Energy System Calculation of Automobile Plant Supplying from 200MW Thermal Power Centre

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Abstract – This article presents energy system calculation of automobile plant supplying from thermal power center (TPC) with certain strength. The purpose of this calculation is correct selection of the energy system equipment according to the given parameters of the plant and preparing the electric supplying scheme of the plant. The power supplying TPC is such a kind of electric power stations that produces not only electric energy, but also, heat energy for the inner part of the plant. From this point of view, the coefficient of efficiency of such stations is more than 80%.

Produced electric power is supposed to be transferred to industry establishments, distributed and used with high economy and effectiveness. Correct structure of the electric supplying system in industry establishments has great importance in providing the necessary capacity and relevant quality of electric energy to industry objects, mountings, devices and mechanisms by the power systems.

The calculation of the electric loads of the plant and the ways of choosing efficient voltage of the supply net are represented in this article.

The article provides information about location of the main step-down substation (MSDSS) in the plant territory that are used for lowering the voltage from step-up sub-station and conveying it to the consumers, its constructive structure and choosing the number, power and types of transformers for placing within it.

It is impossible to imagine power supply schemes without conductive electric lines and cables.

Choosing of electric transmission lines, switchgears for opening and closing circuit and types of protecting apparatuses relevant to the calculated short circuit current are given here.

In former times, it was not possible to analyze the power supply scheme before the scheme construction; with the help of available new software, it is possible now. From this point of view, ETAP program was used and it is more effective for the analysis of the schemes.

Index Terms: Calculation of energy systems, ETAP, Design of protection system, reliability of the supply system, short circuit currents.

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I. INTRUDUCTION

Electric power supply system of the industry objects consists of voltage nets below and higher than 1000V; it plays the role of conveying electric power from the source to the consumers in the volume and quality relevant to the demands of the production, with various frequency and voltage, with one and three-phase alternating and direct current.

Electric power supply system consists of the collection of devices necessary for production, transmission and distribution of the electric energy.

Electric mountings of the consumers of electric energy have specific features. They must meet definite requirements: reliable supply, quality of the electric power, keeping some elements in the reserve, safety conditions etc. Reliability of the electric supply scheme means the scheme that makes possible non-stop supply of all electric receivers.

An interval in the electric power supply can cause great damage to the national economy. Sometimes, it can cause even death of a man. When calculating, it is necessary to take into consideration all the above said, especially, the electric arc ovens in the territory of a plant influencing the quality of the electric energy.

II. THEORETICAL PART

According to the need of reliability of the electric supply system, electric equipment is divided into three categories. For the first category consumers, if there is an interval in electric power supply, a pause can occur in the difficult technological process, expensive equipment can be broken, mass products can be damaged during the production time. For consumers under category two, the importance of electric power supply differs from the consumers of the first category very little. A break in energy supply for this group of consumers can be permitted by personnel or automatically, whereas connecting to the reserve. In general, the consumers under this category should be considered the same as the consumers under the first category. The third category consumers include all the rest consumers; an energy supply break can long only 24 hours. According to the rules of setting electric installations, for the first category electric power consumers, not less than two supply sources are intended [1].

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For a group of consumers or just a consumer, a supply source is considered independent, if during the conditions after an accident, in comparison to the normal work voltage, in case when the consumers' other supply voltage is none, its voltage is not more than five percent.

Two-section buses or systems of one or two electric power station and substation are related to the source of independent supply, so the following conditions are fulfilled at the same time:

1) In its turn, each section bus or section system has two independent sources;
2) Section buses are connected between themselves, but if there is a break in normal work, it cuts this connection automatically [2].

For providing reliability of the scheme, electric power supply scheme has two sections. This principle is taken into account whereas choosing main step-down substation and department transformer substations. The first stage of the project of the power supply system consists of calculating the electric load. When electric power supply system is designed and exploited, special attention must be paid to the following problems: electric load defining, correctly choosing voltage, and correctly choosing the number and the power of the transformers, compensation of reactive power, choosing high voltage equipment. Implementing all the above said, the main plan of the plant (Fig 1), type and power of the departments and equipment located in them were used as initial data.

