DARBHANGA COLLEGE OF ENGINEERING

DARBHANGA

COURSE FILE

OF

POWER SYSTEM-II

(EE 508)

TABISH SHANU

ASSISTANT PROFESSOR, DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

विज्ञान एवं प्रावैधिकी विभाग

Department of Science and Technology

Government of Bihar

Department of Electrical Engineering

Vision of EEE: - To bring forth engineers with an emphasis on higher studies and a fervor to serve national and multinational organisations and, the society.

Mission of EEE: -

M1: - To provide domain knowledge with advanced pedagogical tools and applications.

M2: - To acquaint graduates to the latest technology and research through collaboration with industry and research institutes.

M3: - To instil skills related to professional growth and development.

M4: - To inculcate ethical valued in graduates through various social-cultural activities.

Program Educational Objectives:-

PEO 1. Graduates will excel in professional careers and/or higher education by acquiring knowledge in Mathematics, Science, Engineering principles and Computational skills.

PEO 2. Graduates will analyze real life problems, design Electrical systems appropriate to the requirement that are technically sound, economically feasible and socially acceptable.

PEO 3. Graduates will exhibit professionalism, ethical attitude, communication skills, team work in their profession, adapt to current trends by engaging in lifelong learning and participate in Research & Development.

Program Outcomes of B.Tech in Electrical and Electronics Engineering

1.Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2.Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3.Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4.Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5.Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6.The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7.Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8.Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9.Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10.Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11.Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12.Life-long learning: Recognize the need and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO 1. An ability to identify, formulate and solve problems in the areas of Electrical and Electronics Engineering.

PSO 2. An ability to use the techniques, skills and modern engineering tools necessary for innovation.

Course Description

This course is designed to introduce the concepts different types of Electrical Power Generation and to give an idea about the economy of power system. It also imparts knowledge of symmetrical components and symmetrical three phase faults on synchronous machines. It will give clear understanding of unsymmetrical faults and power system stability. This curriculum is designed to prepare interested students to make their career in generating stations such as thermal power plants and hydel power plants. There is also good scope in design of power system.

Course Objectives

- This course has the fundamentals as well as full description of Power Plants.
- Thermal power and hydel power plants are studied descriptively.
- Also, this course gives emphasis on the use of power system stability.

After the completion of this course the students will be able to:

CO1: Understand working and operation of thermal and hydel power stations.
CO2: Compute cost allocation of power station two par tariff and evaluation.
CO3: Analyze symmetrical components in power system.
CO4: Select proper design parameters after doing fault analysis.

Mapping of CO's with PO's

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	2	2	3	2	-	2	-	-	-	2	2	3	1
CO2	2	3	2	2	3	-	-	-	-	-	1	1	3	2
CO3	2	2	3	1	2	-	-	-	-	-	3	1	3	3
CO4	3	2	3	3	3	1	1	1	-	-	2	2	2	1

B. Tech. V Semester (EEE)

EE- 508 Power System -II

L T P/D Total	Max Marks:	100	
3-1-0 4		Final Exam:	70 Marks
		Sessional:	20 Marks
		Internals:	10 Marks.

UNIT-I

Power station and sub-station : Hydro and power station: Site selection, Layout, calculation of available power, classification, Salient features, Pumped hydro plants.

Thermal power Station : Site selection, Layout, calculation of coal requirements, cooling water tower efficiency,co-ordination of hydro and thermal power stations.

UNIT-II

Economy of power system : Load curves, Load duration curves, Diversity Factor, Base and peak Load station, Cost allocation of power station- fixed cost, Two par Tariff and Evaluation.

UNIT-III

Symmetrical three phase faults on synchronous machines : Short circuit current and reactance of

synchronous machines, Internal voltage of loaded machines under transient conditions.

UNIT-IV

Symmetrical components : Synthesis of unsymmetrical phases from their symmetrical components

operators, The symmetrical components of unsymmetrical phase, phase shift in transformer bank: power in terms of symmetrical components; unsymmetrical series impedances; sequence impedances and sequence networks; sequence networks of unbalanced generators; sequence impedance of circuit elements positive and negative sequence networks; zero sequence network.

UNIT-V

Unsymmetrical Faults : Signal line to ground fault, line to line fault, double line to ground fault on unloaded generator and power systems, Interpretation of inter guidance sequence networks.

UNIT-VI

Power System Stability : Steady state power limit of cylindrical rotor and salient pole machines without saturation, Maximum power transmitted to a transmitting network, series capacitor, Transient stability power angel curve, Inertia clearance angel, equal swing equation, equal area criterion and its application.

Books:

1. Elements of Power System Analysis 3rd Edition by Stevenson, McGraw Hill

2. A Course of Electrical Power by Soni Bhatnagar and Gupta, Dhanpat Rai & Sons.

3. Modern Power System Analysis by Nagrath and Kothari, Tata McGraw Hill.

4. Electrical Power System by C.L.Adhwa, Wiley Eastern

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA w.e.f. – 05-07-18

EEE Semester – 5th, Session (2018-19)

Day	Branch	1 (10am-10.50am)	2 (10.50am-11.40am)	3(11.40am-12.30pm)	4(12.30pm-1.20pm)	Lunch (1.20pm – 1.50pm)	5(1.50pm – 2.40pm)	6(2.40pm-3.30pm)	7(3.30pm-4.20pm)
Monday	E.E.E.								
Tuesday	E.E.E.								
Wednesday	E.E.E.	PS-II(T)							
Thursday	E.E.E.		PS-II			LUNCH			
Friday	E.E.E.		PS-II						
Saturday	E.E.E.		PS-II				PS-II(T)		

<u>Mechanical</u> – M1 - 1 to 30   <u>E.E.E.</u> - E1 - 1 to 30   <u>C. Sc.</u> - CS1 – 1 to30   <u>Civil</u> - C1 – 1 to 30

S-1 M2 –31 to All   S-2 E2 – 31 to All   S-3 CS2 – 31 to All   B.C.R. C2 – 31 to All

Prof . Incharge Routine
D.C.E. Darbhanga

Principal
D.C.E., Darbhanga

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

5th Sem. Branch:- Electrical & Electronics Engineering Batch (2016-20)

Subject :- Power System-II

Sl. No.	Name	Class Roll No.
1.	Rajbala Kumari	16-EE-01
2.	Sushmita Kumari	16-EE-03
3.	Shweta Rani	16-EE-04
4.	Nisha Raj	16-EE-05
5.	Priyanka Kumari	16-EE-07
6.	Rashmi Bharti	16-EE-08
7.	Sonika Kumari	16-EE-09
8.	Puja Prabhakar	16-EE-11
9.	Devashish Dubey	16-EE-12
10.	Alok Ranjan	16-EE-13
11.	Hemant Kumar patel	16-EE-14
12.	Kumar Satyam	16-EE-15
13.	Pratik Kumar	16-EE-17
14.	Prabhash Kumar Yadav	16-EE-18
15.	Ranjesh Kumar	16-EE-19
16.	Upendra Kumar	16-EE-20
17.	Amit Kumar	16-EE-21
18.	Wajahat Khalil	16-EE-22
19.	Prakash Ranjan	16-EE-24
20.	Rahul Kumar	16-EE-26
21.	Ankit Ranjan	16-EE-27
22.	Varinder Kumar	16-EE-29

23.	Vikash Kumar Bharti	16-EE-30
24.	Navneet Kumar	16-EE-31
25.	Prem Raj	16-EE-32
26.	Juhi Kumari	16-EE-33
27.	Appu Kumar	16-EE-34
28.	Ashish Kumar	16-EE-35
29.	Babloo Kumar	16-EE-36
30.	Niraj Kumar Nirala	16-EE-37
31.	Poonam Priya	16-EE-38
32.	Kamal Nayan Jha	16-EE-40
33.	Rajneesh Kumar	16-EE-41
34.	Rohit Kumar	16-EE-42
35.	Amrita Kumari	16-EE-43
36.	Dimple Kumari	16-EE-44
37.	Khushbu Kumari	16-EE-45
38.	Alok Kumar	16-EE-46
39	Md. Ataur Rahman	16-EE-47
40	Shubhra Verma	16-EE-48
41	Khushboo Kumari	16-EE-49
42	Priti Kumari	16-EE-50
43	Md. Sharmajul Haque	16-EE-51
44	Saurav Kumar	16-EE-52
45	Anubhav Anand	16-EE-53
46	Shankar Suwan Kesri	16-EE-54
47	Tanuj Anand	16-EE-55
48	Ganesh Kumar	16-EE-56
49	Ashish Ranjan	16-EE-57
50	Shashi Kumar	16-EE-58

