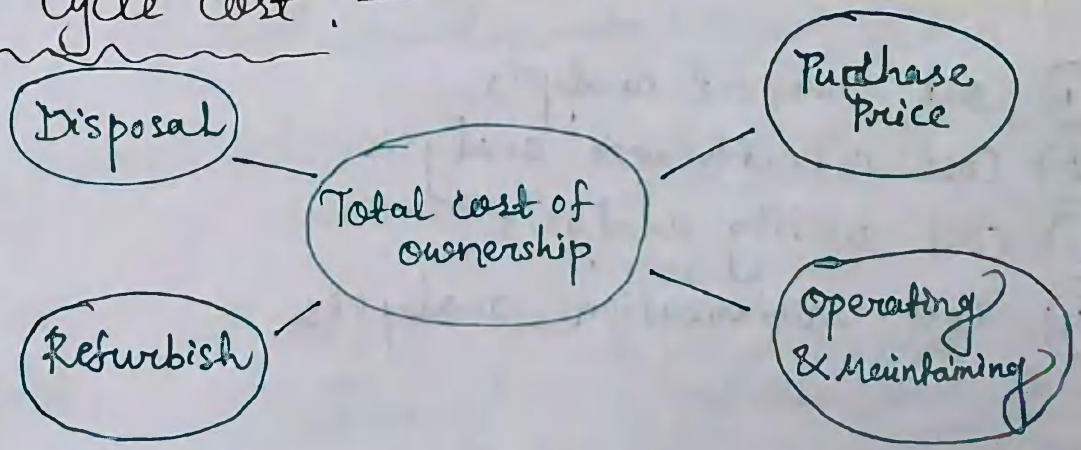
$$NPV = \frac{R_t}{(1+i)^t}$$

t = time of the cash flow

i = discount rate

R_t = net cash flow

Life Cycle cost :—



These costs include the initial investment, future additional investment, annual recurring costs.

Adding up all the costs associated with an asset starting from its initial cost to its end of life.

Life cycle costing provides an estimate of the cost that an asset will incur in its lifetime.

Life cycle costing can be highly benefitial to businesses of all types & sizes.

. How much money you will spend on an asset in lifetime.

Economic Evaluation :—

It is the process of systematic identification, measurement & valuation of i/ps & outcomes of two alternative activities & subsequent comparative analysis.

The purpose or objective of economic evaluation is to identify the best course of action, based on the evidence available.

Types of Economical Evaluation :—

1. Cost benefit analysis
2. Cost effectiveness analysis
3. Cost utility analysis
4. Cost minimization analysis.

Study	Measurement of Consequences
Cost minimization Analysis	No measurements of consequences as the consequences / outcomes are same.
Cost Effective Analysis	Outcomes are measured in natural units. eg: life years gained, life years saved.
Cost utility Analysis	Utility of the intervention is measured.
Cost benefit Analysis	Consequences are measured in monetary terms.

Types of Evaluation	Cost Measurement	Outcome Measurement	Outcome Valuation
Cost Minimization	Any currency	Assumed equivalent or demonstrated equivalent	No evaluation
Cost effectiveness	Any currency	Single major outcome common to alternatives being evaluated	No evaluation Common units
Cost utility	Any currency	Single or multiple effects, common or unique to the alternatives	valuation with result expressed
Cost benefit	Any currency	Any effects produced by the Alternatives	valuation with results expressed in currency units

Understanding of Energy cost :—

The energy cost means the cost of electricity, fuel oil, Gasoline, heating oil & other source of energy which is connected to the operation of energy & related to energy authority.

To understand the energy charges & fees on energy related cost i.e. electric bill, gas bill etc. for each month is an important part of regular budget.

The objective of an understanding the energy cost that the energy related issues which includes the energy cost and the number of items that are used in every energy related bills. energy related issues

① Categories to understand the energy cost :—

① Electricity cost :—

Ex :- In our electricity bill we will see a least of lines & amount of electricity for consumer used in every month & also listed in kwh.

Every consumer have to control over this portion of kwh in two ways.

a) Every consumer can work to cut down the energy by reducing load uses.

b) Every consumer can control by selecting a supplier that offer a fixed rate plan to avoid fluctuations of energy due to change in energy supply.

(2) Capacitive Cost :—

To understand on our electric bill Capacitive cost.

The electricity bill usually is curried by Commercial Customer ensure that the electric utility has enough capacitive that cover the total power demand of consumer.

