Power supply of industrial enterprises

Laboratory work

Study of electrical load diagrams and their characteristics

The objective of the work is

- to study main methods of electrical load diagram plotting;
- to study characteristics of electrical load diagram.

After execution of work student should

- know: how to plot individual and group load diagram; what is demand factor, load factor, coefficient of use, power factor, coefficient of maximum, coefficient of filling of the diagram and so on;
- be able: to calculate characteristics of electrical load diagram; to plot shift electrical load diagram according to electric meter registrations.

Load values are one of the most important characteristics that should be taken into account in designing of electric power systems.

Electrical load characterize power consumption by a singular energy receiver or group of them or by a field or a whole enterprise. Mainly as an electrical load active power, reactive power and current values are used.

Types of maximum demand loads:

- maximal continuous loads. The highest probabilistic load during 30 min is the **calculated (rated) load**. It is used for selection of equipment according to heating and for maximal losses calculation.
- maximal stand by loads. It is **peak loads**. They are used to select cut-off operation, to calculate voltage losses and voltage fluctuations.

Graphical representation of a change in time of the load values is an electrical load diagram (example is shown in Fig. 1).

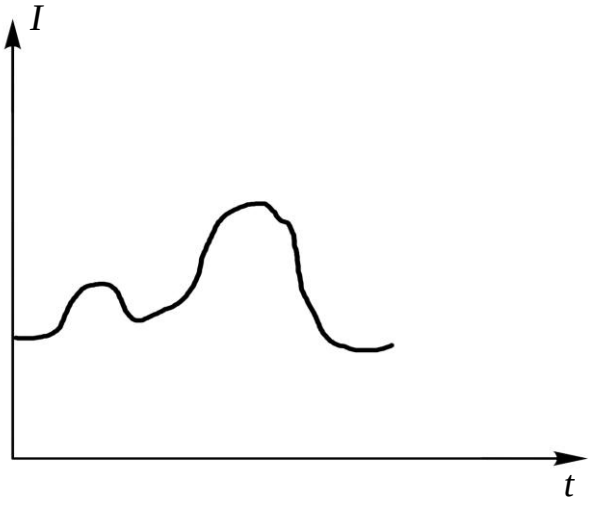

Figure 1. Current load diagram

Usually electrical load diagram is a stepwise diagram with time step 30 min as shown on Fig. 2. Diagram could be composed for a working shift, week, month, year or another working period of equipment.

For more convenient processing of data load diagrams often are being ordered as represented on Fig. 3.