51	Vishnu Kumar	16-EE-59
52	Anku Rani	16-EE-60
53	Santosh Kumar Mahto	16-EE-61
54	Shubham Kumar	16-EE-62
55	Md. Seraj	16-EE-63
56	Amrendra Kishor	16-EE-64
57	Amit Kumar Jha	16-EE-65
58	Rohit Kumar Yadav	16-EE-66
59	Rahul Kumar Sahni	16-EE-67
60	Saurabh Kumar	16-EE-68
61	Pankaj Kumar	16-EE-69
62	Pooja Roy	16(LE)EE-01
63	Surya Rai	17(LE)EE-01
64	Santosh Kumar	17(LE)EE-02
65	Lalit Kumar Ram	17(LE)EE-03
66	Deepak Kumar Prabhat	17(LE)EE-04
67	Sumit Kumar	17(LE)EE-05
68	Avinash Choudhary	17(LE)EE-06
69	Ranjeet Kumar Sah	17(LE)EE-07
70	Baby Kumari	17(LE)EE-08
71	Virendra Kumar Sah	17(LE)EE-09
72	Abhinav Raj	17(LE)EE-10
73	Ejaz Ahmad Ansari	17(LE)EE-11

Institute/College Name:	Darbhanga College of Engineering
Program Name:	B.Tech (EEE, 5th semester)
Course Code:	031508
Course Name:	Power System-II
Lecture/Tutorial(per week):	3/1
Course Credits:	4
Course Co-coordinator Name:	Mr. Tabish Shanu

1. Scope and Objective of Course

This course is designed to introduce the concepts different types of Electrical Power Generation and to give an idea about the economy of power system. It also imparts knowledge of symmetrical components and symmetrical three phase faults on synchronous machines. It will give clear understanding of unsymmetrical faults and power system stability. This curriculum is designed to prepare interested students to make their career in generating stations such as thermal power plants and hydel power plants. There is also good scope in design of power system.

The course outcomes are

1. Articulate power system concepts required in engineering problems.
2. Design power system components for a specified system and its applications.
3. Ability to discuss various sources for generation of power and their descriptive layout and components description.
4. Ability to calculate tariff of electrical power.
5. Ability to discuss symmetrical components in power system.

2. Textbooks

TB1: Elements of Power System Analysis 3rd Edition by Stevenson, McGraw Hill
TB2: A Course of Electrical Power by Soni Bhatnagar and Gupta, Dhanpat Rai & Sons.
TB3: Modern Power System Analysis by Nagrath and Kothari, Tata McGraw Hill.

3. Reference Books

RB1: Electrical Power System by C.L.Wadhwa, Wiley Eastern

Other readings and relevant websites

S. No.	Link of journals, Magazines, websites and Research papers
1.	http://nptel.ac.in/courses/112107216/6
2.	http://nptel.ac.in/courses/112107216/14
3.	http://nptel.ac.in/courses/117105140/49
4.	https://www.youtube.com/watch?v=IdPTuwKEfmA&t=130s
5	https://www.youtube.com/watch?v=Uhjhufhg3Xk&t=31s
6	http://nptel.ac.in/courses/108106026/3
7	http://indianpowersector.com/power-station/thermal-power-plant/
8	http://www.cea.nic.in/monthlyinstalledcapacity.html
9	https://powermin.nic.in/en/content/overview

Course plan

Lecture No.	Date of Lecture	Topics	Web Links for Videos Lecture	Text Books/Reference books/Reading Materials	Page No. of Text Books
1-3		**Introduction** Hydro and power station, thermal power stations	https://www.youtube.com/watch?v=Uhjhufhg3Xk&t=45s https://www.youtube.com/watch?v=IdPTuwKEfmA&t=147s	TB2	13,27
		Tutorial-1			
4-6		**Power station and sub-station** Hydro power station: Site selection, Layout, calculation of available power classification, Salient features, Pumped hydro plants.	https://www.energy.gov/eere/water/types-hydropower-plants	TB2	27-42
		Tutorial-2			
7-12		**Thermal power Station** Site selection, Layout, calculation of coal requirements, cooling water tower efficiency,	http://indianpowersector.com/power-station/thermal-power-plant/	TB2	13-26

		co-ordination of hydro and thermal power stations.			
		Tutorial-3			
13-18		**Economy of power system**		TB2	1-12
		Load curves, Load duration curves, Diversity Factor, Base and peak Load station, Cost allocation of power station- fixed cost, Two par Tariff and Evaluation.			
		Tutorial-4, Assinment-1			
19-24		**Symmetrical three phase faults on synchronous machines**	http://nptel.ac.in/courses/117105140/45	RB1	257-295
		Short circuit current and reactance of synchronous machines, Internal voltage of loaded machines under transient conditions.			
		Tutorial-5			
25-29		**Symmetrical components**	http://nptel.ac.in/courses/117105140/49	RB1	297-356
		Synthesis of unsymmetrical phases from their symmetrical components operators, The symmetrical components of unsymmetrical phase, phase shift in transformer bank: power in terms of symmetrical components; unsymmetrical series impedances; sequence impedances and sequence networks; sequence networks of unbalanced generators; sequence impedance of circuit elements positive and negative sequence networks; zero sequence network			
		Tutorial-6			
		Unsymmetrical Faults			
30-34		Signal line to ground fault, line to line fault, double line to ground fault on unloaded		TB2	501-524

		Power System Stability			
35-38		Steady state power limit of cylindrical rotor and salient pole machines without saturation, Maximum power transmitted to a transmitting network, series capacitor,	http://nptel.ac.in/courses/117105140/55	RB1	533-589
		Tutorial-8			
		generator and power systems, Interpretation of inter guidance sequence networks.			
		Tutorial-7			
		Power System Stability			
39-42		Transient stability power angel curve, Inertia clearance angel, equal swing equation, equal area criterion and its application..	http://nptel.ac.in/courses/117105140/55	RB1	533-589
		Tutorial-9, Assinment-2			

Syllabus

Topics	No. of Lectures	Weightages
Power station and sub-station : Hydro and power station: Site selection, Layout, calculation of available power classification, Salient features, Pumped hydro plants. **Thermal power Station :** Site selection, Layout, calculation of coal requirements, cooling water tower efficiency, co-ordination of hydro and thermal power stations.	**10**	24%
Economy of power system : Load curves, Load duration curves, Diversity Factor, Base and peak Load station, Cost allocation of power station- fixed cost, Two par Tariff and Evaluation.	**10**	24%
Symmetrical three phase faults on synchronous machines : Short circuit current and reactance of synchronous machines, Internal voltage of loaded machines under transient conditions.	**4**	10%
Symmetrical components : Synthesis of unsymmetrical phases from their symmetrical components operators, The symmetrical components of unsymmetrical phase, phase shift in transformer bank: power in terms of symmetrical components; unsymmetrical series impedances; sequence impedances and sequence networks; sequence networks of unbalanced generators; sequence impedance of circuit elements positive and negative sequence networks; zero sequence network.	**6**	14%
Unsymmetrical Faults : Signal line to ground fault, line to line fault, double line to ground fault on unloaded generator and power systems, Interpretation of inter guidance sequence networks.	**6**	14%
Power System Stability : Steady state power limit of cylindrical rotor and salient pole machines without saturation, Maximum power transmitted to a transmitting network, series capacitor, Transient stability power angel curve, Inertia clearance angel, equal swing equation, equal area criterion and its application.	**6**	14%

