SEMESTER-III

SECOND YEAR DIPLOMA

ENGINEERING AND TECHNOLOGY

ELECTRICAL ENGINEERING GROUP

MSBTE's I SCHEME

ELECTRICAL POWER GENERATION

B. P. PATIL

Ms. POOJA MOGRE (BISEN)

NIRALI PRAKASHAN

ADVANCEMENT OF KNOWLEDGE

A Text Book Of

ELECTRICAL POWER GENERATION

(22327)

Semester - III

SECOND YEAR DIPLOMA IN ELECTRICAL ENGINEERING

As Per MSBTE's 'I' Scheme Curriculum

B. P. PATIL

Former Head, Deptt. of Electrical Engineering
Govt. Polytechnic, Aurangabad, Jalgaon
Have Received Best Teacher Award from
Govt. of Maharashtra in First Batch, 5 September, 1995

Mrs. POOJA MOGRE (BISEN)

M.E. (Elect.)
Modern Engineering College,
Pune.

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Preface ...

Dear students and teachers, it gives us a great pleasure to present the textbook on **'Electrical Power Generation**. The book is written as per the revised I scheme curriculum of Board of Technical Examinations, Mumbai. It is prescribed for Third Semester of Diploma in Electrical Engineering and is to be implemented w.e.f. June 2017.

It is tried to add required matter and additional solved examples has been added to help the students for examination purpose. It is also tried to make the book error free.

We are thankful to students and teachers as they have highly appreciated and accepted the book on subject 'Electrical and Electronics Measurements' and hope that they will welcome this book also.

In this edition, question papers of previous B.T.E. examination, Maharashtra State, Mumbai has been added for reference and study of students accordingly.

Our special appreciation goes to Shri. Dineshbhai Furia, Shri. Jigneshbhai Furia, Mr. Akbar Shaikh, Mr. Kiran Velankar, Mrs. Anjali Muley and Mrs. Shilpa Jathar of Nirali Prakashan, Pune for publishing this book in a good and presentable manner within very short time.

Teachers and practicing engineers are requested to suggest for further improvement of this book.

Authors

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Syllabus ...

Unit 1 - Thermal Power Plants: Coal, Gas/Diesel and Nuclear-Based (Hours 20, Marks 13)

1.1 Layout and Working of a Typical Thermal Power Plant with Steam Turbines and Electric Generators

1.2 Properties of Conventional Fuels used in the Energy Conversion Equipment used in Thermal Power Plants: Coal, Gas/Diesel, Nuclear Fuels – Fusion and Fission Action

1.3 Safe Practices and Working of Various Thermal Power Plants: Coal-based, Gas-based, Diesel-based, Nuclear-based

1.4 Functions of the following types of Thermal Power Plants and their major auxiliaries:

(a) Coal Fired Boilers: Fire Tube and Water Tube

(b) Gas/Diesel based Combustion Engines

(c) Types of Nuclear Reactors: Disposal of Nuclear Waste and Nuclear Shielding

1.5 Thermal Power Plants in Maharashtra.

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(b) Medium Head – Francis Turbine

(c) Low Head – Kaplan Turbine

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3.2 **Solar Power Technology**

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(b) Solar Photovoltaic (PV) Power Plant: Layout, Construction, Working.

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(a) Layout of a Bio-chemical-based (e.g. Biogas) Power Plant

(b) Layout of a Thermo-chemical-based (e.g. Municipal Waste) Power Plant

(c) Layout of a Agro-chemical-based (e.g. Bio-diesel) Power Plant

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4.2 **Layout of Horizontal Axis Large Wind Power Plant:**

(a) Geared Wind Power Plant

(b) Direct Drive Wind Power Plant

4.3 **Salient Features of Electric Generators used in Large Wind Power Plants:**

(a) Constant Speed Electric Generators:

Squirrel Cage Induction Generators (SCIG)

Wound Rotor Induction Generator (WRIG)

(b) Variable Speed Electric Generators:

Doubly-Fed Induction Generator (DFIG), Wound Rotor Synchronous Generator (WRSG), Permanent Magnet Synchronous Generator (PMSG)

