PPD 8th

(2016 fall)

(3)(b) From a load duration curve the following data are available:

The maximum demand on the system is 25 MW. The load is supplied by two generating units, unit I is of 15 MW and unit II is of 12.5 MW. The unit I acts as a base load unit and the unit II as a peak load. The base load unit operates for 100% of the time while the peak load unit operates for 40% of the time. The energy generated by the unit I is 1×10^6 units and that by the unit II is 1×10^7 units. Determine:

i) the load factor, the plant capacity factor and the plant use factor for unit I

ii) the load factor, the plant capacity factor and the plant use factor for unit II. (9)

Soln:

For peak Load Unit II:

Assuming maximum demand on base load unit equal to its rated capacity i.e 15 MW.

peak load on the standby unit i.e. peak load unit

= maximum demand of the system − maximum demand on base unit

= 25 − 15 = 10 MW (maximum demand of peak load unit)

capacity of peak load unit = 12.5 MW
Annual peak load unit output = $1 * 10^7$ KWh.

Hours of operation of peak load unit during the year = $\frac{40}{100} * 365 * 24$ = 3504 hours

Annual average load of peak load unit

$= \frac{\text{output in KWh}}{24 * 365} = \frac{1 * 10^7}{8760} = 1141.55$ KW

Annual load factor

$= \frac{\text{Annual average load}}{\text{Maximum demand}} = \frac{1141.55 \text{ KW}}{10 \text{ MW}}$

$= \frac{1141.55}{10 * 10^3} = 0.114$ or 11.4 % Ans

plant capacity factor = $\frac{\text{Average load}}{\text{Rated capacity}}$

$= \frac{1142.55}{12.5 * 10^3} = 0.0914$ or 9.14 % Ans

plant use factor = $\frac{\text{Total units generated}}{\text{Rated capacity} * \text{no. of operating hours}}$

$= \frac{1 * 10^7}{12.5 * 10^3 * 3504} = 0.2283$ or 22.83% Ans

For Base Load Unit I:

Annual output $= 1*10^6$ KWh.

~~Annual Average load~~ Hours of operation of Base load unit during the year $= \frac{100}{100} * 24 * 365 = 8760$ hr.

Annual average load $= \frac{\text{output in KWh}}{24*365} = \frac{1*10^6}{8760} = 114.16$ KW

Annual load factor $= \frac{\text{Annual average load}}{\text{Maximum demand}} = \frac{114.16}{15*10^3}$

$= 0.0076$ or 0.7611% Ans

plant capacity factor $= \frac{\text{Annual average load}}{\text{Rated capacity}} = \frac{114.16}{15*10^3}$

$= 0.0076$ or 0.7611% Ans

plant use factor $= \frac{\text{Total units generated}}{\text{Rated capacity * no. of operating hours}}$

$= \frac{1*10^6}{15*10^3 * 8760} = 0.0076$ or 0.7611% Ans

again

Load factor of the total plant

$= \frac{\text{Total KWh generated by unit I and II}}{\text{Rated capacity of unit I and II * 8760}}$

$= \frac{1*10^6 + 1*10^7}{(15+12.5)*10^3 * 8760} = 0.0457 = 4.566\%$

Ans

Q 1.C. (2016, Sp)

1(C). The maximum demand of power station is 96000 KW and daily load curve is described as follows:

Time (hours)	0-6	6-8	8-12	12-14	14-18	18-22	22-24
Load (MW)	48	60	72	60	84	96	48

(i) Determine the load factor of power station.
(ii) What is the load factor of standby equipment rated at 30MW that takes up all load in excess of 72 MW? Also calculate its use factor. (5)

Soln: Load curve is shown in fig(a) below:

Total units generated = area under the load curve

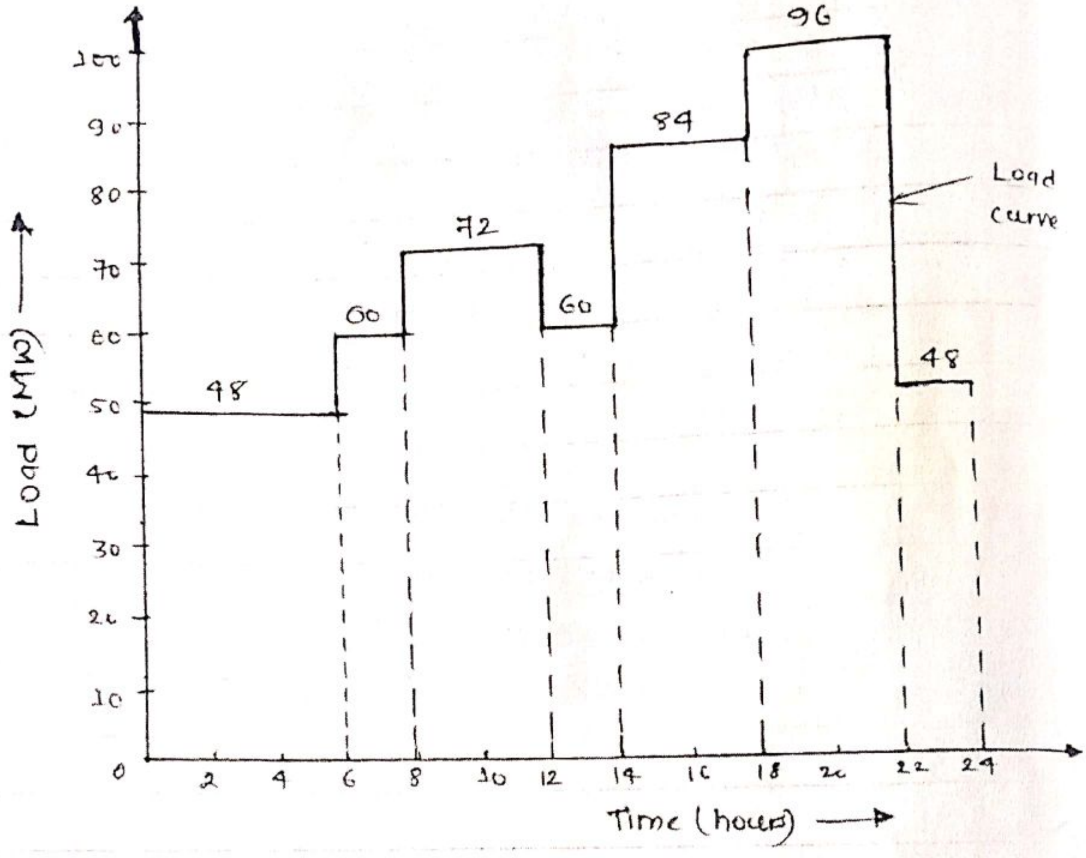
$= 48*6 + 60*2 + 72*4 + 60*2 + 84*4 + 96*4 + 48*2$

$= 1632 \text{ MWhr} = 1632*10^3 \text{ KWh}$

Average load $= \dfrac{\text{Output in Kwh}}{24 \text{ hr}}$

$= \dfrac{1632*10^3}{24} = 68000 \text{ KW}$

since (24hr is time of operation).



Fig(9) Load curve.

Maximum demand = 96000 KW. (given)

(i)

∴ Load factor = $\frac{\text{Average load}}{\text{Maximum demand}}$

$= \frac{68000}{96000} = \underline{0.71.}$ Ans //

(ii) Load factor of standby equipment (30 MW) that takes up all load in excess of 72 MW.

Now: from load curve (fig(a)); load excess of 72 MW are 84 MW and 96 MW then

The standby equipment supplies

$84 - 72 = 12$ MW for 4 hours (14 − 18)

$96 - 72 = 24$ MW for 4 hours (18 - 22).

maximum demand

$\therefore$ Total units generated by standby equipment

$= (12 \times 4 + 24 \times 4)$ MWh

$= 144 \times 10^3$ KWh

Time for which standby equipment remains in operation (from the load curve)

$= 4 + 4 = 8$ hour.

$$\text{Average load} = \frac{\text{output in KWh}}{8\text{ hr}}$$

$$= \frac{144 \times 10^3}{8} = 18 \times 10^3 \text{ KW}$$

$$\text{Load factor} = \frac{\text{Average load}}{\text{Maximum demand}}$$

$$= \frac{18 \times 10^3}{24 \times 10^3} = 0.75 \text{ Ans}$$

also,

$$\text{plant use factor} = \frac{\text{Total KWh generated}}{\text{Rated capacity} * \text{no. of operating hours}}$$

$$= \frac{144 * 10^3}{30 * 10^3 * 8}$$

$$= \underline{0.6} \quad \text{Ans}$$

(2016, SP) (Same as 2015, SP, 3(b))

(3) (Same as 2013, SP, 3(b)), (Same as 2012, SP, 2) (10 marks)

(b) A power system having a maximum demand of 350 MW can be supplied by one of the following schemes:-

i) A steam power plant capable of supplying the whole load.

ii) A nuclear station capable of supplying the whole load.

iii) A hydro station capable of supplying the whole load, and

iv) A steam power plant in conjunction with a hydro station, the latter supplying 200×10^6 units per annum with a maximum output of 50 MW.

particulars.	Steam	Hydro	Nuclear
Capital cost per KW of installat. capacity	Rs 800	Rs 2500	Rs 3500
Interest and depreciation on the capital cost	12 %.	10 %.	10%.
operating cost per unit generation.	Rs. 4.00	Re. 1.00	Rs. 3.00
Transmission per unit energy	Negligible	Re. 0.60	Negligible

Find the energy generation cost per KWh for each case. Indicate which alternative is most economical. Assume system annual load factor to be of 65%.

Soln: Maximum demand on the power system
$= 350 \text{ MW} = 350{,}000 \text{ KW}$.

Load factor $= 65\% = 0.65$

we know:

Load factor $= \dfrac{\text{Average Load}}{\text{maximum demand}}$

$\therefore$ Average load $=$ Load factor $*$ maximum demand
$= 0.65 * 350000 = 227500 \text{ KW}$

we know:

Annual average load $= \dfrac{\text{Units generated per annum}}{24 * 365 \text{ (hr)}}$

$\therefore$ Units generated per annum $= 24 * 365 *$ average load
$= 24 * 365 * 227500 = 1992900000 \text{ KWh}$

(i) Steam power plant:

Capital cost $= 800 * 350000 =$ Rs 280000000

Annual interest and depreciation cost on the capital cost $= \dfrac{12}{100} *$ Rs $280000000 =$ Rs 33600000

Annual operating cost per unit generation
$=$ Rs$4.00 * 1992900000 =$ Rs 7971600000.

Annual transmission cost per unit energy = negligible.

Total annual cost = Rs 33600000 + Rs 7971600000
= Rs 8005200000

∴ Energy generation cost = $\dfrac{\text{Total annual cost}}{\text{Units generated per annum}}$

= Rs $\dfrac{8005200000}{1992900000}$

= Rs 4.02 / KWh

(iii) <u>Hydropower plant</u>:

Capital cost = ~~Rs ...~~ Rs 2500 × 350000
= ~~Rs 875000000~~

Annual interest and depreciation cost on the capital cost = $\frac{10}{100}$ × Rs 875000000 = Rs 87500000.

Annual operating cost per unit generation
= Rs. 1.00 × 1992900000 = Rs 1992900000.

Annual transmission cost per unit energy
= Rs 0.60 × 1992900000 = Rs 1195740000

Total annual cost = Rs 87500000 + Rs 1992900000 +
Rs 1195740000
= Rs 3276140000.

$\therefore$ Energy generation cost = $\dfrac{\text{Total annual cost}}{\text{Units generated per annum}}$

$= Re. \dfrac{3276140000}{1992900000}$

$= Re\ 1.64/KWh.$

(ii) Nuclear station:

Capital Cost = Rs 3500 * 350000 = Rs 1225000000.

Annual interest and depreciation cost on the capital cost

$= \dfrac{10}{100} * 1225000000 = Rs\ 122500000$

Annual operating cost per unit generation

$= Rs\ 3.00 * 1992900000 = Rs\ 5978700000$

Annual transmission cost per unit energy

= negligible

Total annual cost = Rs 122500000 + Rs 5978700000

= Rs 6101200000.

$\therefore$ Energy generation cost = $Re\ \dfrac{6101200000}{1992900000}$

$= Re\ 3.06/KWh$

(iv) Steam power plant in conjunction with a hydropower plant:

maximum demand on hydropower station = 50000 KW (given)

Annual units generated by hydropower station
= 200×10^6 KWh (given)

capital cost on hydropower station =
2500×50000 = Rs 125000000

Annual interest and depreciation cost = 0.1×125000000
= Rs 12500000

Annual operating cost = Re. $1.0 \times 200 \times 10^6$
= Rs 200×10^6
= Rs 200,000000.

Annual transmission cost = Rs $0.60 \times 200 \times 10^6$
= Rs 120000000

Now:

maximum demand on steam power plant
= 350,000 − 50,000
= 300000 KW.

Annual units generated by steam power plant
= 1992900000 − 200000000
= 1792900000 KWh.

Capital cost of steam power plant

$= Rs\ 800 * 300000 = Rs\ 240000000.$

Annual interest and depreciation cost

$= 0.12 * 240000000 = Rs\ 28800000.$

Annual operating cost $= Rs\ 4.00 * 1792900000$

$= Rs\ 7171600000.$

Annual transmission cost = negligible.

Total annual cost $= Rs.\ 12500000 + Rs\ 200000000 +$

$Rs\ 120000000 + Rs\ 28800000 +$ ~~Rs 7171~~

$Rs\ 7171600000.$

$= Rs.\ 7532900000.$

$\therefore$ Energy generation cost $= \dfrac{Rs\ 7532900000}{200 * 10^6 + 1792900000}$

$= Rs\ 3.78/Kwh.$

Hence, from the above four (4) alternative, it is concluded that energy generation cost · Cost/Kwh is minimum of Rs 1.64/Kwh in case of Hydropower plant. So, the hydropower plant is most economical.

Ans

(2014, F) 2(b) (Same as 2014, Sp, 2(b)) (8 marks)

Compute the generation cost per KWh from the following data.

Installed Capacity = 200 MW;
Capital cost = Rs 3000 per KW;
Interest and depreciation = 10%.
Fuel consumption = 0.9 Kg / KWh;
Fuel cost = Rs 4000 per 1000 Kg;
other operating cost = 30% of fuel cost;
Load factor = 80%;
peak load = 170 MW.

Soln: Given, (Consider annual calculations)

peak load = 170 MW = 170,000 KW = maximum demand

Load factor = 80% = 0.8

We know:

$$\text{Load factor} = \frac{\text{Average load}}{\text{maximum demand}}$$

and

$$\text{Average load} = \frac{\text{Units generated per annum}}{24 \times 365\ (\text{hr})}$$

$\therefore$ Units generated per annum = Average Load $\times$ 24 $\times$ 365

= Load factor $\times$ maximum demand $\times$ 24 $\times$ 365

$= 0.8 * 170000 * 24 * 365 =$ 1191360000 KWh

Capital cost per KW = Rs 3000 * 200,000

= Rs 600000000.

Annual interest and depreciation cost $= \frac{12}{100} * 600000000$

= Rs 72000000.

Fuel consumption = 0.9 * 1191360000 = 1072224000 Kg

Annual fuel cost = Rs $\frac{7000}{1000}$ * 1072224000

= Rs 7505568000.

Annual other operating cost $= \frac{30}{100} * 7505568000$

= Rs. 2251670400

Total annual Cost = Rs. 72000000 + Rs 7505568000 + Rs 2251670400

= Rs. Rs 9829238400.

$\therefore$ Generation cost per Kwh = Rs $\frac{9829238400}{1191360000}$

= Rs 8.25/Kwh Ans

same as 2012 f, 3(b)

(same as 2014 sp, 3(b)) (same as 2013 sp, 2(b))

(same as 2015 sp, 2(b)) (same as 2014 f, 3(b))

(2013, fall) (same as 2015 f, 3(b))

4(b). A generating station has a maximum demand of 10 MW and the daily load on the stations is as below:

Time	Demand (MW)	Time	Demand (MW).
11pm to 6am	2.00	1pm to 5pm	7.50
6 am to 8am	3.50	5pm to 7pm	8.50
8am to 12 noon	8.00	7pm to 9pm	10.00
12 noon to 1pm	3.00	9pm to 11pm	4.50.

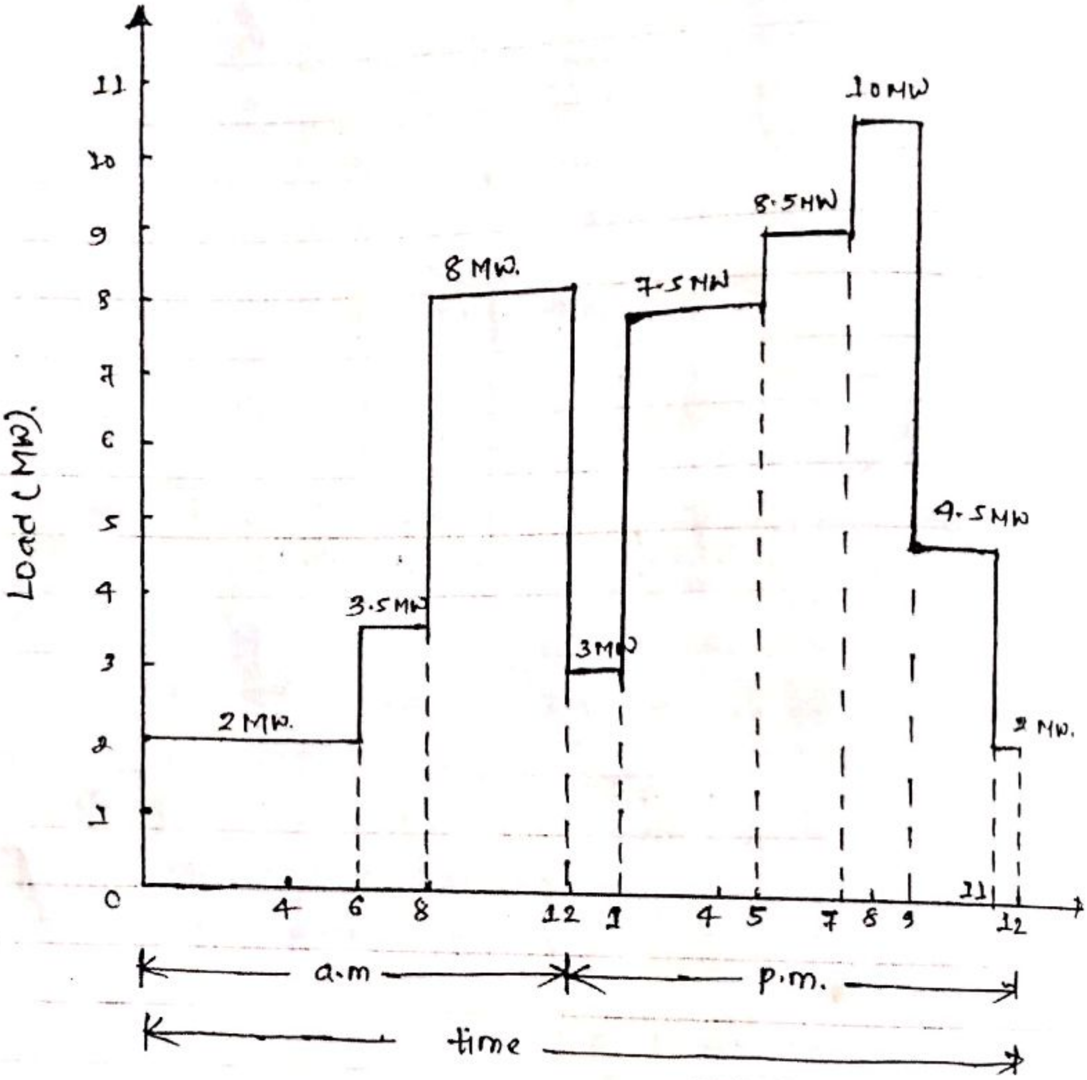
choose the number and size of the generating units needed to supply this load. find the reserve capacity required and also determine the operating schedule of the units in the station.

Soln: The chronological load curve is shown in fig(9) below:-

Total units generated in 24 hours

$= 2*7 + 3.5*2 + 8*4 + 3*1 + 7.5*4 + 8.5*2 + 10*2 + 4.5*2 = 132 \text{ MWh}$

$= 132000 \text{ KWh.}$



fig(a) Load curve.

$$\text{Average load} = \frac{\text{output in KWh}}{24 \text{ hr}}$$

$$= \frac{132000}{24} = \underline{5500 \text{ KW}}.$$

Maximum demand = 10 MW = 10000 KW (given)

$$\text{Load factor} = \frac{\text{Average load}}{\text{Maximum demand}}$$

$$= \frac{5500}{10000} = 0.55 \text{ or } \underline{55\%}$$

From the shape of the load curve, it is obvious that three generating units of capacities $\underline{5000\,KW, 3000\,KW, 2000\,KW}$ would be the best choice to meet the given daily load on the station (See operating schedule).

$\therefore$ $\underline{\text{Reserve plant capacity}}$ = Capacity of units of the largest size

$= \underline{5000\,KW}$ Ans

Installed capacity $= 5000 \times 2 + 3000 + 2000$

or Rated capacity $= \underline{15000\,KW}.$

$$\text{plant capacity factor} = \frac{\text{Average load}}{\text{Rated capacity}}$$

$$= \frac{5500}{15000} = 0.367 \text{ or } 36.7\%$$

operating schedule will be as follows:-

- one unit of 2000 KW from 11 pm to 6am
- one unit of 2000 KW in parallel with one unit of 3000 from 6am to 8am.
- One unit of 5000 KW in parallel with ~~the~~ one unit of 3000 from 8am to 12 noon. (2000 KW unit stoped).
- one unit of 3000 KW remains running and unit of 5000 KW will be stopped from 12 noon to 1 pm.
- one unit of 5000 KW in parallel with one unit of 3000 MW from 1pm to 5pm.
- ~~one unit~~ All three units of 5000 KW, 3000 KW and 2000 in parallel from 5pm to 9 pm.
- One unit of 3000 KW and one unit of 2000 KW in parallel from 9pm to 11pm (5000 KW unit stopped)
- At 11pm unit of 3000 KW will also be stopped.

Ans //

(2013.f) (Same as 2012.f, OR 2(b))

3(b). The annual fixed and operating cost of a 500 MW power station is Rs. 5000 per KW of the installed capacity per annum and Rs 2 per KWh respectively. plot the variation of unit cost of energy with load factor.

Soln: Given;

Installed capacity = 500 MW = $5 * 10^5$ KW

Assuming maximum demand on the power station to be equal to installed capacity i.e $5*10^5$ KW.

Annual Fixed cost = Rs $5000 * 5 * 10^5$

$= Rs\ 25 * 10^8$.

we know;

$$\text{Average load} = \frac{\text{Unit generated per annum}}{24 * 365 (hr)}$$

$$\text{Load factor} = \frac{\text{Average load}}{\text{maximum demand}}$$

$\therefore$ Unit generated per annum = Average Load * 24 * 365

= Load factor * maximum demand * 24 * 365 —— (1).

at Load factor = 1.

