The Shirpur Education Society's

R. C. Patel College of Engineering and Polytechnic, Shirpur

Department of Mechanical Engineering

NAME OF COURSE: - POWER PLANT ENGINEERING

CODE OF COURSE: - 315374

SEMESTER: - TYME-5K

SUBJECT TEACHER: - Mr. ANUP PRALHAD PATIL

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Department of Mechanical Engineering

NAME OF COURSE & CODE: - POWER PLANT ENGINEERING -315374	**Academic Year:** 2026-27
Program Code, Semester & Scheme: ME-5K	

CHAPTER:- 05:- Recent Trends and Economic Analysis of Power Plants

COURSE LEVEL LEARNING OUTCOMES (COS):- Calculate economic parameters of various power plants.

Learning Hours	R-Level	U-Level	A-Level	Total Marks
6	2	4	8	14

APatil

Subject Teacher

Mr.Anup P.Patil

24/06/28

HOD ME

Mr.A.D.Patil

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R. C. Patel College of Engineering and Polytechnic, Shirpur

Program Name: Mechanical Engineering | **Program Code:** ME5k

Name of Subject & Code : Power Plant Engineering (315374) | **Semester :** Fifth | **Date:-** 18/06/2026

QUESTION BANK

Unit - V Recent Trends And Economic Analysis of Power Plants

Sr.NO	QUESTION	MSBTE QUE. NO	MARKS	EXAMINATION	BLOOSMS LEVEL
1	Define captive power plant.	QUE-01	2M	W-2025	CO-05,TLO-5.1,R
2	State the four schemes under National Mission for Enhanced Energy Efficiency (NMEEE).	QUE-01	2M	W-2025	CO-05,TLO-5.2,R
3	Define Average load and Peak load.	QUE-01	2M	S-2026	CO-05,TLO-5.1,U
4	What is Perform Achieve and Trade (PAT) scheme under NMEEE.	QUE-02	4M	S-2026	CO-05,TLO-5.2,R
5	Explain fixed cost and running cost of a power station.	QUE-03	4M	S-2026	CO-05,TLO-5.1,U
6	Define following terms : i. Demand factor ii. Load factor	QUE-04	4M	W-2025	CO-05,TLO-5.1,R
7	Define plant capacity factor and plant use factor. Give their mathematical expression.	QUE-04	4M	S-2026	CO-05,TLO-5.4,U
8	A thermal power plant consists of two units of 60 MW each running at 7000 hours and one unit of 20 MW runs at 3000 hours per year. Energy produced by the plant is 850 × 106 KWh per year. Determine the plant load factor and plant use factor.	QUE-06	6M	W-2025	CO-05,TLO-5.4,A
9	A generating station has a maximum demand of 30 MW, a load factor of 0.6 and plant capacity factor 0.48. Find :- 1. Daily energy produced 2. Reserve Capacity of plant 3. Plant Use Factor	QUE-06	6M	S-2026	CO-05,TLO-5.4,A

APatil

Subject Teacher

Mr.Anup P.Patil

24/6/26

HOD (ME)

Mr.Amol D.Patil

Unit-5 - Recent Trends and Economic Analysis of Power Plant.

TLO.5.1 - Introduction to Captive power Plant:-

A Captive Power Plant is power generation facilities setup by an industry for its own use.

It is operated independently from the national grid or may be connected for emergency use only.

It is usually located on site or near the industrial facility and its designed to meet the specific power requirnment of the plant.

The electricity Act 2003 in india allows industry to generates transmit and distribute electricity for their own use without needing a license.

Examples of Captive Power Plant:-

① Tata steel:-
use captive thermal & waste Heat Recovery plant - Jamshedpur (90 MW). & Meramandli (427 MW)

② Grasim Industry:-
for textile & cement production plant Bharuch (90 MW) - Gujarat.

③ sagar mill:-
Use Bagages (sugarcane waste) as a fuel power Generation - Bhimanshankar sahakari sakhar karkhana - Pune - (19 MW)

* Benefits of Captive Power Plant:-

① uninterrupted power supply:-
- Ensures contineous power supply.
- Avoid delay or shutdown due to power cut from main grid.

(2) Cost effective operation:-

- Generation power inhouse can be cheaper than buying from the electricity Board.