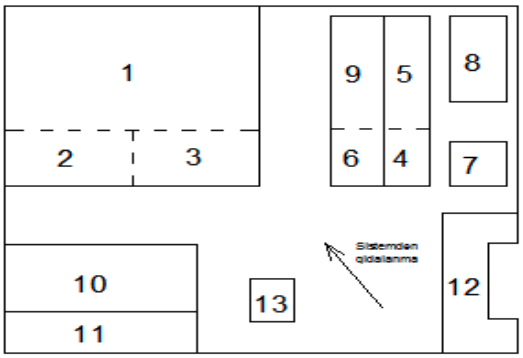

Fig 1. Main plan of the plant

III. RESULTS AND DISSCUSION

Calculations carried out in this part of the article, their methods and obtained results have been presented.

Electric load defining: In the nets of voltage below and higher than 1000 volts, for specifying calculated loads of separate consumers groups' and units at the departments, regulated diagrams method is used, as this method has less errors [3].

According to the plant's main plan (Fig 1), areas of the departments are specified and power of the lightening is defined for each department. Electric load calculation of the plant is done separately for 0.4kV and 10 kV nets. As we know, synchronous motors have capacity of giving some reactive power to the system. Therefore, when calculating reactive powers of the synchronous motors placed in the compressor-room of the plant, obtained power is taken into account with negative sign. This task has great importance whereas calculating reactive power compensation. Taking into account active and reactive powers of the department, calculated full power of the plant is specified by defining the lighting power of the plant area, power loss in transformers in the department substations and MSDSS and compensated reactive power. Specified power is 26MW.

Choosing supply voltage and transformers: Choosing of relevant power of the electric power system of supply of the industry establishments and transformers should be done too. Electric equipment of the sub-stations and nets, capital investment, usage of non-ferrous metals, electric energy expenditure and exploitation expenses are defined according to the tension value.

Dependence of capital investment and exploitation expenses from the voltage curves are worked out and according to these curves, voltage is chosen on the basis of maximal capital investment and exploitation expenses.

Therefore, chosen for this plant tension is 110kV for providing supply from TPC to MSDSS, and for providing supply from MSDSS to the department transformer substations – 10 kV.

Transformers for the MSDSS are chosen according to the calculated loads of normal regime. Often, in installed for industry plants MSDSSs there are two transformers. In an accident regime, if one of the transformers is broken, all consumers will continue getting energy supply from the working second transformer. In this case, for preventing the overload of the working transformer more than allowed norm, opening of some of the less important consumers is allowed.

Choosing department transformers' substations can be implemented in similar way. But not only the calculation, but also location of the departments within the plant should be considered and several departments should be supplied from one substation and thus, it is possible to purchase economically efficient number of substations. MSDSS's constructive structure is shown on Fig 2.

Reactive power compensation: VAR compensation is defined as the management of reactive power to improve the performance of power systems. The concept of VAR compensation embraces a wide and diverse field of both system and customer problems, especially related with power quality problems, since most of power quality problems can be attenuated or solved with an adequate control of reactive power. Our purpose in compensating reactive power is diminishing of the energy losses of the system of electric power supply and raising the efficiency of the work of the electric devices. As compensation devices, condenser batteries or synchronous compensators could be used. However, in recent years, static VAR compensators employing thyristor switched capacitors and thyristor controlled reactors to provide or absorb the required reactive power have been developed. In our case for this purpose, as a compensation device, condenser batteries were used.

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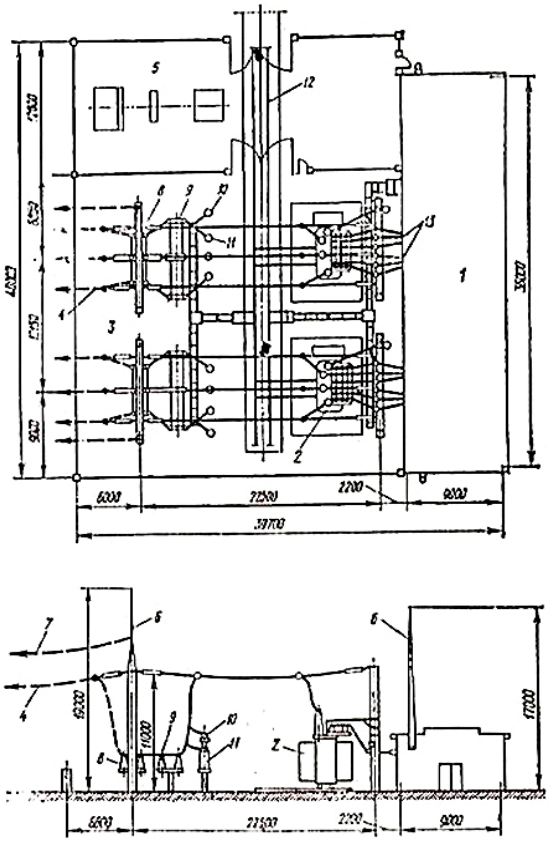

Fig 2: MSDSS's constructive structure.