Units generated per annum = $1 * 5 * 10^5 * 8760$
$= 438 * 10^7$ KWh.

at Load factor = 0.2

Units generated per annum = $0.2 * 5 * 10^5 * 8760$
$= 87.6 * 10^7$ KWh

at Load factor = 0.4

Units generated per annum = $0.4 * 5 * 10^5 * 8760$
$= 175.2 * 10^7$ KWh.

at Load factor = 0.6

Units generated per annum = $0.6 * 5 * 10^5 * 8760$
$= 262.8 * 10^7$ KWh

at Load factor = 0.8

Units generated per annum = $0.8 * 5 * 10^5 * 8760$
$= 350.4 * 10^7$ KWh.

since

operating cost = Rs 2 per Kwh (given)

at Load factor = 1

$$\text{Generation cost per Kwh} = \frac{\text{Total fixed cost}}{\text{Units generated per annum}} + \text{operating cost}$$

$$= \frac{25 \times 10^8}{438 \times 10^7} + Rs\ 2$$

$$= Rs\ 0.571 + Rs\ 2 = Rs\ 2.571/Kwh.$$

at Load factor = 0.2

$$\text{Generation cost per Kwh} = \frac{25 \times 10^8}{87.6 \times 10^7} + Rs\ 2$$

$$= Rs\ 4.854/Kwh.$$

at Load factor = 0.4

$$\text{Generation cost per Kwh} = \frac{25 \times 10^8}{175.2 \times 10^7} + Rs\ 2$$

$$= Rs\ 3.427/Kwh.$$

at Load factor = 0.6

$$\text{Generation cost per Kwh} = \frac{25 \times 10^8}{262.8 \times 10^7} + Rs\ 2$$

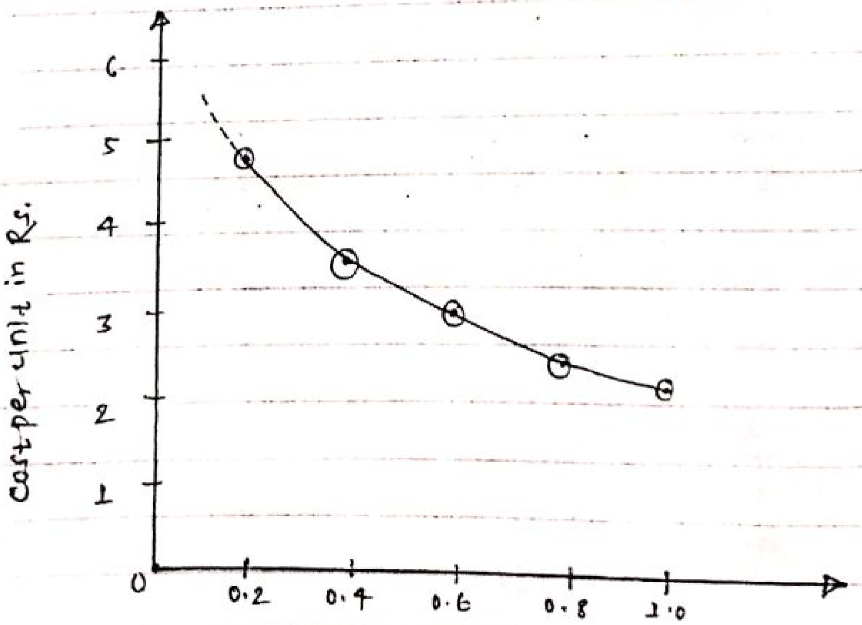
$$= Rs\ 2.951/Kwh.$$

at Load factor = 0.8

$$\text{Generation cost per Kwh} = \frac{25 \times 10^8}{350.4 \times 10^7} + Rs\ 2$$

$$= Rs.\ 2.713/Kwh.$$

Now: variation of unit cost of energy with Load fa[ctor] is shown in fig(a) below:-



fig(a)

Ans

(2012 spring) (10 marks)

(4(a)) The daily demand of three consumers are given below:

Time	Consumer 1	Consumer 2	Consumer 3.
12 mid night to 8 am	No load	200W	No load
8 am to 2 pm	600W	No load	200W
2 pm to 4pm	200W	1000W	1200W
4 pm to 10 pm	800W	No load	No load
10 pm to mid-night	No load	200W	200W.

plot the load curve and find:

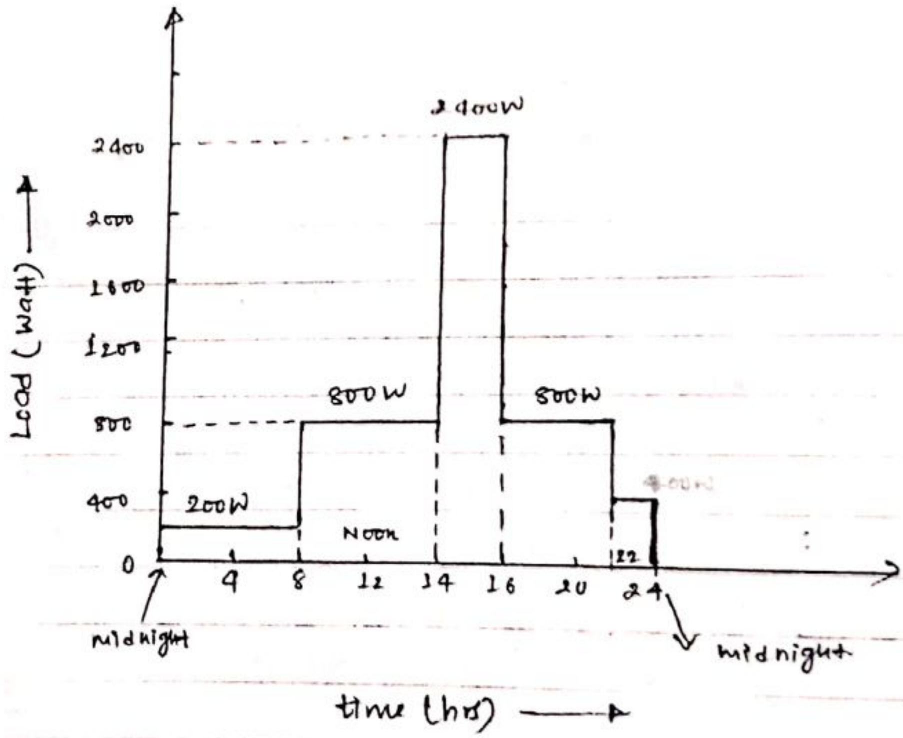
(i) Maximum demand of individual consumer.
(ii) Load factor of individual consumer.
(iii) Diversity factor
(iv) Load factor of the station.

Soln:

Daily demand of all the three consumers is as u

0 - 8 hours → 200W
8 - 14 hours → 600 + 200 = 800W
14 - 16 hours → 200 + 1000 + 1200 = 2400W
16 - 22 hours → 800W
22 - 24 hours → 200 + 200 = 400W.

The load curve is drawn in fig(a) below:-



fig(a) load curve

(i)

Maximum demands of

consumer 1 = 800W

consumer 2 = 1000W

consumer 3 = 1200W. Ans//

We Know:

$$\text{Average load} = \frac{\text{output in Kwh}}{24\ (\text{hr})}$$

$$\text{Load factor} = \frac{\text{Average load}}{\text{maximum demand}}$$

$$\therefore \text{Load factor} = \frac{\text{output in Kwh}}{\text{maximum demand} * 24} \quad -(1)$$

(ii) Load factors :

$$\text{consumer } 1 = \frac{600*6 + 200*2 + 800*6}{800*24}$$

$$= 0.4583 \text{ or } 45.83\ \%$$

$$\text{consumer } 2 = \frac{200*8 + 1000*2 + 200*2}{1000*24}$$

$$= 0.1667 \text{ or } 16.67\ \%$$

consumer 3 $= \dfrac{200*6+1200*2+200*2}{1200*24}$

$= 0.1389$ or 13.89% Ans//

(iii) diversity factor

Sum of individual maximum demands of all the consum

$= 800+1000+1200 = 3000W.$

simultaneously maximum demand on the powe station is 2400W that occurs from 2 pm to 4

∴ Diversity factor $= \dfrac{3000W}{2400W} = 1.25$ Ans//

(iv) Load factor of the station

$= \dfrac{200*8+800*6+2400*2+800*6+400*2}{2400*24}$

$= 0.2916$ or 29.16%

Ans//

(2012 Sp) (~~[illegible]~~) (10 Marks)

3(b) A generating plant has a maximum capacity of 100KW and costs Rs 160,000. The fixed charges are 12% consisting of 5% interest, 5% depreciation and 2% taxes. Find the fixed charges per KWh if the load factor is

(i) 100%

(ii) 50%

Soln: Assuming maximum demand equal to generating plant capacity.

Maximum demand = 100KW.

Annual fixed charges = Rs 0.12 * 160000

= Rs 19200.

We Know:

$$\text{Average load} = \frac{\text{Units generated per annum}}{24 * 365 (\text{hr})}$$

$$\text{Load factor} = \frac{\text{Average load}}{\text{maximum demand}}$$

∴ Units generated per annum = Load factor * maximum demand * 24 * 365 — (1)

(i) Load factor is 100% i.e. 1

Units generated per annum = $1 \times 100 \times 8760$

$= 876,000$ KWh.

∴ Fixed charges per KWh = $\frac{\text{Annual fixed charg}}{\text{Units generated per a}}$

$= \frac{19200}{876000} =$ Re 0.0219

or 2.19 paise

(ii) when Load factor is 50% i.e 0.5

Units generated per annum = $0.5 \times 100 \times 8760$

$= 438,000$ KWh

∴ Fixed charges per KWh = $\frac{19200}{438000}$

= Re 0.0438

or 4.38 paise

Ans//

(2014, f) (same as 2014 sp, 4(b)) (7 marks)

8. 4(a) It is necessary to choose a power transformer for a new power station. The expected load on the transformer is as follows

500 KVA for 4 hrs

1000 KVA for 6 hrs

1500 KVA for 14 hrs

two transformers each rated 1500 KVA with 0.8 p.f lagging have been quoted as:-

particulars	Transformer I	Transformer II
Full Load efficiency	98.5%	99%
core loss	2.7 KW	2.5 KW
price	Rs 4,00,000	Rs 450000

Determine which transformer should be choosen. If the annual charges of interest and depreciation are 10% and the energy cost is Nrs. 5.00 per Kwh.

Soln: Given

KVA rating of each transformer = 1500 KVA

lagging p.f = 0.8.

Full Load output of the transformer = Rated capacity × p.f

$= 1500 \times 0.8 = 1200$ KW.

For transformer I

Input power to the transformer at full Load

$$= \frac{\text{full load output}}{\text{full load efficiency}}$$

$$= \frac{1200}{0.985} = \underline{1218.274 \text{ KW}}$$

Also,

Full load input power = output power + copper loss + Iron loss.

$\therefore$ copper loss at full Load = $1218.274 - 1200 - 2.7$

$= \underline{15.574 \text{ KW}}$

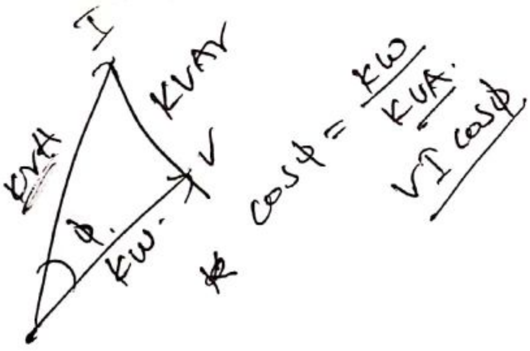
We know:

$$\frac{\text{Cu. loss at any load current} = I}{\text{Cu. loss at full load current}, I_f} = \left(\frac{I}{I_f}\right)^2$$

$\therefore$ Cu. loss at any load $= \left(\frac{I}{I_f}\right)^2 *$ Cu. loss at full Load

$\Rightarrow$ Cu. loss at any load $= \left(\frac{I*V}{I_f*V}\right)^2 *$ Cu. loss at full Load

$\therefore$ Cu. loss at any load $= \left(\frac{\text{any KVA}}{\text{full KVA}}\right)^2 *$ Cu. loss at full lo[ad]



$\therefore$ Cu loss at 500 KVA output $= \left(\frac{500}{1500}\right)^2 * 15.574$

$= 1.73 \text{ KW}$

Cu loss at 1000 KVA output $= \left(\frac{1000}{1500}\right)^2 * 15.574$

$= 6.92 \text{ KW}$

Cu. loss at 1500 KVA output $= \left(\frac{1500}{1500}\right)^2 * 15.574$

$= \underline{15.574 \text{ KW}}$

Energy consumption due to Cu. loss in a day

$= 1.73 * 4 + 6.92 * 6 + 15.574 * 14$

$= \underline{266.476 \text{ KWh}}$

Energy consumption due to iron loss in a day

$= 2.7 * 24$

$= \underline{64.8 \text{ KWh}}$

Total energy loss due to Cu. and iron in a day $= 266.476 + 68.4$

$= 331.276 \text{ KWh/day}$

Energy cost per anncem (due to loss).

$= Rs\ 5 * 331.276 * 365$

$= Rs\ \underline{604578.70}$

Interest and depreciation cost of tbr. I per annu

$= 400000 * \frac{10}{100}$

$= \underline{Rs\ 40000}$

Hence total cost per anncem $= Rs\ 604578.70 + 40{,}000$

$= Rs\ \underline{644578.70}$ —— (a)

<u>Transformer - II</u>

Input power to the transformer II $= \frac{1200}{0.99}$

$= \underline{1212.12 Kw}$

Full load input power = output power + copper loss + iron

∴ copper loss at full load $= 1212.15 - 1200 - 2.5$

$= \underline{9.62 Kw}$

<u>again.</u>

cu loss at 500 KVA output $= \left(\frac{500}{1500}\right)^2 * 9.62$

$= \cancel{1.07\ KW}\ 1.069\ KW$

cu. loss at 1000 KVA load $= \left(\frac{1000}{1500}\right)^2 * 9.62$

$= 4.275\ KW$

cu. loss at 1500 KVA load $= \left(\frac{1500}{1500}\right)^2 * 9.62$

$= 9.62\ KW$

Energy consumption due to cu. loss in a day

$= 1.069 * 4 + 4.275 * 6 + 9.62 * 14$

$= \underline{164.61\ KWh}$

Energy consumption due to Iron loss in a day

$= 2.5 * 24$

$= \underline{60\ KWh}$

Total energy consumption due to cu. and Iron in a day

$= 164.61 + 60 = 224.61$ KWh/day

Energy cost per annum (due to cu. & iron loss)

$= Rs\ 5 * 224.61 * 365$

$= Rs\ 409913.25$

Interest and depreciation cost per annum

$= 450000 * \frac{10}{100}$

$= Rs\ 45000$

Total cost per annum $= Rs\ 409913.25 + Rs\ 45$

$= Rs\ 449913.25$ — (b)

Comparing eqn (a) and (b) the cost per year of t

II is less than cost per year ~~of tran~~ of tran.

So, ~~the~~ transformer-II will be more economi

and so choosen the best economic.

Ans

Q. 5(c). Two electrical units used for the same purpose are compared for their economic working;

(i) Cost of Unit 1 is Rs 5000 and it takes 100 KW.

(ii) Cost of Unit 2 is Rs 14000 and it takes 60 KW.

Each of them has a useful life of 4000 hours. Which unit will prove economical if the energy is charged at Rs. 80 per KW of maximum demand per year and 5 paisa per KWh? Assume both units run at full load.

(5 marks)

Soln:

Unit-1

Capital Cost per hour $= \frac{5000}{4000} = $ Re 1.25

Maximum demand = 100 KW.

charge of maximum demand per ~~ye~~ hour

$= \frac{80 * 100}{(365 * 24)} = $ Re. 0.91.

charge per Kwh = maximum demand * one hour * charge per Kwh

$= 100 * 1 * \frac{5}{100} = $ Rs. 5.

∴ Total charges per hour for operation of Unit-1

$= Rs. 1.25 + Rs. 0.91 + Rs. 5$

$= Rs. 7.16$

Unit-2

Capital cost per hour $= \frac{14000}{4000} = Rs\ 3.5$

Maximum demand = 60 KW

charge of maximum demand per hour

$= \frac{(80 \times 60)}{(365 \times 24)}$

$= Rs. 0.55$

charge per Kwh = maximum demand × one hour × charge per Kwh

$= 60 \times 1 \times \frac{5}{100} = Rs. 3.$

∴ Total charges per hour for operation of Unit-2.

$= Rs. 3.5 + Rs\ 0.55 + Rs\ 3$

$= Rs. 7.05$

Hence The charges of operation for the Unit-2 per hour are less than the charges of operation for Unit-1, therefore Unit-2 is more economical in this case.

Ans //

Q. 2(b) A motor of 30 HP connected to a condensate pump has been burnt beyond economical repairs. Two alternatives have been proposed to replace it by:

	Cost	η at full load	η at half load
Motor A	Rs 6000	90%	86%
Motor B:	Rs 4000	85%	82%

The life of each motor is 20 yrs and its salvage value is 10% of its initial cost. The rate of interest is 5% annually. The ~~rate of interest~~ motor operates at full load for 25% of time and at half load for the remaining period. The annual maintenance cost of motor A is Rs. 420 and that of motor B is Rs. 240. The energy rate is 10 paisa/Kwh. Which motor will be economical.

(8 marks)

Soln:

Motor A:

$$\text{Salvage Value} = \frac{10}{100} * 6000 = \text{Rs } 600.$$

$$\text{Depreciation} = \frac{6000-600}{20} = \text{Rs } 270/\text{year}.$$

$$\text{Interest} = \frac{5}{100} * 6000 = \text{Rs } 300/\text{year}$$

$$\text{Maintenance} = \text{Rs. } 420./\text{year}$$

$$\therefore \text{Energy cost} = \Big[\Big(30 * 0.7355 * (365*24) * \frac{25}{100}$$

$$+\Big(30*0.7355 * \frac{1}{2}(365*24) * \frac{75}{100} * \frac{1}{0.86}\Big)$$

$$= \cancel{(2433.6 + 85249.2) * \frac{10}{100}} \; (53691.5 + 8$$

$$\cancel{\text{Rs } 8770.8/\text{year}} \qquad = \text{Rs } 1379$$

$$\therefore \text{Total cost of motor A} = 290 + 300 + 420 + \cancel{}$$

$$= \cancel{\text{Rs. } 9780.8/\text{year}} \; \text{Rs } 147$$

Motor B:

$$\text{Salvage value} = \frac{10}{100} * 4000 = \text{Rs } 400.$$

$$\text{Depreciation} = \frac{4000-400}{20} = \text{Rs } 180/\text{year}$$

$$\text{Interest} = \frac{5}{100} * 4000 = \text{Rs } 200/\text{year}.$$

$$\text{Maintenance} = \text{Rs. } 240/\text{year}.$$

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$$\text{Energy cost} = \left[\left(30 * 0.7355 * (365 * 24) * \frac{25}{100} * \frac{1}{0.85}\right) + \left(80 * 0.7355 * \frac{1}{2}(365 * 24) * \frac{75}{100} * \frac{1}{0.87}\right)\right] * \frac{10}{100}$$

$$= (56849.8 + 88394.5) * \frac{10}{100}$$

$$= \underline{\text{Rs } 14524.4/\text{year}}$$

$\therefore$ Total cost of motor B $= 180 + 200 + 240 + 14524.4$

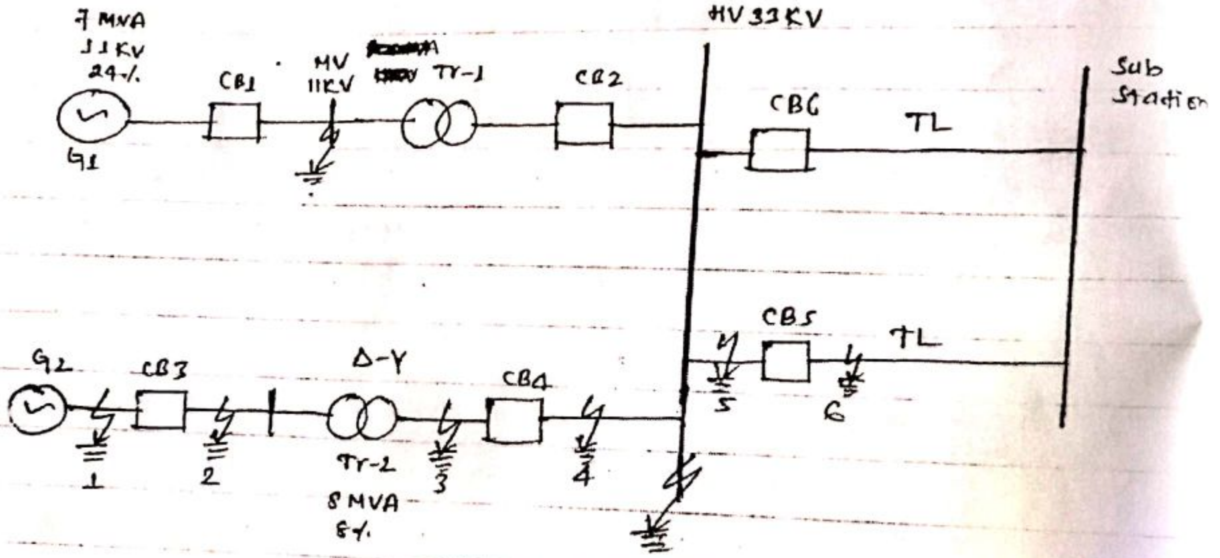
$$= \underline{\text{Rs } 15144.4/\text{year}}$$

Hence motor A is more economical since its annual cost is less than motor B.

Ans //

(Q). Calculate the fault current (KA) and fault level (MVA) at medium voltage bus and high voltage bus. Determine the breaking and making current capacity (interrupting capacity) of all the CB used in the power plant that has been designed. Tabulate the result & display it graphically as well. (Note: Making current 2.5 times the braking current for CB)

Calculation of Fault current and fault MVA level



fig(1)

for the generator capacity of 7 MVA and synchronous speed 250 RPM the per unit sub-transient reactance of generator selected from the graph: typical generator sub transient reactance is 24%.

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Similarly, for the transformer capacity of 8MVA and high voltage winding 33KV, the transformer impedance is selected from the table: Transformer impedance as 8%.

Now,

for transmission line (TL) we normally take inductance of the line as:

$L = 0.97 \text{ mH/Km}$.

Length of the line = 18 Km Line conductor

= Rabbit conductor.

$\therefore$ Total reactance of the line $= \boxed{2\pi f L}$

$= 2\pi \times 50 \times 0.97 \times 10^{-3} \Omega/\text{Km}$

$= 0.3047 \times 18$

$= 5.485\ \Omega$

Now, we take

Base KV (on LV side of transformer) = 11 KV

Base KV (on HV side of transformer) = 33 KV.

Base MVA = 7 MVA

$\therefore$ Base reactance (on HV side) $= \boxed{\dfrac{(\text{Base KV})^2}{\text{Base MVA}}}$

$= \dfrac{(33)^2}{7} = 155.57\Omega$.

$R = X =$

$R = \frac{V}{I} = (KV)^2$

pu reactance of Transmission line (TL) = $\frac{\text{Actual reactance}}{\text{Base reactance}}$

$$= \frac{5.485}{155.57} = \underline{0.035\,pu}$$

$$\boxed{\text{pu reactance of transformer } (pu_{new}) = pu_{old} * \left(\frac{\text{Base KV}_{old}}{\text{Base KV}_{new}}\right)^2 * \left(\frac{\text{Base MVA}_{new}}{\text{Base MVA}_{old}}\right)}$$

$$= 0.08 * \left(\frac{11}{11}\right)^2 * \left(\frac{7}{8}\right) = \underline{0.07\,pu.}$$

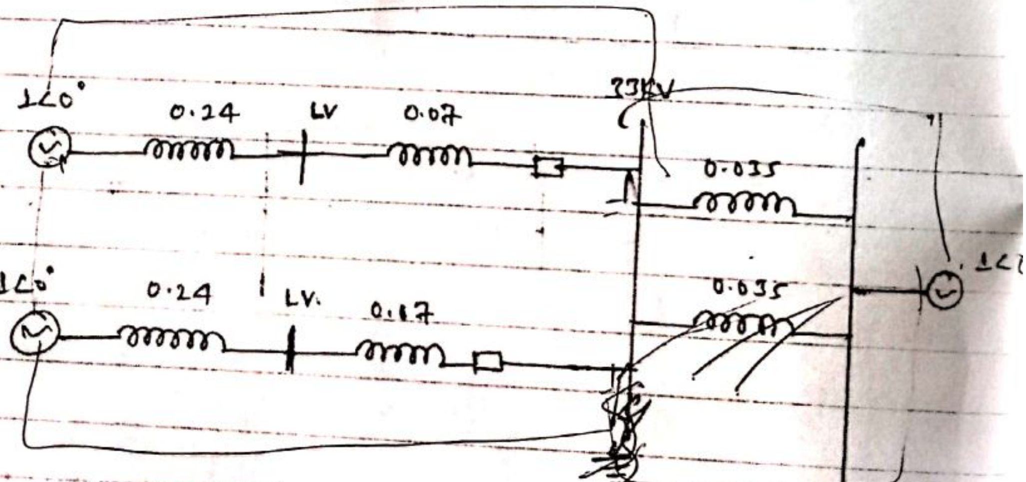
Now,

X_{pu}(generator) = 0.24 pu

X_{pu} (transformer) = 0.07 pu

X_{pu} (line) = 0.035 pu.

<u>Fault at HV Bus (33 KV):</u>



$$(X_{pu})_{eq} = \left(\frac{0.24}{2} + \frac{0.07}{2}\right) \| \left(\frac{0.035}{2}\right)$$

$$= (0.155) \| (0.018)$$

$$= \underline{0.016 \, pu}$$

$$\therefore I_{fault(pu)} = \frac{1\angle 0^0}{0.016} = \underline{62.5 \, pu}$$

$$\therefore I_{fault\,(actual)} = \frac{62.5 * 7}{\sqrt{3} * 33} = \underline{7.65 \, KA.}$$

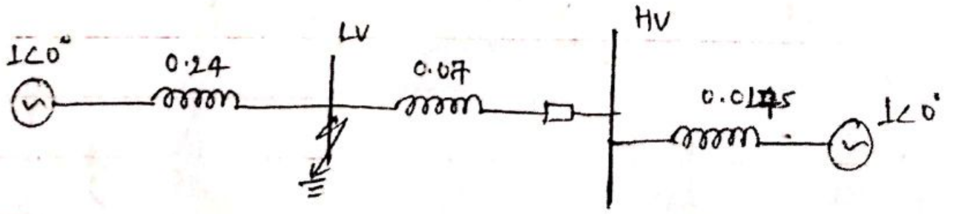
$$\therefore \text{fault MVA} = \frac{\text{Base MVA}}{(X_{pu})_{eq}} = \frac{7}{0.016} = \underline{437.5 \, MVA}$$

$$\therefore \text{Making current} = 2.5 * \text{Breaking current} (I_{fault}).$$

$$= 2.5 * 7.65$$

$$= \underline{19.13 \, KA.} \quad \text{Ans}$$

Fault at LV Bus (11 KV)



$$(X_{pu})_{eq} = (0.07 + 0.0175) \,||\, (0.24) = (0.087) \,||\, (0.24)$$
$$= \underline{0.064\ pu.}$$

$$\therefore I_{fault}(pu) = \frac{1\angle 0^\circ}{0.064} = \underline{15.625\ pu}$$

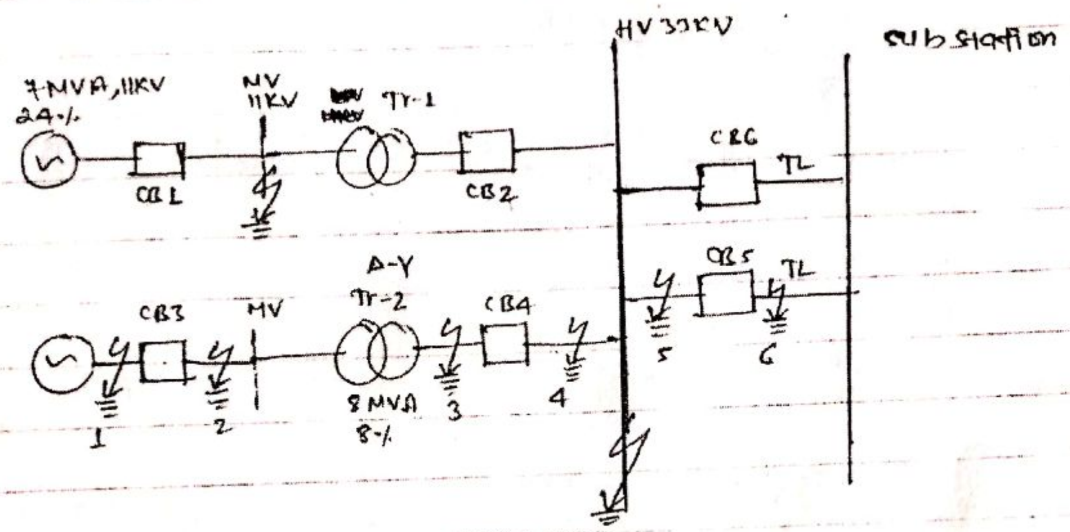
$$\therefore I_{fault}(actual) = \frac{15.625 * 7}{\sqrt{3} * 11} = \underline{5.741\ KA.}$$

$$\therefore \text{Fault MVA} = \frac{\text{Base MVA}}{(X_{pu})_{eq}} = \frac{7}{0.064} = \underline{109.375\ MVA}$$

$$\therefore \text{Making current} = 2.5 * \text{Breaking current } (I_{fault})$$
$$= 2.5 * 5.741$$
$$= \underline{14.353\ KA}$$

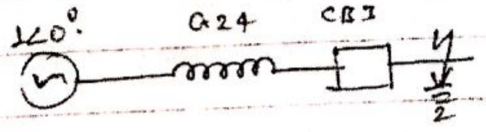
Ans

Breaking and making current capacity of circuit Breakers:



fault at LV Breaker

a) fault at point 2 (at generator breaker):



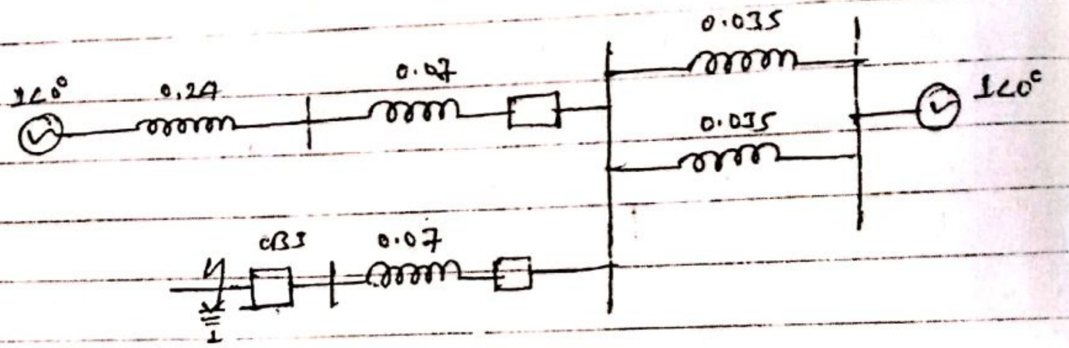
$(X_{pu})_{eq} = 0.24$ pu.