4.4 Construction Layout of different types of Horizontal and Vertical Axis Small Wind Turbines

4.5 Working of different types of Horizontal and Vertical Axis Small Wind Turbines; Direct-Drive and Geared; Permanent Magnet Generators and Induction Generators

4.6 Location and Installation of Small Wind Turbines.

Unit 5 - Economics of Power Generation and Interconnected Power System (Hours 10, Marks 15)

5.1 **Related terms:** Connected Load, Firm Power, Cold Reserve, Hot Reserve, Spinning Reserve, Base Load and Peak Load Plants; Load Curve, Load Duration Curve, Integrated Duration Curve.

5.2 **Cost of Generation:** Average Demand, Maximum Demand, Demand Factor, Plant Capacity Factor, Plant Use Factor, Diversity Factor, Load Factor and Plant Load Factor.

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5.4 **Causes and Impact and Reasons of Grid System Fault:** State Grid, National Grid, Brownout and Black out, Sample Blackouts at National and International Level.

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Chapter 1...

Thermal Power Plants: Coal, Gas/Diesel and Nuclear-Based

Weightage of Marks = 13, Teaching Hours = 20

Syllabus

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- (c) Types of Nuclear Reactors: Disposal of Nuclear Waste and Nuclear Shielding

1.5 Thermal Power Plants in Maharashtra.

About this chapter

- Describe the layout of the electric power generating process with labelled block diagram of the specified thermal power plant
- Distinguish the major properties of the fuel(s) that is used in the specified thermal power generating plant(s)
- Explain with sketches working of the given type of nuclear power plant
- Explain with sketches the function of the specified thermal power plant auxiliary
- Describe the specified safe practice to be followed with respect to specified thermal power plant
- State the location of the specified thermal power plant in Maharashtra

INTRODUCTION

- Generating stations convert one form of energy into another form of energy.
- There are various sources in the nature having some form of energy from which mechanical energy is obtained which is converted into electrical energy.
- Following is the line block diagram giving the energy conversion basically.

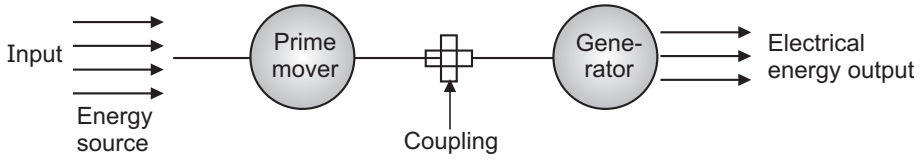

Fig. 1.1

Energy Conversion in Thermal Power Plant:

- In the thermal power station, coal is burnt in the boiler, water is heated and steam is formed at high pressure. The steam is impinched on the blade assembly of steam turbines which rotate

and mechanical energy is produced by rotation. To the turbine shaft the shaft of the generator (alternator) is coupled, so generator starts rotating which convert mechanical energy into electrical energy. This is the basic flow of energy conversion in thermal power plant. Here steam turbines act as a prime mover of generator.

- For any power station, **"site selection"** is very important to help the power station to run economically.
- "Thermal" has a broad meaning. To get the thermal energy by various methods and use it to convert it into "Electrical Energy"
  (i) We get the thermal energy by burning (firing) coal in boilers. This is converted into electrical energy and the plant or station is called "Thermal Power Plant".
  (ii) Gas produced by various methods can also be used in electricity production. The plant is called Gas Power Station.
  (iii) Liquid fuel like diesel can be used to produce thermal power in diesel engine to which generator can be coupled to get electrical energy. This plant is called as "Diesel Electric Power Plant".
- By electronic fission of uranium, large amount of heat energy is obtained to boil the water to form steam to drive steam turbine and connecting generator to it we get electricity. Such plant is called as Nuclear Power Plant.
- In all such plants the input energy is a thermal energy which is finally converted into electrical energy.
- All such plants are called as thermal plants:
  (i) Coal based thermal power plant
  (ii) Gas based thermal power plant
  (iii) Diesel based thermal power plant
  (iv) Nuclear based thermal power plant
- In all plants, site selection is important.