This document is approved by

Designation	**Name**	**Signature**
Course Coordinator	Mr. Tabish Shanu	
H.O.D	Mr. Santosh Kumar Gupta	
Principal		
Date		

Evaluation and Examination Blue Prints:

Internal assessment is done through quiz tests, presentations, assignments and project work. Two sets of question papers are asked from each faculty and out of these two, without the knowledge of faculty, one question paper is chosen for the concerned examination. The components of evaluations along with their weightage followed by the University is given below

Sessional Test	20%
Internals	10%
End term examination	70%

Institute / School Name :	DARBHANGA COLLEGE OF ENGINEEERING		
Program Name	**B.E, EEE**		
Course Code	031508		
Course Name	POWER SYSTEM- II		
Lecture / Tutorial (per week):	3/1	**Course Credits**	3.5
Course Coordinator Name	Mr. TABISH SHANU		

LECTURE PLAN

Topics	**Lecture Number**
Introduction	
thermal power stations	**1**
thermal power stations ,Hydro and power station	**2**
Hydro and power station	**3**
Power station and sub-station	
Hydro and power station: Site selection, Layout	**4**
calculation of available power classification	**5**
Salient features, Pumped hydro plants	**6**
Thermal power Station	
Site selection	**7,8**
Layout	**9**
calculation of coal requirements	**10**
cooling water tower efficiency	**11**
co-ordination of hydro and thermal power stations	**12**
Economy of power system	
Load curves, Load duration curves	**13**
Diversity Factor, Base and peak Load station	**14,15**
Cost allocation of power station- fixed cost	**16**
Two par Tariff and Evaluation	**17,18**
Symmetrical three phase faults on synchronous machines	
Short circuit current	**19,20**
reactance of synchronous machines	**21,22**
Internal voltage of loaded machines under transient conditions	**23,24**
Symmetrical components	
Synthesis of unsymmetrical phases from their symmetrical components operators	**25**
The symmetrical components of unsymmetrical phase, phase shift in transformer bank: power in terms of symmetrical components;	**26**
unsymmetrical series impedances; sequence impedances and sequence networks;	**27**
sequence networks of unbalanced generators;	**28**

sequence impedance of circuit elements positive and negative sequence networks; zero sequence network	**29**
Unsymmetrical Faults	
Signal line to ground fault, line to line fault	**30,31**
double line to ground fault on unloaded generator and power systems,	**32**
Interpretation of inter guidance sequence networks.	**33,34**
Power System Stability	
Steady state power limit of cylindrical rotor and salient pole machines without saturation	**35,36**
Maximum power transmitted to a transmitting network, series capacitor	**37,38**
Transient stability power angel curve,	**39,40**
Inertia clearance angel, equal swing equation	**41**
, equal area criterion and its application	**42**

TUTORIAL-I

Tutorial-II

Tutorial-III

Tutorial-III

Darbhanga College of Engineering
Department of Electrical and Electronics Engineering

ROLL No.										

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

MID-SEM EXAMINATION

Subject Name	Power System-I	**Subject Code**	031404
Branch & Sem.	EEE, 4^{th}	**Date**	
Max Marks	20	**Max Time**	2 Hr.

Code : 031508

B.Tech 5th Semester Examination, 2016

Power System-II

Time : 3 hours *Full Marks : 70*

Instructions :

(i) The marks are indicated in the right-hand margin.

(ii) There are Nine questions in this paper.

(iii) Attempt five questions in all.

(iii) ***Question No. 1 is Compulsory.***

1. Write short answers of the following (any seven): 7×2=14

(a) What are superheater and reheater?

(b) On what factors does the power output of hydro-plant depends?

P.T.O.

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(c) What is load duration curve ? What information does it provides?

(d) Name some of the categories of heat losses in a thermal plant.

(e) Define critical clearing angle in equal area criterion?

(f) Why ash handling plant necessary in thermal power plant?

(g) What is two par tariff?

(h) What is hydrograph? What information does it provides?

(i) List the different methods to improve transient stability

(j) Define the sequence impedances.

2 (a) Define the terms plant capacity factor and plant use factor and explain their importance in an electrical power system. Also explain the effect of the load factor on the cost of generation. 7

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(b) The power station supplies the peak loads of 25 MW, 20 MW and 30 MW to three localities. The annual load factor is 0.60 pu and the diversity of the load at the station is 1.65 pu. Calculate 7

(a) The maximum demand on the station.

(b) The installed capacity.

(c) The energy supplied in a year

3. (a) Derive the sequence impedance of transmission lines. 7

(b) A set of unbalanced line currents in a three phase four wire system in as follows:

$$I_a = -j6 \text{ A}, I_b = (-8+j5) \text{ A and } I_c = 7 \text{ A}$$

Determine the zero sequence, positive sequence and negative sequence components of the current. 7

4. (a) Prove that a line-to-ground fault at the terminals for a synchronous generator with solidly grounded neutral is more severe than a three-phase fault. 7

(b) A 100 MVA, 11 KV, three-phase synchronous generator was subjected to different type of faults. The faults currents are as follows:

LG fault–4200 A; LL fault–2600 A; LLL fault-2000 A.

The generator neutral is solidly grounded. Find the per unit values of the three sequence reactances of the generator. 7

5. (a) Distinguish between steady state and transient stability of a power system and also discuss the factors on which these depends. 7

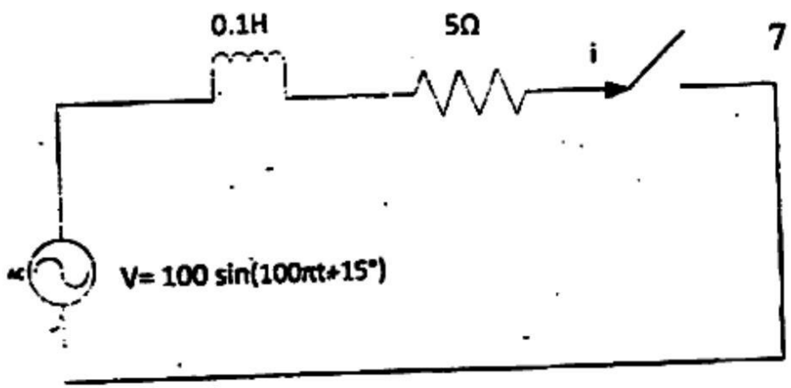
(b) A 100 MVA, 2 pole, 60 Hz generator has a moment of inertia of 50×10^3 kg-m^2. Determine the following: 7

(a) The energy stored in the rotor at the rated speed

(b) The angular Momentum M and

(c) The inertia constant H

6. (a) A transmission line of reactance 0.1 H and resistance 5 ohms is suddenly short circuited at t = seconds at the bar end as shown in the figure. Write the expression for the short circuit current i(t) with a neat diagram. Find approximately the value of the first current maximum (maximum momentary current). Assume that the first current maximum occurs at the same time as the value of the first current maximum of the short circuit current. 7



Figure

(b) Three 60 MVA ac generators, each having 15% reactance are connected via three 36 MVA reactors each of 10% reactance to a common busbar. The feeders are each connected to the junction of each alternator and is reactor. What must be the minimum rating of each feeder circuit breaker? 7

7. Write short notes on the following: 14

(a) Cooling water tower efficiency

(b) Transient stability

(c) Equal area criterion

(d) Swing equation

8. (a) What are the advantages of pumped storage plants? Discuss how water hammer and negative pressure can be prevented in hydro electric plants. 7

(b) Compare the essential requirements for the favourable site selection for hydroelectric plants and thermal power plants. Also discuss the limitations of each. 7

9. (a) Explain the interconnection of sequence network for 7

(i) Line-to-line fault.