(3) Better Control over Power:-

- The industry can monitor & control the quality, volatage & frequency of power.
- Reduce risk of equipment damage due to voltage fluctuation.

(4) Revenue Generation:-

- Often power generation excess power & buying & selling that excess power to grid or neighbouring facilities, additional revenue can be added to your income.

(5) Effecient use of Resources:-

- Some CPP use waste Heat, gas or by product from the industry as fuel use.
- Increase overall Efficiency & Sustainablity

TLO-5.2- National Mission for Enhanced Energy Efficiency (NMEEE) in power plant:-

The NMEEE is one of the Eight Core mission under india National Action plan on climate change (NAPCC) lanuched in 2008 by the government of India.

It aims to promotes energy efficiency in industries building and other than energy intensive sector to help reduce greenhouse gas emission and save energy.

It is implemented by the bureau of Energy Efficiency (BEE) under the ministry of power, Government of India.

Objectives:-

- To promote cost effective energy efficiency as a market based mechanism.
- Encourage industries & institution to adopt energy efficient technology.
- Help india efficient meet its climate goal by reducing CO_2 emission.
- To improve energy efficiency in energy intensive sector.

* Perform, Achieve and Trade (PAT):-

PAT scheme air at reducing specific Energy consumption (SEC) i.e. energy use per unit of production for designated consumers (DC's) energy intensive sector, with an associated market mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded. The sectorwise designated consumer under PAT scheme (cycle-I & cycle VII) along with energy saving Targets.

* PAT cycle steps:-

step-1- Identification of Designated Consumer (DC's):-

Ex:- Cement, Iron & steel, Fertilizer, Thermal power plant, Paper etc.

step-2- Baseline Energy Audit:-

Each DC conduct an energy audit to measure current energy consumption.

step-3- setting the Energy Reduction Target:-

Beauro of Energy Efficiency (BEE) set a specific Energy Consumption (SEC) reducing target for each DC.

This target customized based on current efficiency & sector.

The target is to be achived in a specific period (Ex:- 3 year/cycle)

Step-4:- Implementation of Energy Efficiency Measure:-

Industries adopt Energy saving technologies and process improvement.

Step-5 - Monitoring & Varification:-

At the end of cycle independent accredited energy auditors verify the actual performance and energy saving achived.

Step-6 - Issurance of Escerts (Energy Saving Certificate)

If a DC exceeds its target, it is issused Escerts.

(1 Escerts - 1 metric ton of oil equivanent saved)

Step-7 - Compliance & Trading:-

DC's who fall short of their target must purchase Escerts from over achiver or pay a panelty.

Step-8 - Reporting & Review by BEE:-

The final result are reviewed and published by the BEE. learning are used for planning the next PAT cycle.

* Market Transformation for Energy Efficiency:- (MTEE):-

MTEE are for accelerating the shift to energy efficient appliancer in designated sector through incentive & innovative business model.

objective:-

1. Promote cutting edge technology that enhance energy efficiency.
2. Create a platform for knowledge shearing and collabrating between industry, acadmia and the government.
3. Encourage local innovation and reduce dependence on foregin technologies.
4. Facilitate technology transfer and commericialization.

* Energy-Efficiency Financing platform:-(EEFP):-

The EEFP aims to encoverage and facililate financing of energy efficiency in India.

Many industries and businesses hesitate to implement energy saving project due to lack of awareness, perceived ~~risk~~ risks or insufficient fund.

EEFP act as a bridge between energy efficiency project developers and finicial institution.

* Objective:-

1. Promote dialogue between stake holder, industries technology provider bank and financial institutions.

(2) Create awareness about financial instruments available for energy efficiency project.
(3) Help to set up financial model to support energy efficiency investments.

(*) ~~Framework~~ for Energy Efficient Economic Developement (FEEED):-

- The aims to integrate energy efficiency into economic planning and policy making. It focuses on developing appropriate policy framework business model and finiancial instrument, that promote investment in energy efficiency project at national, state and local level.

*objective:-

(1) Promote Energy efficient infrastructure developement through public and private investment.
(2) Develop fininicial instrument and incentives for energy efficiency.
(3) support energy efficiency planning in government and urban local bodies.
(4) Create a policy environment favorable to larger scale ~~eff~~ energy efficiency programs.