Site selection of coal/steam thermal power plant

- So many factors are to be considered for the site selection from the economical and environmental point of view.
- Selection of site for a thermal power plant plays an important role in the economy of the station. One central generating unit is preferred in comparison to number of small units erected here and there which results in low cost of generation. The most economical and ideal station is that which is installed at the centre of gravity of the load, because it reduces the length of transmission lines and cables, reducing their cost. Hence, reduction in capital cost of installation can be achieved.
- Though the location at the C.G. of load is best, it may not be feasible since the C.G. of load may be in the heart of city, for example, C.G. for Mumbai may be at V.T., the most feasible and commercial centre, where firstly the land will not be available, if made available it will be very costly and if power station is installed at such a place it will cause a nuisance to the public.
- **Hence, following points should be considered at the time of deciding location of the thermal power station:**
  (i) The cost of land should not be high, it should be reasonable. [The cost of land will be high in city area as compared with rural area].
  (ii) The land selected be such that it should not require to acquire private land, if at all required it should be minimum.

(iii) A large quantity of water must be available. Because a thermal plant needs nearly 560×10^3 kg of water per tonne of coal used in the boiler, for condensers etc. Hence, the site should be near a river, dam or canal. Otherwise cooling towers are required, increasing the cost of the plant and also some other source of water for make-up of water lost in evaporation.

(iv) Fuel used in the plant should be cheap and available in nearby mines or there should be ample facilities available for the transportation of fuel to the site.

(v) The site should be such as to provide good and firm foundation to the building and the plant.

(vi) The land should not be rocky, otherwise it will need blasting for foundation etc., at the same time it should not be marshy so as to be required for pile foundations.

(vii) As far as possible the site should not be surrounded by residential buildings so as to avoid nuisance of smoke, noise, steam, water vapour etc. for the people residing nearby.

(viii) There should be possibility of development of industry in the surrounding area of the site.

(ix) Future expansion of the plant should be possible.

(x) There should be ample scope for development of industry in the nearby area of site.

(xi) There should be ample facility of accommodation of operational and maintenance staff available at reasonable charges.

(xii) The chimney of the power station should not cause obstruction to flying of aeroplanes.

(xiii) Facility for disposal of ash etc. should be available.

(xiv) If canal or river water is used for plant, it should not be polluted.

(xv) The site should be such as to serve the interests of national defence.

1.1 LAYOUT AND WORKING OF A TYPICAL THERMAL POWER PLANT WITH STEAM TURBINES AND ELECTRIC GENERATORS

- Basically, a central steam power station works on Rankine cycle in which steam is produced by firing of fuels in the boiler. Then it is used in prime movers, it expands, it is then condensed in the condensers used for the purpose of condensing steam.
- The condensed water is again fed into the boiler. In this cycle a number of modifications and improvements are being made so as to achieve the economy in cost and increase the thermal efficiency of the plant.
- Fig. 1.2 represents the schematic layout of a coal-fired modern power station. The plant can be divided into the following main parts, namely:
  (i) Fuel and ash circuit.
  (ii) Air and gas circuit.
  (iii) Feed water and steam circuit.
  (iv) Cooling water circuit.

1.1.1 Fuel and Ash Circuit

[S-16, 14]

- Fuel i.e. coal, from the storage is fed to the boiler through feeding device, which consists of conveyor belt, crushing mill etc and is called as **coal handling plant**. Ash produced as a result of combustion of coal collects at the back of the boiler and is removed to ash storage through ash handling equipment.