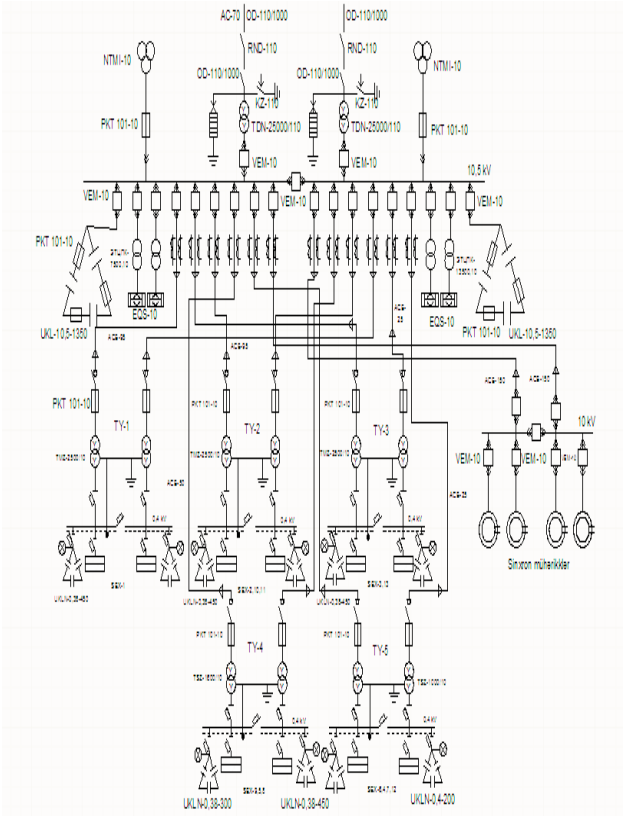

Fig 3. Electric power supply scheme of the plant.

Choosing transmission lines and cables: Conveying electric energy from supply source to consumer's point is implemented via air and cable lines. Cross-section of the wire and cable is chosen according to technical and economic conditions. Technical conditions include heating of the cross-section due to calculated current, mechanical durability, heating due to the heat of short circuit current, intense caused by the work of normal and emergency regimes. Economic conditions rely to the choice of a cross-section with minimal installation expenses. Referred to these conditions and results of cross-section calculations for each department substation transmission lines and cables were chose. [1]

Electric power supply scheme of the plant: By carrying out the above mentioned calculations, electric power supply scheme of the plant has been set [3] (Fig 3).

This scheme describes department substations and the departments supplying form them, electric apparatuses and their connection order, type of all used elements, reactive power compensation elements and supplying of high voltage equipments located at special departments of the plant from the main bus.

Estimation of the short circuit currents: Principal cause of the electric power supply system's regime breach is damaging of the isolation or wrong actions of the working team. In the result, short circuit current occurs in the net or in the elements of the electric equipment. In order to diminish the loss of equipment breach in the result of internal flowing of short circuit currents and also, to quickly restoring electric supply system's normal regime, it is important to correctly define the short circuit currents and on that basis, to choose electric equipment, protective devices and methods of limiting short circuit currents. If short circuit happens, currents in electric supply system or electric installation's phases are increased in comparing to the normal regime indexes. In its turn, this causes the voltage diminish in the system, especially in the places near the points of the short circuit [4].

For the estimation of short circuit currents in a system relative units method were used. A simplified scheme used for the short circuit currents calculation is shown below (Fig 4 & 5). These figures appeared from the main electric supply scheme of the plant and describes only these equipment and apparatuses which is directly affect short circuit current. Every item of these schemes has their own inductive resistance estimated by special formulas [1], [7].