* Cost of Electrical Energy:-

The art of determining the per unit (1Kwh) cost of production of electrical energy in known as economics of power generation.

a) Fixed cost:-

It include cost of land and construction of building does not changes with different types of plant but the cost of equipment changes with intrest on capital.

b) Depreciation cost:-

The decrease in value of the power plant equipment and building due to constant use is known as depreciation.

From the time of power plant is intalled its equipment steadily deteriorates the value due corrossion weather condition and wear and tear so that there is a gradual reducing in the value of the plant. This reduction in the value of plant every year is known as annual depreciation.

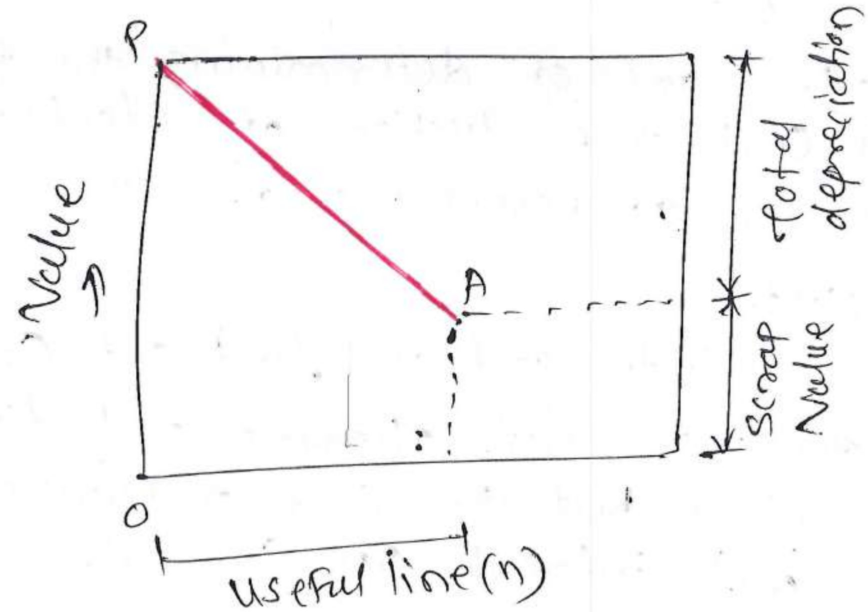
(1) straighline method:-

In this method a constant depreciation charge is made every year on the basis of total depreciation and the useful life of the property.

$$\boxed{\text{Anual Depreciation charge} = \frac{P-S}{n}}$$

where,

P - initial cost of Equipment
n - useful life of equipment in year.
s - Scrap or salvage value after the useful life of the plant.



Disadvantage:-

1. The assumption of constant depreciation charge exergy year is not correct.
2. It does not account for the intrest which may be drawn during accumuation.

2. Diminishing value method:-

In this method depreciation charge is first applied to the initial cost of equipment and then to its diminishing value and the annual depreciation charge of this method.

Supposed, The annual unit depreciation is 'r'. It is desired to find the value of 'r' in terms of P, n and S. If annual depreciation is 10%, then we can say that annual unit depreciation is 0.1.

$$\text{Value of equipment after 1 year} = P - Pr = P(1-r)$$

$$\text{Value of equipment after 2 year} = \text{Diminished value} - \text{Annual Depreciation}$$

$$= (P - Pr) - \{(P-Pr)r\}$$

$$= P(1-x)^n$$

$$x = 1 - (S/P)^{1/n}$$

$$\boxed{\text{Depreciation for the first year} = x \cdot P = P\left[1-(S/P)^{1/n}\right]}$$

③ Shrinking Fund method:-

In this method, a fixed depreciation charge is made every year and intrest compounded on it annually. The constant depreciation charge is such that total of annual installments plus the intrest accumulation equal to the cost of replacement of equipment after its useful life.

P - Initial value of equipment.
n - useful life of equipment in year.
s - scrap value after useful life
r - Annual rate of intrest expressed as a decimal.

Cost replacement = P − S

$$\boxed{\text{shrinkage fund } K = (P-S)\left\{\frac{r}{(1+r)^n - 1}\right\}}$$

④ operating or Running Cost:-

The cost which depends only upon the number of unit generated. This include cost of fuel, labour repair, lubricating oil, cooling water and number of consumable items and supervision.