Life cycle cost :—

There are 5 category of life cycle cost.

a) Initial cost
b) Service cost
c) Meintenence cost
d) operating cost
e) Disposal cost

Acquisation cost = Initial cost + Service cost

Acquisition Cost :—

The process of acquiring new customers for business.

Refers to bringing in new customers - or convincing people to buy your products.

The total amount of money a company or a business spends on acquiring assets, getting new clients, or overtaking a new company.

Maintenance Cost :—

Maintenance costs are necessary business expenses used to keep assets in good working condition.

Ex:- The costs associated with keeping a road, building, vehicle or machine in Good condition by regularly checking it & repair it when necessa -ry.

Operating cost :—

Operating costs are the expenses which are related to the operation of a business or to the operation of a device, equipment; These cost are used by an organization to maintain its existence.

Disposal cost :—

It is the cost changed by a third party for disposal of damaged or waste product from the manufacturer of every product.

Life cycle cost refers to the an accounting for internal & external cost associated with a process throughout its life span.

Classification of Energy Conservation Measures

There are 3 types of Energy conservation measures.

a) Low cost high return
b) Medium cost medium return
c) High cost high return

Necessity of Classification of Energy conservation of plant :—

It reduces the energy consumption of any equipment or an essential part of project or business or power plant.

The energy conservation measures do upgrade, replacement & repairing of project or business to become more energy efficient. These measures can significantly reduce the operating cost while providing the operational benefit by organize to replace or outdated equipments.

An energy conservation measure for short or a single initiative is taken to reduce the energy consumption of a particular equipment which relates to s/y service of any project or business & also it implies a combination of several energy conservation measures initiative to reduce the energy consumption across an entire facility of any project.

Plant energy performance :-

It is measure of how well the energy management program is doing.

It is the measure of whether a plant is now using more or less energy to manufacture its products that it did in the past.

It compares the change in energy consumption from one year to the other considering production o/p.

$$\text{Plant energy performance} = \frac{\text{Reference year equivalent} - \text{Current year energy} \times 100}{\text{Reference year equivalent}}$$

Plant energy performance can determine If a plant is using more or less energy to produce it's product then the

Past product. It can also helps to build up an energy with energy team members & internal process for managing energy with a focus on continuously improvement in energy performance in plant.

Benchmarking performance :—

The process of measuring products, services & process against those of organizations known to be leaders in one or more aspects of their operations. 'or'

Bench marking is a process of measuring the performance of a company's products, services, operations & processes against other companies.

Objective of benchmarking performance :—

It is the process of comparison of business to business performance which identify the strength & weak of business & also need to improvement of business.

There are 3 types of bench marking performance.

1. process bench marking
2. strategy bench marking
3. Performance bench marking

Energy performance ? —

Energy performance index = $\frac{\text{Total energy uses}}{\text{Unit area of project}}$

Unit = kwh/m^2 is subsequent or every year.

Energy performance index is the key matric used for bench marking energy uses in any commercial project or building.

Energy performance means how efficiently a product, system or building uses energy to provide an energy service.

Electrical energy performance is a term to indicate the qualitative energy uses for different real time application.

Maximize the energy system Efficiency ? —

① Monitoring energy uses : —

By the help of monitoring of real time. Monitoring tools to track electrical energy consumption & Identify the electrical energy deficiency.

② Regular maintenance ! —

Perform the regular maintenance to ensure the systems are operating efficiently & to identify the potential issues.

(3) Use of Energy Efficient equipment :—

Installation of high efficiency equipment in power plant real time application. So that it consumes less energy for the same outcomes

(4) Uses energy Management System :—(EMS)

By the use of EMS it can helps to plant for monitoring, controlling & optimise the energy consumption & generation in plant as well as real time application.

Incorporate the renewable energy s/y to operate the power s/y for different load.

Maximum Energy Efficiency :—

The maximum energy efficiency will be provided in production of power plant where maximum work is done for i/p energy & energy losses of plant should be minimized.

The maximum cost effectiveness in energy uses where the total cost of investment & cost of fuels are minimized.

It is one of the most cost effectiveness & fastest to reduce money or transactional inflow, Green hous gas Emission & to meet growing energy demand of power plant. So that renewable energy sources can be utilized effectively which with power plant.

Energy Efficiency :—

$$\frac{\text{Total power}}{\text{operational power}} + \text{Transient power}$$

Benefit of Energy Efficiency :—

(1) To Improve the economic standard of plant.
(2) Improve the efficiency of plant & decrease the stabilize of electricity price & decrease of electrical tariff rate.