(ii) Double line-to-ground fault

(b) Explain the equal-area criterion for the stability of an alternator supplying infinite busbars via an inductive interconnector. 7

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Code : 031508

B.Tech 5th Semester Exam., 2015

POWER SYSTEM—II

Time : 3 hours *Full Marks* : 70

Instructions :

(i) *The marks are indicated in the right-hand margin.*

(ii) *There are* **NINE** *questions in this paper.*

(iii) *Attempt* **FIVE** *questions in all.*

(iv) *Question No.* **1** *is compulsory.*

1. Write short answer of the following (any *seven*) : 2×7=14

   (a) Why is pulverized fuel used?

   (b) What is pondage?

   (c) What is the necessity of power factor improvement?

   (d) What is a single-line diagram?

   (e) Define positive sequence impedance.

   (f) Name the fault, which do not have zero sequence current flowing.

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   (g) Define stability limit.

   (h) What for surge tank is provided?

   (i) What is meant by per unit value of any quantity?

2. (a) What are the functions of economizer and superheater in a thermal power plant? 7

   (b) A thermal power plant spends ₹ 25 lakhs in one year as coal consumption. The coal has heating value of 5000 kcal/kg and costs of ₹ 500 per ton. If the thermal efficiency is 35% and electrical efficiency is 90%, find the average load on the power plant. 7

3. (a) What are the factors of selection of site for hydroelectric station? 7

   (b) Give a general layout of a hydroelectric power plant. Explain the function of different components in plant. 7

4. (a) Define the following terms in connection with a power supply system : 7

   Connected load; Maximum demand; Demand factor and Load factor.

(b) A generating station has a connected load of 450 MW and a maximum demand of 250 MW; the units generated being 615×10^6 per annum. Calculate the demand factor and load factor. 7

5. (a) A synchronous generator rated 500 kVA, 440 V, 0·1 per unit, sub-transient reactance is supplying a passive load of 400 kW at 0·8 lagging power factor. Calculate the initial symmetrical r.m.s. current for a 3-phase fault at the generator terminals. 7

(b) What are current limiting reactors? In what positions are they connected employed in large stations? 7

6. (a) Explain how an unsymmetrical system of 3-phase current can be resolved into three symmetrical component systems. 7

(b) The phase voltage across a certain unbalanced 3-phase load are given as :

$$E_A = 176 - j132,\ E_B = -128 - j96,\ E_C = -160 + j100$$

Determine the positive, negative and zero sequence components for above voltages. 7

7. (a) Draw the sequence network diagram for the single line to ground fault at the terminal of an unloaded generator. 7

(b) A 10 MVA, 13·8 kV alternator has positive, negative and zero sequence reactance's of 30%, 40% and 5% respectively. What value of resistance must be put in the generator neutral so that the fault current for a line to ground fault of zero fault impedance will not exceed the rated line current? 7

8. (a) Deduce an expression for the maximum steady state power which can be transmitted over a line (neglecting capacitance of the line) if the voltage at each end is kept constant. 7

(b) Derive the swing equation of a synchronous machine swinging against an infinite bus. Clearly state the assumptions made in deducing the swing equation. 7

9. Write short notes on (any *two*) : 7×2=14

(a) Pumped hydroplant

(b) Transient stability

(c) Tariff

★ ★ ★

1. What is the principle involved in the working of the thermal power plant?

THERMAL POWER PLANT

CONTENTS

INTRODUCTION

- A Thermal Power Plant converts the heat energy of coal into electrical energy. Coal is burnt in a boiler which converts water into steam. The expansion of steam in turbine produces mechanical power which drives the alternator coupled to the turbine.Thermal Power Plants contribute maximum to the generation of Power for any country.

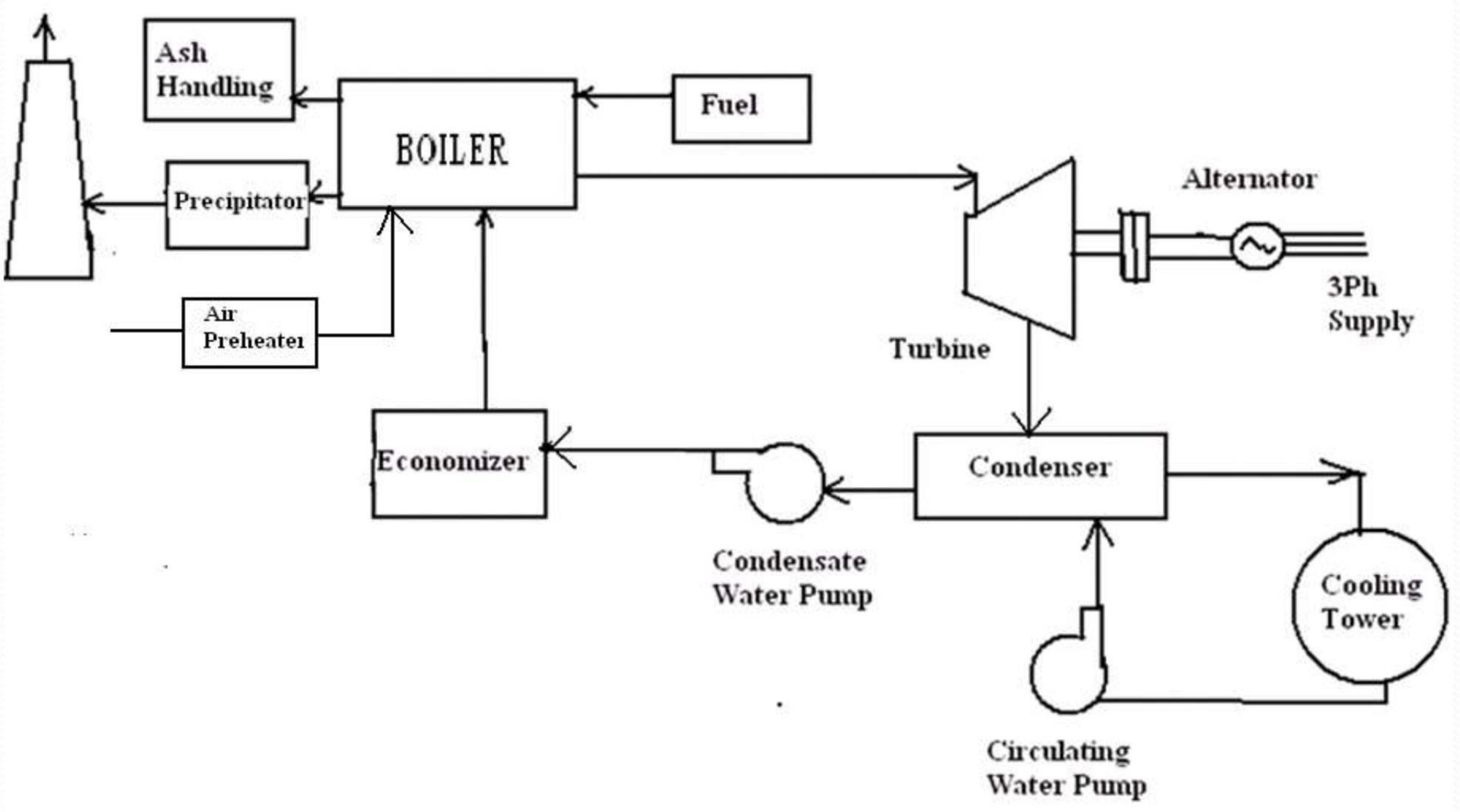
- Thermal Power Plants constitute 75.43% of the total installed captive and non-captive power generation in India.

- In thermal generating stations coal, oil, natural gas etc. are employed as primary sources of energy.

WORKING PRINCIPLE

- Firstly the water is taken into the boiler from a water source. The boiler is heated with the help of coal.
- The increase in temperature helps in the transformation of water into steam. The steam generated in the boiler is sent through a steam turbine.
- The turbine has blades that rotate when high velocity steam flows across them. This rotation of turbine blades is used to generate electricity.
- A generator is connected to the steam turbine. When the turbine turns, electricity is generated and given as output by the generator, which is then supplied to the consumers through high-voltage power lines.