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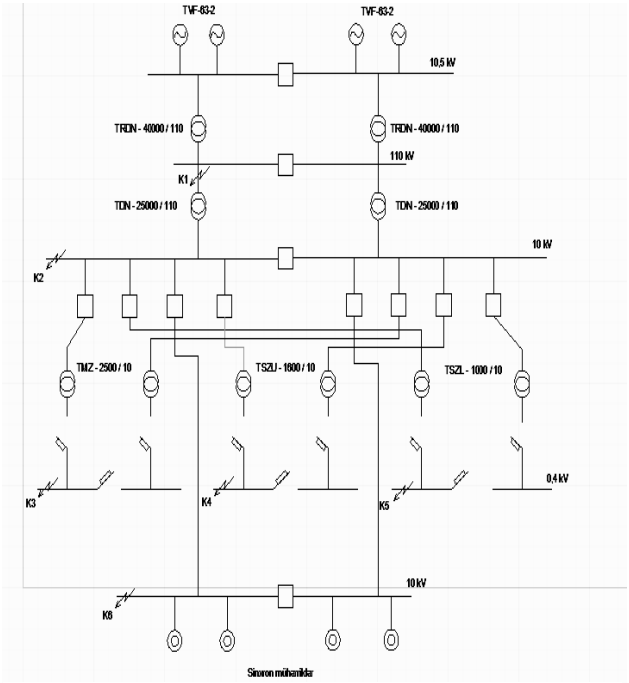

Fig 4. A simplified scheme used for the short circuit currents calculation

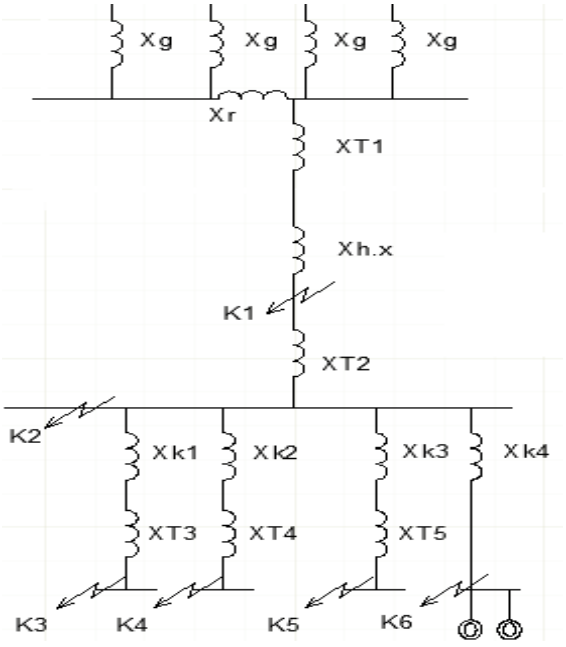

Fig 5. Substitution scheme used for short-circuit currents calculation

Choosing high voltage apparatuses: High voltage apparatuses include disconnectors, isolated distances, switches, circuit breakers, fuses etc. Every device has its own electrical characteristics like peak current, breaking current, opening time, closing time, breaking capacity etc. which help to choose useful one for current proposes.

Choosing high voltage apparatuses is carried out according to three regimes of the exploitation condition: long-term, overloaded and short circuit regimes.

Reliable work of the apparatuses is provided by correctly choosing them according to the rated voltage and rated current in the long-term regime.

In overloaded regime, reliable work of the apparatuses is obtained by restricting the period of the voltage and current values' influence, due to the durability reserve calculation.

In the regime of short circuit, reliable work of the electric apparatuses is provided by choosing devices relevant thermic and electrodynamics durability conditions. High voltage apparatuses are chosen, according to conditions of the recorded values of short circuit currents [5].

Choosing devices of relay maintenance and automation: A relay is automatic device which senses an abnormal condition of electrical circuit and closes its contacts. These contacts in turns close and complete the circuit breaker trip coil circuit hence make the circuit breaker tripped for disconnecting the faulty portion of the electrical circuit from rest of the healthy circuit.

Some of the elements of the system of electric power supply get damaged in the time of exploitation. For air and cable lines are long, they undergone different kinds of damages [6].

Inter-phase and inter-coil short circuits in the transformers also need protection. For this purpose, transformers with special construction in the cable lines are used and maximal current protection is obtained; in transformers, differential length protection is used. Pictures of the used protection schemes are given bellow (Fig 6), (Fig 7):

ETAP program usage: ETAP is a computer program created for direct and alternating current circuit analysis. ETAP is used by engineers in thousands of companies for design, analysis, and exploitation experience of the systems of electric power supply and for carrying out different operations on schemes.

Whereas this article was prepared, ETAP program was used for checking the results of different carried out calculations.

