EFFECT OF VARIABLE LOAD ON ELECTRICAL NETWORKS

Sharobiddinov Mirzokhid Shakhobiddin ugli [1]
Eshquziev Khurshidjon Musajonovich [2]
Zoxidov Iqboljon Zokirjonovich [3]
[1] Ferghana polytechnic institute, Republic of Uzbekistan, mirzohidsharobiddinov2@gmail.com
[2] Institute of Energy Problems of the Academy of Sciences of the Republic of Uzbekistan, great93@umail.uz
[3] Ferghana polytechnic institute, Republic of Uzbekistan, yoturk1986@gmail.com
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Abstract Today's system operators face the big challenge of constructing simulation of systems that make efficient select of generation resources under variable load profiles. This paper describes the effect of maximum loads generated by various electricity consumers on electric networks is studied. Recently, the demand for energy consumption and their types, situations in the graph of loads, methods of eliminating the maximum points have been studied. The effect of alternating loads on the quality of electricity and low-voltage devices is discussed. In order to solve this problem rural property and population consumption have a positive effect on lowering loads on power grids during peak load times using more alternative energy sources.

Keywords - Electrical energy, Power System Analysis, power station, load profile, Structure of Electric Power System, variable load, transformers.

Introduction

The function of an electric power system is to connect the power station to the consumers' loads The power demanded by the consumers is supplied by the power station through the transmission and distribution networks. As the consumers' load demand changes, the power supply by the power station changes accordingly. A power station is designed to meet the load requirements of the consumers. An ideal load on the station, from standpoint of equipment needed and operating routine, would be one of constant magnitude and steady duration. However, such a steady load on the station is never realized in actual practice. The consumers require their small or large block of power in accordance with the demands of their activities. Thus the load demand of one consumer at any time may be different from that of the other consumer. The result is that load on the power station varies from time to time [1].

Effects of variable load. The variable load on a power station introduces many perplexities in its operation. Some of the important effects of variable load on a power station are:

Need of additional equipment. The variable load on a power station necessitates to have additional equipment. By way of illustration, consider a steam power station. Air, coal and water are the raw materials for this plant. In order to produce variable power, the supply of these materials will be required to be varied correspondingly [2, 3]. For instance, if the power demand on the plant increases, it must be followed by the increased flow of coal, air and water to the boiler in order to meet the increased demand. Therefore, additional equipment has to be installed to accomplish this job. As a matter of fact, in a modern power plant, there is much equipment devoted entirely to adjust the rates of supply of raw materials in accordance with the power demand made on the plant [4].

Increase in production cost. The variable load on the plant increases the cost of the production of electrical energy. An alternator operates at maximum efficiency near its rated capacity. If a single alternator is used, it will have poor efficiency during periods of light loads on the plant. Therefore, in actual practice, a number of alternators of different capacities are installed so that most of the alternators can be operated at nearly full load capacity. However, the use of a number of generating units increases the initial cost per kW of the plant capacity as well as floor area required. This leads to the increase in production cost of energy.

The load on a power station is never constant; it varies from time to time. These load variations during the whole day (i.e.,24 hours) are recorded half-hourly or hourly and are plotted against time on the graph. The curve thus obtained is known as daily load curves it shows the variations of load time during the day. Fig.1. shows a typical daily load curve of a power station. It is clear that load on the power station is varying, being maximum at 6 P.M. in this case. It may be seen that load curve indicates at a glance the general character of the load that is being imposed on the plant. Such as clear representation cannot be obtained from tabulated figures. The monthly load curve can be obtained from the daily load curves of that month. For this purpose, average*values of power over a month at different times of the day are calculated and then plotted on the graph. The monthly load curve is generally used to fix the rates of energy. The yearly load curve is obtained by considering the monthly load curves of that particular year. The yearly load curve is generally used to determine the annual load factor [5, 6].

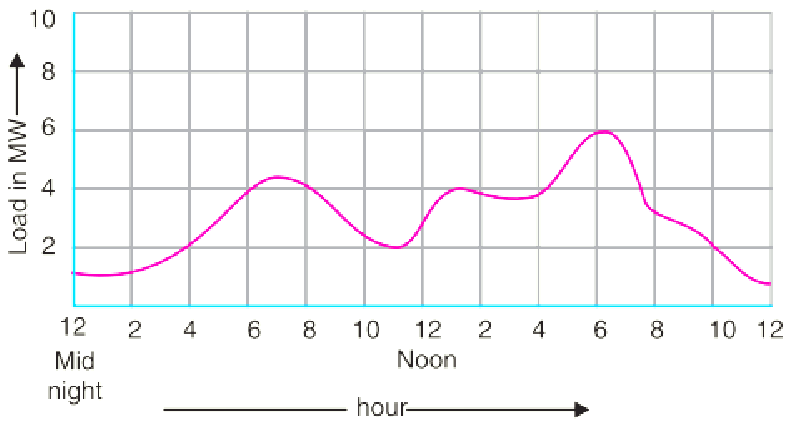

Fig.1. Shows a typical daily load curve of a power station.