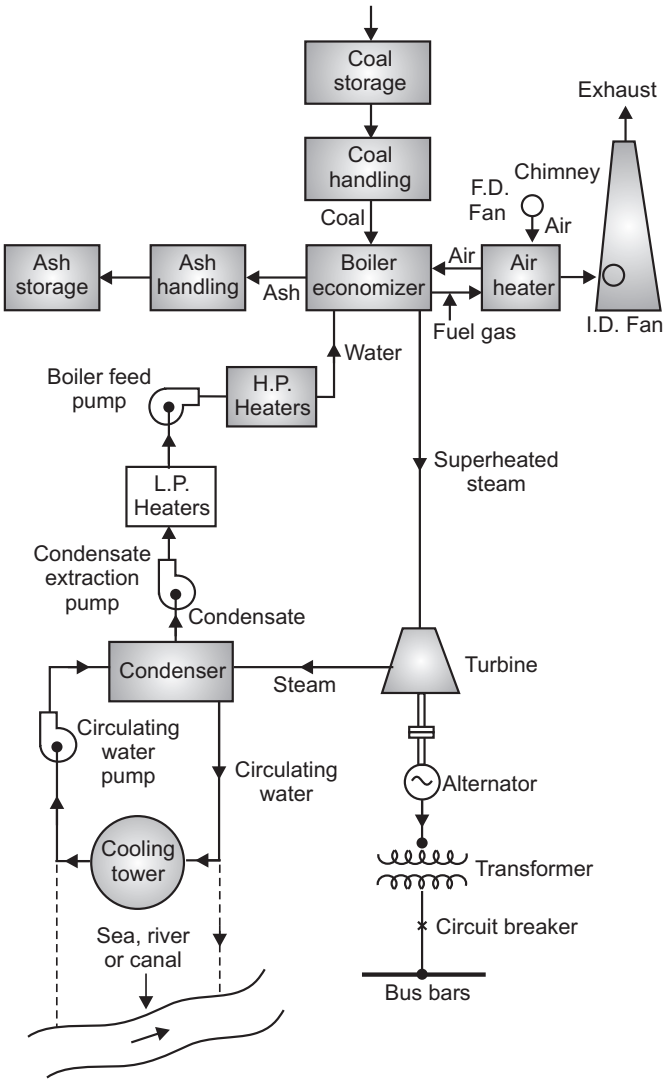

Fig. 1.2: Schematic layout (Block diagram) of a typical coal-fired power station

1.1.2 Air and Gas Circuit

- Atmospheric air is supplied for combustion of coal in the boiler, through the action of Forced Drought (F.D.) fan or Induced Draught (I.D.) fan. The air, before being supplied to the boiler, passes through air preheater where it is heated by the heat of flue gases, which then passes to the chimney. The flue gases first pass around the boiler tubes and superheater tubes in the furnace, thereafter they pass through dust collector or dust precipitator, and then pass through economizer. At the end they are exhausted to the atmosphere through air preheater.

1.1.3 Feed Water and Steam Circuit

- The steam from turbine is condensed in the condenser, then it is heated in a closed feed water heater by means of extracted steam from the low pressure extraction point of the turbine. This heated water then passes through evaporator and few more water heaters before it is made to go to the boiler through the economizer. The reduced quantity of water is made up by adding water in the feed water system. Raw water from river or canal system passes through evaporator, is heated to steam and condensed into water in the evaporator and then passes through the feed water pump into the feed water system in the boiler. Refer Fig. 1.3.

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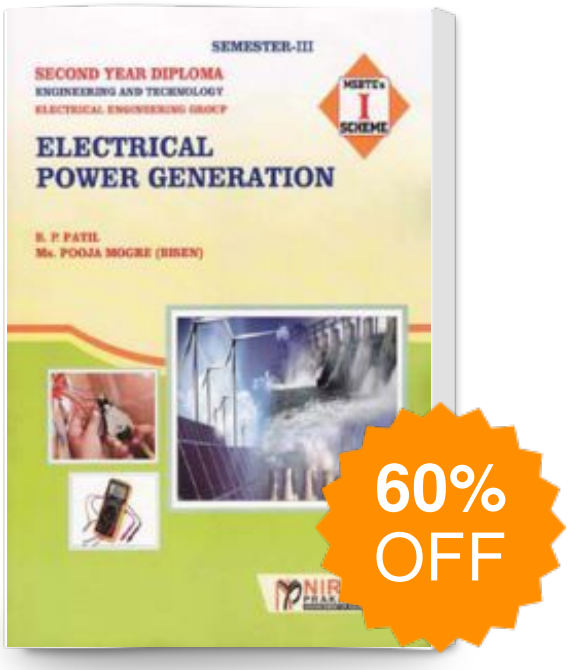

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