Different ways to increase energy efficiency :—

(1) proper insulation to all electrical appliance.
(2) Seal incomplete work which is related to electricity.
(3) clean & replace the various filter uses in various electrical appliance.
(4) Replace the electrical appliance before damage.
(5) Use thermostat for proper ventilation.

What is optimization ?

This optimization process having widely used in all field of engg. to select the best designing performance.

It is also for improving the performance, reliability & efficiency of a system such as different types of business process, networking system, Software application.

Business optimization ? —

It is the process of improving the efficiency, productivity & performance of an organization.

It is the process of identifying and implementing new methods that make the business more efficient and cost effective.

optimization process has 3 components.

1. objective function
2. Decision variable
3. Constraints

It is the collection of mathematical principle methods for solving quantitative problem in various discipline of engg.

Fuel and Energy Substitution ? —

A fuel is a substance that stores the energy while energy is a natural process that can be extracted from different natural process. when the fuels are burned the chemical energy is produced which is also used to generate the another form of energy such as heat energy, light energy & kinetic energy.

A fuel is a substance that provides an energy as a result of different types of chemical changes.

The substitution of energy refers to electricity & electricity refers to the replacement of energy consumption more.

The energy conservation from chemical energy which will be stored as a fuel & produce heat energy as it burns & also which is converted kinetic energy also. kinetic energy as it drives as large motion so that it is converted into electrical energy.

Energy Substitution ? —

The substitution method of energy is perform by calculating the amount of primary energy required to the i/p of power plant in order to generate the amount of electricity or heat energy equivalent to generated by is non compustable.

Ex:- Solid, liquid, Gas.

Energy balance ? —

The energy balance states that the total energy consumed in power plant which is equal to the total energy expenditure by users.

The basic components of energy balance are:- energy intake, energy consumed, energy expenditure

It is also defined as the process of energy i/p, outcomes of plant & uses of energy through the entire operating process of plant.

Matching energy is used to requirement ? —

To meet the changes in demand of electrical system which have enough capacity to supply the energy to users.

Transformer :-

Ideal Transformer :-

(i) Primary & secondary winding resistance must be negligible.

(ii) The magnetic core has maximum permeability so that the mmf of transformer is very negligible. which is required to build up the magnetic flux in transformer core.

(iii) There are no losses due to resistance hysteresis & eddy current.

(iv) The leanage flux and leanage inductance are near about zero.

Q A Transformer is rated at 100 KVA at full load condition it's copper loss is 1200 watt & Iron loss is 960 watt. Calculate (i) the efficiency at full load, unity pf.

(ii) The efficiency at half load, 0.8 pf lagging.

(iii) The efficiency at 75% of full load condition, 0.7 pf lagging.

(iv) The load KVA at which the maximum efficiency will be occur.

(v) The maximum efficiency at 0.85 Pf lagging.

Soln:-

KVA = 100

P_c = 1200 w

P_i = 96 w

$$\%\eta = \frac{x \text{ KVA} \times 10^3 \times pf}{x \text{ KVA} \times 10^3 \times pf + x^2 P_c + P_i} \times 100$$

1 $x = 1$, $pf = 1$

$$\%\,\eta = \frac{1 \times 100 \times 10^3 \times 1}{1 \times 100 \times 10^3 \times 1 + (1)^2 \times 1200 + 960} \times 100$$

$$= 97.88\%.$$

(2) $x = 1/2$ or 0.5, $pf = 0.8$

$$\%\,\eta = \frac{0.5 \times 100 \times 10^3 \times 0.8}{0.5 \times 100 \times 10^3 \times 0.8 + (0.5)^2 \times 1200 + 960} \times 100$$

$$= 96.94\%.$$

(3) $x = 75\%$ or 0.75, $pf = 0.7$

$$\%\,\eta = \frac{0.75 \times 100 \times 10^3 \times 0.7}{0.75 \times 100 \times 10^3 \times 0.7 + (0.75)^2 \times 1200 + 960} \times 100$$

$$= 96.97\%.$$

(4) New KVA = Old KVA $\times \sqrt{\frac{P_i}{P_c}}$

$$= 100 \times \sqrt{\frac{960}{1200}}$$

$$= 89.44 \text{ KVA}$$

(5) $x^2 P_c = P_i$, $pf = 0.85$, KVA $= 89.44$

$$\%\,\eta_{max} = \frac{KVA \times 10^3 \times pf}{KVA \times 10^3 \times pf + 2p_i} \times 100$$

$$= \frac{89.44 \times 10^3 \times 0.85}{89.44 \times 10^3 \times 0.85 + 2 \times 960} \times 100$$

$$= 97.53\%.$$

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Q A 100KVA, 50HZ, 440/11000V, 1-ϕ T/f has an efficiency of 98.5%. when supplying the full load current at 0.8 Pf lagging & an efficiency of 99%. when supplying half load current at unity Pf. Calculate the core loss and cu loss corresponding to full load current At what value of load current will be maximum efficiency is produced?

