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Dr. Mohammed Kdair Abd
14-Nov. 2017

Base load and peak load on power system:

A close look at the load curve reveals that load in power station can be considered into parts:

1. Base load: the unvarying load which occurs almost the whole day on the station.

2. Peak load: the varicose peak demands of load over and above the base load of the station. See Figure (2).

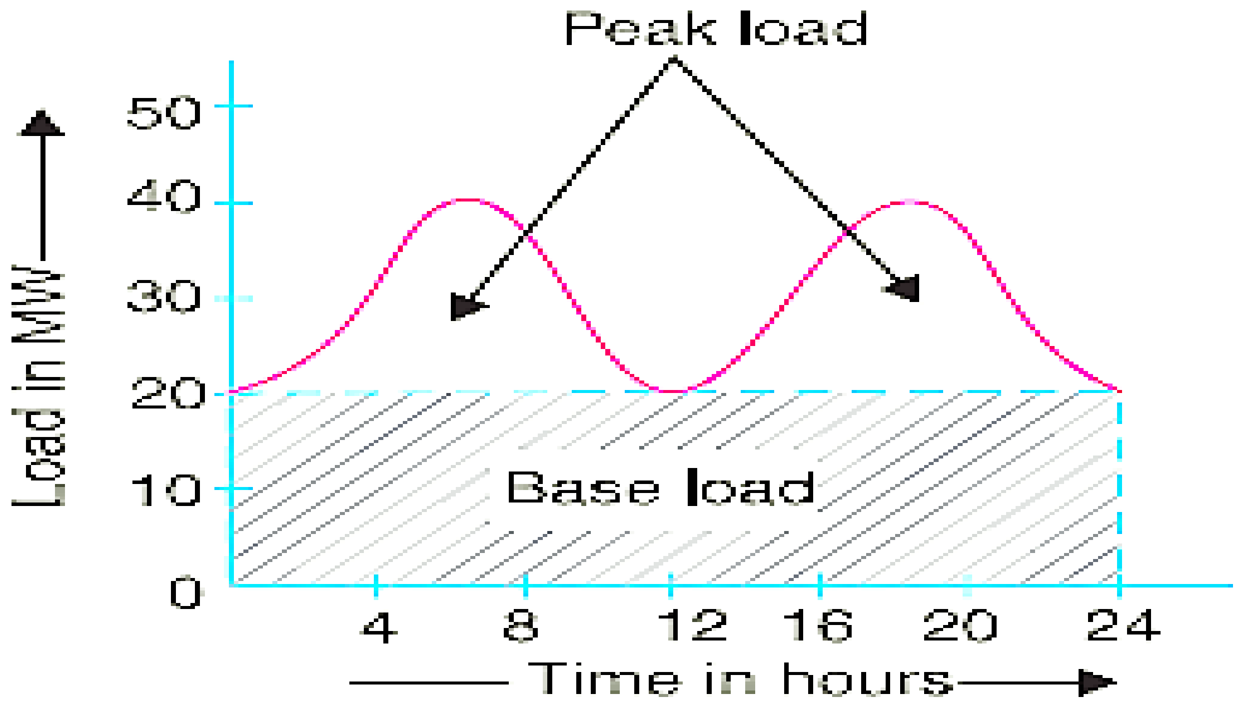

Figure (2)

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Load Curve and Methods of Selection of Generating Units:

In actual practice, a number of generating units of different sizes are installed in power system. The selection of the number and the size of the generating units are decided from the annual load curve. The number and the size of the units are selected in such a way that they correctly fit the station load curve.