$(I_{fault})_{pu} = \dfrac{1\angle 0^\circ}{0.24} = 4.167$ pu.

$I_{CB3(2)} = \dfrac{4.167 * 7}{\sqrt{3} * 11} = 1.53$ KA.

$\text{fault MVA} = \dfrac{\text{Base MVA}}{(X_{pu})_{eq}} = \dfrac{7}{0.24} = 29.16$ MVA.

b) Fault at point 1:



$$(X_{pu})_{eq} = [(0.24 + 0.07) \parallel (0.035/2)] + (0.07)$$
$$= 0.0866\, pu.$$

$$(I_{fault})_{pu} = \frac{1\angle 0^\circ}{0.0866} = \underline{11.55\, pu}$$

$$I_{CB3(1)} = \frac{11.55 * 7}{\sqrt{3} * 11} = 4.24\ KA$$

$$\text{fault MVA} = \frac{7}{0.0866} = 80.87\ MVA$$

Since $I_{CB3(1)} > I_{CB3(2)}$

$\therefore$ Breaking current of CB3 = 4.24 KA

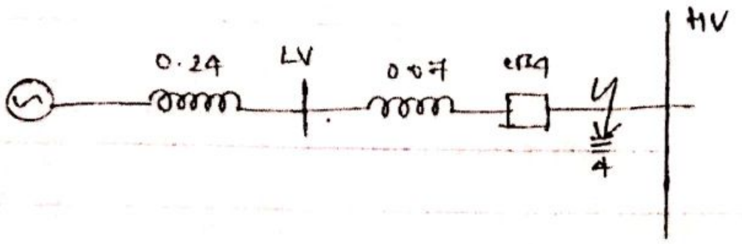
Making current = $2.5 * 4.24$

= 10.6 KA

fault MVA = $\underline{80.87\ MVA}$.

Fault at HV Breaker:

a) Fault at point 4:



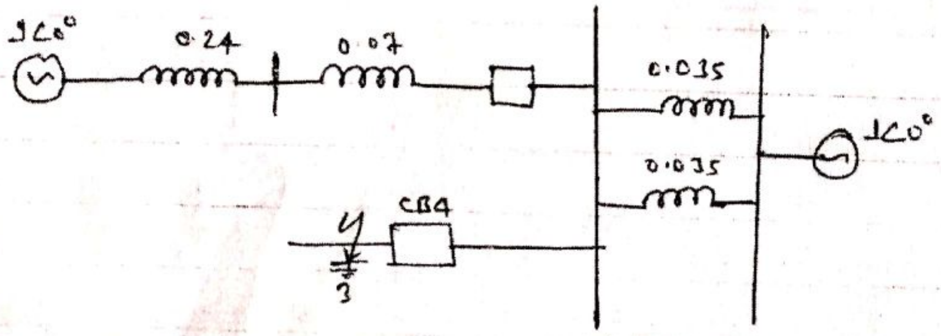
$(X_{pu})_{eq} = (0.24+0.07) = 0.31\ pu.$

$$(I_{fault})_{pu} = \frac{1\angle 0^\circ}{0.31} = 3.225\ pu$$

$$I_{CB4}(4) = \frac{3.225 * 7}{\sqrt{3} * 33} = 0.395\ KA$$

$$\text{Fault MVA} = \frac{\text{Base MVA}}{(X_{pu})_{eq}} = 22.58\ MVA$$

b) Fault at point 3:



$(X_{pu})_{eq} = (0.24 + 0.07) \parallel (0.035/2) = 0.01656\ pu.$

$(I_{fault})_{pu} = \frac{1\angle 0^\circ}{0.01656} = 60.37\ pu.$

$I_{CB4(3)} = \frac{60.37 * 7}{\sqrt{3} * 33} = 7.39\ KA$

$\text{fault MVA} = \frac{7}{0.01656} = 422\ MVA$

Since $I_{CB4(3)} > I_{CB4(4)}$.

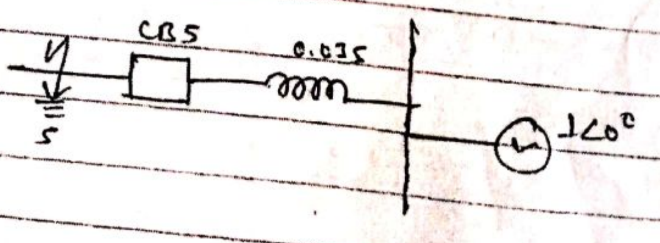
$\therefore$ Breaking current of CB4 = 7.39 KA

$\therefore$ Making current = 2.5 * 7.39
= 18.475 KA

fault MVA = 422 MVA.

fault current at transmission line breaker

a) fault at point 5:



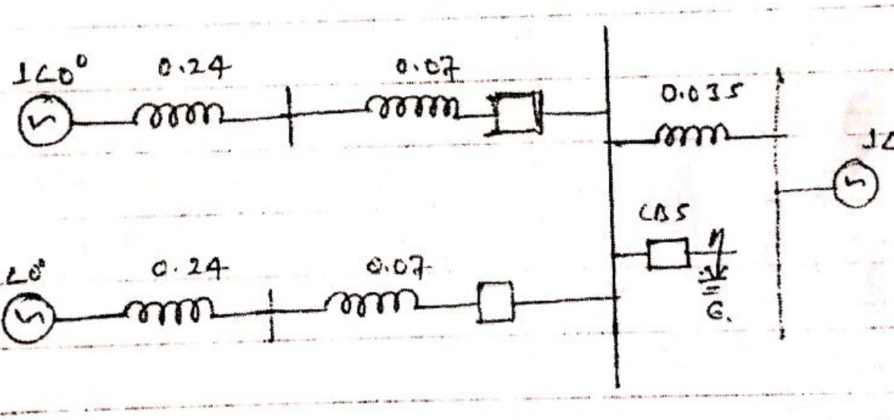
$(X_{pu})_{eq} = 0.035 pu.$

$(I_{fault})_{pu} = \frac{1\angle 0}{0.035} = 28.57 pu$

$I_{CB5}(5) = \frac{28.57 * 7}{\sqrt{3} * 33} = 3.5 KA$

$\text{Fault MVA} = \frac{7}{0.035} = 200 MVA$

b) <u>fault at point 6:</u>



$(X_{pu})_{eq} = (0.24/2 + 0.07/2) \parallel 0.035$
$= 0.0285 pu$

$(I_{fault})_{pu} = \frac{1\angle 0}{0.0285} = 35 pu$

$I_{CB5}(6) = \frac{35 * 7}{\sqrt{3} * 33} = 4.289 KA$

Fault MVA = $\frac{7}{0.0285}$ = 245.61 MVA

Since $I_{cbs}(6) > I_{cbs}(5)$.

$\therefore$ Breaking current of CB5 = 4.289 KA

$\therefore$ Making current = 2.5 * 4.289
= 10.72 KA

Fault MVA = 245.61 MVA.

Table of CB rating:

CB	Breaking current (KA)	Making current (KA)	Fault [illegible]
CB-1, CB-3	4.24	10.6	80.8[illegible]
CB-2, CB-4	7.39	18.475	42[illegible]
CB-5, CB-6	4.289	10.72	245[illegible]

Breaker Ratings

i) Calculation of I_n for LV CB

Capacity of the generator = 7 MVA

Voltage level = 11 KV

$I_n = \frac{7}{\sqrt{3} * 11} = 367.4$ KA

(ii) Calculation of I_n for HV CB:

Capacity of the generator = 7 MVA

Voltage level = 33 KV

$$I_n = \frac{7}{\sqrt{3} \times 33} = 122.5 \text{ KA}$$

Breaking current = 7.35 KA

(iii) Calculation of In for line CB:

Capacity of the generator = 7 MVA

Voltage level = 33 KV

$$I_n = \frac{7}{\sqrt{3} \times 33} = 122.5 \text{ KA}$$

Breaking current = 4.3 KA.

Hence from the LV 11KV and HV 33 KV Bus bar CB; from the coordination table of rated values for CB, the following Breaker rating charts can be tabulated.

Breaker Rating charts:

CB	Rated Voltage (KV)	Rated short-ckt Breaking current (KA)	Rated Normal current (KA)
CB - 1, CB-3	12	8	900
CB - 2, CB-4	36	8	630
CB - 5, CB-6	36	8	630

Ans //

(2017,f)

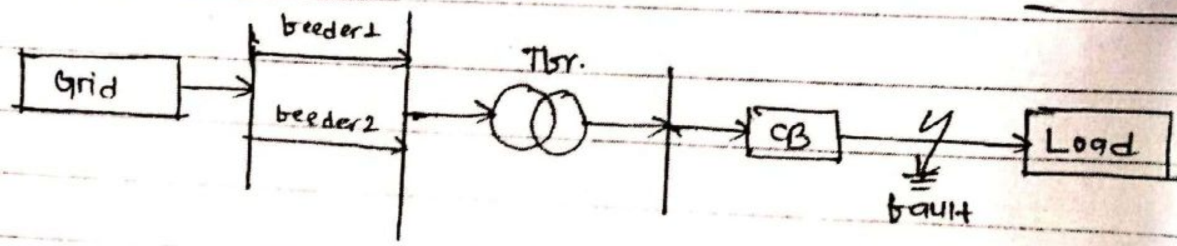
4(a) Determine the short-circuit rating of the circuit Breaker for the system shown below, the grid as infinite bus and 6MVA as base MVA.

Transformer: 3 phase, 33/11 KV, 6MVA, $0.01 + j0.08$ pu

Load: 3 phase, 11KV, 5800 KVA, 0.8 lag, $j0.2$ pu

Impedance of each feeder: $9 + j18$.

(10 marks)



Soln: Given,

Base MVA = 6 MVA.

Base Voltages (KV_B) = 33 KV for transformer.

= 33 KV for feeder.

= 11 KV for load.

Now:

For Transformer:

~~Actual Impedance = (0.01 + j0.08) pu.~~

pu Impedance = $(0.01 + j0.08)$ pu (given).

For load:

pu impedance = (j0.2) pu (given)

For feeder: each

Actual impedance = (9+j18)

Base MVA = 6 MVA

Base KV for feeder = 33 KV.

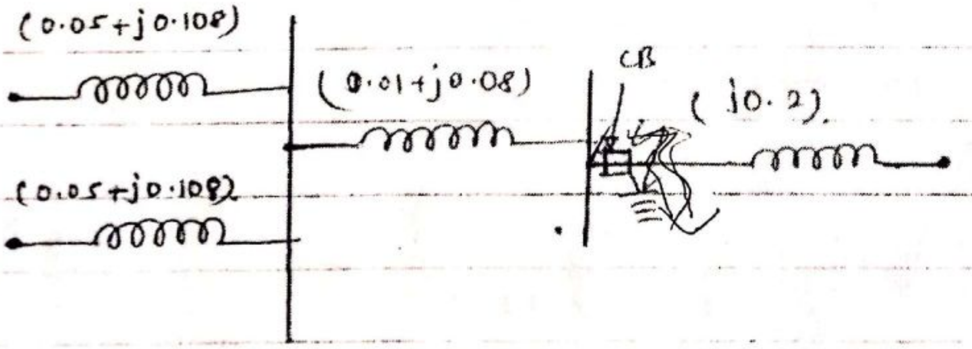
Now, pu impedance = $\frac{\text{Actual impedance}}{\text{Base impedance}}$

$$= \frac{(9+j18)}{\frac{(\text{Base KV})^2}{\text{Base MVA}}} = \frac{(9+j18) * 6}{(33)^2}$$

$$= (9+j18) * 0.006$$

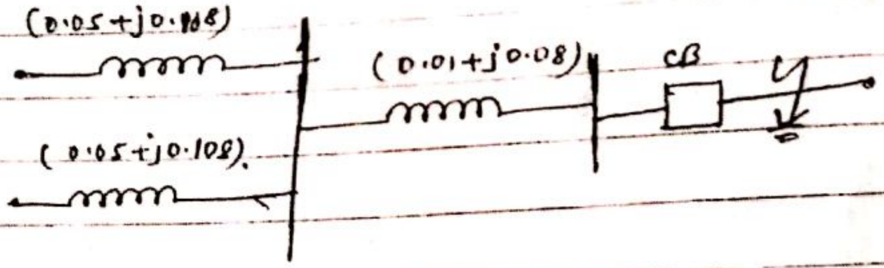
$$= \underline{(0.05+j0.108)\,pu}$$

The reactance diagram is shown below:-



Fig(a)

Now, If the fault occurs at the right side of the CB then the impedance diagram will be



fig(b)

$$(X_{pu})_{eq} = [(0.05+j0.108) \parallel (0.05+j0.108)] \parallel (0.01+j0.08)$$

$$= \left[\frac{(0.05+j0.108) * (0.05+j0.108)}{(0.05+j0.108)+(0.05+j0.108)}\right] \parallel (0.01+j0.08)$$

$$= \left(\frac{1097}{46472} + j0.040\right) \parallel (0.01+j0.08)$$

$$= (0.024 + j0.040) \parallel (0.01+j0.08)$$

$$= \frac{(0.240 + j0.040) * (0.01+j0.08)}{(0.24 + j0.040) + (0.01+j0.08)}$$

$$= \frac{538}{19225} + j\frac{1249}{19225}$$

$$= \underline{0.071 \angle 66.7^\circ}$$

$$\therefore (I_{fault})_{pu} = \frac{1\angle 0^\circ}{0.071\angle 66.7} = \underline{14.08 \angle -66.7^\circ \text{ pu}}$$

$$\therefore I_{CB} = \frac{(14.08\angle -66.7) * 6}{\sqrt{3} * 11}$$

$$= (4.41\angle -66.7)\ KA$$

$$\text{Fault MVA} = \frac{6}{(0.071\angle 66.7)}$$

$$= (84.51\angle 66.7^\circ)\ MVA.$$

$\therefore$ Breaking current of CB = $(4.41\angle 66.7)$ KA

$\therefore$ Making current of CB = $2.55 * (4.41\angle -66.7)$

=

$\therefore$ Breaker Ratings

$$I_n = \frac{6}{\sqrt{3} \times 11} = 114.92\ KA$$

$I = \frac{V}{}$

$VI =)$

$I = \frac{S}{V}$

$= \frac{6}{\sqrt{3} \times 11}$

For base voltage rated of 11KV, the rated short-circuit breaking current is 8KA and Rated normal current is 400KA from table: coordination table of rated values for CB. ~~the following Breake~~

Ans //

(8). The following data available for a hydro plant:

Turbine efficiency = 90%

Generator efficiency = 97%.

Transformer efficiency = 98%.

27IIJS

$K = \frac{3}{2}\pi N r$

Head loss of 5% of gross head.

Catchment Area (Km^2) = 400

Mean Monsoon precipitation (mm) = 2600

Gross Head (m) = 470

Soln: Given;

Mean Monthly flow calculation:

According to Medium Hydropower project (NEA 1997), th constant for MHSP prediction equation is given below:- i table 1:

from the below table 1 the discharge available is min during May and Maximum during August. During our de process we need to consider all this factor so that the plant output is good for whole of the year.

$S = K T_m$ $K = \frac{S}{T_m}$ $S = \frac{S\omega}{T}$

$\frac{3\pi N_s}{2}$ $K = T.S.$ $\frac{S}{T_m}$ $K = \frac{e^3}{2\pi N_s}$ $\frac{8\times10}{2\pi N_s}$

$S = K T_m$ $K = \frac{3}{2\pi N_s}$ $\frac{2\pi N_s}{60} K T_m$

$K = \frac{2\pi \times N_s}{60 \times T_m}$ rpm $\frac{2\pi \times N_s}{60}$

Mean Monthly Flow analysis (m^3/s)

$S = K T_m$

$K = \frac{3\pi N_s}{2}$ $K = \frac{\frac{2\pi N_s}{60}}{T_m}$ $\frac{2\pi N_s}{T_m 60} = \frac{3\pi N_s}{2}$ $T_m = \frac{4}{90}$

Jan.	5.53
Feb.	4.58
Mar.	4.25
Apr.	5.47
May.	3.89
Jun	21.80
July	66.07
Aug.	77.15
Sep.	59.49
Oct.	27.06
Nov.	13.00
Dec.	8.42

Table 1: (given)

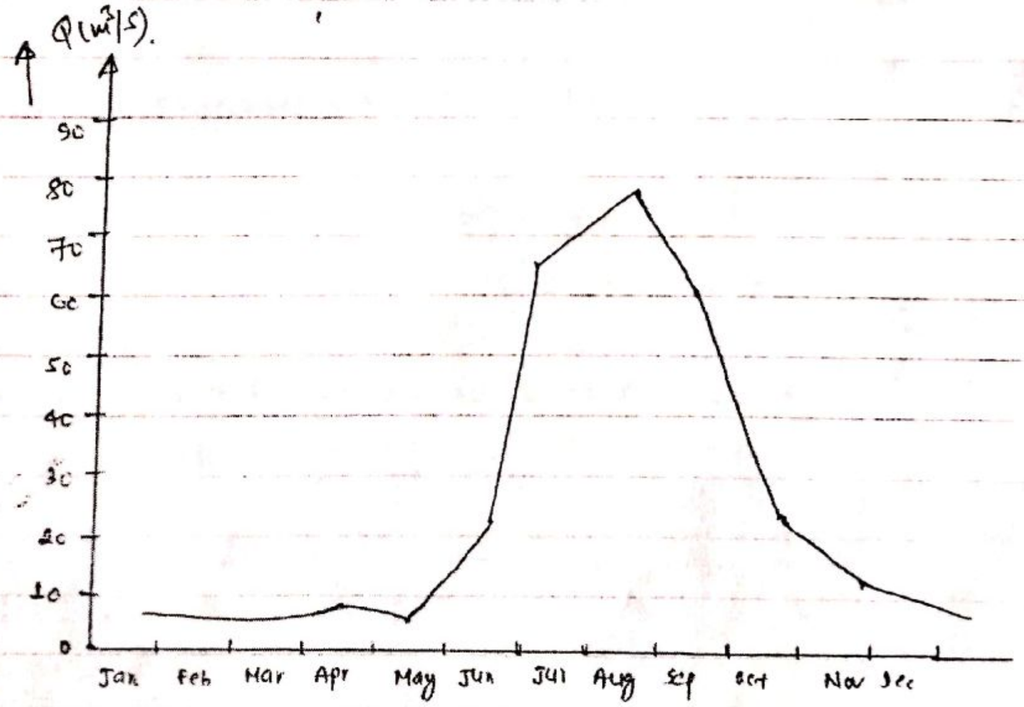


Fig: ~~Flow duration curve~~ Hydrograph.

Month

Given: Daily flow duration curves coefficients developed by NEA.

Dependent Variable	b	a	c
Maximum flow (Q_0).	0.8120	0.5337	0.0614105
25% exceedance	0.9279	0.2986	0.0124336
45% exceedance	0.9239	0.2018	0.0089146
65% exceedance	0.9044	0.0000	0.0248313
85% exceedance	0.9256	0.0000	0.0199905
95% exceedance	0.9531	0.0000	0.0056995
Minimum flow	1.1689	0.0000	0.0007382

Table 2: (Given).

Sample calculation:

$$\boxed{Q_{45\%} = C * \text{catchment area}^{b} * \text{mansoon ppt}^{a}}$$

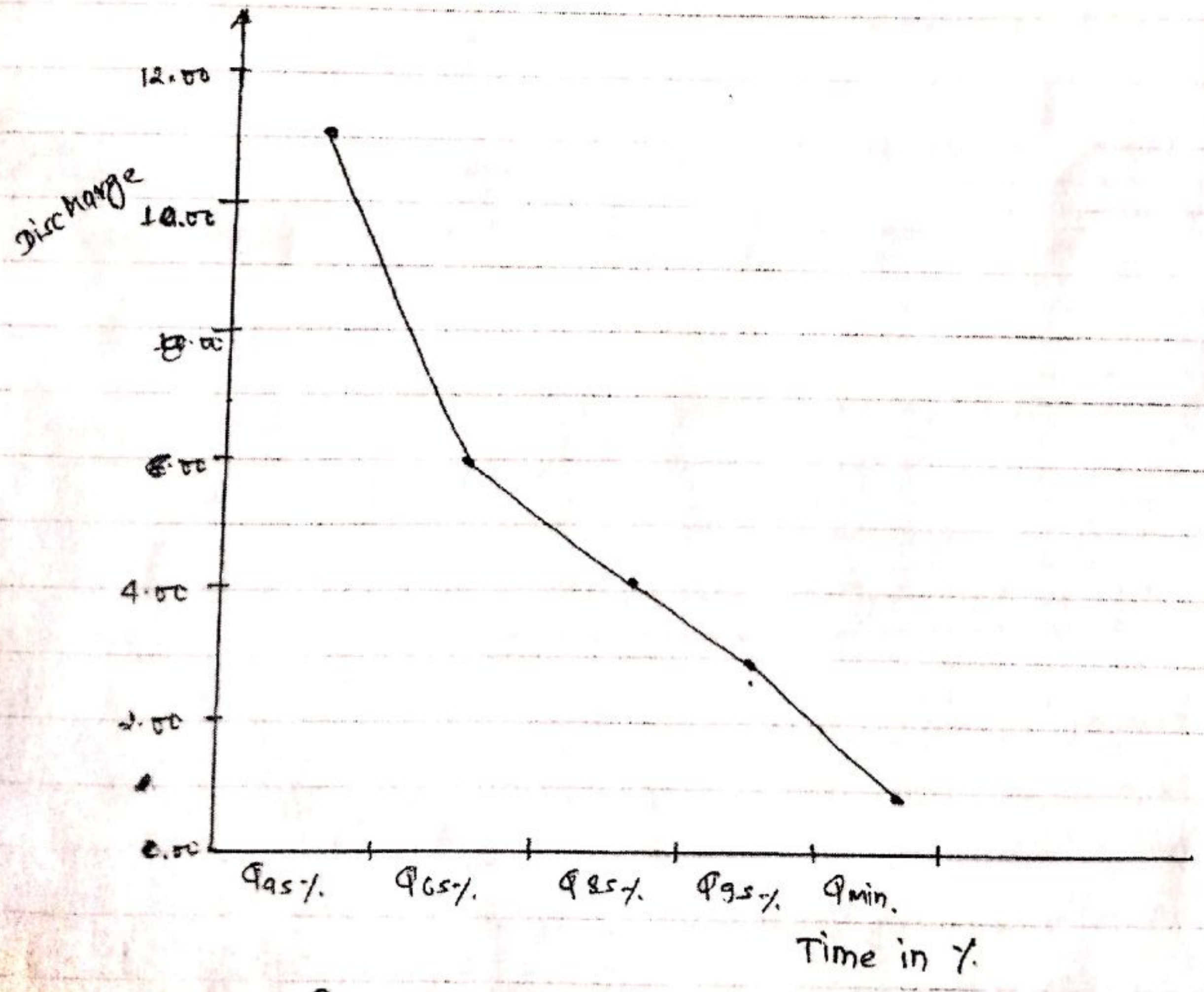
$$= 0.0089146 * 400^{0.9239} * 2600^{0.2018}$$

$$= 11.05\, m^3/s.$$

from similar calculation we can generate the below given chart and FDC can be plotted.

Flow Duration chart: (Given)

Q_{max} (Q_0)	434.24	m^3/s
$Q_{25\%}$	31.98	m^3/s
$Q_{45\%}$	11.02	m^3/s
$Q_{65\%}$	6.23	m^3/s
$Q_{85\%}$	4.14	m^3/s
$Q_{95\%}$	2.92	m^3/s
Q_{min}	0.93	m^3/s



Flow Duration Curve

Assume Riparian release = 10% of mean monthly flow in driest month.