Sol^{n} S = 100 KVA 440/11000 V

f = 50HZ

1-ϕ T/f

η_{full} = 98.5%.

Pf = 0.8

η_{half} = 99%.

Pf = unity

(1) $\eta_{half\ load} = \dfrac{1/2 \times 100 \times 10^3 \times 1}{1/2 \times 100 \times 10^3 \times 1 + \left(\frac{1}{2}\right)^2}$

(2) $\eta_{full\ load} = \dfrac{0.8 \times 100 \times 10^3 \times 0.99}{0.8 \times 100 \times 10^3 \times 0.99 + (0.99)^2}$

$$\frac{98.5 \times 0.8 \times 100 \times 10^3 \times 0.99}{0.8 \times 100 \times 10^3 \times 0.99 \times (0.99)^2} = 98.49$$

Efficiency at full load $= \dfrac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + \text{iron loss} + \text{cu loss}}$

$$98.5\% = \frac{100 \times 10^3 \times 0.8}{100 \times 10^3 \times 0.8 + \text{iron loss} + \text{cu loss}}$$

$$\Rightarrow 98.5 \times 100 \times 10^3 \times 0.8 = \frac{100 \times 10^3 \times 0.8}{\text{loss}}$$

$$\Rightarrow 98.5 \times 100 \times 10^3 \times 0.8 \times 100 \times 10^3 \times 0.8$$

$$\Rightarrow P_i + P_c = 1218$$

efficiency at full load $= \dfrac{1/2\ VI\cos\phi}{1/2\ VI\cos\phi + (1/2)^2\ P_i + P_c}$

$P_i + 1/2\ P_c =$ ——

Substracting the eqn 2 to 1

$P_c = 950.7\ W \qquad P_i = 267.3\ W$

The full load current at maximum efficiency in secondary side of t/f is $I_{2max} = I_{2fl\ load} \sqrt{\dfrac{P_i}{P_c}}$ (Secondary side)

full load current of secondary side t/f is equal to

$I_{2full\ load\ current} = \dfrac{\text{Total o/p power of t/f}}{11000\ V}$

$$\frac{100 \times 10^3}{11000} = 9.09$$

$I_{2max} = 9.8\ A$

$i/p = o/p + \text{loss}$

$\text{loss} = i/p - o/p$

Q A 600-KVA, 1-ph transformer when working at unity power factor has an efficiency of 92% at full-load and also at half-load. Determine its efficiency when it operates at unity p.f and 60% of full load.

ans) At full load :—

output = 600 kw

Input = $\frac{600}{0.92}$ = 652.2 kw

Total loss = 652.2 − 600 = 52.2 kw

Let x = Iron loss

y = full load cu loss (It is $\propto (KVA)^2$)

$x + y = 52.2$ ——— (1)

$P_i + P_c = 52.2$

At half load :—

output = 300 kw

Input = $\frac{300}{0.92}$ = 326.1 kw

losses = (300/0.92 − 300) = 26.1 kw

cu loss becomes one-fourth of its full load value, hence

$x + y/4 = 26.1$ ——— (2) $\quad \frac{1}{4} P_c + P_i = 26.1$

$x = 17.4$ kw

$y = 34.8$ kw

At 60% full-load :— full load unity pf = o/p = 600 × 0.6 × 1 = 360 kw

efficiency at 60% of $0.6^2 \times 34.8 = 12.53$ kw

cu loss = $0.6^2 \times 34.8 = 12.53$ kw

Total loss = 17.4 + 12.53 = 29.93 kw

output = 600 × 0.6 = 360 kw

$\eta = \frac{360}{389.93} = 0.965$ or 96.5%

$\frac{360}{360 + 29.93} = 0.923$ or 92.3%

Cooling System :—

To remove heat from different equipment ~~of~~ that are used in plant by spraying water through cooling tower to exchange the heat inside the equipment as well as plant. It is defined as the cooling system is a heat exchanger in which the air & water both are ____ to direct contact with each other. In order to reduce the water temp.