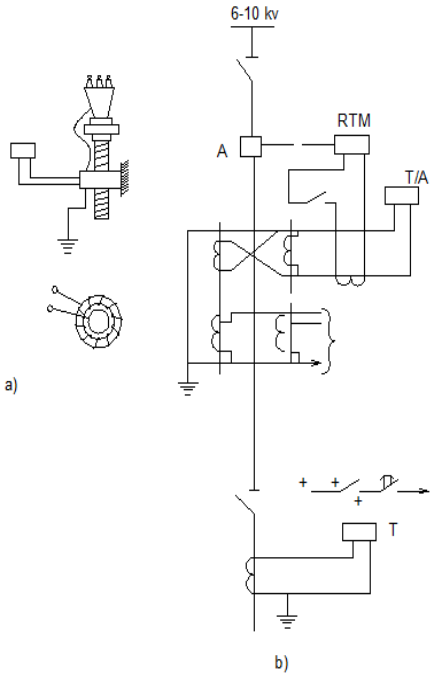

Fig 6. Cable's protection

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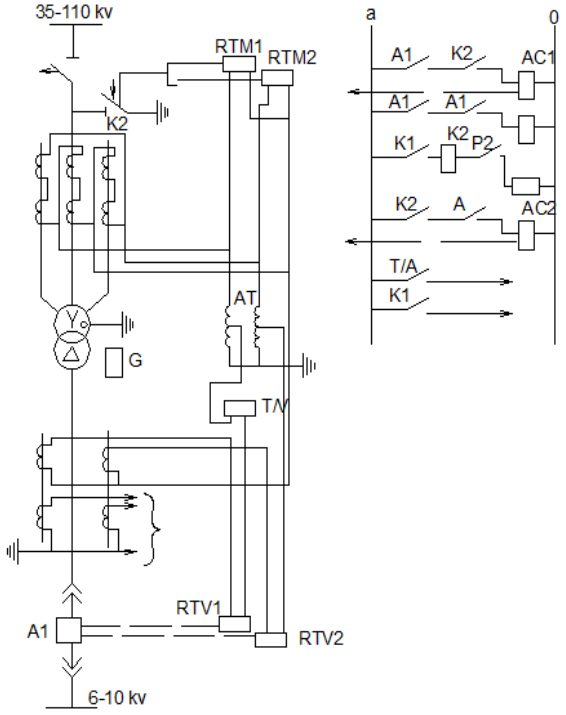

Fig 7. Constructive system of the MSDSS

IV. CONCLUSION

When designing industry establishments' scheme of electric power supply, it is necessary to take into account the problem of electric power supply complex from the general supply center of another establishments in the same region.

As it was mentioned in discussions regulated diagrams method is used for the estimation of load, as this method has less errors. Other methods like static method, survey coefficient, coefficient of maximum etc. are not as effective as used method in this article. All mentioned methods have approximate results which are useful for special departments of the plant only.

Electric power supply scheme of automobile plant (Fig 3) was made according to the rules of installation of electric mountings. For the first category consumers inside of the plant, as two independent supply sources, TPC's two generators' different section buses or section buses of connected to different sources two transformers could be used.

In accordance with the demands, electric power supply scheme was made 3 stepped. Supply of the plant is realized via two air-lines of 110 kV coming from TPC's step-up substation located on 4km distance. Main step-down substation (MSDSS) was constructed in the plant. In MSDSS buses, section key was provided by ARC scheme. Instead of high voltage key, a separator and short-circuit switchgear were put in the 110kV lines side of the MSDSS; this increases the reliability of this scheme. The department in the plant territory is supplied from buses of the MSDSS's radial transformer substations. As an option instead of radial supply scheme main arterial supply scheme could be used. The advantage of radial supply scheme is its easiness in exploitation. In case maintenance in one substation, it does not affect to others stable work [3].

The main equipment of the electric power supply scheme was protected; this increased the reliability of this scheme and made it more fit for exploitation.

REFERENCES:

[1] B.Y. Lipkin "Electric supplying of industrial enterprise mountings" Publication, Baku, 1985
[2] A.A. Fedorov, Q.V. Seqbinskiy; "The questionnaire for electric power supply of industrial enterprises". Proceding1 and Proceeding 2, Moscow, 1973
[3] T.Sh. Huseynov "Design of electric supply systems" , Publication, Baku, 2005
[4] A.A. Federov, P.E.Starkova, "Textbook for diploma and cours projects" Publication, Moscow, 1987
[5] B.N Neklepayev, I.P.Kryuchkov "Electrical part of power plants" (the questionnaire for diploma projects design) Moscow, 1989
[6] R.V. Babayev, N.S. Akhundov , T.Sh. Huseynov, "Guidelines and instructions for the implementation of power supply works" Publication, Baku, 2002
[7] E.H. Suleymanli, V.A. Kalantarov "Electrical system commutation proces" Publication, Baku, 2009

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