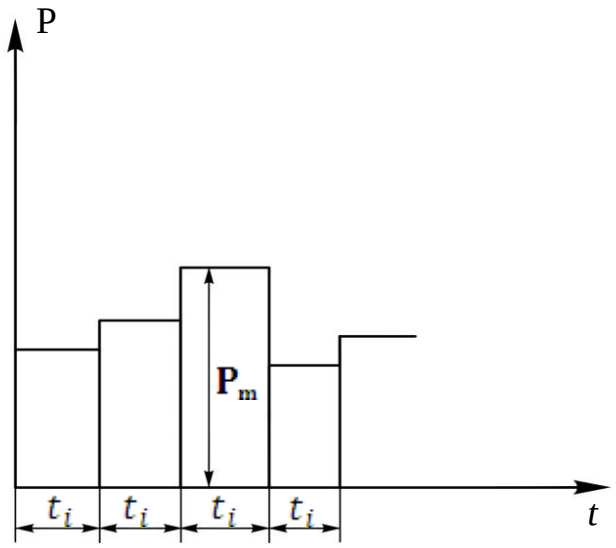

Figure 2. Stepwise load diagram

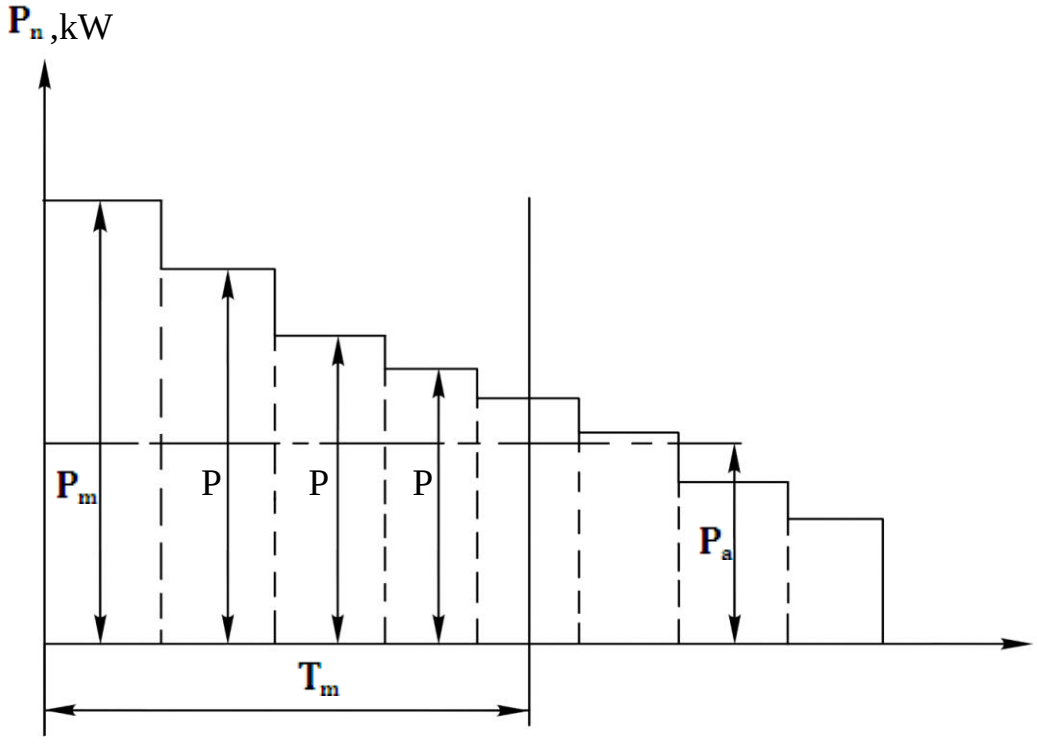

Figure 3. Ordered load diagram

Plan

1. Measure parameters of active and reactive power consumption according to Table 1. Duration of each measurement is 1,5 min.

2. Calculate quantity of electricity supply meter turns during rated period 30 min:

$n_{w30} = 20 n_w$,

$n_{v30} = 20 n_v$.

where n_W, n_V – quantity of active and reactive energy meter turns.

Active energy consumption:

$$W = \frac{K_{CT} \cdot K_{VT}}{800} n_{W30}, \text{ kWh,}$$

reactive energy consumption:

$$V = \frac{K_{CT} \cdot K_{VT}}{800} n_{V30}, \text{ kvarh,}$$

where K_{CT}, K_{VT} – transformation coefficients for current transformer and voltage transformer are given by lecturer individually.

Table 1. Presentation of results of experiments and calculations

№	Active power				Reactive power			
	Quantity of electricity supply meter turns (fact)	Quantity of electricity supply meter turns during rated period (30 min)	Active energy consumption	Active power	Quantity of electricity supply meter turns (fact)	Quantity of electricity supply meter turns during rated period (30 min)	Reactive energy consumption	Reactive power
	n_w	n_{w30}	W, kWh	P, kW	n_v	n_{v30}	V, kvarh	Q, kvar
1								
2								
3								
4								
…								
16								

3. Calculate consumption of active power:

$$P = \frac{W}{T}, \text{ kW,}$$

where T – duration of power consumption measurement (30 min), h.

4. To calculate consumption of reactive power:

$$Q = \frac{V}{T}, \text{ kvar.}$$

5. Plot diagrams of active and reactive load for a shift.

6. Define quantity of hours of operation with maximal load:

$$T_M = \frac{\sum(P_i t_i)}{P_{\max}} = \frac{\sum(P_i T)}{P_{\max}},$$

where P_{max} – maximal value of active power within measurements, kW.

7. Define coefficient of filling of the diagram:

$$K_{f.d.} = \frac{\sum(P_i T)}{P_{\max} T_{shift}},$$

where T_{shift} – duration of the shift, h.

8. Calculate average load:

$$P_a = \frac{\sum(P_i T)}{T_{shift}}.$$

9. Calculate coefficient of maximum:

$$K_M = \frac{P_{\max}}{P_a}.$$

10. Repeat items 6 – 9 for reactive power.

11. Define power factor:

$$\cos\varphi = \frac{P_a}{\sqrt{P_a{}^2 + Q_a{}^2}}.$$

12. Define reactive power factor:

$$tg\varphi = \frac{Q_a}{P_a}.$$

13. Calculate coefficient of use:

$$K_u = \frac{P_a}{P_{nom}},$$

where P_{nom} – nominal (rated) capacity of power consumer is given by lecturer individually, kW.

14. Calculate demand factor:

$$D = \frac{P_{\max}}{P_{nom}} = K_M K_u .$$

15. Plot diagram of irregular loads with the same value of average power consumption for active and reactive power (summary value of power should be the same).

16. Repeat items 6 – 14 for irregular loads.

17. To analyze results of experiments and calculations, make conclusions about effect of operational duty (continuous or intermittent, regular or irregular) on characteristic coefficients of load diagrams.

Report contents

Title, objective, table with results of measurements and calculations, regular and irregular diagrams of active and reactive load, calculation of characteristic coefficients for diagrams, conclusions.

Quiz

1. The purpose of load calculations.
2. What kinds of loads diagrams are usually used?
3. What coefficients characterize load diagrams?
4. How do quantity of hours of operation with maximal load and coefficient of filling of the diagram change according to regularity of load diagram?
5. What kinds of loads are calculated and what for?
6. What coefficient of use and demand factor characterize?
7. How does operational duty of consumers effect on coefficients of load diagrams?

Further reading

1. Handbook of Electrical Engineering: For Practitioners in the Oil, Gas and Petrochemical Industry. Alan L. Sheldrake © 2003 John Wiley & Sons, Ltd ISBN: 0-471-49631-6.
2. Power systems / editor, Leonard Lee Grigsby. 2007 by Taylor & Francis Group, LLC. ISBN-13: 978-0-8493-9288-7.
3. Методичні рекомендації для виконання лабораторної роботи ЕГР – 1 «Дослідження графіків електричних навантажень»
4. Справочник по электроснабжению и электрооборудованию. / Под ред. А.А. Федорова. – М.: Энергоатомиздат, 1986. – 508 с.

5. Федоров А.А., Старкова Л.Е. Учебное пособие для курсового и дипломного проектирования по электроснабжению промышленных предприятий: Учеб. пособие для вузов. – М.: Энергоатомиздат, 1987. – 368 с.