Discharge taking $Q_{45} = 11.05\ m^3/s$.

$\therefore Q_{design} = 11.05 - 10\%$ of 3.89 (may : table 1).

$= 11.05 - 0.389$

$= 10.661\ m^3/s$.

Now:

Head = 470m (gross)

Net Head = $0.95 * 470 = 446.5\ m$.

power input to turbine = $Q_{design} * h * g$

$= 10.661 * 446.5 * 9.81$ KW

$= 46.69$ MW.

Electrical power output = $0.90 * 0.97 * 0.98 * 46.69$

$= 39.39$ MW.

Selection of the number of Units:

No. of units = 2

Installed capacity of each unit = 20 MW

power factor = 0.85.

MVA rating of each unit = $20/0.85 = 23.5$ MVA

Total MVA rating of the plant = $2 * 23.5 = 47$ MVA.

TWO units are selected each of 20MW due to the following reasons:

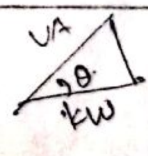
- In dry season we can operate only one unit thus losses are minimized.
- If one unit gets damaged or requires maintenance a part of power demand can be fulfilled by another unit.
- No. of units is not taken more than two because our plant is a small plant and too many units for a small sized plant is not preferred.
- Higher no. of units means more maintenance and more losses so more running cost.

P = kW
kWh
E/t =

NO.	Month	Q	Q subs reperian flow	Q for calculation	MW	Monthly MWH	Monthly GWH.
1.	Jan	5.53	5.14	5.14	19.49	14031.5	14.04
2	Feb	4.58	4.19	4.19	15.86	11425.3	11.43
3	Mar	4.25	3.86	3.86	14.69	10541.2	10.55
4	Apr	5.47	5.08	5.08	19.27	13868.2	13.87
5	May	3.89	3.50	3.50	13.25	9535.4	9.62
6	Jun	21.80	21.41	10.66	40.40	29082.9	29.09
7	July	66.07	65.68	10.66	40.40	29082.9	29.09
8	Aug	77.15	76.76	10.66	40.40	29082.9	29.09
9	Sep	59.49	59.10	10.66	40.40	29082.9	29.09
10	Oct	27.06	26.67	10.66	40.40	29082.9	29.09
11	Nov	13.00	12.61	10.66	40.40	29082.9	29.09
12	Dec	8.42	8.03	8.03	30.41	21895.9	21.91
Annual Energy (GWH)							255.80.

E = kWh.
MW = E/t.
(P) =
E = P×t.
= P×30×24

MVA



$\cos\theta = \frac{kW}{VA}$.

Maximum annual energy generation

$= 9.81 * 0.9 * 0.97 * 0.98 * 446.5 * 10.661 * 12 * 30 * 24 = 345.17$ GWH.

Annual plant factor $= \frac{255.80}{345.17} = 0.73.$

Turbine Selection Criteria

- Net Head

Turbine Type	Head range in metres
Kaplan and propeller	$2 < H < 40$
Francis	$10 < H < 350$
Pelton	$50 < H < 1300$
Michell-Banki	$3 < H < 250$
Turgo	$50 < H < 250$

Table 3: Range of Heads (Given)

The net head of our plant is 446.5 m so from the above table, the suitable turbine is pelton turbine which is a high head impulse turbine.

- **Discharge**

ALSTOM Turbine selection chart will be given which is discharge (m^3/s) Vs Head (m)

we have ~~from graph~~.

Net Head = 446.5m

~~from graph~~. Q_{design} for each unit = 5.33 m^3/s.

From ALSTOM turbine selection chart for our rated flow and net head it lies in the envelope of pelton Turbine.

- **Cavitation problem:**

In turbine, only reaction turbines are subjected to cavitation. In reaction turbines the cavitation may occour at the outlet of the runner or at the inlet of the draft tube where the pressure is considerably reduced. Due to cavitation, the metal of the runner vanes draft tubes is gradually eaten away, which result in lowering the efficiency.

There will not be the problem of cavitation if we use the impulse turbine i.e pelton turbine in our plant.

- **specific Speed:**

The working formula for the calculation of the specific speed is

$$n_s = \frac{n\sqrt{P}}{H^{5/4}}.$$

where n_s is the specific speed, n is the synchronous p is the power output in KW, H is the net head.

$$n = \frac{120f}{p}.$$

where $f = 50Hz$, p is the no. of poles

✓ Table 6.2: Generator synchronisation speed (rpm) will be given.

from the table, we have selected the no. of poles to 20, since our system has the frequency of 50Hz; the v of synchronous speed is 300 rpm.

$$\therefore n_s = \frac{300 * \sqrt{20000}}{446.5^{5/4}}$$

Power output of each
(P) = 20 * 1000 = 2[illegible]
Net Head (H) = 4[illegible]

$$= 20.67 \text{ rpm}$$

fig 6.14: Specific speed (n_s) Vs Net head (m) graph will be given

from the graph, for n_s = 20.67 rpm and net head of 446.5 m, we found that pelton turbine suit our data.

Turbine efficiency

The efficiency of a pelton is good from 30% to 100% of the maximum discharge for a one-jet turbine and from 10% to 100% for a multi-jet one.

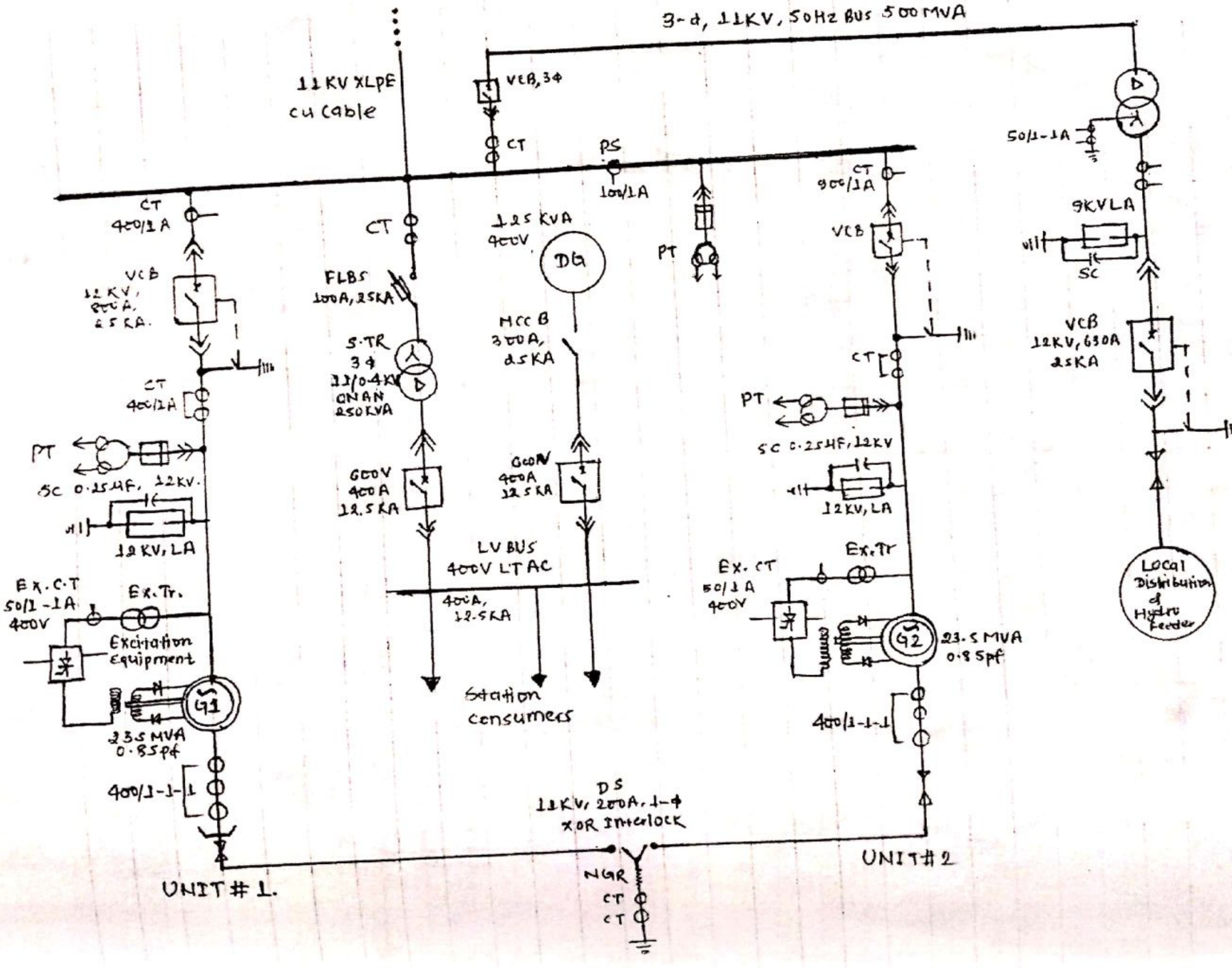
from the graph: η/η_{max} Vs Q/Q_{max} given, for $Q/Q_{max} = \frac{11.05}{434.24} = 0.03$ for different efficiencies. pelton turbine is suited.

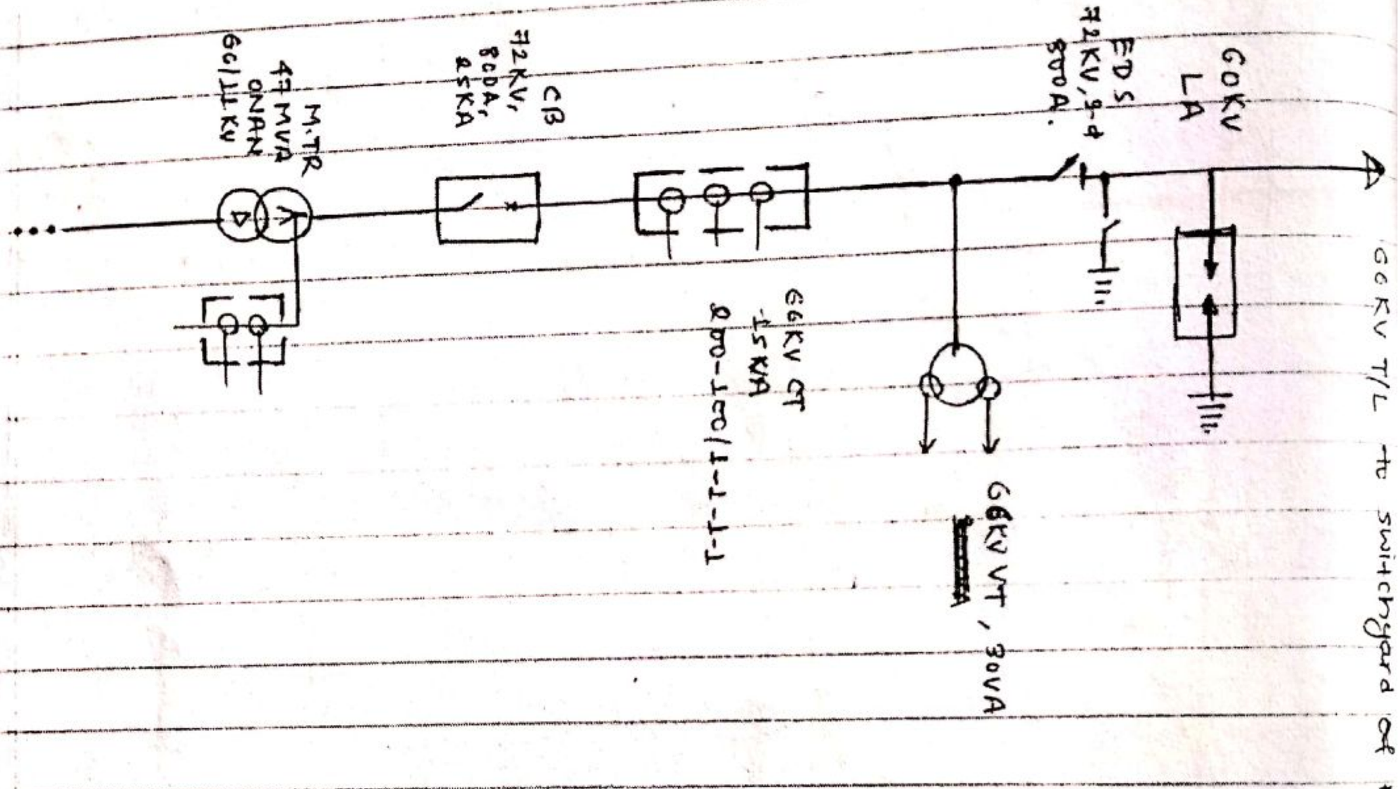
Now: from the above discussion, we found that the most suitable types of turbine for our design is pelton-Turbine of 1, 2, 3, 4 injector.

Given: Efficiencies: PELTON Turbine graph

Pelton turbine ~~increases~~ efficiency increases as the no injector increases, but the things to be noted while selecting the no. of injector is that water jet from injector should not interfere with water jet from the

moreover the cost of the turbine also increases on increasing the no. of injector. Hence considering all thi factor we select the Pelton-Turbine with 2 injector.


3-ф, 11KV, 50Hz Bus 500MVA
11KV XLPE cu cable
VCB, 3ф
CT
PS
100/1A
CT
400/1A
VCB
12KV,
800A,
25KA.
CT
400/1A
PT
SC 0.25μF, 12KV.
12KV, LA
Ex.C.T
50/1-1A
400V
Ex.Tr.
Excitation Equipment
23.5 MVA
0.85pf
400/1-1-1
UNIT # 1.
CT
FLBS
100A, 25KA
S.TR
3ф
11/0.4KV
ONAN
250KVA
600V
400A
12.5KA
LV BUS
400V LTAC
400A,
12.5KA
Station consumers
125 KVA
400V
DG
MCCB
300A,
25KA
600V
400A
12.5KA
PT
CT
900/1A
VCB
CT
PT
SC 0.25μF, 12KV
12KV, LA
Ex. CT
50/1A
400V
Ex.Tr
G2
23.5 MVA
0.85pf
400/1-1-1
DS
11KV, 200A, 1-ф
XOR Interlock
NGR
CT
CT
UNIT#2
50/1-1A
9KVLA
SC
VCB
12KV, 630A
25KA
Local Distribution of Hydro Feeder



Fig(A) Single Line Diagram (S.L.D)

- Showing main equipment, switchgear and instrument transformer.
- The protection circuit and control scheme is not included in this S.L.D.

(2015-fall) (2019, f, 6) (2014, sp, 6)

(6) The following data available for a hydro plant:

Available head = 45 m

Total catchment area = 60 sq.km

Average rainfall ~~utilized = 140cm~~ per annum = 140 cm

percentage rainfall utilized = 68%

Turbine efficiency = 82%

Generator efficiency = 90%

Penstock efficiency = 74%

Assume that plant daily load factor = 55%, select the suitable size of the turbine-generator set for the plant. Also draw the single line diagram of the plant incorporating all the major types of equipment such as power transformers, CBs, isolators, ~~CTs~~, PTs etc.

Soln: Given;

Head available, H = 45 m.

Catchment area, A = 60 sq.Km = $(60 \times 10^6)\,m^2$

Available rainfall, $h = (0.68 \times 1.4)\,m$

Turbine efficiency, $\eta_t = 82\%$

Generator efficiency, $\eta_g = 90\%$

penstock efficiency, $\eta_p = 74\%$

$\frac{68}{100} \times \frac{14\cancel{4}}{100}$

Quantity of water available per annum,

$= A * h$

$= (60*10^6) * (0.68 * 1.4)\ m^3$

$= 57.12 * 10^6\ m^3/annum$

Hence, quantity of water available per seconds.

$$Q = \frac{57.12 * 10^6}{365 * 24 * 60 * 60}$$

$= 1.81\ m^3/s.$

Now,

overall efficiency $(\eta_o) = \eta_p * \eta_t * \eta_g.$

$= 0.74 * 0.82 * 0.9$

$= 0.546.$

∴ power developed from the plant

$P = \eta_o w Q H.$

$= 0.546 * 9.81 * 1.81 * 45$

$= 436.27\ KW.$

If the plant daily load factor is 55%. then the maximum demand can be calculated as

$$L.F = \frac{\text{average demand}}{\text{Maximum demand}}$$

Axh.

16.

$\therefore$ Maximum demand = $\frac{\text{Average demand}}{L.F}$

$= \frac{436.27}{0.55} = 793.213$ KW.

So, a generator of 800 KW maximum rating can be selected.

Now: Rating of Turbine

Input to the generator = output of the turbine

$\therefore$ output of the turbine = $\frac{\text{generator output}}{\eta_g}$

$= \frac{793.213}{0.9} = 881.35$ KW.
$\simeq$ 882 KW.

Selection of the no. of Units:

No. of units = 1.

Installed capacity of each unit = ~~441 KW~~. 882 KW

power factor = 0.85

KVA rating of each unit = 882/0.85 = ~~520 KVA~~ 1040 KVA

~~Total KVA rating of the plant = 2 × 520 = 1040 KVA~~

Axh.

Turbine selection: a) Head.

since the head is 45m, we can use ~~Kaplan and propeller (2<H<40~~ Francis (10<H<350)

from the table: Range of heads given.

b) Discharge

for Head (H) = 45m

$Q = 1.81\ m^3/s$

from ALSTOM turbine selection chart given for our rated flow and net head it lies in the envelope of Francis Turbine.

c) sp. speed:

$$n_s = \frac{n\sqrt{P}}{H^{5/4}}$$

where, $n = \frac{120f}{p}$.

Assume, no. of pole = 20

$\therefore n = 300rpm$

$\therefore$ $P = 882$ kW.

$\therefore$ $$n_s = \frac{300 \times \sqrt{882}}{45^{5/4}}$$
$$= 76.44 \text{ rpm}$$

From the sp. speed (n_s) Vs Head (m) graph given the, crossflow turbine can be selected.

Single Line Diagram

As drawn previously, but only one unit will be considered.

(2016, f, 6)

The following data are available from the investigation of a hydrosite:

Available head = 750 m

Total catchment area = 50 sq. Km

Average rainfall per annum = 160 cm

percentage of rainfall utilized = 77%

Turbine efficiency = 86%

Generator efficiency = 91%

penstock efficiency = 78%

If the daily load factor for the plant is 55%, select the suitable size of the turbine-generator set(s) for the plant. Also draw the single-line diagram of the plant incorporating all the major types of equipment such as power transformers, circuit breakers, isolators, CTs, PTs etc.

Soln: Given,

Available head (H) = 750m

Catchment area (A) = 50 sq. Km = $(50 \times 10^6)\ m^2$

~~Averag~~ Available rainfall = 0.77 * 1.6

= 1.23 m

Turbine efficiency = 86% (η_t)

Generator efficiency (η_g) = 91%

penstock efficiency (η_p) = 78%

Quantity of water available per annum

$= (50*10^6)*(1.23)\ m^3$

$= 61.50*10^6\ m^3/annum$

Hence, quantity of water available per seconds,

$$Q = \frac{61.50*10^6}{365*24*60*60}$$

$= 1.95\ m^3/s.$

Now,

overall efficiency $(\eta_o) = \eta_t * \eta_g * \eta_p$

$= 0.86 * 0.91 * 0.78$

$= 0.61.$

∴ power developed from the plant

$P = 0.61 * 9.81 * 1.95 * 750$

$= 8757.89\ KW$

$= \underline{8.76\ MW}.$

If the plant daily load factor is 55%, then the

maximum demand $= \frac{\text{Average demand}}{L.F}$

$= \frac{8.76}{0.55} = \underline{15.92\ MW}.$

So, a generator of 16 MW maximum rating can be selected.

Now, Rating of Turbine

output of the turbine = $\frac{\text{generator, output}}{\eta_g}$ $\left(\frac{g_m}{\ }\right)$.

$= \frac{16\,MW}{0.91}$

$= 17.58\,MW.$

$\simeq 18\,MW.$

Selection of the no. of Units

a) Head : Since the head is 750m, we can use pelton turbine ($50 < H < 1300$). from the table: Range of heads given.

b) Discharge: for head 750m and discharge of $1.95\,m^3/s$, we can choose pelton Turbine from ALSTOM turbine selection chart given.

c). Specific speed:

$$n_s = \frac{n\sqrt{P}}{H^{5/4}}$$

where, $n = 120f/p$

Assume $p = 20$ pole ; $n = 300$rpm

since $P = 18\,MW = 18000\,KW$

$$\therefore n_s = \frac{300 \times \sqrt{18000}}{750^{5/4}} = 10.25\ rpm$$

from the sp. speed (n_s) Vs Head (m) graph given, the pelton Turbine can be selected

Single Line Diagram

As drawn previously, but only one unit will be considered.

60 MC

600

[5] State what is meant by "Base load" and "Peak load" plants. Discuss briefly the reasons why the hydro and nuclear power plants are generally used to operate on base loads and diesel plants are used to operate on peak loads.

2014 SP 3(a)

2013 SP 3(a)

2013 SP 4(a)

Soln:

Base Load:

The unvarying load, which occour almost the whole day on the power plant is called the base load.

Peak Load:

The various peak demands of the load over and over the base load of the power plant is called the peak load.

Base load power plant:

Base load power plant is a power plant that usually provides a continuous supply of electricity through the year with some minimum power generation requirement. Base load power plants will only be turned off during periodic maintenance, upgrading, overhaull or service.

The followings are the eg of base load power plants.

i) Thermal (steam).

ii) Hydro.

Disadvantages

i) No many place for this installation.
ii) Drilling operation is noisy
iii) Hazardeous gaseous and minerals may come up from underground and can be difficult to safely dispose of.
iv) Low overall power production efficiency.

Ans //

X [illegible]

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(iii) Nuclear

(iv) Wind

(v) Solar

(vi) Run-off River.

Peak load power plants:

Peak load power plants is a power plant that generally run only when there is a high demand, known as peak demand, for electricity.

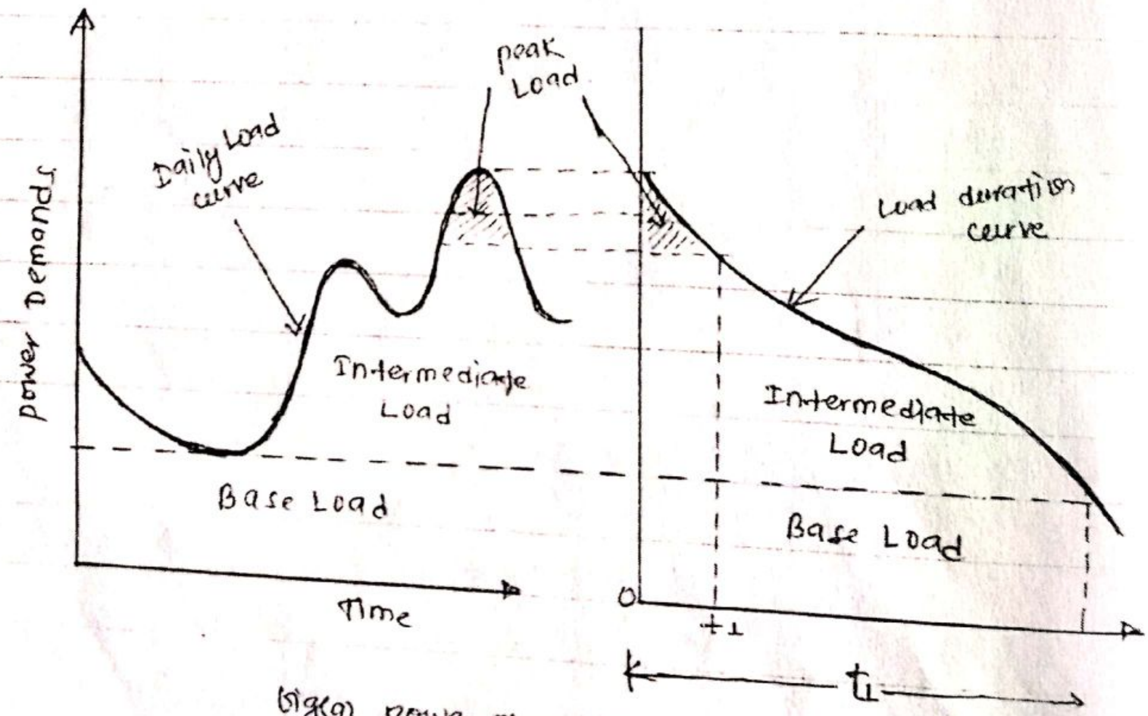
The following are the eg. of peak load power plants.

(i) Hydro.

(ii) pumped storage

(iii) Diesel

(iv) gas.



fig(a) power plant load duration curve.

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Characteristics of Base load power plants

(i) Base load plants should be such that they supply power at high capital cost but low cost of operation.

(ii) Continuous supply of the load.

(iii) Requirements of plant maintenance should be minimum.

(iv) Plant should be such that it can be easily located near the load centre.

(v) The number of operators required should be minimum.

(vi) The spare parts etc should be readily available.

(vii) High Load factors.

Characteristics of peak load power plants.

(i) peak load plants should be such that they supply power at low capital costs, although at high cost of operation.

(ii) Quick start

(iii) faster synchronization to the grid.

(iv) should be faster in taking up the system loads.

(v) Quick response to the load variations.

(vi) ~~base~~ should be inexpensive in starting and shutting down operations.

(vii) Low load factors

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Steam, Hydro and Nuclear power plants for Base load plant.

The economic characteristics of base load plants should be such that they supply power at high capital cost but low operating cost. Hydro, steam and nuclear power plants are usually used for supplying base load demand because of the reasons explained in characteristics of Base load power plants.

pumped-storage, Diesel power plants for peak load plant

The economic characteristics of peak load plants should be such that they supply power at low capital costs, although at high cost of operation. pump storage, diesel power plants are usually run for a few hours in the year and are usually used for supplying peak load demand, because of the reasons explained in characteristics of peak load power plants.