Types of cooling System :—

(1) Cross flow System
(2) Counter flow system
(3) Hyperbolic flow system

Application of cooling System :—

Cooling towers are primarily used for over heating of equipment, proper ventilation, Air conditioning system and industrial purpose. It provides the energy efficient operation of electrical system & also it is cost effective of electrical system. Hence cooling tower must be needed for every power plant.

Main components of cooling System :—

(1) Engine
(2) Radiator (Heat exchanger)

(3) Heater pump
(4) Cooling fan (to circulate the cooling air)
(5) Thermostat

(2) Function of Radiator? —

To regulate the engine temperature and to prevent the damage by excess heat Freeduce from engine and keeping the coolant fluid circulating the right level in engines.

The radiators which circulate throughout the engine which prevents the total engine from overheating process.

(1) Difference Between: —
Fan & Blower :

Fan moves large volume of air with very small or no changing in Air pressure.

Blower operates at moderate pressure with air pressure 1.1: 1.2 to continue the cooling air.

Similarities :—
Both fans and blowers are used for cooling system and air circulation either in indoor area or inside the industry or industrial equipments.

It operates at high speed with significant flow area.

Fan can create air flow with large volume they are usually in big size.

It can create high Pressure air flow with small volume which are used for small size of equipment.

It creates more air flow & it is more energy efficient.

Feature	Fan	Blower
Definition	A fan circulates air around an entire room or space.	A blower circulates the air only on the specific or pointed area.
Pressure	It is uses less pressure to Produce large amount of gas.	It is uses high pressure to produce large amount of gas.
Pressure ratio	The ratio of pressure is below 1.1.	The ratio of pressure is from 1.1 to 1.2.
Air Area	It provides air in the complete area.	It provides air in a specific location or point.
Types centrifugal	Axial flow fans Centrifugal fans Cross flow fans	blowers positive-displacement blowers
Consists of	It consists of a motor and blades which run of electricity.	It consists of a fan, outer cover inlet, out-let.

Q A 220 shunt motor hence the total current of 80 Amp runs at 800 rpm. The shunt field resistance & armature resistance are 50Ω & 0.1Ω respectively.

If the iron & friction loss is 1600 watt. Calculate the (i) Cu loss
(ii) Armature torque
(iii) Shaft torque
(iv) Efficiency of motor

Soln

220 shunt motor

Total current = 80 Amp = I_{Total}

$$I_{sh} = \frac{\text{o/p of motor}}{R_{sh}} = \frac{220}{50} = 4.4 \text{ Amp}$$

$$I_a = I_L = I_{sh} = 80 - 4.44 = 75.6 \text{ Amp}$$

Back emf of motor

$$E_b = V - I_a R_a = 220 - 7.56 \times 50$$
$$= 212.44 \text{ V}$$

i/p of motor = $VI_L = 220 \times 80 = 17600$ watt

Power developed in Armature (o/p power of motor) =

$$E_b \times I_a = 212.44 \times 75.6 = 16060 \text{ w}$$

(i) Cu loss = i/p − o/p = 17600 − 16060 = 1540 w

(ii) Armature torque = $T_a = 9.55 \times \frac{E_b \times I_a}{N}$

$$= 9.55 \times \frac{16060}{800}$$

$$= 192 \text{ N-m}$$

(iii) Shaft torque $\Rightarrow 9.55 \times \frac{\text{o/p}}{N}$

$\Rightarrow 9.55 \times \frac{\text{o/p}}{800} \Rightarrow 9.55 \times 800 = 7640$

Iron & friction loss

$o/p = 16060 - 1600 = 14460$

$T_{sh} = 9.55 \times \frac{o/p\ power}{N}$

$= 9.55 \times \frac{14460}{800}$

$= 172.6\ N.m$

(iv) Efficiency of motor :—

$\eta = \frac{o/p}{i/p} \times 100 = \frac{14460}{17600} \times 100$

$= 82.1\%.$

Q A 200 DC shunt motor takes 4 Amp at no load when running at 700 RPM. The field resistance is 100 Ω. The resistance of armature at strand still gives a drop of 6 V across the armature terminal when 10 Amp where passed through it. Calculate (i) Speed on load
(ii) Armature drop
(iii) Efficiency of motor
Assume the normal i/p of motor is 8KW.

200 DC shunt motor

$I = 4$ Amp

$N = 700$ RPM

$R_f = 100\ \Omega$

6 V drop

Total no load losses = $200 \times 4 = 800$ W

At no load condition :—

Total i/p power

Shunt field $I_{sh} = \frac{200}{100} = 2$ Amp.