Importance. The daily load curves have attained a great importance in generation as they supply the following information readily:

(i) The daily load curve shows the variations of load on the power station during different hours of the day.

(ii) (ii) The area under the daily load curve gives the number of units generated in the day. Units generated/day = Area (in kWh) under daily load curve.

(iii) (iii) The highest point on the daily load curve represents the maximum demand on the station on that day.

(iv) (iv) The area under the daily load curve divided by the total number of hours gives the average load on the station in the day.

$$\text{Average load} = \frac{\text{Area (in kWh)under daily load curve}}{24 \text{ hours}}$$

The ratio of the area under the load curve to the total area of rectangle in which it is contained gives the load factor

$$\text{Load factor} = \frac{\text{Average load}}{Max.demand} = \frac{\text{Average load}*24}{Max.demand*24} = \frac{\text{Area (in kWh) under daily load curve}}{Total\ area\ of\ rectangle\ in\ which\ the\ load\ curve\ is\ contained}$$

TYPICAL DEMAND FACTORS

Type of consumer		Demand factor
Residence lighting	$\frac{1}{4}$ kW	1·00
	$\frac{1}{2}$ kW	0·60
	Over 1 kW	0·50
Commercial lighting	Restaurants	0·70
	Theatres	0·60
	Hotels	0·50
	Schools	0·55
	Small industry	0·60
	Store	0·70
General power service	0–10 H.P.	0·75
	10–20 H.P.	0·65
	20–100 H.P.	0·55
	Over 100 H.P.	0·50

TYPICAL DIVERSITY FACTORS

	Residential lighting	*Commercial lighting*	*General power supply*
Between consumers	3 – 4	1·5	1·5
Between transformers	1·3	1·3	1·3
Between feeders	1·2	1·2	1·2
Between substations	1·1	1·1	1·1

Fig.2. Shows a small part of electric power system.

Load and demand factors are always less than 1 while diversity factors are more than unity. High load and diversity factors are the desirable qualities of the power system. Indeed, these factors are used to predict the load. Fig. 2 shows a small part of electric power system where a distribution transformer is supplying power to the consumers. For simplicity, only three consumers a, b, and care shown in the figure. The maximum demand of consumer ais the product of its connected load and the appropriate demand factor. Same is the case for consumers band c. The maximum demand on the transformer is the sum of a, band c's maximum demands divided by the diversity factors between the consumers. Similarly, the maximum demand on the feeder is the sum of maximum demands on the distribution transformers connected to it divided by the diversity factor between transformers. Like wise

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diversification between feeders is recognized when obtaining substation maximum demands and substation diversification when predicting maximum load on the power station. Note that diversity factor is the sum of the individual maximum demands of the subdivisions of a system taken as they may occur during the daily cycle divided by the maximum simultaneous demand of the system. The "system" may be a group of consumers served by a certain transformer, a group of transformers served by a feeder etc. Since individual variations have diminishing effect as one goes farther from the ultimate consumer in making measurements, one should expect decreasing numerical values of diversity factor as the power plant end of the system is approached. This is clear from the above table showing diversity factors between different elements of the power system [7].