GENERAL LAYOUT OF THERMAL POWER PLANT



MAIN EQUIPMENTS

- Coal handling plant
- Pulverizing plant
- Boiler
- Turbine
- Condenser
- Cooling towers and ponds
- Feed water heater
- Economizer
- Air preheater

COAL HANDLING PLANT

- Coal is transported to power station by rail or road and stored in coal storage plant and then pulverized.
- The function of coal handling plant is automatic feeding of coal to the boiler furnace.
- A thermal power plant burns enormous amounts of coal.
- A 200MW plant may require around 2000 tons of coal daily.

PULVERIZING PLANT

- In modern thermal power plant, coal is pulverized i.e. ground to dust like size and carried to the furnace in a stream of hot air. Pulverizing is a means of exposing a large surface area to the action of oxygen and consequently helping combustion.
- Pulverizing process consists 3 stages classified as:

1. Feeding
2. Drying
3. Grinding

BOILER

The function of boiler is to generate steam at desired pressure and temperature by transferring heat produced by burning of fuel in a furnace to change water into steam.

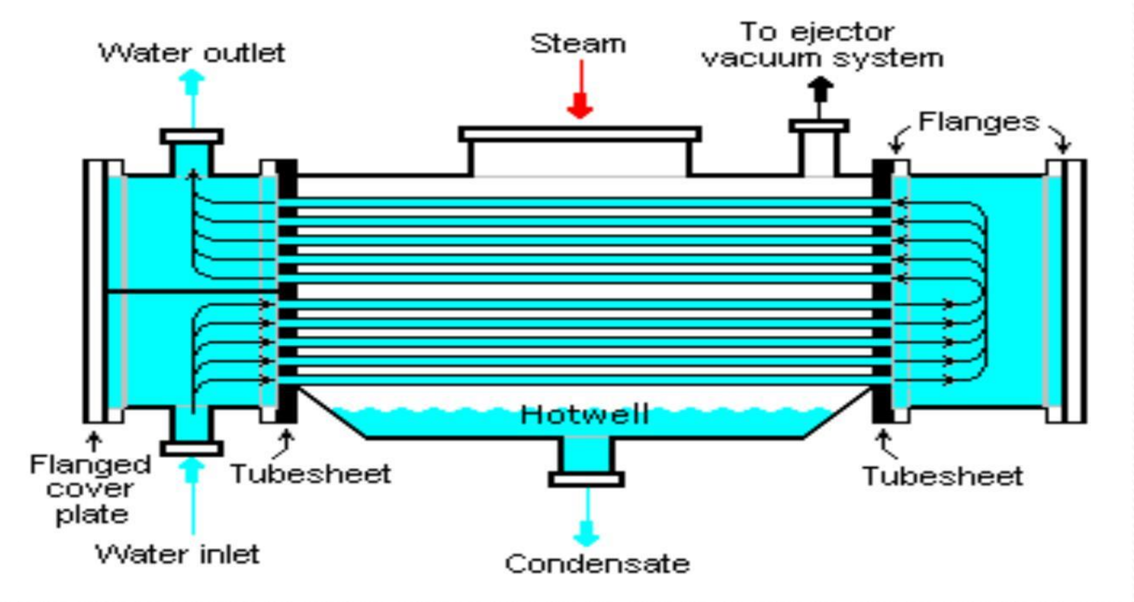
TURBINE

In thermal power plants generally 3 turbines are used to increases the efficiency.

- High pressure turbine
- Intermediate pressure turbine
- Low pressure turbine

CONDENSER

The surface condenser is a shell and tube heat exchanger where cooling water flows through tubes and exhaust steam fed into the shell surrounds the tubes. as a result, steam condense outside the tubes.



COOLING TOWERS AND PONDS

- A condenser needs huge quantity of water to condense the steam.
- Most plants use cooled cooling system where warm water coming from condenser is cooled and reused.
- Cooling tower is a steel or concrete hyperbolic structure with the height of 150m.

FEED WATER HEATER

- Feed water heating improves overall plant efficiency.

- Thermal stresses due to cold water entering the boiler drum are avoided.

- Quality of steam produced by the boiler is increased.

ECONOMIZER

- Flue gases coming out of the boiler carry lot of heat. An economizer extracts a part of this heat from flue gases and uses it for heating feed water.

- Saving coal consumption and higher boiler efficiency.

AIR PREHEATER

- The function of air preheaters is to preheat the air before entering to the furnace by utilizing some of the energy left in the flue gases before exhausting them to the atmosphere.

- After flue gases leave economizer, some further heat can be extracted from them and used to heat incoming heat. Cooling of flue gases by 20 degree centigrade increases the plant efficiency by 1%.

WASTE GENERATED AND THEIR CONTROL

- ASH HANDLING PLANT
- WATER HANDLING PLANT

ASH HANDLING PLANT

- The ash from the boiler is collected in two forms-
- Bottom ash(slurry): It's a waste which is dumped into ash pond.
- Fly ash: Fly ash is separated from flue gases in esp.

WATER HANDLING PLANT

Water in a Power Plant is used for:-

- Production of Steam- for rotating turbine.
- Cooling Purpose- For cooling of various equipment .
- Water is recycled and used for various purpose:

Raw Water → For Cooling Purposes → Steam → Condenser → Raw Water

- About 4 cubic meter water is lost/day/mw.

ADVANTAGES:

- The fuel used is quite cheap.
- Less initial cost as compare to other generating stations.
- It can be installed at any place irrespective of the existence of coal. The coal can be transported to the site of plant by rail or roads.

DISADVANTAGES:

- It pollutes the atmosphere due to producing large amount of smoke and fumes.
- Higher maintenance cost and operational cost.
- Huge requirement of water.

REFERENCES

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- http://www.reliancepower.co.in/power_industry/power_generation/working_of_a_power_plant.htm
- http://www.meritnation.com/ask-answer/question/what-are-the-advantages-and-disadvantages-of-thermal-power

Thank you

DAY 1 :-> Generating Station classification :- (1)

i) Thermal Power stations. ii) Hydroelectric power station.
iii) Diesel power stations iv) Nuclear power stations.
-> Coal fired power plant.

-> Prediction of Load and energy Requirements :-

(1) Load survey :-> Detailed information category wise & area wise is collected to estimate the demand. (Category -> residential, commercial, industrial etc.)

(2) Methods of extrapolation :- It estimates the yearly increase in energy consumption. These methods are statistical & can be found on the basis of per capita electrical energy consumption.

(3) Mathematical method :-> It uses linear or exponential curve fitting techniques for extrapolation of the curves showing energy consumption for past several years.

(4) Methods using economic parameters :- It is based on the assumption that per capita consumption of electrical energy in a country depends upon economic factors such as gross investment, industrial production, specific GNP, steel consumption. etc.

Thermal Power Station :-

Site selection :-> (1) Cost & type of land :- Land should be cheaply available & further extension is possible. Load bearing capacity of land should be adequate so that heavy equipments can be installed.