//

Cost Analysis of power plants:

The generating cost per unit (KWh) of energy depends upon the cost covering the purchase, installation and erection of equipment, cost of fuel, labour, repair etc. The generation cost can, broadly divided into

1) **Capital cost or fixed cost:**

It includes the following:

(i) Initial cost

(ii) Interest

(iii) Depreciation cost

(iv) Taxes

(v) Insurances.

2) **Operational cost:**

i) fuel cost

ii) Operating labour cost

iii) Maintenance cost

iv) supplies

v) supervision

vi) operating taxes.

The above mentioned costs are discussed as follows:-

a) <u>Initial cost:</u>

Some of the several factors on which cost of a generating station or a power plant depends are:-

i) Location of the plant
ii) Time of construction.
iii) Size of units
iv) Number of main generating units

The initial cost of power station include the following:

i) Land cost
ii) Building cost
iii) Equipment cost
iv) Installation Cost.
v) overhead charges which will include the transportation cost, stores and storekeeping charges, interest during constructions etc.

- to reduce the cost of building, It is desirable to eliminate the superstructure over the boiler house and as far as possible on turbine house also.

- the cost on equipment can be reduced by adopting unit system where one boiler is used for one turbogenerator.

b) <u>Interest:</u>

Interest is the difference between money borrowed and money returned. It may be charged at a simple rate expressed as % per annum or may be compounded, in which case the interest is reinvested and adds to the principal, thereby earning more interest in subsequent years. Even if the owners invests his own capital the charge of interest is necessary to cover the income that he would have derived from it through an alternative investment or fixed deposit with a bank.

c) Depreciation:

Depreciation accounts for the deterioration of the equipment and decrease in its value due to corrosion, weathering and wear and tear with use. It also covers the decrease in value of equipment due to absolescence.

The following are the methods to calculate the depreciation cost:

i) Straight line method
ii) percentage method
iii) sinking fund method
iv) unit method.

d) Operational cost:

The elements that make up the operating expenditure of a power plant include the following costs:-

i) cost of fuels
ii) Labour costs.
iii) cost of maintenance and repairs
iv) cost of stores (other than fuel)
v) supervision
vi) taxes.

Cost of Fuels:

The selection of the fuel and the maximum economy in its use are, therefore, very important considerations in thermal plant design. It is desirable to achieve the highest thermal efficiency for the plant so that fuel charges are reduced. The cost of fuel includes not only its price at the site of purchase but its transportation and handling cost also. Plant heat rate can be improved by the use of better quality of fuel or by employing better thermodynamic condition in the plant design.

The cost of fuel varies with the following:

i) Unit price of the fuel
ii) Amount of energy produced
iii) Efficiency of the plant

Labour cost: For plant operation labour cost is another item of operating cost. Maximum labour is needed in a thermal power plant using coal as a fuel. A hydraulic power plant or a diesel power plant of equal capacity require a lesser number of persons. In case of automatic power stations the cost of labour is reduced to a great extent. However labour cost cannot be completely eliminated even with fully automatic station as they will still require some manpower for periodic inspection etc.

Cost of maintenance and repairs: In order to avoid plant breakdowns maintenance is necessary. Maintenance includes periodic cleaning, greasing, adjustment and overhauling of equipments. The materials used for maintenance is also charged under this head. Sometimes an arbitrary percentage is assumed as maintenance cost. A good plan of maintenance would keep the sets in dependable condition and avoid the necessity of too many stand-by plants.

Cost of stores (other than fuel): The items of consumable stores other than fuel includes such articles as lubricating oil and greese, cotton waste, small tools, chemicals, paints and such other things.

Supervision: In this head the salary of supervising staff is included. A good supervision is reflected in lesser breakdowns and extended plant life. The supervising staff includes the station superintendent, chief engineer, chemist, engineers, supervisors, stores incharges, purchase officer and other establishment.

Taxes: The taxes under operating head includes the following:

i) Income tax.
ii) Sales tax
iii) Social security and employee's security etc.

principles of power plant Design

factor affecting power plant Design

following are the factors should be considered while designing a power plants as well as the factor affecting while designing a power plants:-

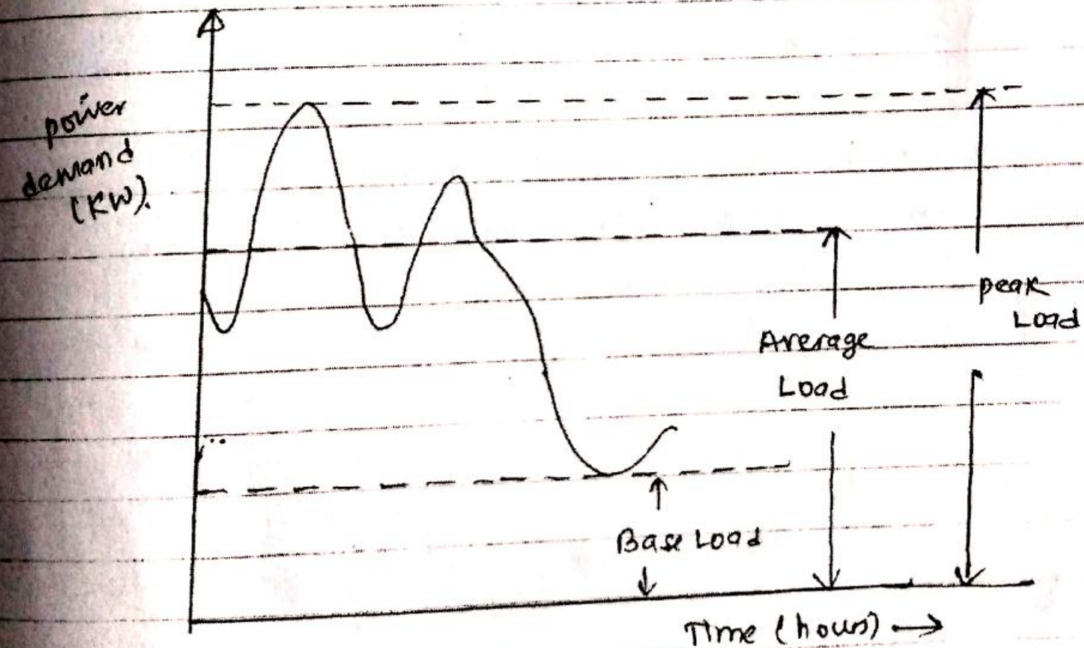
i) Location of power plant.
ii) Simplicity of design.
iii) Availability of labour nearer to power plant
iv) Reliability of supplying power.
v) Reserve capacity to meet future power demand.
vi) Low capital cost
vii) Low cost of energy generated.
viii) Low maintenance cost
(ix) Low operating cost
(x) Land cost of power plant
(xi) High efficiency.

(Internal, 3(a)) (2014, f) (3(a))

What are Load Curve and Load Duration curves. Discuss their utility in economics of generations.

Soln:

Load curve: A load curve (or load graph) is a graphic records showing the power demands for every instant during a certain time interval. Such a record may cover 1 hour, in which case it would be an hourly load graph; 24 hours, in which case it would be a daily load graph; a month in which case it would be a monthly load graph; or a year (8760 hours), in which case it would be a yearly load graph.



Fig(a) Load curve

The following points are worth noting:-

(i) The area under the load curve represents the energy generated in the period considered.

ii) The area under the curve divided by the total number of hours gives the average load on the power station.

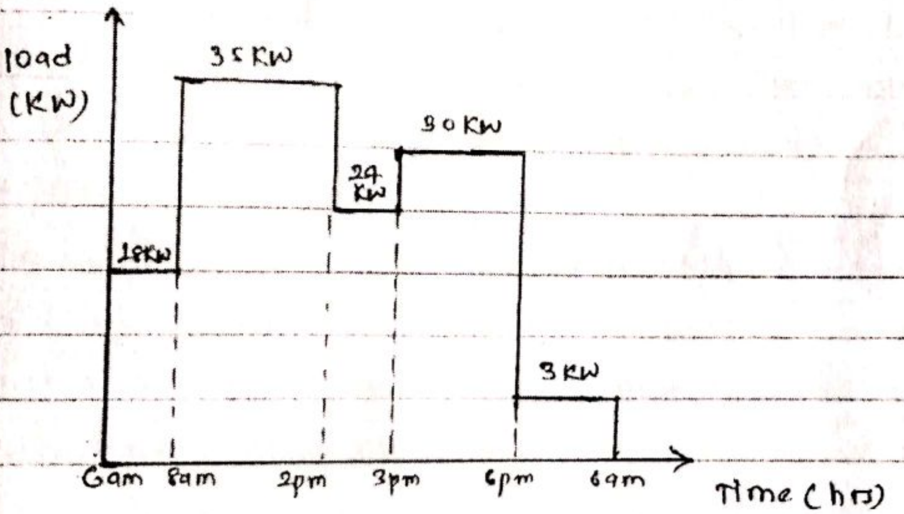
iii) The peak load indicated by the load curve/graph represents the maximum demand of the power station.

Significance of Load Curves:

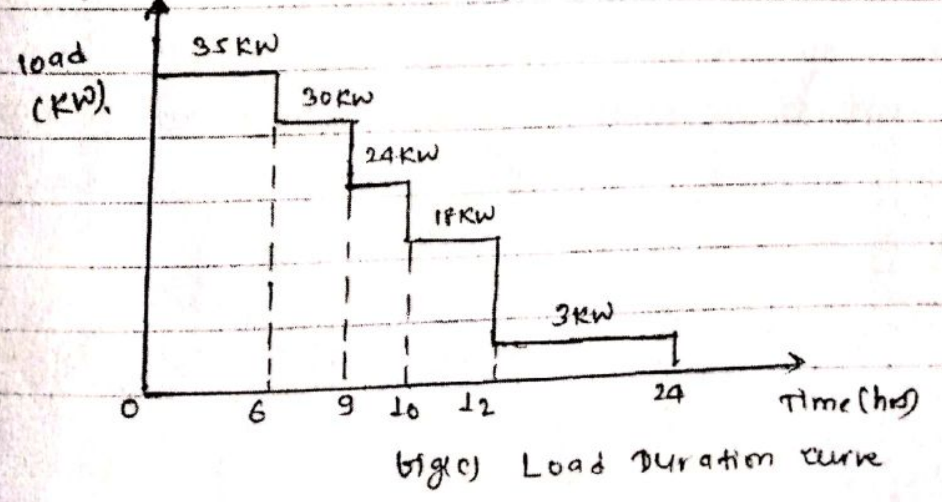
- Load curves gives full information about the incoming load and helps to decide the installed capacity of the power station and to decide the economical sizes of various generating units.
- These curves also help to estimate the generating cost and to decide the operating schedule of the power station; ie the sequence in which different units should be run.

Load Duration curve: A load duration curve represent re-arrangement of all the load element of chronological load curve in order of ~~ascending~~ descending magnitude. The curve is derived from the chronological load curve.

fig(b) shows a typical daily load curve for a power station. It may be observed that the maximum load on power station is 35 KW from 8AM to 2PM. This is plotted in fig(c). Similarly other load of the load curve are plotted in descending order in the same figure. This is called load duration curve (fig(c))



fig(b) Typical daily load curve



fig(c) Load Duration curve

8

The following points are worth noting:

i) The area under the load duration curve and the corresponding chronological load curve is equal and represent total energy delivered by the generating station.

ii) Load duration curve gives a clear analysis of generating power economically. proper selection of base load power plants and peak load power plants becomes easier.

Ans//

(2016, sp, 3(a)) (2012, f, 2(a)) (2012, sp, 3(a)) (2016, f, 2(a))

Significance of Load factor and Diversity factor

- Load factor and diversity factor play an important part in the cost of the supply of electrical energy.
- Higher the values of Load factor and diversity factor, lower will be the overall cost per unit generated.

- Higher LF means greater average load, resulting in greater no. of units generated for a given maximum demand. Thus, the standing charges, which are proportional to maximum demand and independent of number of units generated, can be distributed over a large number of units supplied and therefore overall cost per unit of electrical energy generated will be reduced.
- The capital cost of the power station depends upon the capacity of the power station. Lower the maximum demand of the power station, the lower is the capacity required and therefore lower is the capital cost of the plant. With a given number of consumers the higher the diversity factor of their loads, the smaller will be the capacity of the plant required and consequently the fixed charges due to capital investment will be much reduced.

- The suppliers should always try to improve the load factor as well as diversity factor by inducing the consumers to use the electrical energy during off-peak hours and they may be charged at lower rates for such schemes

Typical value of demand factors and diversity factors for different type of consumers are given below:-

Type of consumers	Demand factor	Diversity factor
Domestic lighting upto 1KW	0.5 – 0.7	3 – 5
Commercial loads mostly of lighting	0.5 – 0.7	1.5 – 2
Domestic power	0.5	1.5 – 2
Industrial power	0.5 – 0.8	1.5 – 2

Ans//

(2015, f, 2(b))

choice of size and number of generating units

The selection of units and their operation play an important role in the working of a power station and on the economics of power generation. The number of units and the size of each unit is decided from the load curve.

The following factors should be considered while deciding the no. of units and preparing the operating schedule.

i) The total capacity of the generating units must be capable of meeting the peak demand of the power station

ii) since the machines operate with maximum efficiency at the three-fourth of the rated capacity, hence the number and size of units must be so selected that they operate at maximum efficiency and better overall efficiency and load factor of the power station is had.

iii) Reliability of service is a very important factor. cheaper power without reliability of supply is of no use. There should be a spare set of capacity of that largest unit in the power station so that maintenance and repairs or overhaul of the working unit may be carried out without any disturbance in power supply.

CR9

U9

(iv) The growth of the demand in near future should be Kept in view.

(v) The capacity of the power station should be 15 or 20% more than expected maximum demand.

The minimum no of generating units choosen could be one having a capacity equal the maximum demand on the power station. Large size units have lower capital cost per KW, need less floor area, require less operating labour and have better efficiency. Thus larged units are economical both from the point of view of initial investment and operating cost.

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(2012f, 2(a))

Briefly discuss the factors affecting cost of generation of power in the following types of power plants.

i) Hydro power plants
ii) Diesel power plants.

Soln: **Factors affecting economics of generation and Distribution of power:**

The economics of power plant operation is greatly influenced by:-

i) Load factor
ii) Demand factor
iii) Utilisation factor.

- **Load factor.**

- In a hydro-electric power station with water available and a fixed staff for maximum output, the cost per unit generated at 100% factor would be half the cost per unit at 50% load factor.
  - Hydro electric power station should be run at its maximum load continuously on all units.

- In a steam power station the difference would not be so pronounced since fuel cost constitutes the major item in operating cost and doesnot vary in the same proportion as load factor. The cost at 100% load factor in case of this station may, therefore be about 2/3rd of the cost 50% load factor.
  - Steam power station should be run in such a way that all its running units are economically loaded.
- For a diesel station the cost per unit generated at 100% Load factor may be about 3/4th of the same cost at 50% load factor.
  - diesel power station should be worked for fluctuating loads or as a stand by.

Demand factor and utilisation factor:

- A highly efficient station, if worked at low utilization factor, may produce power at high unit cost.
- The stations in the full range efficiency are operated 24 hours and such stations are called base-load stations.
- The stations in the medium range efficiency are operated 16 hrs, or 8 hrs two shifts of average load.

- The stations is less efficient are used as peak or stand by stations only and are operated for short periods of time.
- Running of large sets for long periods at lower than maximum continuous rating increase cost of unit generated.

//

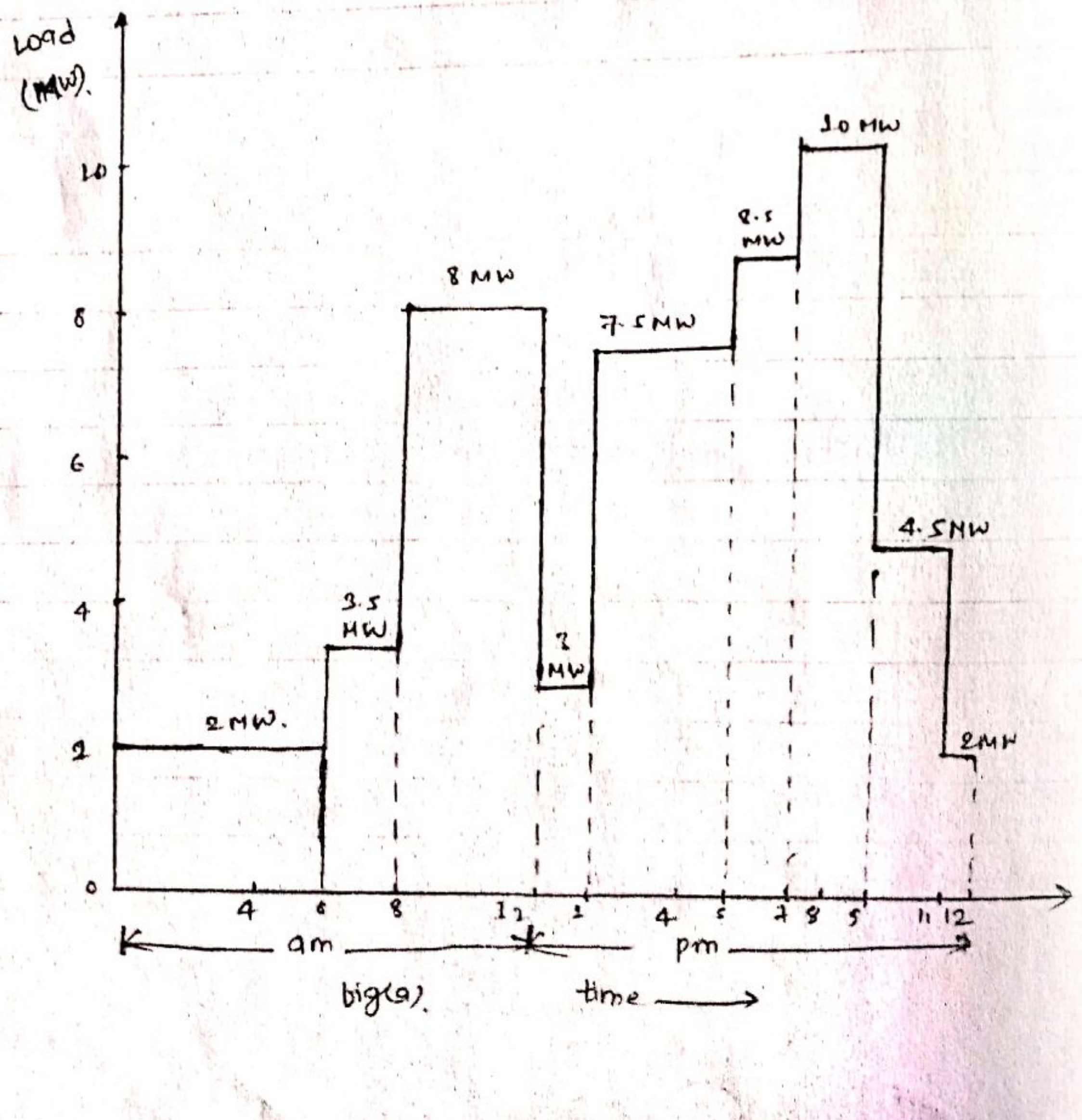
(2015f, 4(a))

With the help of a Load curve, discuss about the reserve capacity needed for a plant supplying power to an isolated area.

Soln:

Reserve capacity for a power plant supplying power to an isolated area:

Let us consider the chronological load curve as shown in fig(a) below.



fig(a).

from the shape of the load curve it is obvious that three generating units of capacities 5 MW, 2 MW and 2 MW would be the best choice to meet the given daily load on the station.

∴ Reserve plant capacity = capacity of units of the largest size

= 5 MW.

- In an isolated area, power generated from one station is confined in the one station and local supply.
- So, Reserve plant capacity is need in an isolated area to supply the power to peak loads.

Ans //

Internal, 7(b)

Factors for selecting the location of power plant

Following are the main points to be considered in selecting the location of power plants:-

i) centre of electrical load.
ii) Nearness of the fuel source
iii) Availability of water
iv) Type of soil available and land cost
v) power transmission network
vi) Transportation network.
vii) Rivers and floodway.
viii) Environmental resources.
ix) population centre.
x) climate
xi) Land cover.
xii) Area size
xiii) Archeological and Historical sites.

(2015 f, 3(a))

what are the factors to be taken into consideration in selecting a site for a thermal power plant? Discuss

Soln: **Factors for selecting a site for a Thermal power plant**

i) Transportation network:

Easy and enough access to transportation network is required in both power plant construction and operation periods.

ii) Gas pipe network:

Vicinity of the gas pipes reduces the required expenses.

iii) power transmission network:

To transfer the generated electricity to the consumers, the plant should be connected to electrical transmission system.

iv) geology, soil type and topography

- need an area with soil and rock layers that could stand the weight and vibrations of the power plant.
- no high elevation topography.

water

PEC, PPLt

14

v) Water Resources

For the construction and operation of power plant different volumes of water are required.

vi) Environmental resources

priority will be given to the locations that are far enough from ~~natural~~ national parks, wildlife protected areas etc

vii) Population centres

- the site should have an enough distance from population centres

viii) Climate:

parameters such as temperature, humidity, wind directions and speed affect the productivity of power plant and always should be taken into considerations

//

Internal 3(a) (2017, f, 3(a))

Compare Isolated and Grid connected power systems

Grid Connected	Isolated system
1) Maximum utilisation of the available hydropower potential.	1) Low utilisation of the available potential, continuous power capacity.
2) Plant factor limited by the available flow (about 0.5 - 0.6).	2). Plant factor limited by the demand (typically 0.15 - 0.3)
3) Low generation costs.	3) Higher generation costs.
4). Synchronisation equipment.	4) Components to enable the reaction on fast demand variations (flywheel, electric ballasts, load shedding).
5). Transmission line to connect to the grid.	5). Distribution grid and household connections
6) High technical requirements, approved by utility.	6) Utilisation of simpler technology possible.
7) (Usually) full automatic control, often managed by an investor	7) Manually operated (operator), often managed by a community.

up loco ATMBM

8). Biling to Utility (1 consumer).	8) Biling to various end users (meter reading required).
9). maindenance is done in dry season.	9) maintenance is done in power plant down-time: consumer do not have electricity

//

Advantages of Interconnection of two or more generating stations:

(i) Greater reliability of supply to the consumer.

(ii) When one of the stations fails to operate the consumers can be fed.

(iii) The overall cost of energy per unit of an interconnected system is less.

(iv) There is more effective use of transmission line facilities at higher voltage.

(v) Less capital investment required.

(vi) Less expenses on supervision, operation and maintenance.

(vii) In an interconnected system the spining reserve required is reduled.

2015 f
4(a) Comparison between Interconnected power supply and Isolated power supply:

Interconnected power supply	Isolated power supply
1) connection of several generating station in parallel.	1) power generated from one s... is not connected to other st...
2) Most of the large generation power plants in Nepal operating in interconnected mode	2) Most of the microhydro in N... are operating in isolated mo...
3) This type of power plant is more complex in operation.	3) This type of plant is very e... for operation.
4). It is dependent to other power plant.	4) It is independent to other power plant
5). During the failure of plant and excess of power generation, it can be solved.	5). During this case the prob... cannot be solved.
6) It needs coordination between each station for the stability of the system.	6) It does not need co-ordina...

Coc Fd

(2013 f,i)

2(b). Explain the need for the coordination of different types of power plants connected to an inter-connected power system.

Soln:

Need for the coordination of different types of power plants connected to an inter-connected power system

If different types of power plants are available it becomes necessary to coordinate them and use them with maximum economy. The problem of co-ordination of different types of power plants (hydro, thermal, nuclear, gas etc) for best possible working and economy is very complicated as the factors to be considered for economical coordination are large in number.

Some factors are

i) ~~Initial~~ Initial capital cost
ii) Fuel cost
iii) operation and maintenance cost
iv) Availability of fuel.
v) The economics of base load and peak load operation.
vi) The working characteristics of the plants

(vii) The transmission liability.

(viii) The cost of incremental powers.

Ans //

(d). Discuss the reliability of a supply system. what the measures to be taken into consideration to improve the reliability of a supply system?

Soln: Reliability: Reliability is the probability of a device performing its function adequately for the intended period of time under specified operating conditions.

→ the definition consists of four basic parts: probability, adequate, performance time and operating conditions.

Thus, we can quantitatively define reliability as the probability that the device will meet the qualitative definition.

If T is the time of failure (T is itself variable) the reliability that the device will not fail before time t

ie $R(t) = P(T>t)$. It is assumed that the device is working satisfactory at time $t=0$. However no device can work indefinitely without failure

ie $R(0) = 1$ & $R(\infty) = 0$

R(t) is generally a decreasing function between the limits of 1 and 0.

→ the probability value is the 1st index of reliability and in most cases it is considered to be most significant and sufficient index. However many other indices are also used.

Some of these are:

- expected no. of failures in a specified period.
- Average time between failures.
- Expected downtime
- Expected loss in plant output due to failure.

Following are the measures to be taken into consideration to improve the reliability of supply system

i) Average number of service interruptions per load point per year.

ii) Average restoration time at each load point.

iii) Average total interruption time per load point per year.

(iv) Maximum expected no. of interruption expe
by any ~~pt~~ load point.

(V) Maximum expected restoration time experience
by any load point.

(Vi) Probability that any load point will be out of
Service at any time longer than a specified tir

(2016, f)

2(a) What are benefits of interconnection with of utility

Soln:

" Distributed generation is the need of hour due to its operational benefits like system reliability, peak power requirements, ancillary services and grid security; however the operational as well as commercial issues related to system and utilities involved, need to be taken care while doing Interconnection of Distributed Generation to the Utility systems"

Interconnection with Utility system:

Benefits:

i) Better handling of two-way electrical flows.

(ii) Easier deployment

(iii) Higher penetration levels.

(iv) Dynamic integration of variable energy generation.

(v) Reduced downtime.

(vi) Maintaining power to local "micro-grids" during system outage.