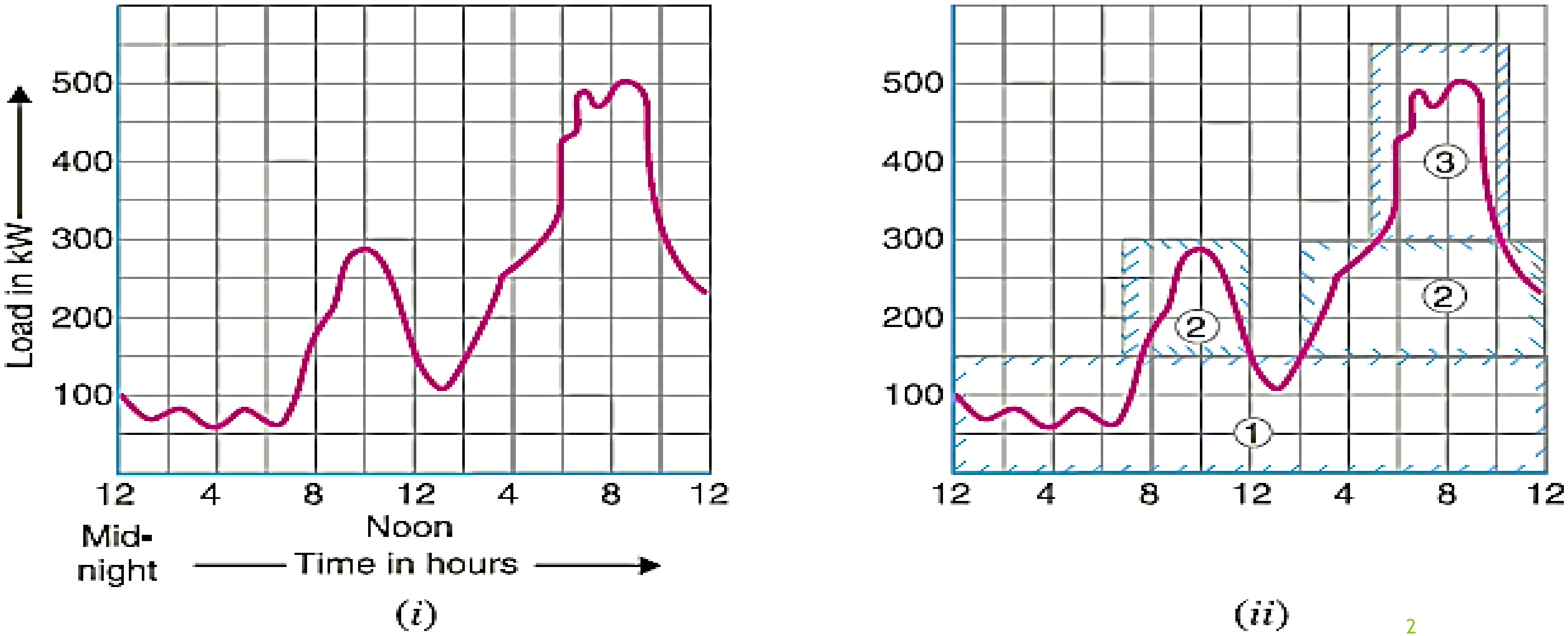

Figure (2) Selection of Generating units

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Time	Units in operation
From 12 midnight to 7 A.M.	Only unit no.1 is put in operation.
From 7 A.M. to 12.00 noon	Unit no. 2 is also started so that both units 1 and 2 are in operation.
From 12.00 noon to 2 P.M.	Unit no. 2 is stopped and only unit 1operates.
From 2 P.M. to 5 P.M.	Unit no. 2 is again started. Now units 1 and 2 are in operation.
From 5 P.M. to 10.30 P.M.	Units 1, 2 and 3 are put in operation.
From 10. 30 P.M. to 12.00 midnight	Units 1 and 2 are put in operation.

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Important points to select the number of generating units:

1. The number and sizes of the units should be so selected that they approximately fit the annual load curve of the station.
2. The units should be preferable of different capacities to meet the load requirements. Although the use of identical units (*i.e.*, having same capacity) ensures saving in cost, they often do not meet the load requirements.
3. The capacity of the plant should be made 15% to 20% more than the maximum demand to meet the future load requirements.
4. There should be a spare generating unit so that repairs and overhauling of the working units can be carried out.
5. The tendency to select a large number of units of smaller capacity in order to fit the load curve very accurately should be avoided. It is because the investment cost per kW of capacity increases as the size of the units decreases.

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Interconnected grid system:

It’s the connection of several generating stations in parallel. Some of its advantages are:

1. ***Exchange of peak loads***: An important advantage of the interconnected system is that the peak load of the power station can be exchanged. If the load curve of a power station shows a peak demand that is greater than the rated capacity of the plant, then the excess load can be shared by other stations interconnected with it.
2. ***Use of older plants***: The interconnected system makes it possible to use the older and less efficient plants to carry peak loads of short durations. Although such plants may be inadequate when used alone, yet they have sufficient capacity to carry short peak of loads when interconnected with other modern plants. Therefore, interconnected system give a direct key to the use of obsolete plants
3. ***Ensures economical operation***: The interconnected system makes the operation of concerned power stations quite economical. It is because sharing of load among the stations is arranged in such a way that more efficient stations work continuously the year at a high load factor and the less efficient plants work for peak load hours only.