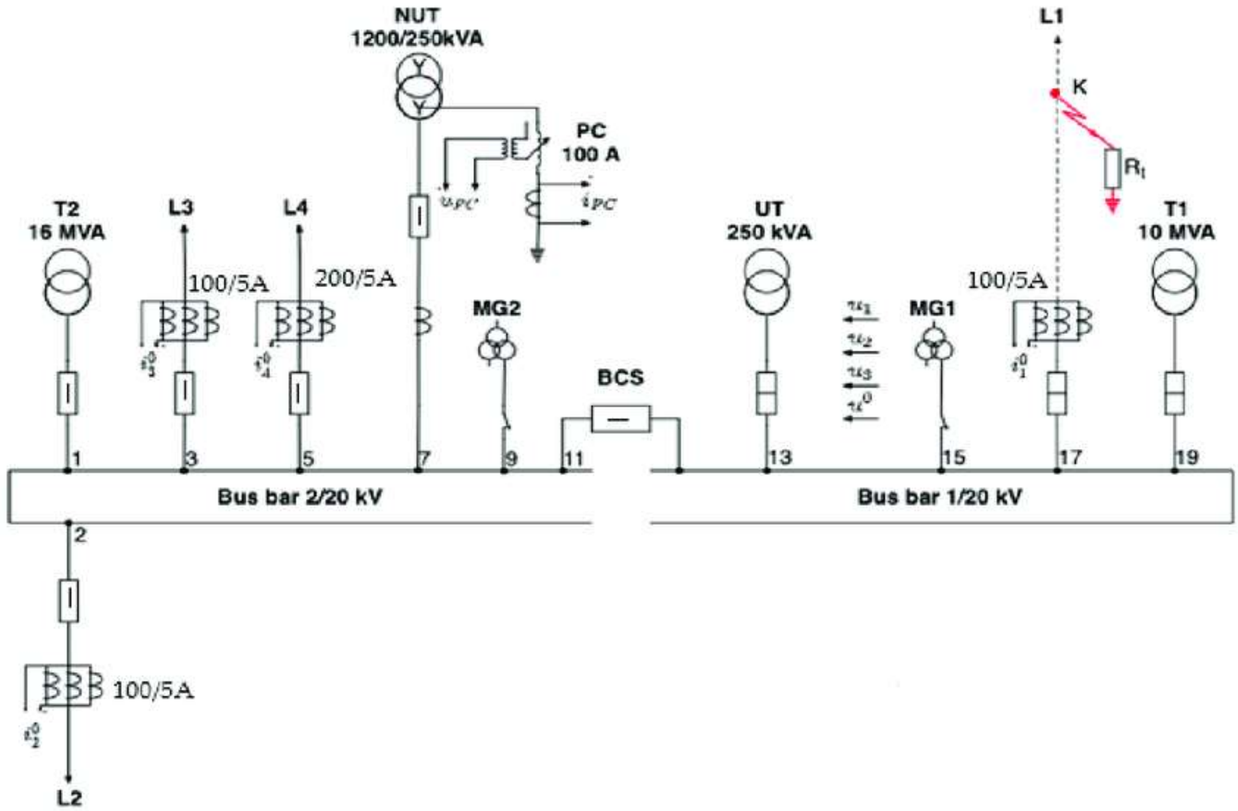

Fig. 3. The annual load curve of the station is shown.

Illustration. The principle of selection of number and sizes of generating units with the help of load curve is illustrated in Fig. 4. the annual load curve of the station is shown. It is clear form the curve that load on the station has wide variations; the minimum load being somewhat near 50 kW and maximum load reaching the value of 500 kW. It hardly needs any mention that use of a single unit to meet this varying load will be highly uneconomical.

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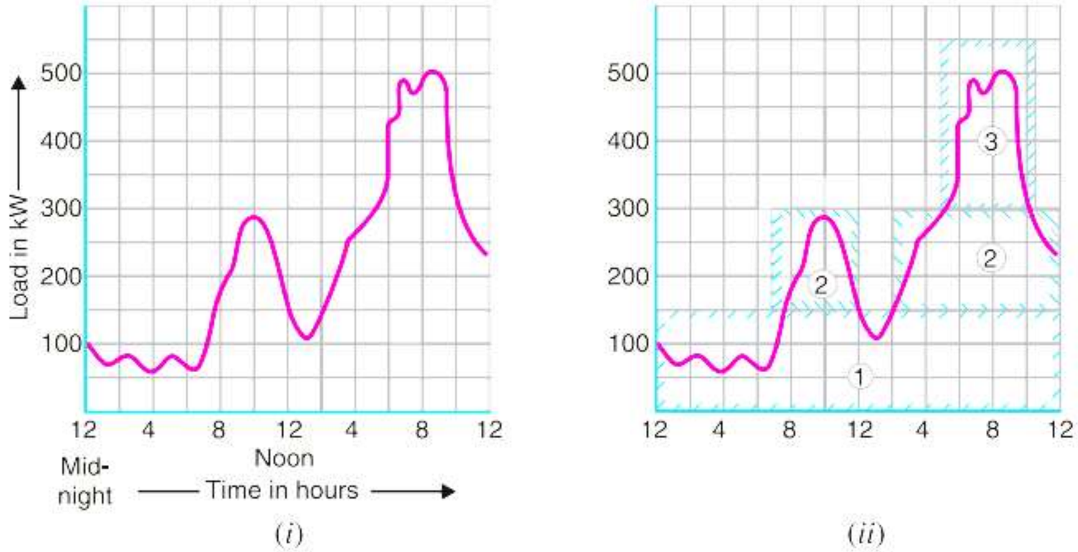

Fig. 4. The annual load curve of the station is shown.

As discussed earlier, the total plant capacity is divided into several generating units of different sizes to fit the load curve. This is illustrated in Fig. 4 (ii) where the plant capacity is divided into three units numbered as 1, 2 and 3. The cyan colour outline shows the units capacity being used. The three units employed have different capacities and are used according to the demand on the station. In this case, the operating schedule can be as under:

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.

Thus by selecting the proper number and sizes of units, the generating units can be made to operate near maximum efficiency. This results in the overall reduction in the cost of production of electrical energy [8].

Conclusion

Today, the bulk of electricity consumers are industrial, agricultural and population consumers. The fact that these consumers are supplied with electricity is seasonally and unevenly located on the load graph creates a variable load on electrical networks and leads to a violation of the quality of electricity. And the use of alternative energy sources during maximum loads is one of the optimal solutions to the problem [9-19]. For example, rural property and population consumption have a positive effect on lowering loads on power grids during peak load times using more alternative energy sources.

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