(vii) providing ancillary services. //

(2014f) (2012, sp. 4(b))

4 (b) Discuss the Balancing of power generation with load

Soln: There are many benefits to balance the loads of the two legs of power in our electrical panel.

- A balanced load in an electrical panel means that the current flowing through one leg is equal to the amount of current flowing through the others leg.
- The closes these numbers are, the more balanced the load.
- When the amperage is split up equally, the neutral current is cancelled out.
- But when the current is placed all on one leg, the neutral must carry the entire load.

So we may conclude that

- for balanced load, neutral current cancels out
- for unbalanced load, neutral ~~current~~ gets over loaded.

for eg

If we are using two 230V air conditioners which draw 10 amps each and they are on the same leg of power, our demand is 20 amps on a leg. But if we place them on separate legs of powers, now our demand is only 1 amps.

//

(2013 Sp, 4(b)):

Discuss why the balancing of generation with load is necessary. Explain how the balancing of generation with load achieved with help of governors?

Soln: The balancing of generation with load is necessary because of the following reasons:

i) To achieve high availability that's sustainable as we grow

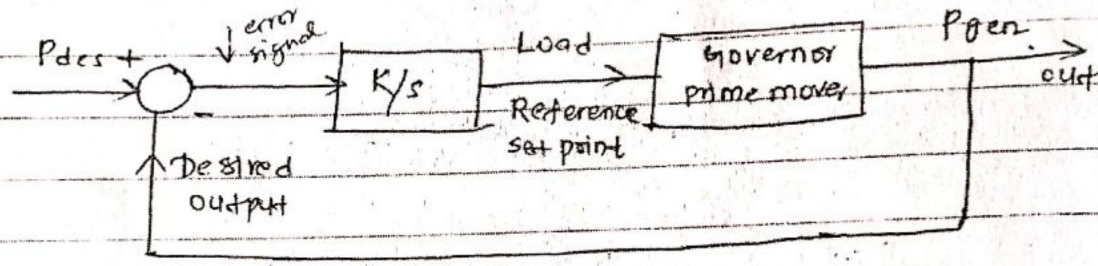
ii) To put a control in front of our service.

(iii) To operate the equipment in generation unit safely.

Balancing of generation with load with the help of governors

The modern automatic generation control schemes consist of a central location where information about the system is telemetered. Control required is determined in a digital computer and then transmitted to the generator unit via the same telemetry channels.

- For controlling the output of each unit, raise or lower pulses of varying lengths are transmitted to the unit.
- Control equipment changes the unit's load reference set point up or down in proportion to the length of the pulse signal.
- The basic reset control loop for a unit consists of an integrator with gain K.
- The basic generation control loop is shown in fig(a) below



fig(a) Basic generation control loop.

- Pdes, the control o/p is a function of system frequency deviation - net interchange error, and each unit's deviation from its scheduled economic output.
- The Area Control Error (ACE) is the error in total generation from total desired generation.
- Sum of the unit o/p errors is added to ACE to form a composite error signal. This drives the entire control system.
- The overall ~~sys~~ control system will try to drive ACE to zero, also drive each units output to its required economical value.

Load forecasting:

The load growth of the geographical area served by a utility company is the most important factor influencing the expansion of the distribution system. Therefore forecasting of load increases and system reaction to these increases is essential for the planning process.

- There are two common time scales of importance to load forecasting: long-range, with time horizons in the order of 15 or 20 yr away, and short-range, with time horizons of up to 5 yr away.
- Ideally, these forecasts would predict future loads in detail, extending even to the individual customer level, but in practice, much less resolution is sought or required.

- Fig(a) below indicates some of the factors which influence the load forecast.
- As one would expect, load growth is very much dependent on the community and its development.
- Economic Indicators, demographic data, and official land use plans all serve as raw input to the forecast procedure.
- Output from the forecast is in the form of load densities (KVA / Unit area) for long-range forecast.

(2015, f)

4(b)

Load Forecasting Techniques

The load forecasting techniques are based on :

1) ~~Bexpd~~ · Extrapolation or correlation or a combination of both
2) Deterministic, ~~par~~ probabilistic or Stochastic.

1) Extrapolation

This can be done by the following methods:-

i) straight line method : $Y = a + bx$

(ii) parabola : $Y = a + bx + cx^3$

iii) S Curve : $Y = a + bx + cx^2 + dx^3$

iv) Exponential : $Y = ce^{dx}$.

v) Gompertz : $Y = \ln^{-1}(a + ce^{dx})$

- The most common curve fitting technique for finding coefficients are exponents of a function in a given forecast is the method of least square.

- ~~The uncertainty of the extrapolated results can be quantified by using statistical entities such as mean and variance. This becomes the par p.~~

2) Deterministic, probabilistic or stochastic

The uncertainty of the extrapolated results can be quantified by using statistical entities such as mean and variance. This becomes the probabilistic extrapolation.

- With regression method, the best estimate of model describing the trend can be obtained and used to forecast the load.

- Stochastic models can be used to generate forecast from random inputs derived from the historical data.
- The statistics of all the random input plus the weighting factor are determined by matching the statistics of the historical demand data with the corresponding statics for the o/p of the model.
- With the model matching to fit historical demand rate, the forecast is obtained by exiting the transformed model by random inputs whose statics are known.
- The resulting time series, after an inverse transformation is the forecast desired.

Internal, 7 (a)
2017 f, 7(a)
2016 sp, 5(a)
2012 f, 7(b)
2012 sp, I(a)

Co-generation and its types:

The process of simultaneous generation of electricity and process steam (or heat) in a single power plant is called Co-generation. It is also known as "Heat-electric generation" plant.

- The steam obtained in the steam generators of thermal power plants can be used both for energy production (electricity) and heat supply to the consumers. These power plants are called "Heat-electric generating plants".

There are mainly two categories of Co-generation:-

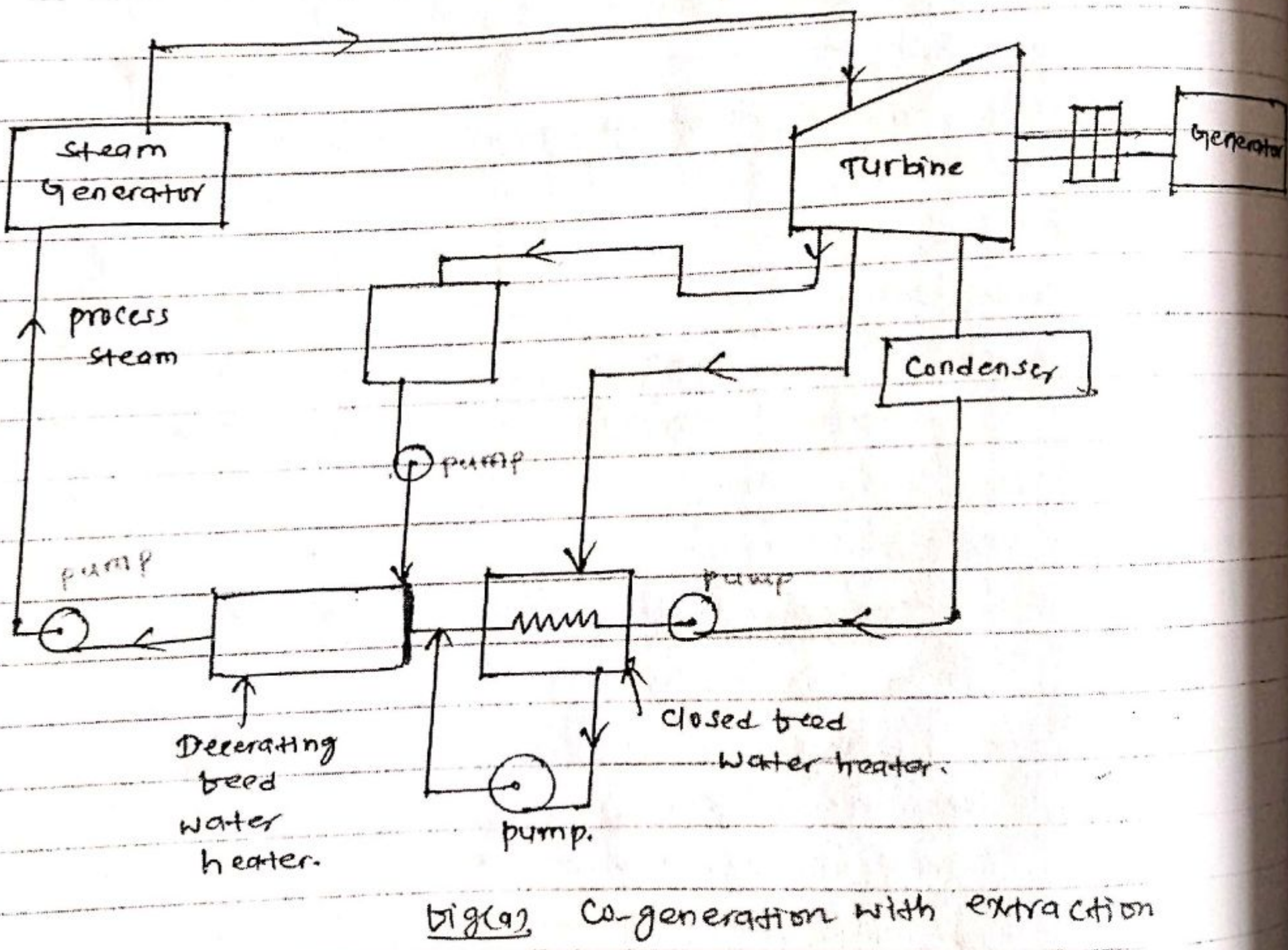
(i) Topping cycles
(ii) Bottoming cycles.

(i) Topping cycles:

In topping cycles, the primary energy is used to generate high-pressure and high temperature steam and electric power in the usual manner. The process steam at low-pressure and tempr is either extracted from the turbine at an intermediate stage depending upon requirements.

(ii) Bottoming cycles: In bottoming cycles, the primary heat is used at high tempr directly for process requirements. The low grade waste heat is then used to generate electric power. The combined efficiency of bottoming cycle will most certainly be less than the combined efficiency for separate generation of process steam and electric power.

Thus, only the topping cycles is suitable for co-generation.



fig(a) Co-generation with extraction condensing turbine.

Different schemes for co generation in a topping cycles:-

i) steam - ~~turbine~~ electric power plant with a back pressure turbine.

ii) steam - electric power plant with steam extraction from a condensing turbine

iii) Gas turbine power plant with a heat recovery boiler.

iv) Combined steam - gas turbine cycle power plant.

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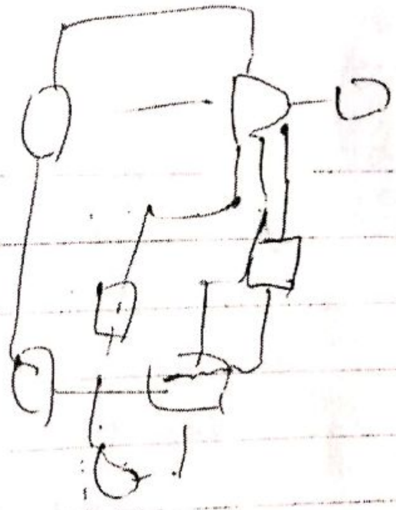
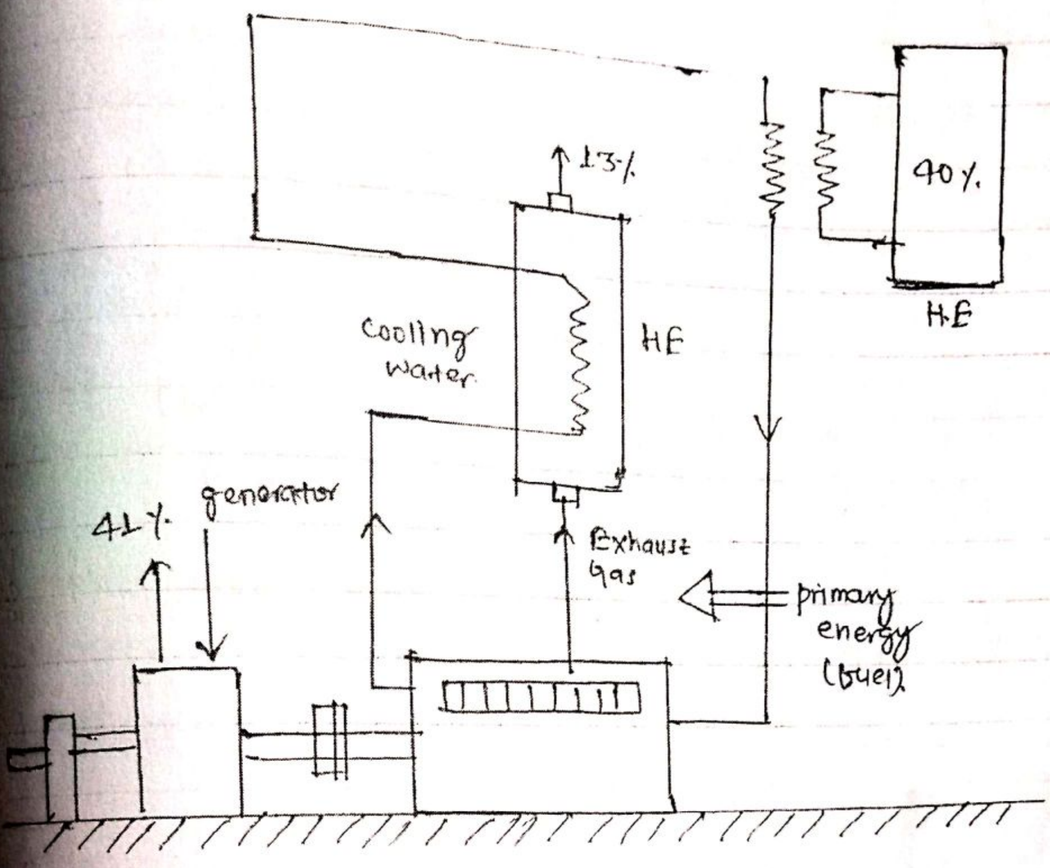


2012 † 1(b)

2012 sp 1(b)

Total Energy System :

- Total energy is the optimum utilization of primary energy (of any fuel) when it is converted into mechanical ~~energy~~ electrical energy, while exploiting the heat of exhaust gas and cooling water.
- This means that all of the energy types needed by the consumer can be produced by means of a single type of primary energy: electrical energy, mechanical energy, thermal energy.
- For this purpose, any of thermal engines (Diesel or gas engines, steam turbines and gas turbines) can be used.
- However, diesel or gas engine are especially well suited for use in "Total Energy System" due to its maximum efficiency.
- The total energy systems achieve an overall efficiency of above 80%.
- The effective engine output of approx 41%, the thermal energy contained in the exhaust gas and the cooling water, amounting to approx 40% is exploited in systems placed in line with the engine as shown in fig(a) below:-



fig(a) Schematic diagram of TES

Advantages

i) Cost efficiency
ii) Reliability
iii) Independence

//

Energy storage system:

The generation of electric power by conventional power plants is fairly uniform but the demand for electric power may vary. It varies daily, weekly, monthly and seasonally etc. The maximum demands occour only for short durations. So to fix the capacity of the power plant on the maximum demand is highly uneconomical. In order to deal this problem " Energy storage " is best method of supplying the variable demand, for electric power.

→ When the demand is lower than the capacity of the plant, the energy is stored. When the demand is higher than the capacity, the stored energy is released.

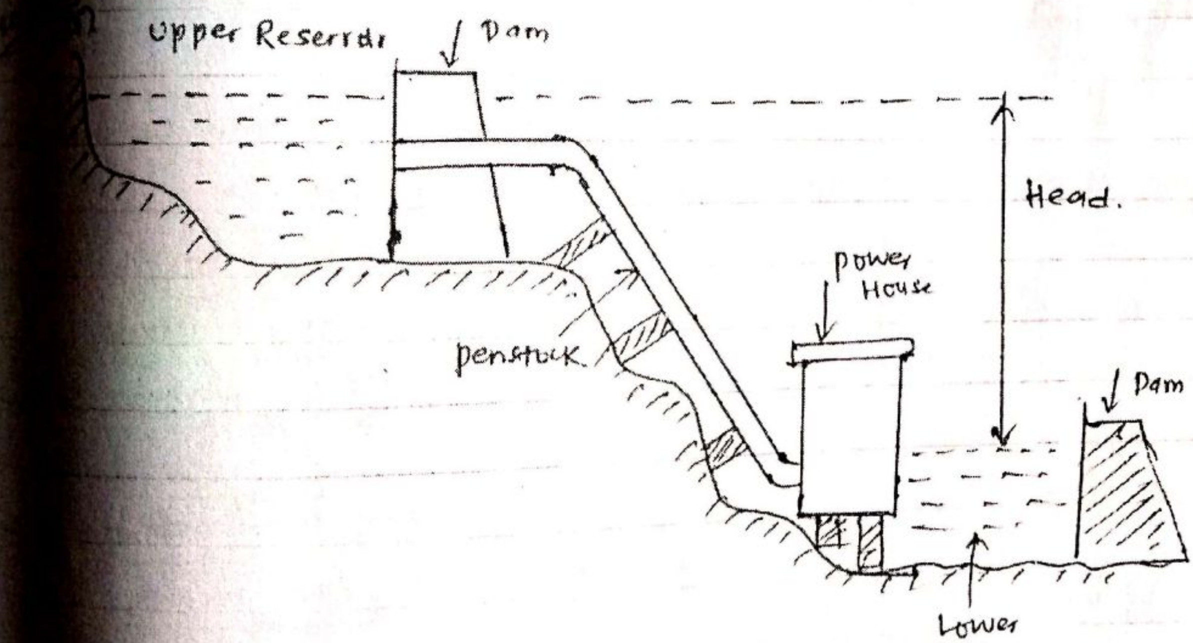
- The objectives of energy storage is to offset the adverse effect of fluctuating demand of electricity and to assure a steady output from existing power plants.

- Discharge of the stored energy during periods of peak load demand would then reduce or replace fuel-burning peaking plant capacity, then conserving fuel resources.

Types of Energy storage systems:

a) pumped hydro.
b) Compressed air energy storage
c) · Energy storage by flywheels
d) Electrochemical energy storage
e) Magnetic energy storage
f) Thermal energy storage.
g) chemical energy storage
h) Hydrogen energy. storage.

pumped hydro storage plant



fig(a) pumped hydro storage plant

- pumped storage plants are employed at the place where the quantity of water available for power generation is inadequate.
- Here, the water passing through the turbines is stored in tail race pond (lower reservoir)
- During low load periods this water is pumped back to the upper reservoir using the extra energy available.
- This water can be again used for generating power during peak load periods
- pumping of water may be done seasonally or daily depending upon the conditions of the site and the nature of load on the plant.

Advantages:

i) there is substantial increase in peak load capacity of the plant at comparatively low capital cost.

ii) Due to load comparable to rated load on the plants, the operating efficiency of the plant is high.

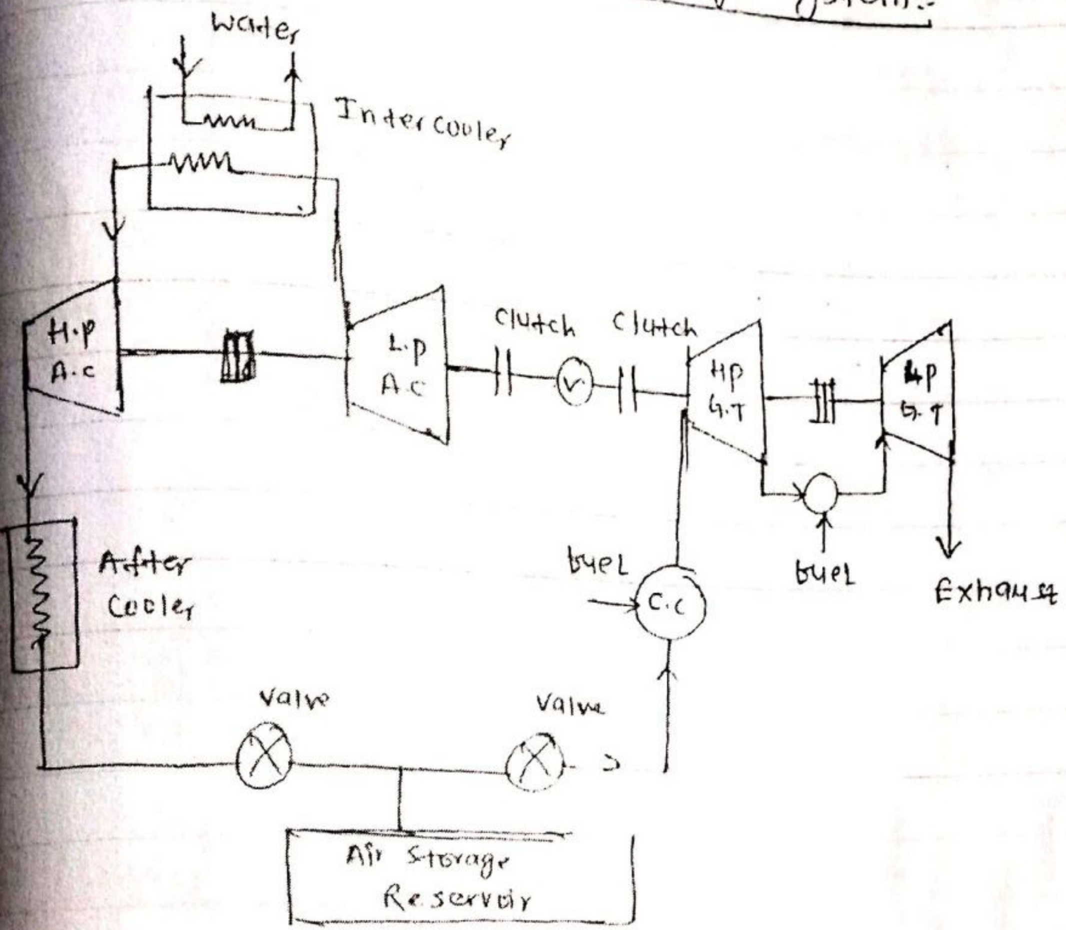
iii) There is an improvement in the load factor of the plant.

iv). The energy available during peak load periods is higher than that of during off peak periods.

v) Load on the hydro-electric plant remains uniform.

2016 f

5(a) Compressed air Energy Storage system:-



fig(a) Schematic diagram of CAES system.

- Since liquid is incompressible, therefore all compressed fluid energy storage system employ gases or vapours.
- In compressed air storage system, during off peak periods, the excess electric power is used to compress the air which is stored in reservoir tank and convert during peak load periods, this compressed air is used to run air turbines.

- In CAES system, It is desirable to Keep the compressed air pressure in the storage chamber as constant as possible in order to achieve high turbine and compressor efficiencies.

//

Q1. Briefly explain about the pollutions and environmental hazards caused by following power plants.

a) Diesel power plants
b) Geo-thermal power plants
c). Thermal power plants
d) Hydro power plants
e) Nuclear power plants

Soln:

a) Diesel power plants.

Pollutions and Environmental hazards

i) Carbon dioxide (CO_2): CO_2 actually is not noxious as a product of combustion of all fossil fuels. It is now considered to be one of the main causes of greenhous effect.

ii) Sulphur dioxides (SO_x): Sulpher oxides are formed due to the combustion of sulpher contained in the fuel. They are one of the primary cause of acid rain.

(iii) Nitrogen oxides NO_x (NO, NO_2, N_2O) : Nitrogen oxides which are generally referred to as NO_x in the case of internal combustion engines comprise nitrogen monoxide N_2O (colourless, water insoluble gas), nitrogen dioxide - NO_2 (reddish brown gas, highly toxic) and dinitrogen monoxide N_2O (laughing gas, colourless gas previously used as a narcotic). Nitrogen oxides, together with the sulphur oxides are the main causes of acid rain.

They also contribute essentially to ozone formation in the air and ground. level.

(iv) Noise pollution: Noise caused by diesel power plant is considerable. During plant operation it can reach above the pain threshold of 120dB and once in operation reach 90 dB. In the open landscape such noise can be heard for some distances and reduces the value of tourist sites and local recreation.

//

Scanned with CamScanner

b) Geothermal power plants.

1) Air and chemical pollution including radio-active element Radon, toxic elements Arsenic, Mercury, Ammonia, Boron (highly toxic to plants) and other polluting heavy metals. Waste ~~steam~~ steam is sprayed over surrounding vegetation (usually rare species in geothermal areas), while waste water is reinjected (including earthquakes).

H2S is also emitted, causing a bad smell and forming the acid rain causing SO_2 in the atmosphere.

(ii) Induced earthquakes: caused by lubrication of faults when waste fluid is reinjected into the rocks.

(iii) Landslides can occur due to tempr and water level in rocks, especially in tectonically active areas.

(iv) Subsidence or sinking of land.

(v) Toxic waste water entering clean aquifers due to lowering of the water ~~table~~ table.

(vi) Drying of hot spring and geysers in the surrounding area, leading to loss of scenary and tourism and loss of rare ~~the~~ thermophilic plant and algal growth. //

c) Thermal power plants:

i) Air pollution: The thermal power plants burning conventional fuels (coal, oil or gas) contribute to air pollution in a large measure. The combustible elements of the fuels are converted to gaseous products, and non-combustible elements as ash. The common gaseous products of interest are sulphur dioxide, nitrogen oxide, carbon dioxide and carbon monoxide, and large quantities of particulate materials as fly ash, carbon particles, silica, alumina and iron oxide.

(ii) Water pollution: Water pollution is caused by discharging hot condenser water and water discharged into the river carrying the ash of the plant. The discharge of polluted water causes hydrological and biological effects on the surrounding ecology.

d) Hydro power plants:

(i) Hydropower plant need huge amounts of water storage and therefore large dams are to be constructed. This leads to displacement of the inhabitant of the area.

(ii) The dam's lake change markedly the local ecological conditions, vary the pressure applied to the land and the groundwater level, which adversely effect plant and animal life in the nearby region.