$R_a = 6/10 = 0.6$

$I_l - I_{sh} = 4 - 2 = 2$ Amp

Armature cu loss ? —

$I_a^2 R_l = 2.4$

$\Rightarrow 800 - 2.4 = 797.6$

No loaded back Emf

$E_b = V - I_a R_a$

$= 200 - 2 \times 0.6$

$= 198.8$

full load condition of dc motor ? —

full load line current = $\frac{\text{Total } I/p \text{ power of motor 8kw}}{\text{voltage}}$

$I_l = \frac{8 \times 10^3}{200} = 40$ Amp

full load armature current

$I_a = 40 - I_{sh}$

$= 40 - 2 = 38$ Amp.

full load armature cu loss ? —

$A_{cu} = I_a^2 R_a = 38^2 \times 0.6 = 866.4$ watt

full load back Emf ? —

$E_b = V - I_a R_a = 200 - (3.8 \times 0.6)$

$= 177.2 V$

Now back Emf of full load ? —

$\frac{\text{full load } E_b}{\text{no load } E_{bo}} = \frac{E_b}{E_b} = \frac{N}{N_o}$

(i) $N = 624$ RPM

(ii) full load $T_a = \frac{9.55 \times E_b I_a}{N}$

$= \frac{9.55 \times 38}{624} = 103.5$ Nm

(iii) Total full load armature losses + Iron losses

$866.4 + 797.6 = 1664$ W

full load o/p $- 1664 = 6336$ W

$\eta_{fl} = \frac{\text{full load o/p}}{\text{full load i/p}} = 79.2\%$.

Power factor Improvement ? —

It is the process of increasing the efficiency of an electrical s/y by improving its pf as a result efficiency will be increased and cost will be reduced

Benefits of higher pf & lower pf ? —

If the pf is lower the electrical power consumption will increases and efficiency will decreases along with tariff rate or cost will decreases.

pf↓ E.P.↑ η↓ cost↓

A higher pf is better for both customer as well as utility while the low pf indicates power uses are very less. The ideal pf is 1 which indicates that the voltage and current are in same phase. If the pf is zero then voltage and current are 90° out of phase.

what are the factors of low p.f ?

(1) Inductive load :—

Induction m/c s which are used in 90% of industrial load and they draw magnetizing current to magnetic field.

(2) Transformer :—

In every substation the t/f have lagging pf due to inductive loads are used in substation.

(3) Varying power loading :—

when the electrical s/y is lightly loaded the voltage increases which causes the m/c s draw more current from the supply.

(4) Electrical appliance :—

Most of electrical appliance like Induction motor have low lagging pf.

Methods of Improvement of pf :—

There are 3 types of Improvement methods are used in electrical s/y.

(1) Capacitor bank
(2) Synchronous condenser
(3) phase advancer

(1) Capacitor bank :—

The pf can be improved by connecting the capacitors in parallel with electrical appliance in operating mode.

The capacitors are generally drawn a leading current which will compensate or suppress the lagging reactive component of load current.

Capacitors are less maintenance and very cheap & also it maintains the ideal pf in electrical appliance.

(2) Synchronous Condenser :—

When a synchronous motor operates at no load condition with maximum field excitation then it is known as Synchronous condenser.

When Synchronous motor is maximum field excited then it provides leading current which will compensate or suppress the lagging current of electrical s/y or appliance.

When a synchronous condenser is connected across supply voltage which is in parallel and it draws leading current and also element the reactive component of current which will flow in electrical appliance then pf of electrical appliance is improved.

(3) Phase Sequence :—

Phase advancer is a simple AC exciter which is connected in the main shaft of induction motor & operates with the motor cut for improvement pf.

Phase advancer is used to improve the pf of Induction Motors. The stator winding of induction motors the stator winding of induction motor takes lagging current which is 90° out of phase with voltage. So, pf of induction motor is lower. If the Ampere turns are excited by external Ac source then there would be no effect of exciting current on stator winding. So that the pf of Induction motors will be improved by suppressing or eliminating the lagging current of Induction Motors.

Q Explain details the types & methodology of energy auditing system.

Energy Audit :—

An energy audit is an inspection, analysis & survey of energy flows in a building, system or process.

To determine how much energy a building uses & Identify ways to reduce energy consumption.

Need of Energy Auditing :—

(1) Reduce energy consumption per unit of product.
(2) To lower operating costs.
(3) Three top operating expenses are labor, energy, materials.
(4) Possibility in cost reduction & "Bench-marking" for managing energy in the organization.