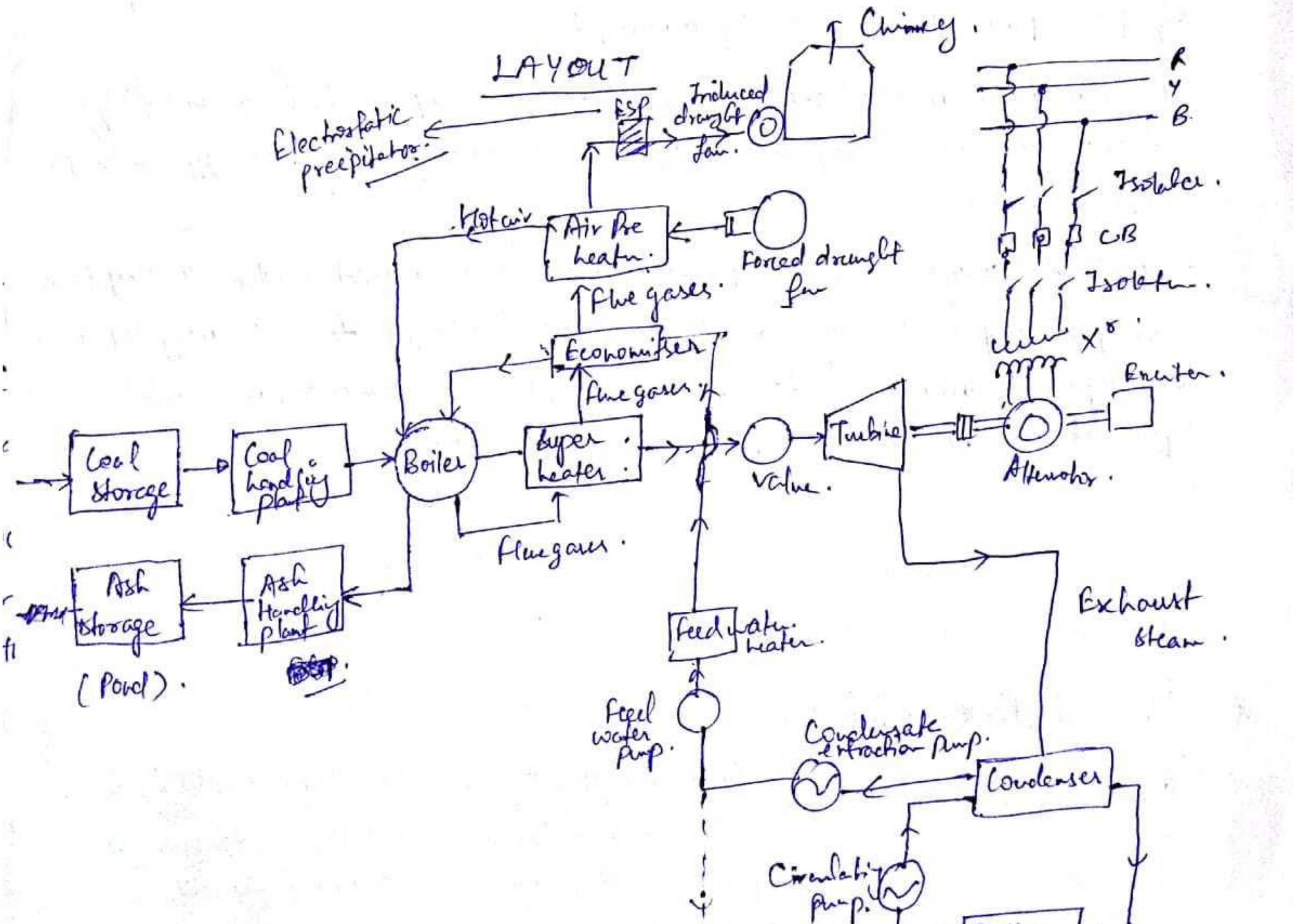
(3) Transportation facilities :- Adequate transportation facilities should be available for transporting material & machinery. The power plant should be well connected by rail & road.

(4) Nearness to the load centres :- In order to reduce transmission & distribution cost, the plant should be located near load centres.

(5) Fuel supply :- Location of plant should be in such a way so as to reduce the transportation cost of fuel.

(6) Distance from a populated area :- Plant should be located at a considerable distance from populated areas to avoid smoke & fumes.

LAYOUT



Components :- (2). (2)

The plant can be divided into 4-main circuits :→

(1) Fuel & Ash circuit :→ Coal is feed to the boiler from coal handling plant (CHP). Ash produced as a result of combustion of coal is collected & is removed to ash storage.

(2) Air & Gas circuit :- Air from the atmosphere is supplied to the combustion chamber of the boiler through the action of FD fan. or ID fan. The air before being supplied to the boiler. passes through air preheater where it is heated by the heat of flue gases. The flue gases first pass around the boiler tubes & superheater tubes in the furnace, next through dust collector. Finally they are exhausted to the atmosphere through ESP.

(3) Feed water & steam circuit :→ The condensate leaving condenser is first heated in a closed feed water heater. This water then passes through deaerator & few more water heaters before it goes into boiler. Small part of steam & water in passing through different components of the system is lost. Therefore water is added in the feed water system as make-up water.

(4) Cooling water circuit :→ To condensate the steam, large quantity of water is required. Cooling water may be taken from the upper side of the river & after passing through condenser, it may be discharged to the lower side of river. If adequate quantity of water is not available throughout the year then water coming out of condenser may be cooled either in cooling pond or cooling tower.

→ Components :→ ① Boiler :- It is a device meant for producing steam under pressure. Types :-

Boilers.

Fire tube boilers	Water tube boilers.
(water outside tubes)	(water inside tubes)
(hot gases inside the tube)	(hot gases outside the tube)
(low initial cost)	(High initial cost)
(high risk of explosion).	(lesser risk of explosion)

② Economizers :- Its purpose is to heat feed water so as to recover a part of heat which would otherwise be lost through flue gases.

③ Air preheater :- Economizer cannot extract entire heat from flue gases so air preheaters are employed to recover some heat. Its use is more economical with pulverised fuel boilers.

④ Prime Mover (Steam turbine) :→ These are of two types
ⓐ Impulse ⓑ Reaction.

Impulse turbine :- the steam expands in the stationary nozzle & attains a higher velocity. Potential energy in steam due to pressure & internal energy is converted to kinetic energy when passing through the nozzle.

Reaction turbine :- It has no nozzle. A partial drop of pressure is used to allow the steam into the moving blades. The pressure is gradually reduced in the blades as the steam passes through them.

→ Commercial turbines use series combination of Impulse & reaction types.

(5) Condensers :→ Steam after expansion through the prime mover, goes through the condenser which condenses the exhaust steam & also removes air & other non-condensable gases from steam. The use of condenser improves the efficiency of power plant by decreasing the exhaust pressure of the steam below atmosphere. Another advantage of condenser is that condensed steam can be recovered & this provides a source of good & pure feed water to the boiler thereby considerably the water softening plant capacity.

Cooling water for condenser → the quantity of cooling water for condensing steam in the condenser is quite large. Therefore a source of water capable of supplying water throughout the year is essential. Generally water from the river is taken for this purpose by means of circulating water pumps.

(6) Spray Pond :→ It consists of a tank of water in which water to be cooled is distributed by pipes & sprayed through nozzle at a suitable pressure. The water is cooled by both convection & evaporation. The sprayed water comes in contact with the atmospheric air & is cooled. Mostly the water is cooled by evaporation as the heat for evaporation is withdrawn from the water itself. with the result that it is cooled.

(7) Cooling Tower :— The height of cooling tower & its water handling capacity are suitably designed for particular cases. The splitting of water into small droplets, the draught provided by the water & the large evaporating surface help to cool water very quickly practically during the time when it is descending. Water from the base of cooling tower is pumped to the condenser & the cycle is repeated. Some water is lost owing to evaporation & has to be added from the tank.

(8) Fuel :- Fuels may be classified as solid, Liquid & gaseous. Fuel normally used in a thermal station is coal, oil or gas. ~~Gaseous~~

(9) Control Room :- It houses all the necessary measuring instruments for each panel of alternator & feeder, synchronizing gear, protective gear, automatic voltage regulator, communication arrangement etc.

(10) Switchyard :- It houses transformers, CB's & switches for connecting & disconnecting the x^{rs}. & CB's. It also has lightening arrestors for the protection of the power station against lightening strokes.

Overall efficiency of power plant = {Generator efficiency} × {Thermal efficiency of steam turbine including condenser} × {Boiler efficiency}

(11) & (12) after in page (4).

Numericals :- (1) A steam power station of 100MW capacity uses coal of calorific value of 6400 Kcal/kg. The thermal efficiency of the station is 30%. & electrical generation efficiency is 92%. Determine the coal required per hour when the plant is working at full load.

Soln → overall efficiency of power station = thermal efficiency × electrical efficiency.

$= 0.3 \times 0.92 = 0.276.$

Unit generated per hour at full rated o/p = 100 × 1000 KWh.