(iii) The constructions of dams for power plant slows down the flow of rivers and thus cause the pollution of water, growth of deleterious blue-green alage, encourages the reproduction of epidemic-carrying bacteria,

(iv) Large area acquisition mean destruction of forest cover which is harmful for environments.

(v) It disturbs the demographic balance also.

(vi) Large no. of workers ~~are~~ required for construction are brought into the area and they disturb the every nature of local population.

e) Nuclear power plants:

(i) Radioactive pollution: -

- most dangerous and serious type of pollution.
- due to radioactive elements and fissionable prod in reactor.

(ii) Waste from reactor.

- due to nuclear reactor reaction nuclear waste, are produced which cannot be neutralized by any chemical method.
- If the waste is discharged in the atmosphere, air and water will be contaminated beyond the tolerat limits.

(iii) Nuclear reactor meltdown, which can be devasti to the local environment and population, that happened exactly once in history.

//

Thermal pollutions:

- Thermal pollution is a temperature change in natural water bodies caused by human influence. The tempr change can be upwards or downward.
- Discharge of thermal energy into water is commonly called "Thermal pollution".
- Thermal power stations invariably will have to discharge enormous amount of energy into water since water is one medium largely used to condense steam.
- If this heated water from condenser is discharged into lake or rivers, the water tempr goes up. The ability of water to hold dissolved gases goes down when the tempr increases.
- At about 35°c, the dissolved oxygen will be so low that the acquatic life will die.

methods to reduce thermal pollutions

1) Construction of a separate lake:
- this method improves the thermal efficiency of the plant but can prove expensive.
- If the natural cooling of water from the lake is not sufficient, floating pumps can be employed.

Scanned with CamScanner

(ii) <u>Cooling pond:</u>

- A cooling pond with continuously operating fountains can be adopted for smaller power plants.
- this will also serve as a beautifying feature of the power plant site.

(iii) <u>Cooling towers:</u>

- In order to throw heat into the atmosphere most power stations adopt the cooling towers.
- This is a natural convection cooling.
- They may be wet-cooling tower or dry-cooling tower.
- Both are expensive.

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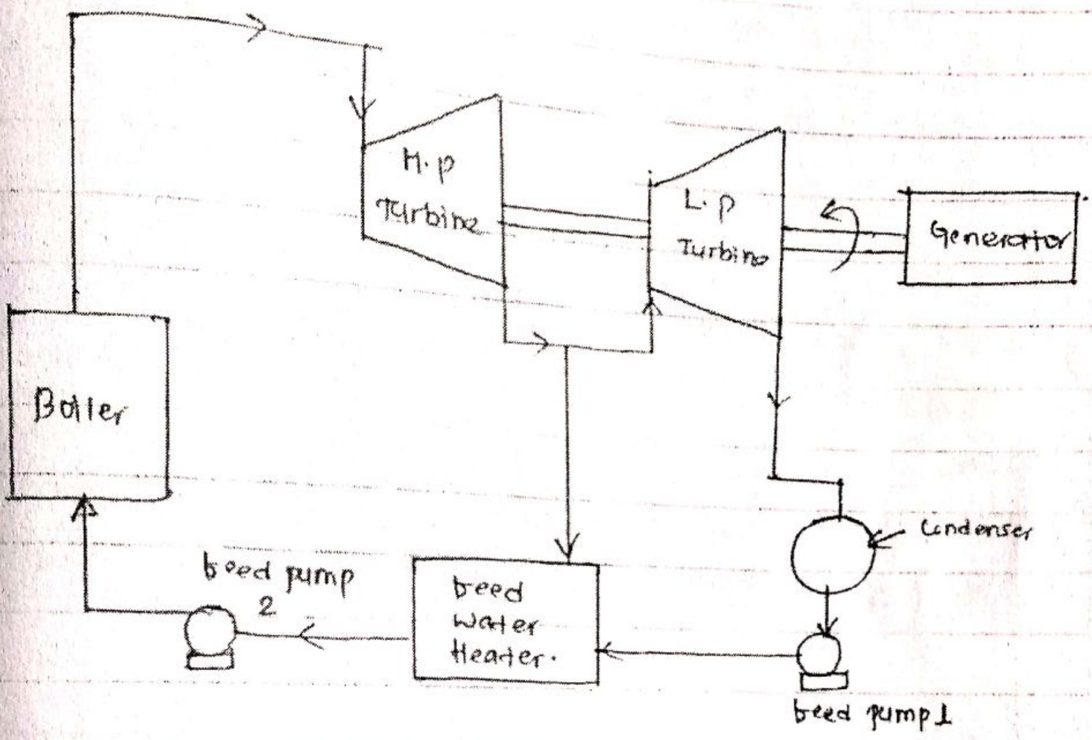
2012f

1(b) Utilization of waste heat from thermal power plant:



fig(a) Utilization of wask heat from thermal power plant

- A thermal power plant is a power plant in which the prime mover is steam driven.
- water is heated, turns into steam and spins a steam turbine which drives an electrical generator.

Scanned with CamScanner

- After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated.
- This process is known as Rankine cycle.

- By this process, the waste heat from thermal power plants is utilized to produce steam and power.

Ans //

Internal 1(b)
2015 sp 1(b)

Geothermal Energy:

2014f 1(b) Geothermal energy is the energy which lies embedded within the earth. Starting from the centre of the earth, it consists of the following zones.
2013sp 1(a)
2011f 2(b)

i) solid metallic core
ii) A molten core
iii) A mantle of solid rock
iv) A thin crust

Temperature range from 3000-4000°c in the core and the base of the mantle. Therefore underfoot there is tremendous heat energy which makes it presence felt in the eruption of volcanoes and in the spouting of hot springs and geysers

Geothermal sources

1) Hydrothermal convective systems
   i) Vapour-dominated system/ dry steam fields.
   ii) Liquid-dominated system/ wet steam fields.
   iii) Hot-water fields
2) Geopressure resourses
3) Hot dry rocks.
4) Magma resources.
5) Volcanoes.

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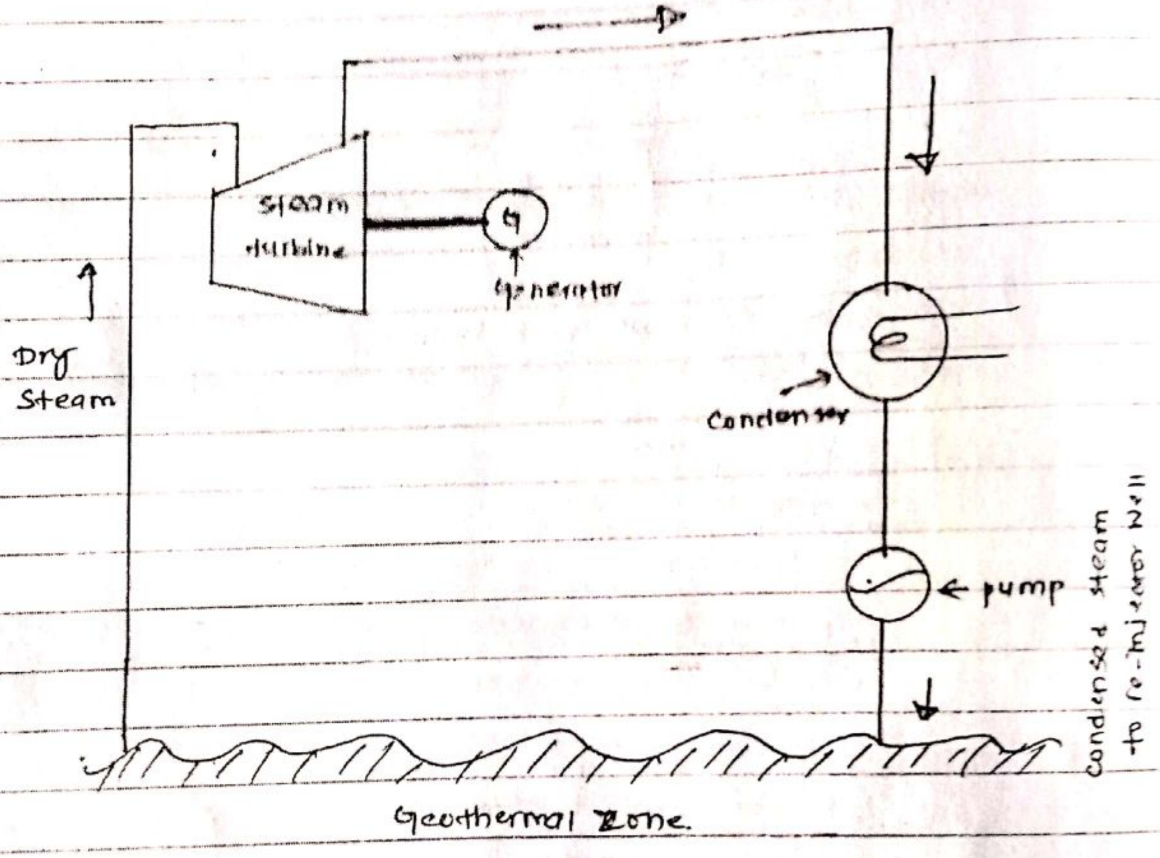
The different types of geo-thermal power plant systems usually employed are as follows:-

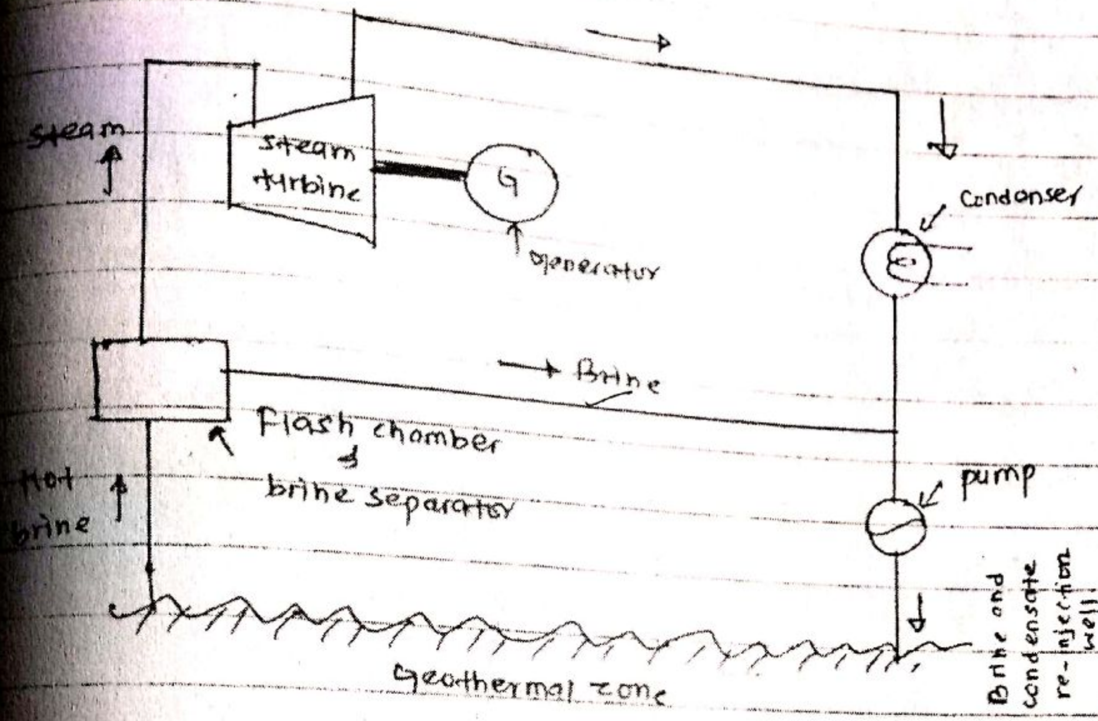
1) Dry-steam open system
2) Flash - steam open type system
3) Hot - water closed system.

1). Dry- steam open system:



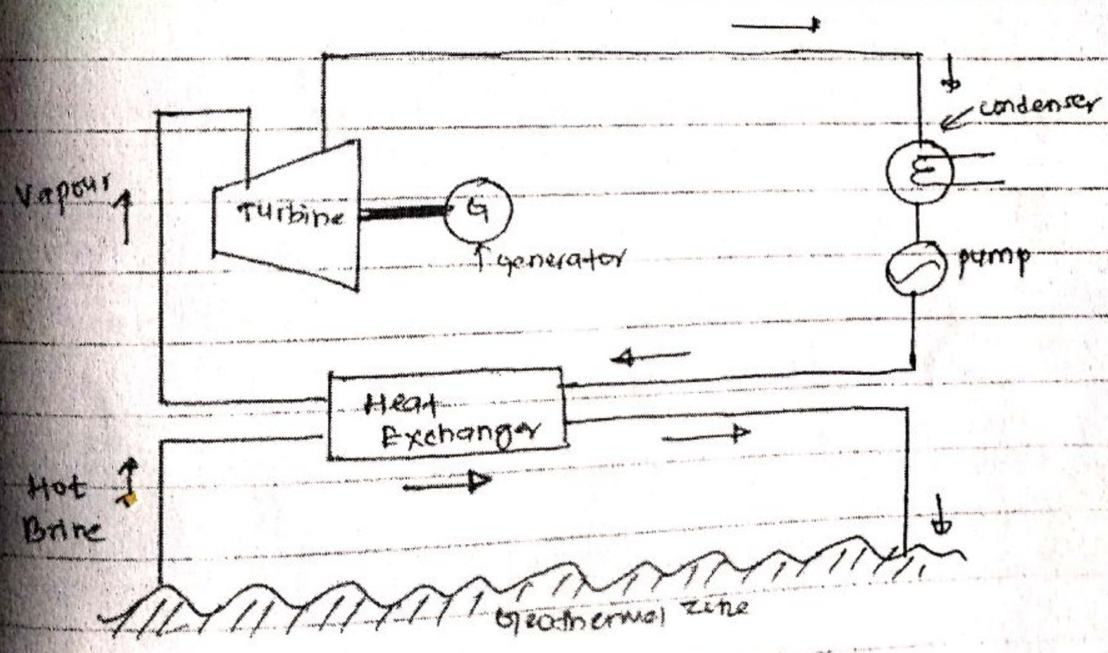
fig(a) Dry- steam open system.

2) Flash- steam open type system:



fig(b) Flash steam open type system.

3) Hot-water closed system:



fig(c) Hot-water closed system.

- the steam or hot brine heated by the earth goes into a special turbine in a geothermal power plant. The turbine blades spin and the shaft of the turbine is connected to a generator to make electri

- the water steam then gets cooled off in a cooling tower. the cooled water can then be pumped back below ground to be reheated by the earth.

Applications

i) Generation of electric power.
ii) space heatings for buildings
iii) Industrial process heat

Advantages

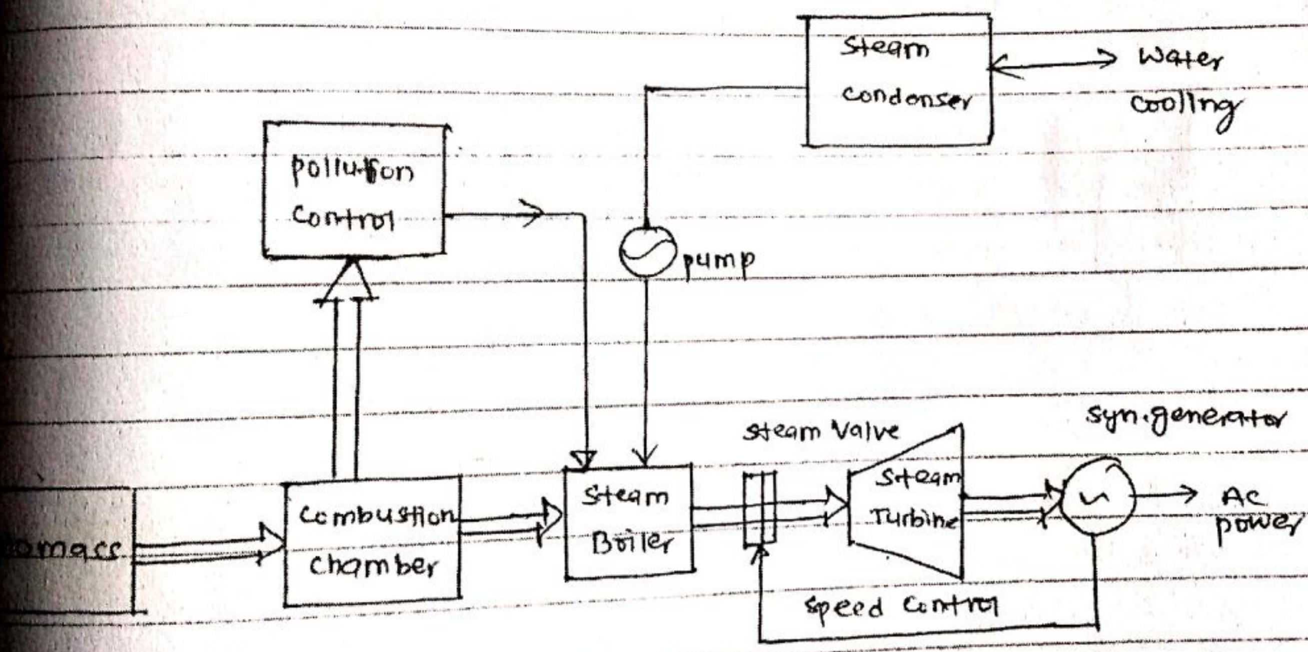
i) No fuel is needed
ii) Geothermal energy is cheaper after once construction.
iii) Doesnot produce any pollution and doesnot contribute to the green house effect
iv) occupies less area.

2013,f
1(b)

C.

Biomass power plant

- Biomass is an organic matter from plants, animals and micro organism grown on land and water and their derivatives.
- The energy obtained from biomass is called Biomass energy.
- Biomass is considered as a renewable sources of energy.
- Biomass was the first energy source harnessed by humans.



fig(a) Electricity generation powered by Biomass.

- In combustion chamber, the biomass is converted into solid material and liquid and partially to combustible gas by heating to high temperature in absence of oxygen and this process is called ~~pl~~ pyrolysis.

- The solid or liquid biomass is used in the boiler along with the exhaust gas to produce steam for the steam turbine.

- In this way, operation of steam turbine operates the synchronous generator for the production of AC power.

2013.f
1(01)

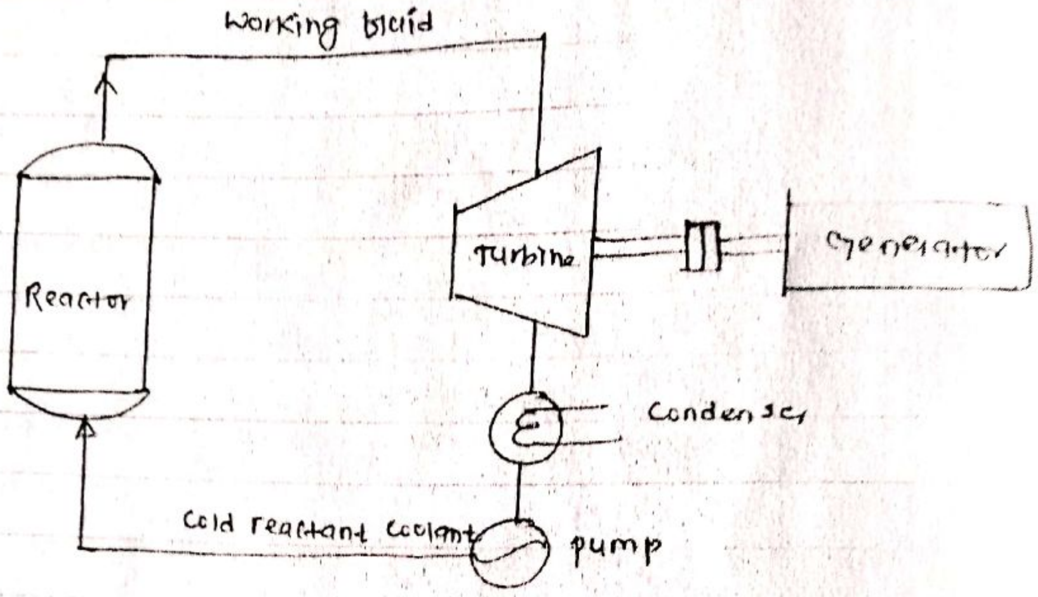
Nuclear power plant

- The need of nuclear power plant lies in the fact that the hunger of electricity is virtually unending and after each decade the world demand for electricity is doubled owing to booming increase in the population and industrial growth.
- The concepts of nuclear power generation are much similar to that of conventional steam power generation. The difference lies only in the steam generation part i.e coal or oil burning furnace and the boiler are replaced by nuclear reactor and heat exchanger.

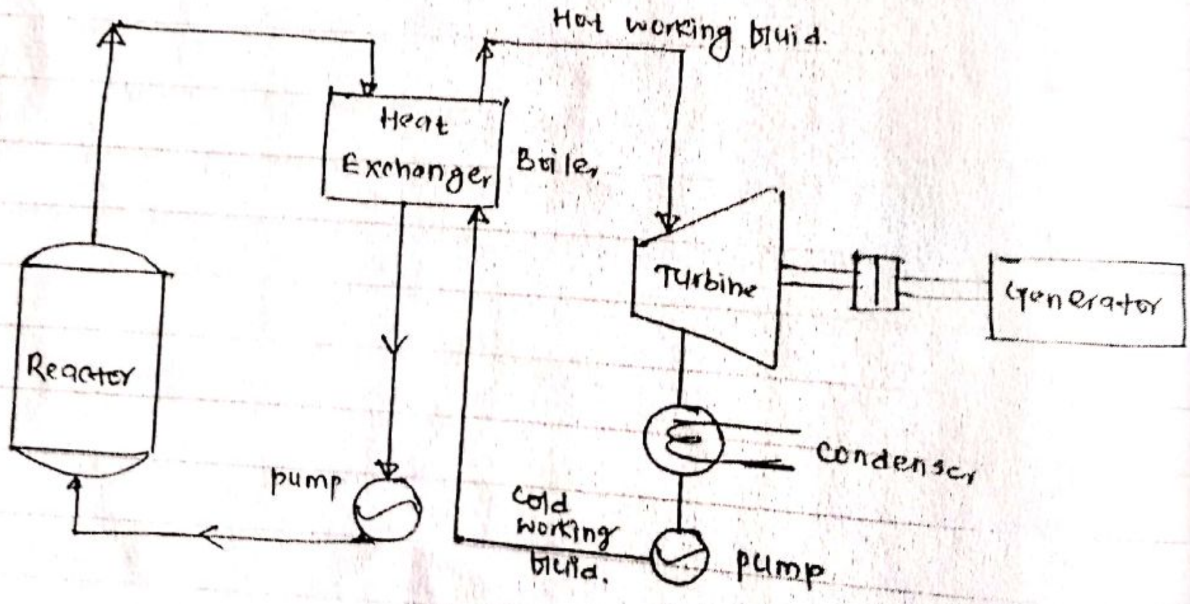
- The nuclear power plant consists of a ~~nuclear~~
  i) nuclear reactor (for heat generation).
  ii) heat-exchanger (for converting water into steam by using heat generated in the nuclear reactor.
  iii) steam turbine
  iv) condenser etc.

The following are the types of nuclear power plant

i) Direct cycle
ii) Indirect cycle.



Fig(a) Direct cycle.



Fig(b) Indirect cycle.

<u>from fig(a)</u> <u>Direct cycles</u>

73

- The nuclear reactor is fueled by uranium dioxide and moderated by water.
- The nuclear ~~reactio~~ reaction produces heat. The reaction is controlled by boron-based rods.
- The coolant pump drives water through the reactor, where the nuclear reaction increases the coolent tempr.
- Similarly. <u>In Indirect cycles fig(b)</u>, the steam is generated in the heat exchanger/ boiler.
- The high pressure steam turbine drives the turbine, which in turn drives the generator.
- The condenser condenses the steam to water, which is pumped back into the boiler.

//

2016 / 1(b).

Solar power plant

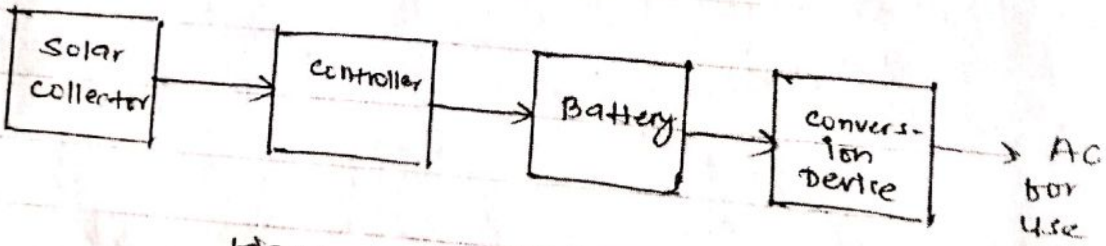
The sun is the primary source of energy. The energy radiated by the sun is in the form of electromagnetic waves, which induce the heat, light and a lot of ultraviolet radiations.

The radiated heat energy by the sun can be utilised for the generation of electric power.