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4. ***Increases diversity factor***: The load curves of different interconnected stations are generally different. The result is that the maximum demand on the system is much reduced as compared to the sum of individual maximum demands on different stations. In other words, the diversity factor of the system is improved, thereby increasing the effective capacity of the system.

5. ***Reduces plant reserve capacity***: Every power station is required to have a standby unit for emergencies. However, when several power stations are connected in parallel, the reserve capacity of the system is much reduced. This increases the efficiency of the system.

6. ***Increases reliability of supply***: The interconnected system increases the reliability of supply. If a major breakdown occurs in one station, continuity of supply can be maintained by other healthy stations.

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Example *A generating station has the following daily load cycle :*

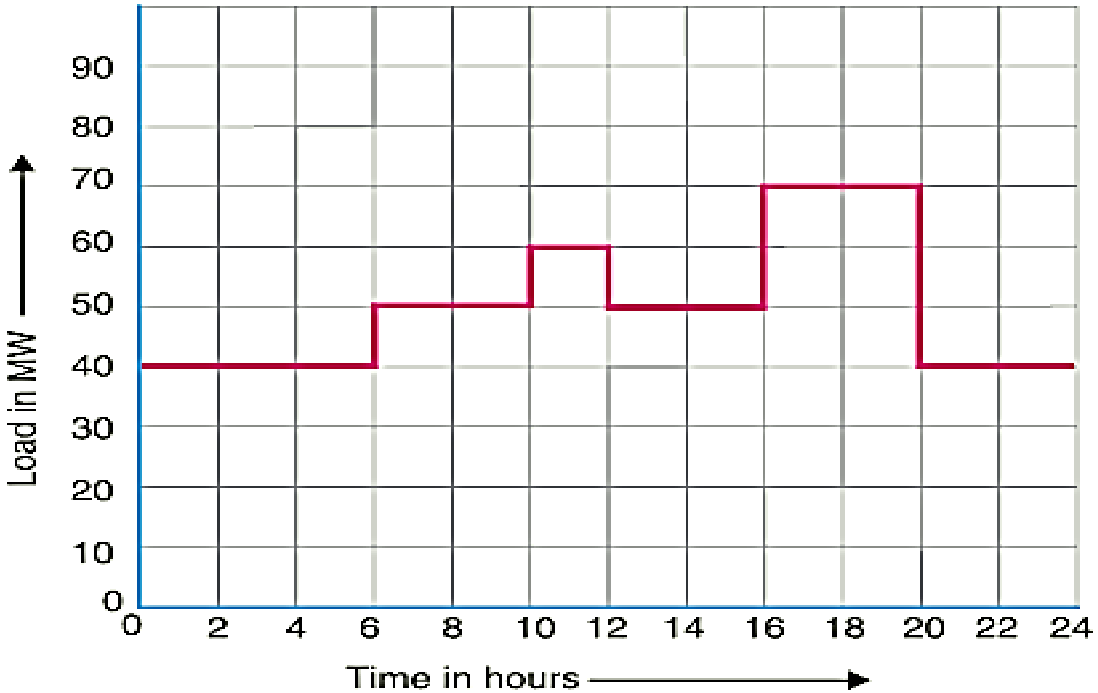
Time (Hours)	*0—6*	*6—10*	*10—12*	*12—16*	*16—20*	*20—24*
Load (M W)	*40*	*50*	*60*	*50*	*70*	*40*

Draw the load curve and find (i) maximum demand (ii) units generated per day (iii) average load and (iv) load factor.

Solution. Daily curve is drawn by taking the load along *Y*-axis and time along *X*-axis. For the given load cycle, the load curve is shown in Fig. 3.6.

(*i*) It is clear from the load curve that maximum demand on the power station is 70 MW and occurs during the period 16—20 hours.

∴ Maximum demand = **70 MW**



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(ii) Units generated/day = Area (in kWh) under the load curve

$$= 10^3\,[40 \times 6 + 50 \times 4 + 60 \times 2 + 50 \times 4 + 70 \times 4 + 40 \times 4]$$

$$= 10^3\,[240 + 200 + 120 + 200 + 280 + 160]\ \text{kWh}$$

$$= \mathbf{12 \times 10^5\ kWh}$$

(iii)

$$\text{Average load} = \frac{\text{Units generated / day}}{24\ \text{hours}} = \frac{12 \times 10^5}{24} = \mathbf{50{,}000\ kW}$$

(iv)

$$\text{Load factor} = \frac{\text{Average load}}{\text{Max. demand}} = \frac{50{,}000}{70 \times 10^3} = 0{\cdot}714 = \mathbf{71{\cdot}4\%}$$

Example *A power station has to meet the following demand :*

Group A : 200 kW between 8 A.M. and 6 P.M.