① Cost of Fuel:- Fuel cost is like the heaviest parameter of operating cost. The selection of the fuel and the maximum economy in it use are therefore very important consideration in thermal power plant.

② Labour cost:-

Plant operation labour cost is another important items of operating cost.

③ Cost of maintenance & Repair:-

maintenance is carried to avoid plant break down of plant and it includes periodic cleaning, greasing, adjustment and overhauling of equipment.

TIL005533 — Estimation of Various Production Cost of Electrical Energy:-

The performance of generating power plant is compared by their average efficiencies over a period of time.

The average efficiency of power plant is the ratio of useful energy output to the total energy input during the period considered.

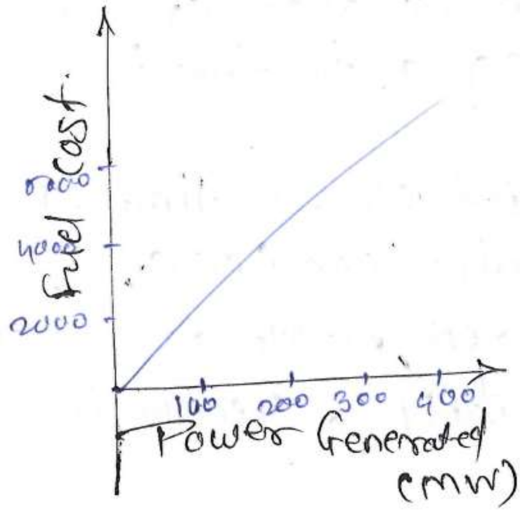
① Fuel Cost Curve:-

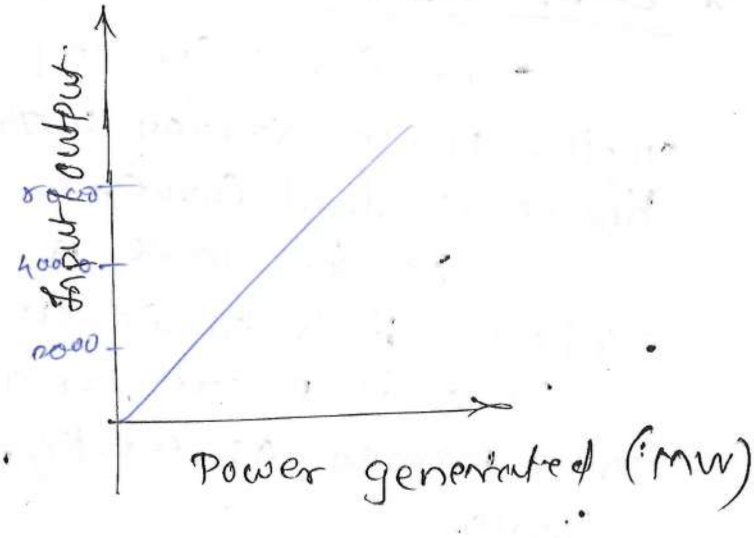
The fuel cost curve specifies the cost of fuel used per hour by the generating unit as a function of the unit MW output.

② Input-Output Curve:-

The input output curve is derived simply from the heat rate curve by multiplying it by the MW output of the unit.

This yield a curve showing the amount of heat input energy required per hours as a function of generator output.



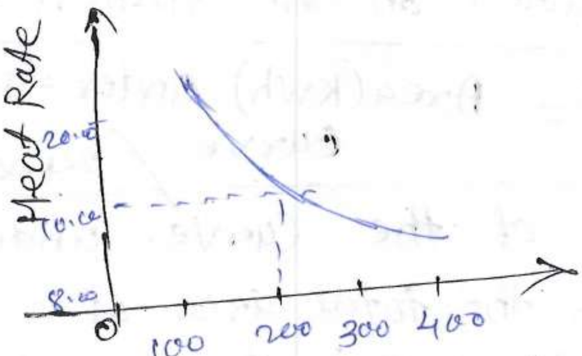


③ Heat rate Curve:-

Heat rate Curve is one measure of the efficiency of a generator that convert a fuel into heat and into electricity.