Heat produced per hour = $\frac{100 \times 1000 \times 860}{0.276} = 311.6 \times 10^6$ kcal.

Coal consumption per hour = $\frac{\text{Heat produced per hour}}{\text{Calorific value}}$

Numerical (1) :- The relation between water evaporated (M kg), coal consumption C (kg) & energy generated (kwh) for 8 hrs shift in a thermal power plant is given by.

$M = 15000 + 10\ kWh$, $C = 5000 + 5\ kWh$.

→ How much coal per hour would be required to keep the station running at no load.

Soln :- At No load :- $kWh = 0$, $C = 5000 + 5 \times 0 = 5000$

Coal consumption per hour $= \frac{5000}{8} = 625\ kg$.

(11) Air Preheater :- Since the entire heat of the flue gases cannot be extracted through the economizers air preheaters are employed to recover some heat of these gases. The use of air preheater is more economical with pulverised fuel boilers because the temperature of flue gases going out is sufficiently large.

(12) Superheaters & Reheaters :- Its function is to superheat steam to the desired temperature. By removing last traces of moisture (1 to 2%) from the saturated steam coming out of the boiler & increasing its temperature sufficiently above ~~st~~ saturation temperature there is an overall ~~efficiency of~~ increase in cycle efficiency. (Consaction will lead to turbine blade corrosion)

Points :- → High ash content fuels can be used more economically in pulverised form because in that form the thermal efficiency may be as high as 90% & the controls could be simplified ...

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HYDRO-Electric Power Plant :→

→ Site selection :→ If a good system of natural storage lakes at high altitudes & with large catchment areas can be located, the plant will be comparatively economical. The essential characteristics of a good site are large catchment area, high average rainfall, steep gradients & a favourable place for constructing the storage or reservoir.

Factors considered in the selection of site :-

(1) Availability of water :→ The maximum of flood flow governs the size of the dam to be built with adequate spillway. For estimation of energy available from a given stream ~~of water~~ or river, the discharge flowing & its variation with time over number of years must be known. The estimates of the ~~stream flow~~ average quantity of water available is prepared on the basis of actual measurements of stream flow over a long period. Previous records of rainfall must be studied & minimum & maximum quantity of water available during the year should be estimated.

(2). Storage of Water :→ Wide variation of rainfall during the year makes it necessary to store water for continious generation of water throughout the year. There are two types of storage :-

(a) where it is intended to provide just sufficient storage for one year only so that there is no carry-over water for the next season.

(b) where it is intended to provide enough storage so as to be useful even during the worst dry periods.

(3) Head of water :- It depends on topography of area. Low falls on unregulated streams are subject to wide variations which effect the net head, & may reduce it to an abnormally low value, uneconomical for power generation.

(4) Distance from load centres.

(5) Accessibility of the site :- Adequate transportation facilities must be available for the transportation of necessary equipment & machinery.

(6) Sedimentation :- Gradual deposition of silt may reduce the capacity of the storage reservoir & may also cause damage to the turbine blades. Silting from the regions subject to violent storms & not protected by vegetation contribute lot of silt to the run-off.

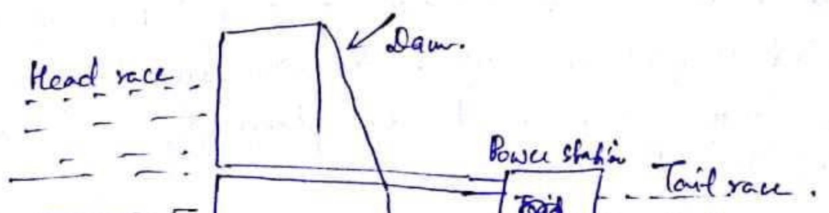
(7) Large catchment area :- The reservoir must have a large catchment area so that the level of water in the reservoir may not fall below the min required in dry season.

(8) Availability of land :- The land available should be cheap in cost & rocky in order to withstand the weight of the large building & heavy machinery.

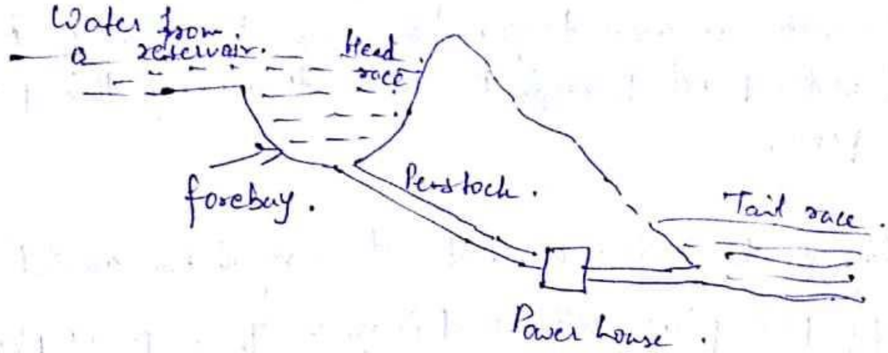
Classification of Hydro-Electric Power Plants :-

(1) According to Available Head → (a) Low head Plants :- (Head < 50m)

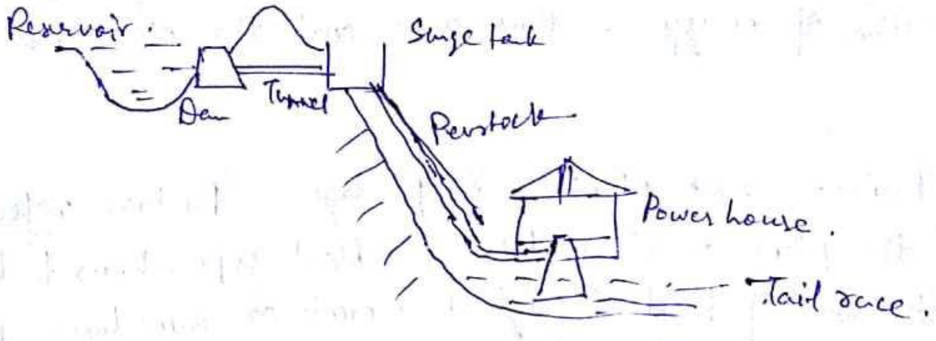
Small dam is built across the river to provide the necessary head. The excess water is allowed to flow over the dam itself. No surge tank is required in this dam.



(b) Medium Head Plants :- The forebay provided at the beginning of the penstock serves as water reservoir for such plants. In these plants water is generally carried in open canals from main reservoir to the forebay & then to the powerhouse through the penstock. (6).



(c) High head Plants :- All the water is carried from the main reservoir by a tunnel upto the surge tank to the power house through penstock.



(2) Classification ~~of~~ based Nature of Load :-

(a). Base load plants :- These plants can take up load on the base portion of the load curve. These are generally of large capacity. Since such plants are kept running practically on block load, the load on them is almost constant. Those plants with large storage are ideally suited to work as base load plant.

(b) Peak load Plants :- Run-off river plants with pondage can be used as peak load plant. These plants supply the peak load of the system

(c) Pumped Storage Plants :- These plants pumps back all or a portion of its water supply during low load period. The generating pumping plant is at the lower end. ~~The plant~~ It uses some of the surplus energy generated by the base load plant to pump the water from the tail water pond into head water pond during off peak hours. During peak load period this water is used to generate power by allowing it to flow from the head water pond through the water turbine of this plant to the tail water pond.

(3) According to the extent of water flow regulation available :-

(a) Run-off powerplants without Pondage :- These power plants take water from river directly & no pondage or storage is possible. These are of low capacity. Such plants can be built at considerably low cost but the head available & the amount of power generated are usually very low. The main objective of such plants is to use whatever flow is available for generation of energy. & thus save coal that otherwise be necessary.

(b) Run-off river plants with pondage :- Pondage refers to storage at the plant which makes it possible to cope, hour to hour, with fluctuations of load throughout a week or some longer period depending on the size of pondage. Such power plants are comparatively more reliable & its generating capacity is less dependent on available rate of flow of water. These can serve as base load or peak load power plants depending on the flow of stream.