Following are the method for energy conversion:

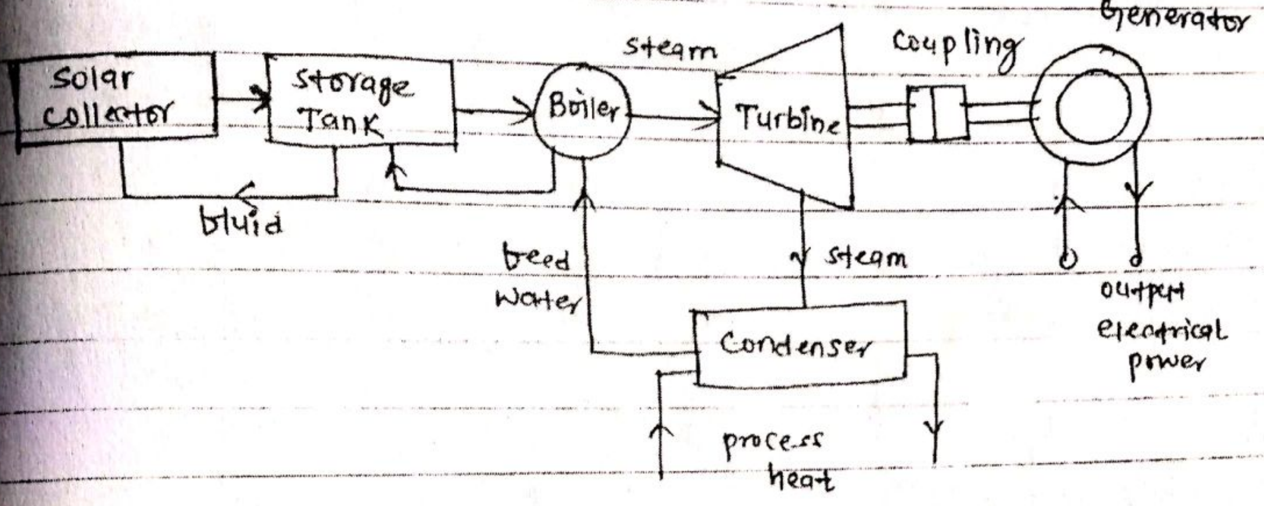
(i) Direct conversion method
(ii) Conventional Boiler method.

(i) Direct conversion method:



fig(a) Direct conversion method.

(ii) Conventional Boiler Method:



big(b) Solar power plant

Major Components:

- Solar collector.
- Storage tank
- Boiler
- Steam turbine
- Generator.

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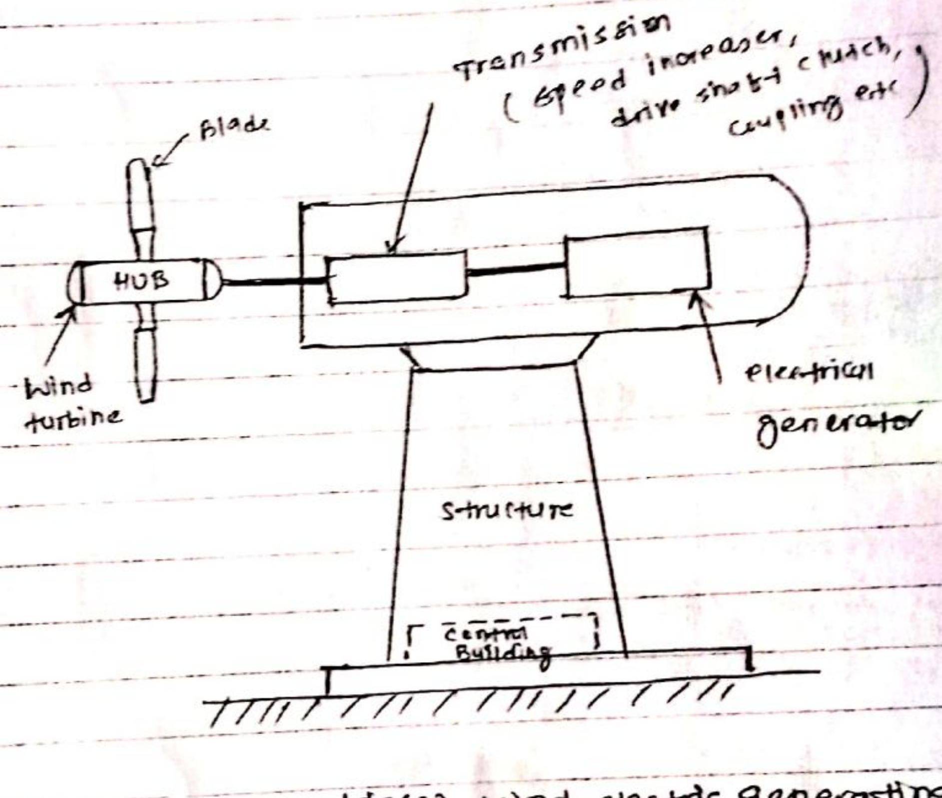
Internal 7(c)

Wind Energy:

2017 8(b) The wind produced by the sun got sufficient energy which can be utilized in wind mills to drive small generators. such generators are used for charging batteries for continuous use.



fig(a) wind-electric generating power plant

- Constent power o/p is achieved by using gear box between turbine shaft and generator shaft.

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4(a) Differentiate between flat plate collector system and focusing collector system used in solar power plant. 77.

Solar collector is a device that absorbs the incident solar radiation and converts into useful heat ~~which is the same as the absorber area (ie the area absorbing the radiation). In~~ which is used for heating a collector fluid such as water, oil or air. The surface of solar collector is designed for high absorption and low emission.

Solar collectors can be classified as:

i) non-concentrating or flat plate type
ii) concentrating or focusing collector

(i) Non-concentrating type or flat plate type:

- the collector area (ie the area that intercept the solar radiation) is the same as the absorber area (ie the area absorbing the radiation).
- The whole solar panel absorbs the light.
- Used for water heating, space heating and power generation,
- It operates at lower temp^r of about 100°c in summer and 40°c in winter.

(ii) Concentrating collectors:

- makes use of optical systems in the form of reflectors or refractors to concentrate the energy of direct solar radiation on the absorbing surface.
- The reflectors may be flat mirrors or in the shape of a parabolic trough or paraboloidal dish concentrating solar collector are employed to heat a working fluid for power cycles.
- The maximum temp is used to operate
- used for vapour engines and turbines, process heating, cooking etc.

//

2012f

1(a) Discuss the advantages & difficulties of generating electric power ~~pto~~ from a nuclear power station ~~as~~ compared with a hydro power station

Soln: **Advantages of generating electric power from a nuclear power stations are as follows:-**

i) A nuclear power station neeeds less space as compared to hydro power station of equal size.

ii) Nuclear power plants are well suited to meet the ~~do~~ large power demands. They give better performance at a high load factor (80-90%).

(iii) The nuclear power plants, beside, producing large amount of power, produce valuable fissible material which is produced when the fuel is renewed.

iv) Nuclear power plants are not affected by advise wether conditions.

The difficulties of generating electric power from a nuclear power station as compared with a hydro power station are as follows:-

i) The requirement of fuel cost and transportation cost.

ii) The capital cost of a nuclear power plant is high.

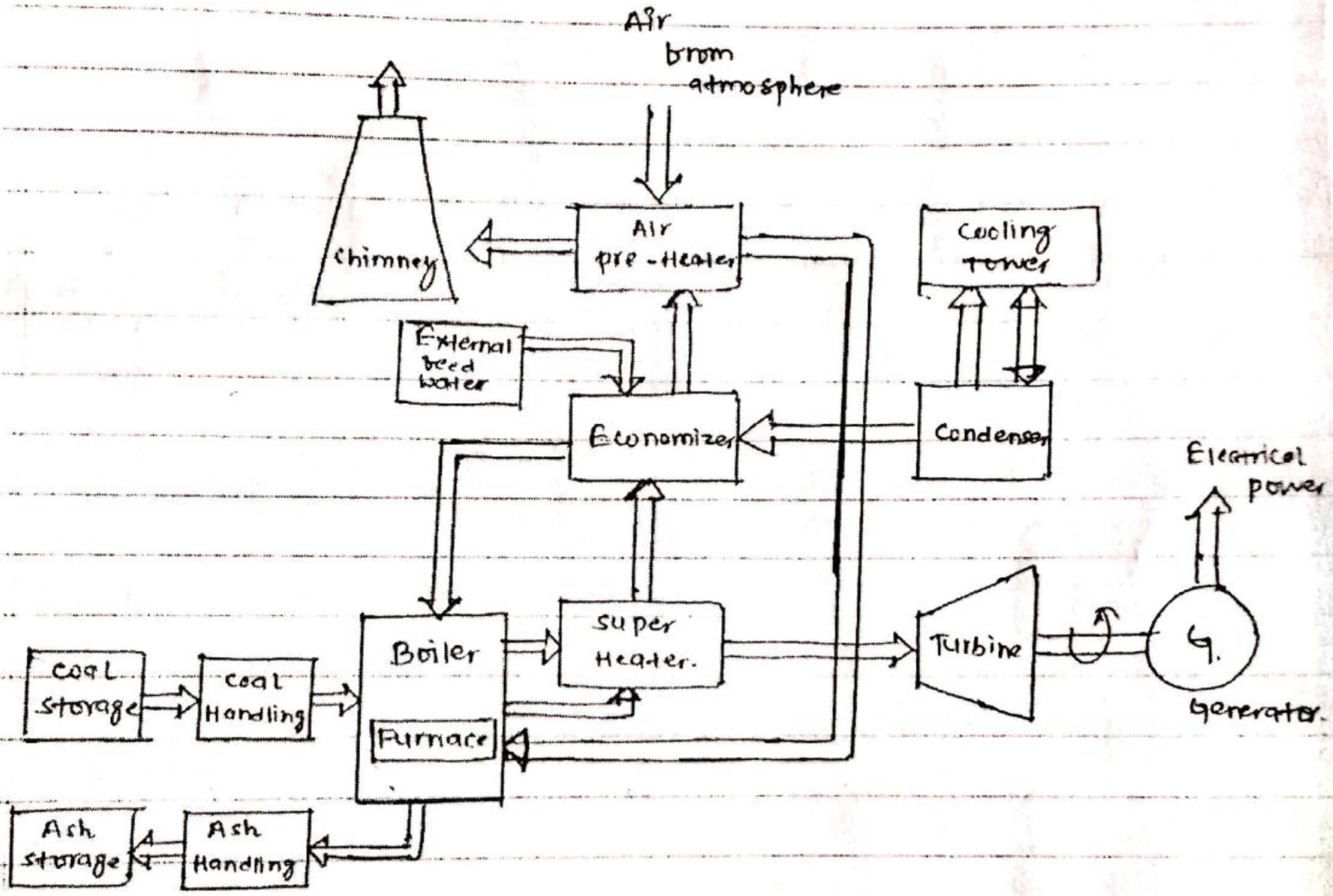
iii) The plants cannot be operated at varying load efficiently.

iv) The disposal of fission products may be a big problem.

v) The danger of radioactivity, working conditions in nuclear power stations are always detrimental to the health of the workers.

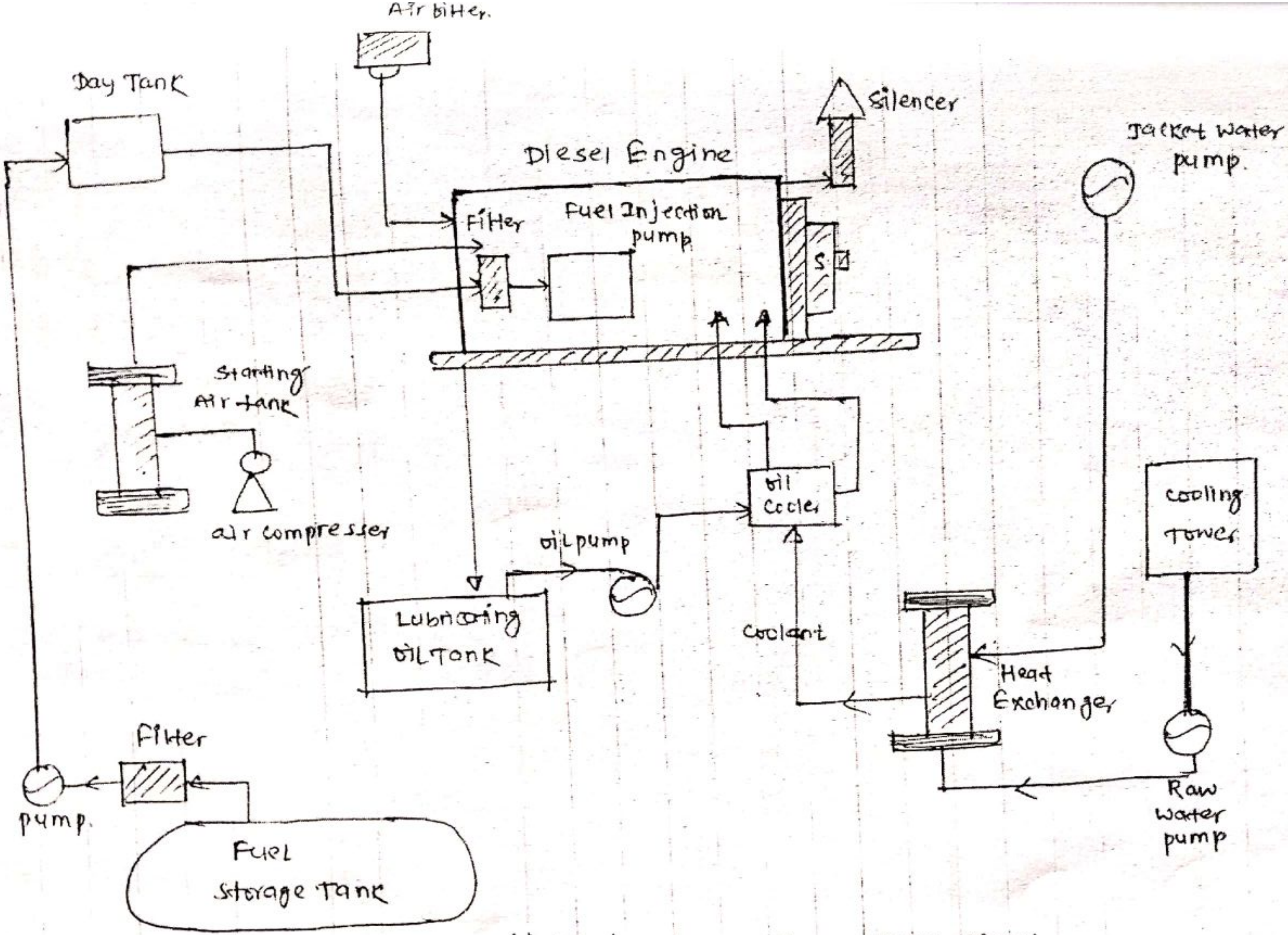
2017 f.

1 (b). Explain with block diagram how you can obtain super-heated steam using coal and nuclear fuel in steam power plant



fig(a) Layout of steam power plant

Diesel power plants



big(a) Layout of Diesel Power plant

System used in Diesel power plants

a) Engine starting system

b) Fuel system.

c) Air Intake system

d) Exhaust system

e) Engine cooling system.

f) Engine lubricating system.

2016f 1(a)

Selection of turbines in Hydro-power plants:

The following points should be considered while selecting the right type of hydraulic turbine:-

i) Specific speed:

- High specific speed is essential where head is low and output is large,

(ii) Rotational speed:

- Rotational speed depends upon specific speed.
- The value of specific speed adopted should be such that it will give the synchronous speed of the generator.

(iii) Efficiency:

- The turbine selected should be such that it gives the highest overall efficiency for various operating conditions.

(iv) Part load operation: In general the efficiency at part-loads and overloads is less than normal. For the sake of economy the turbine should always run with maximum possible efficiency to get more revenue.

(V) Cavitation:

The installation of water turbines of reaction type over the tailrace level is effected by cavitation. The critical value of cavitation factors must be obtained to see that the turbine works in safe zone.

(VI) Disposition of turbine shaft: The vertical shaft arrangement is better for large size reaction turbines therefore it is almost universally adopted. In the case of large sized impulse turbine, horizontal shaft arrangements is used.

(VII) Head:

- Very high heads (350m and above)
  Pelton turbine

- High Heads (150 - 350m):
  - Pelton or Francis turbine

- Medium heads (60m - 150m):
  - Francis turbine

- Low heads (below 60m)
  - Francis and Kaplan Turbine

- Very low heads (~~[illegible]~~) : bulb turbines for head of 2 - 15m

Classifications of Hydraulic Turbines

According to:

1) Head and quantity of water available

i) Impulse turbine — high head and low discharge
ii) Reaction turbine — low head & high discharge

2) Name of the originator

i) pelton turbine — Lester Allen pelton
ii) francis turbine — James Bichens francis
iii) Kaplan turbine — Dr. Victor Kaplan.

3) Action of water on the moving blades

- Impulse turbine — pelton turbine
- Reaction turbine — francis turbine
  - Kaplan and propeller

4) Direction of flow of water in the runner

i) Tangential flow turbine (pelton turbine)
ii) Radial flow turbine (no more used)
iii) Axial flow turbine (Kaplan turbine)
iv) Mixed (radial and axial) flow turbine (francis turbine)

5) <u>Disposition of the turbine shaft</u>

- Horizontal shaft – pelton Turbines
- Vertical shaft – rest others.

6). <u>Specific speed:</u>

$$N_s = \frac{N\sqrt{P_t}}{H^{5/4}}$$

- pelton — slow — 10-20 rpm
  - Normal — 20-28 rpm
  - Fast — 28-35 rpm

- Francis — slow — 60-120 rpm
  - Normal — 120 - 180 rpm
  - fast — 180 - 300 rpm

- Kaplan — — 300 - 1000 //.

2015 sp 2(a) Features of Hydro power plant Generator

- ~~capacity of~~
- Acc. to its axis location, hydrogenerator is usually divided into two types:-
  a) Horizontal — pelton turbines
  b) vertical. — Francis or Kaplan turbines

- Large and medium sized units usually adopt the vertical type layout, whose max. speed can reach 750 r/min.
- while horizontal type usually is used for medium and small capacity units, whose max. speed can reach 1500 r/min.
- As per its excitation mode, Hydrogenerator can be classified as
  - brushless excitation unit
  - excitation with brush

Features of steam power plant Generators:

(i) Small industrial steam-turbine driven AC generators are sometimes 4-pole machines with a speed of 1500 rpm for 50 Hz operation or 1800 rpm for 60 Hz.

(ii) generally 2-pole with speed of 3000 rpm for 50 Hz and 3600 rpm for 60 Hz is used.

(iii) The rotor of a synchronous machine may be of either the cylindrical type or the salient pole type.

(iv) The conductor are bare copper strips insulated by layers of mica.

v) The connections are brought out to the sliprings through the rotor shaft, which is hollow.

vi) The rotor of a turbo-alternator is of small diameter and is very long compared to that of a salient pole machine used for low-speed operation.

vii) The air gap of the turbo alternator is also long compared to that of a salient pole machine.

viii) The rotor and stator of a turbo-alternator may be air cooled of the machine.

2010 s/p

1(b) Generators features used in Diesel power plant

i) The generators used with diesel engines are of the salient pole type having large diameters and short lengths

ii) To obtain a frequency of 50Hz, the no. of poles is from 4 to 28, as the speed range of diesel engines driving the generators is from 1500 - 214 rpm.

iii) The alternators used are of standard available sizes. A common range of capacities is from 25 to 5000 KVA, the power factor rating being 0.8 lagging, so that the corresponding load is from 20 - 4000 KW.

iv) A 3 phase 50 Hz supply is to be obtained from the generators and a common voltage rating is 440V.

v) The generator efficiency varies from 92% for small units to about 95% for large units.

vi) The generator needs an exciter to build up the necessary voltage on no-load and then to keep it constant on load, when greater excitation will be required.

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2016 sp.

1(a). Write some characteristics of wind power plant and derive an ideal power generated by it

Soln: Characteristics of wind power plant

i) The energy used ie wind energy is a renewable energy source.

ii) Wind power system being non-polluted have no adverse effect on the environment.

iii) Fuel provision and transport are not required in wind energy conversion systems.

iv) Economically competitive.

v) Ideal choice for rural and remote areas and areas which lack other energy source.

Expression for ideal power generated by wind power plant

Wind energy is the kinetic energy of air in motion. Total wind energy blowing through an imaginary area 'A' during time 't' is

$$E = \frac{1}{2} m v^2 = \frac{1}{2} (A v t \rho) . v^2 = \frac{1}{2} A t \rho v^3$$

where ρ = density of air

v = wind speed

Avt = Volume of air passing through area A.

Now,

wind power is

$$P = \frac{E}{t}$$

$$= \frac{1}{2} A \rho v^3$$

2016 sp.

1(a). Write some characteristics of wind power plant and derive an ideal power generated by it

Soln: **Characteristics of wind power plant**

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Expression for Ideal power generated by wind power plant

Wind energy is the kinetic energy of air in motion. Total wind energy blowing through an imaginary area 'A' during time 't' is

$$E = \frac{1}{2} mv^2 = \frac{1}{2} (Avt\rho).v^2 = \frac{1}{2} At\rho v^3$$

where ρ = density of air

v = wind speed

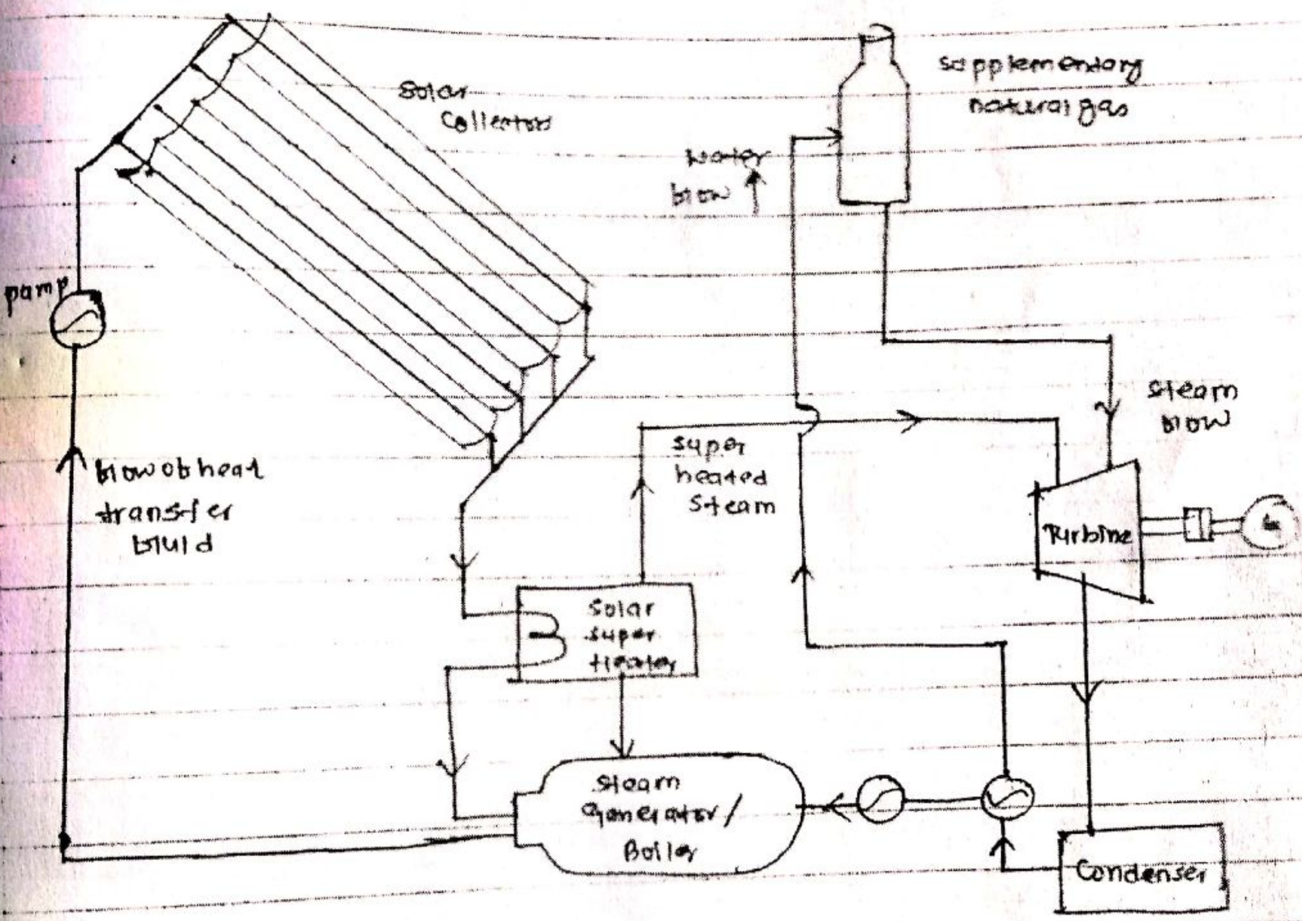
Avt = volume of air passing through area A.

2015f.   91.

1(a)

Explain the energy available from solar power plant in detail

Soln: Solar thermal Electrical plant



fig(a) Solar thermal electrical plant

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Sources of Energy:

1) Renewable Energy sources
- Small hydro
- Biomass
- Tidal
- Solar
- Wind
- Geothermal

2) Non-renewable energy source
- Nuclear
- OIL
- Gas
- Diesel
- Thermal,

2016-S.

4 (a) What do you mean by mechanical stress in bus bar? What are the factors that causes it? Describe the methods of reducing stress on bus bar.

Soln:

Mechanical stress in bus bar:

With the increased magnitudes of short-circuit currents obtained in modern busbar circuits, the mechanical stress on the busbar is imposed during short, circuits.

Factors of causing mechanical stress in bus bar

i) The stress are due to the electromagnetic force produced by the current flowing in adjacent conductors in the bus structure.

(ii) In the days when currents were low, or when large spacings between conductors were maintained, a support sufficiently ~~strong~~ strong to carry the weight of the conductors often was sufficient to withstand the stresses due to the electromagnetic force is absolutely essential.

The following are the methods of reducing stress on bus bar:

a) Reduce the span between insulator supports

This method can be used to reduce the effects of both continuous vibration and that due to short-circuit forces.

b) Increase the span between insulator supports

This method can only be used to reduce the effects of vibration resulting from a continuous current. It will increase the stress, due to short-circuit currents.

c) Increase or decrease the flexibility of the conductor supports

This method will reduce the effects of vibration due to continuous current but has very little effect on that due to short-circuit force.

d) Increase the conductor flexibility

This can only be used to reduce the effect of vibration due to a continuous current. The short-circuit effect is increased.

e) ~~Increase~~ Decrease the conductor flexibility

This method will reduce the effects of vibration due to either a continuous current or a short-circuit.

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d i i i a