- The heat rate is the amount of energy used by an electrical generator 1MW/hr.

$$\boxed{\text{Heat Rate} = \frac{\text{Thermal Energy}}{\text{Electrical Energy out}}}$$



④ Incremental Cost Curve:-

The incremental rate of machine at any given output is the rate of change of the input with respect to the output i.e. ratio of the small change in input to small change in output is known as incremental rate of a machine.

- The incremental rate is define as the ratio of additional input (dI) required to increment additional output.

$IR = dI/dL$ KJ/kw-hr.

* Load Curve:-

The curve showing the variation of load on the power station with respect to time is known as load curve.

If the curve is plotted over a time of 24 hours it is known as Daily Load Curve.

If it is plotted for a week, month or a year then named as weekly, monthly & yearly load curve.

The load duration curve reflect the activity of a consumer quite accurately with respect to consumption of electrical power over a given period of time.

$$\boxed{\text{unit Generated/Day} = \text{Area (kWh) under daily load curve.}}$$

The area under the daily load curvee derived by the total number of hours given the average load on the station in the day.

$$\boxed{\text{Average load} = \text{Area(kWh) under dail load curve} / \text{24 hours.}}$$

The ratio of the curve under the load curve to the total area of a rectangular in which it is contained given the load factor.

$$\boxed{\text{load Factor} = \frac{\text{Average load} \times 24}{\text{max. demand} \times 24}}$$

1. Connected load:-

It is the sum of rating in KW of the equipment installed in the Consumer premises which is Connected to the system.

2. Demand:-

It is the system load that drawn for the source of supply at the receiving therminal average over a suitable and specified interval of time & expresses in (KW), Kilo volt (KVA).

3. Demand Factor:-

The demand Factor of any system is the ratio of maximum demand of the system a part of the system to the total Connected load of the system.

$$\boxed{\text{Demand Factor} = \frac{\text{max. demand}}{\text{Connected load}}}$$

4. Average load:-

Average load is calculated dividing the area under the load curve (KW) by the time period consider to draw the load curve.

$$\text{Average load} = \frac{\text{Area under the load Curve}}{24}$$

$$\text{Average load} = \frac{\text{Energy Consume in 24 hours}}{24}$$

5. Diversity Factor:-

It is the ratio of the sum of the maximum power demands of the individual Consumer of the system or part of a system and simaltaneous maximum demand of the whole system or part of the system during particular time.

$$\boxed{\text{Diversity Factor} = \frac{\text{sum of individual max}^m\text{. demand.}}{\text{simultaneous maximum demand at a given time.}}}$$

(6) Utilization Factor:-

The utilisation factor is defined as the ratio of the maximum generator demand to the generator capacity.

(7) Plant Capacity Factor:-

It is defined as the ratio of actual energy produced in kilowatt hours (kWh) to the maximum possible energy that could have been produced during the same period.

$$\boxed{\text{plant Capacity factor} = \frac{\text{Average load} \times 24}{\text{Plant Capacity}}}$$

$$\boxed{\text{plant Capacity factor} = \frac{\text{Average load}}{\text{plant capacity}} = \frac{E}{C \times t}}$$

where,

E - energy produced (kWh) in given period.

C - Capacity of the plant (kW)

t - total number of hours in the given period.

TL0-5-4 — Estimation of Various Performance Parameters

① A thermal power plant consist of two unit of 30 MW each running for 8200 hours and one unit of 10 MW running for 2000 hours in a year. The energy produced by the plant 400×10 kWh per annum. Determine the plant load factor and plant use factor. The maximum demand is equal to the plant capacity.

→ Given:-

P_1 & P_2 - Power plant unit - 2.

capacity = 30 MW.

P_3 - powerplant = 1 → time = 2000 hr/yr.

= 8200 hr.

$$\text{plant capacity} = 2 \times 30 + 10$$
$$= 60 + 10 = 70 \text{ MW}.$$

It also represent the maximum demand.

$$\text{Average load} = \frac{\text{Energy produced per year}}{8760 \text{ hr/year}}$$

$$= \frac{400 \times 10^6}{8700}$$

$$= 45.662 \times 10^3$$

$$\text{Load Factor} = \frac{\text{Average load}}{\text{max. demand}} = \frac{45.662 \times 10^3}{70 \times 10^3}$$

$$\text{load Factor} = 0.654 \simeq 65.23\%$$

$$\text{plant use Factor} = \frac{\text{Annual Energy Produced}}{\text{max. energy that can be produced by the plant}}$$

$$= \frac{400 \times 10^6}{2 \times 30 \times 8200 + 10 \times 2000 \times 10^3}$$

$$= 0.78125$$

(2) In a power station annual Factor are under load Factor 70%. Capacity Factor 60% and use Factor 65%. The power plant has a maximum demand of 50000 KW.