(c) Reservoir Power Plants :-> Storage increases the ~~capacity~~ effectiveness of plant & it can be used throughout the year. It can be use as base & peak load plant both as per requirement. ~~It can also be~~

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Name of Faculty:-Mr. Tabish Shanu **Branch:- EEE**
Course Code:- EE508
Date of exam:-
Test Abbrevation:SESSIONAL TEST
Maximum Marks **20**
Test Topic:-Power System-II

Sl. No.	Name	Class Roll No.	Marks
1	Rajbala Kumari	16-EE-01	
2	Sushmita Kumari	16-EE-03	
3	Shweta Rani	16-EE-04	
4	Nisha Raj	16-EE-05	
5	Priyanka Kumari	16-EE-07	
6	Rashmi Bharti	16-EE-08	
7	Sonika Kumari	16-EE-09	
8	Puja Prabhakar	16-EE-11	
9	Devashish Dubey	16-EE-12	
10	Alok Ranjan	16-EE-13	
11	Hemant Kumar patel	16-EE-14	
12	Kumar Satyam	16-EE-15	
13	Pratik Kumar	16-EE-17	
14	Prabhash Kumar Yadav	16-EE-18	
15	Ranjesh Kumar	16-EE-19	
16	Upendra Kumar	16-EE-20	
17	Amit Kumar	16-EE-21	
18	Wajahat Khalil	16-EE-22	
19	Prakash Ranjan	16-EE-24	
20	Rahul Kumar	16-EE-26	
21	Ankit Ranjan	16-EE-27	
22	Varinder Kumar	16-EE-29	
23	Vikash Kumar Bharti	16-EE-30	
24	Navneet Kumar	16-EE-31	
25	Prem Raj	16-EE-32	
26	Juhi Kumari	16-EE-33	
27	Appu Kumar	16-EE-34	
28	Ashish Kumar	16-EE-35	
29	Babloo Kumar	16-EE-36	
30	Niraj Kumar Nirala	16-EE-37	
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34	Rohit Kumar	16-EE-42	

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40	Shubhra Verma	16-EE-48	
41	Khushboo Kumari	16-EE-49	
42	Priti Kumari	16-EE-50	
43	Md. Sharmajul Haque	16-EE-51	
44	Saurav Kumar	16-EE-52	
45	Anubhav Anand	16-EE-53	
46	Shankar Suwan Kesri	16-EE-54	
47	Tanuj Anand	16-EE-55	
48	Ganesh Kumar	16-EE-56	
49	Ashish Ranjan	16-EE-57	
50	Shashi Kumar	16-EE-58	
51	Vishnu Kumar	16-EE-59	
52	Anku Rani	16-EE-60	
53	Santosh Kumar Mahto	16-EE-61	
54	Shubham Kumar	16-EE-62	
55	Md. Seraj	16-EE-63	
56	Amrendra Kishor	16-EE-64	
57	Amit Kumar Jha	16-EE-65	
58	Rohit Kumar Yadav	16-EE-66	
59	Rahul Kumar Sahni	16-EE-67	
60	Saurabh Kumar	16-EE-68	
61	Pankaj Kumar	16-EE-69	
62	Pooja Roy	16(LE)EE-01	
63	Surya Rai	17(LE)EE-01	
64	Santosh Kumar	17(LE)EE-02	
65	Lalit Kumar Ram	17(LE)EE-03	
66	Deepak Kumar Prabhat	17(LE)EE-04	
67	Sumit Kumar	17(LE)EE-05	
68	Avinash Choudhary	17(LE)EE-06	
69	Ranjeet Kumar Sah	17(LE)EE-07	
70	Baby Kumari	17(LE)EE-08	
71	Virendra Kumar Sah	17(LE)EE-09	
72	Abhinav Raj	17(LE)EE-10	
73	Ejaz Ahmad Ansari	17(LE)EE-11	
74	Abrar Ahmad	15-EE-03	

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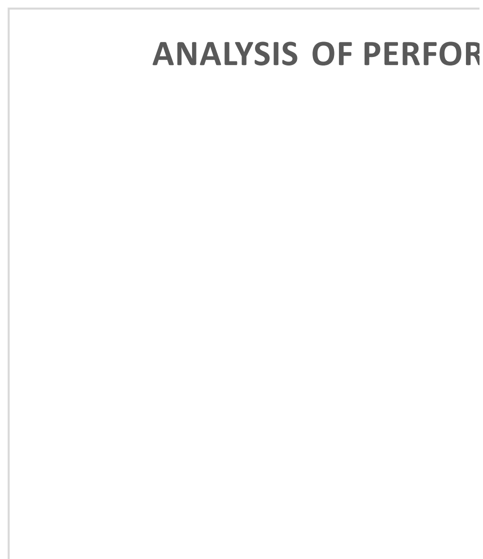

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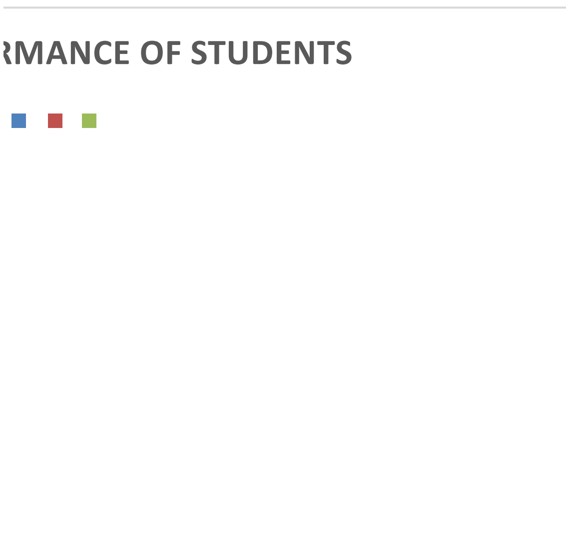

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RESULT ANALYSIS

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Quality Measurement Sheets

a. Course End Survey

ACADEMIC YEAR: 2017-18	SEM: IV	DATE:
COURSE: Power System-I	CLASS: EEE	FACULTY: Mr. Tabish Shanu

Please evaluate on the following scale:

Excellent(E)	Good(G)	Average(A)	Poor(P)	No Comment(NC)
5	4	3	2	1

SNO	QUESTIONAIRE	E 5	G 4	A 3	P 2	NC 1	Avg %
GENERAL OBJECTIVES:							
1	Did the course achieve its stated objectives?						
2	Have you acquired the stated skills?						
3	Whether the syllabus content is adequate to achieve the objectives?						
4	Whether the instructor has helped you in acquiring the stated skills?						
5	Whether the instructor has given real life applications of the course?						
6	Whether tests, assignments, projects and grading were fair?						
7	The instructional approach (es) used was (were) appropriate to the course.						
8	The instructor motivated me to do my best work.						
9	I gave my best effort in this course						
10	To what extent you feel the course outcomes have been achieved.						
Please provide written comments:							

a) What was the most effective part of this course

b) What are your suggestions, if any, for changes that would improve this course?

c) Given all that you learned as a result of this course, what do you consider to be most important?

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d) Do you have any additional comments or clarifications to make regarding your responses to any particular survey item?
e) Do you have any additional comments or suggestions that go beyond issues addressed on this survey?

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TEACHING EVALUATION

Darbhanga College of Engineering, Darbhanga

Department of Electrical and Electronics Engineering

Course Assessment

ACADEMIC YEAR: 2017-18	SEM: IV	DATE:
COURSE: Power System-I	CLASS:	FACULTY: Mr. Tabish Shanu

Assessment	Criteria Used	Attainment Level			Remarks
Direct (d)	Theory				
	External Marks	___			
	Internal Marks (Theory)				
	Assignments				
	Tutorials				
Indirect (id)	Course End Survey				
Theory: Course Assessment (0.6 × d+ 0.4 × id)					