Group B : 100 kW between 6 A.M. and 10 A.M.

Group C : 50 kW between 6 A.M. and 10 A.M.

Group D : 100 kW between 10 A.M. and 6 P.M. and then between 6 P.M. and 6 A.M.

Plot the daily load curve and determine (i) diversity factor (ii) units generated per day (iii) load factor.

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Solution. The given load cycle can be tabulated as under :

Time (Hours)	0—6	6—8	8—10	10—18	18—24
Group A	—	—	200 kW	200 kW	—
Group B	—	100 kW	100 kW	—	—
Group C	—	50 kW	50 kW	—	—
Group D	100 kW	—	—	100 kW	100 kW
Total load on power station	100 kW	150 kW	350 kW	300 kW	100 kW

From this table, it is clear that total load on power station is 100 kW for 0—6 hours, 150 kW for 6—8 hours, 350 kW for 8—10 hours, 300 kW for 10—18 hours and 100 kW for 18—24 hours. Plotting the load on power station versus time, we get the daily load curve as shown in Fig. 3.7. It is clear from the curve that maximum demand on the station is 350 kW and occurs from 8 A.M. to 10 A. M. *i.e.*,

$$\text{Maximum demand} = 350 \text{ kW}$$

Sum of individual maximum demands of groups

$$= 200 + 100 + 50 + 100$$

$$= 450 \text{ kW}$$

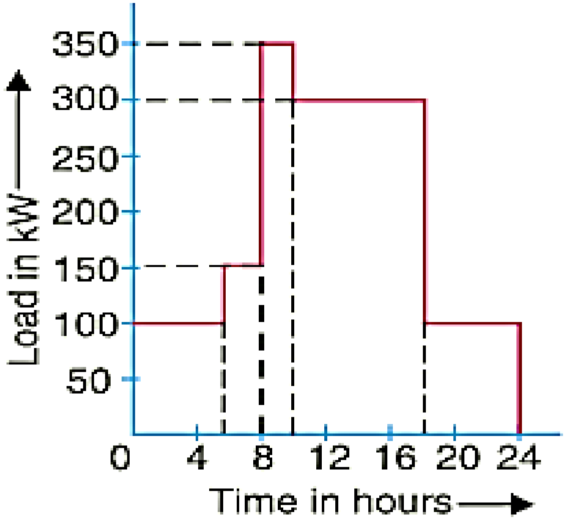

Fig. 3.7

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(*i*) Diversity factor $= \dfrac{\text{Sum of individual max. demands}}{\text{Max. demand on station}} = 450/350 = \mathbf{1{\cdot}286}$

(*ii*) Units generated/day = Area (in kWh) under load curve

$= 100 \times 6 + 150 \times 2 + 350 \times 2 + 300 \times 8 + 100 \times 6$

$= \mathbf{4600\ kWh}$

(*iii*) Average load $= 4600/24 = 191{\cdot}7$ kW

$\therefore$ Load factor $= \dfrac{191{\cdot}7}{350} \times 100 = \mathbf{54{\cdot}8\%}$

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Power Factor:

The power factor is the cosine of the angle between the voltage and the current in an a.c. circuit (cos φ).

In an a.c circuit, the current can be resolved into two components:

1. I cos φ in phase with V was known as an active or watchful component.

2. I sin φ 90° out of phase with V called reactive or wattles components. See Figure (3).

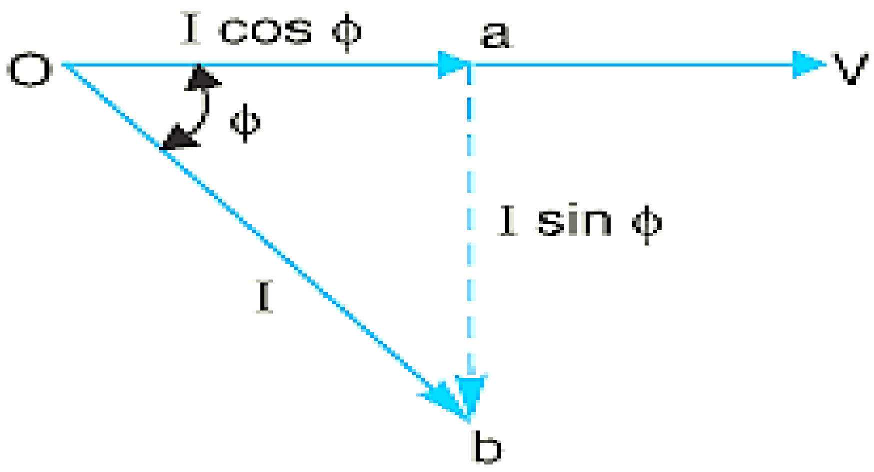

Figure (3)

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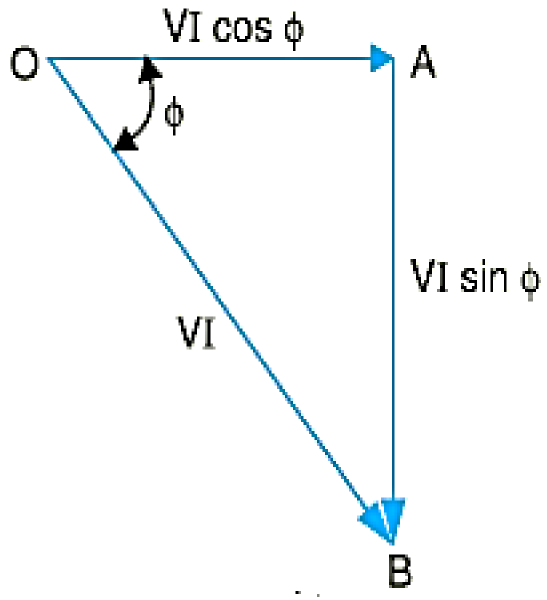
Power Triangle:

The analysis of power factor can also be made in terms of power drawn by the a.c. circuit. If each side of the current triangle *oab* of Fig. 6.1 is multiplied by voltage *V*, then we get the power triangle *OAB* shown in Fig. where



$OA = VI \cos\phi$ and represents the *active power* in watts or kW

$AB = VI \sin\phi$ and represents the *reactive power* in VAR or kVAR

$OB = VI$ and represents the *apparent power* in VA or kVA

The following points may be noted form the power triangle :

(*i*) The apparent power in an a.c. circuit has two components *viz.*, active and reactive power at right angles to each other.

$$OB^2 = OA^2 + AB^2$$

or $$(\text{apparent power})^2 = (\text{active power})^2 + (\text{reactive power})^2$$

or $$(\text{kVA})^2 = (\text{kW})^2 + (\text{kVAR})^2$$

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(ii) Power factor, $\cos\phi = \dfrac{OA}{OB} = \dfrac{\text{active power}}{\text{apparent power}} = \dfrac{\text{kW}}{\text{kVA}}$

Thus the power factor of a circuit may also be defined as the ratio of active power to the apparent power. This is a perfectly general definition and can be applied to all cases, whatever be the waveform.

(iii) The lagging* reactive power is responsible for the low power factor. It is clear from the power triangle that smaller the reactive power component, the higher is the power factor of the circuit.

$$\text{kVAR} = \text{kVA}\sin\phi = \frac{\text{kW}}{\cos\phi}\sin\phi$$

$$\therefore \quad \text{kVAR} = \text{kW}\tan\phi$$

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(*iv*) For leading currents, the power triangle becomes reversed. This fact provides a key to the power factor improvement. If a device taking leading reactive power (*e.g.* capacitor) is connected in parallel with the load, then the lagging reactive power of the load will be partly neutralised, thus improving the power factor of the load.

(*v*) The power factor of a circuit can be defined in one of the following three ways :

(*a*) Power factor $= \cos\phi =$ cosine of angle between V and I

(*b*) Power factor $= \dfrac{R}{Z} = \dfrac{\text{Resistance}}{\text{Impedance}}$

(*c*) Power factor $= \dfrac{VI\cos\phi}{VI} = \dfrac{\text{Active power}}{\text{Apparent Power}}$

(*vi*) The reactive power is neither consumed in the circuit nor it does any useful work. It merely flows back and forth in both directions in the circuit. A wattmeter does not measure reactive power.

Thanks