Find - (1) Annual Energy Production
(2) Reserve capacity above peak load.
(3) Hours per year the plant is not inuse.

→ (1) Annual Energy Production - 'E'

load Factor = 70%

$$\text{load Factor} = \frac{\text{Average load}}{\text{max. demand}}$$

$$0.7 = \frac{\text{Average load}}{\text{max. demand}}$$

Average load = 0.7×50000

$= 35000$ KW

Annual Energy production = Average load × No. of hour/year

$E = 35000 \times 8760$

$E = 3.066 \times 10^8$

(2) Reserve Capacity above Peak load:-

$$\text{Capacity Factor} = \frac{\text{Average demand/year}}{\text{Rated Capacity} \times \text{Number of hr/year}}$$

$$0.6 = \frac{3.066 \times 10^8}{C \times 8760}$$

Capacity 'C' = 58333.3 KW

Reserve capacity 'C'' = C − max^m demand

$= 58333.3 - 50000$

$= 8333.3$ KW

hours / year plant is not in use. factor = 0.65

$$0.65 = \frac{E}{C} \times t$$

$$0.65 = \frac{3.066 \times 10^8}{58333.3} \times t$$

$$\underline{t = 8086.2 \text{ hrs}}$$

No. of hour's plant not use $= 8760 - t$

$= 8760 - 8086.2$

$= \underline{673.8 \text{ hr}}$

(3) For a thermal power plant use factor is 70%. and capacity factor is 60%. How many hour's per year the plant will not be in operation?

→ Use factor $= 70\% = 0.7$

Capacity factor $= 60\% = 0.6$

$$\text{Capacity Factor} = \frac{\text{Actual Energy Generated / year}}{\text{Capacity of plant} \times 8760} \quad \text{—(1)}$$

$$\text{plant use factor} = 0.7 = \frac{E}{C} \times t_1 \quad \text{—(2)}$$

where t_1 - Actual number of hours the plant is in operation.

By dividing eqn (1) & (2)

$$\frac{0.6}{0.7} = \frac{\left(\frac{E}{C}\right) \times \left(\frac{1}{8760}\right)}{\left(\frac{E}{C}\right) \times \left(\frac{1}{t_1}\right) \times \left(\frac{t_1}{8760}\right)}$$

$$\underline{t_1 = 7508.57 \text{ hrs}}$$

Number of hours during which plant is not in operation $= t = 8760 - t_1$

$= 8760 - 7508.57$

$$\underline{t = 1251.43 \text{ hrs.}}$$

(4) The maximum (peak) load on a thermal power plant of 60 MW capacity is 50 MW at an annual load of 25 MW, 20 MW, 8 MW and 5 MW are connected to the power station.

Determine - (1) Average load on power station
(2) Energy generated per year
(3) Demand factor
(4) Diversity factor

→ (1) load factor $= \dfrac{\text{Average load}}{\text{max demand}}$

$$0.5 = \frac{\text{Average load}}{\cancel{\text{max demand}}\,(50)}$$

Average load $= 0.5 \times 50 = 25\,MW$.

(2) E - Energy generated per year
$= \text{Average load} \times 8760$
$= 25 \times 8760$
$E = 219 \times 10^6$ Kwh

(3) Demand factor:-

$$\text{Demand factor} = \frac{\text{max. demand}}{\text{connected load}}$$

$$= \frac{50}{25+20+8+5} = \frac{50}{58}$$

Demand Factor $= 0.86$

(4) Diversity factor:- $\dfrac{m_1}{m_2}$

m_1 - sum of individual max^m demand
$= 25+20+8+5 = 58$ MW.

m_2 - simultaneous max^m demand $= 50$ MW

$$\text{Diversity factor} = \frac{58}{50} = 1.16$$