

Intelligent Active-adaptive Power System of Industrial Enterprises

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Abstract

Intelligent active-adaptive power system of industrial enterprises is presented in this paper. The main elements of this system and active-adaptive principle of interaction between them are detected. The functional assignment of each element of proposed intelligent active-adaptive power system are described. The basic structure and control arrangement of proposed intelligent active-adaptive power system are presented and justified. The influence of proposed intelligent active-adaptive power system on the level of energy saving and efficiency are shown. The practical application of some main elements of proposed intelligent active-adaptive power system are described.

Index Terms: Intelligent, Active, Adaptive, Active-adaptive, Power system.

I. INTRODUCTION

One of the basic Russian Federation energy resources consumers are industrial enterprises especially mineral-raw enterprises. Mineral-raw production complexes are simultaneously supplied from several power systems of Russian Federation. Under the technological condition a number of consumers excludes the interruption of supply during 0.15 second and less. Energy consumers includes fair quantity of installations which can be used for controllable load and taking part in energy consumption control. In addition the wide spread occurrence of alternative energy sources in mineral-raw complexes is typical, which causes the ability of energy fluxes multidirectional movement. Mineral-raw enterprises are equipped of network protection and automatic devices, which allows to produce the automatic standby activation and structuring of electrical networks by means of automatic sectioning devices.

However the existing schematic and technical decisions don't ensure properly the using of latest technical abilities of intelligent power systems and their control and monitoring. Existing energy technologies don't allow to raise power efficiency of mineral-raw enterprises and power supply companies. It must also includes more effective control of electrical energy fluxes at the expense of exchange and control of information about operating conditions of mineral-raw consumers.

II. MAIN PART

A. The aim and contents of intelligent power system creation

The main aims of researches are the next:

- the creation of methodology and proving of structure and parameters of intelligent active-adaptive power systems of mineral-raw enterprises;

- the creation of methodology and proving of structure and parameters of information-management of active-adaptive power systems of mineral-row enterprises;
- to ensure power consumption control in normal and extreme operation;
- to ensure the power supply regularity of especial responsible mineral-row consumers;
- to ensure and power losses minimization and power efficiency increasing.

The mineral-row enterprises, being a basic element of the Russian industry, are the main and large platform for introduction of modern and effective means and decisions not only in the field of technology, but also in power savings and power efficiency sphere.

At the Russian mineral-row enterprises during last 10 years following basic scientific research directions were extended by authors in the field of decreasing power component in the cost price of mineral-row, increase of efficiency of power supply, power savings and power efficiency:

- frequency regulation of mineral-row electric drives for the rising productivity of mineral-row extraction by means of active rectifiers and frequency converters with modern control algorithms;
- power quality increase and maintenance of electromagnetic compatibility of electric equipment by means of active, passive and hybrid harmonics correction systems;
- maintenance of power supply reliability and uninterrupted operation of responsible consumers with use of alternative and renewed energy sources;
- control of power consumption mode by regulation voltage with using fuzzy logic theory and its applications.

All these directions in complex are the basis of intelligent active-adaptive power system. No one of these directions separately can be expected as intelligent active-adaptive power system. That's why the main aim of presented article is to develop basic structure of proposed intelligent active-adaptive power system.

Increase of power reliability, savings and efficiency of the mineral-row enterprises is probably only at joint realization of the specified directions also taking into account following key factors:

- degree of consumers deconcentration;
- correlation of responsible and irresponsible consumers;
- presence or absence of centralized electrical supply.

For joint realization of the specified directions there is a necessity of information and operation interaction between the key elements involved in performance of various functions, which proposed intelligent active-adaptive power system must provide.

Thus the power system gets property of intelligence and active-adaptive, therefore there is a necessity of introduction of the new term: an intelligent active-adaptive power system.

B. Contents of theoretical and practical scientific research

Lately in a number of articles in Russia and other countries the term “intelligent active-adaptive power system” was defined as the system, which can calculate power consumption by itself. But it is only one function of intelligent active-adaptive power

system. As was defined in section A, intelligent active-adaptive power system is the complex of technical devices and decisions, which have different functions for improving power saving and efficiency.

The proposed intelligent active-adaptive power system is a set of the power elements, providing generation, transfer, distribution and transformation of energy. Also every element must have control module, which carry out interaction in information and operation between elements according to algorithms. In this case each control module should have its own algorithm. Besides control modules of each element must provide monitoring of operations on reception, transfer, distribution and transformation of power. Thus proposed intelligent active-adaptive power system should have power elements, their control modules and interaction between them.

The difference between intelligent active-adaptive power system and traditional power system is the presence of following basic elements, technical decisions and methods:

- the automated complex control system of power consumption;
- the active power generators with changeable parameters and structure;
- primary using of alternative renewed energy sources;
- the systems of estimation and diagnostics of current power system mode and condition;
- the power quality automated control and improvement systems;
- the automated control systems of power system structure;
- the automated system of power balance maintenance by means of control of main power lines loading;
- the meteoconditions control with preventive change of network mode parameters.

The specified elements and decisions (methods) can be added by necessary functions depending on specificity of application of proposed intellectual active-adaptive power system. Besides, function mode and elements quantity of proposed intellectual active-adaptive power system can be changed in the big or smaller party depending on application area.

Before intelligent active-adaptive power system creation and designing the following tasks must be decided:

- the correction of power supply mode of mineral-row consumers in case of using of centralized and local power sources under energy fluxes multidirectional movement;
- the structuring of mineral-row consumers on the assumption of great distance from power centers;
- the proving of effectiveness of alternative energy sources using, including wind energetic, solar power and associated petroleum gas power, at the mineral-row objects;
- the analysis of existing designs in the area of power consumption control in mineral-row objects and designing of recommendations for using perspective technical decisions in this area;
- the creation of mineral-row consumers classifier according to criterion of ability to taking part in power consumption control;

- the comparative analysis of performance of mineral-row power systems of different structure with detecting of regularities, which can be used for intelligent power system designing;
- the substantiation of structure and parameters of mineral-row multilevel power system with areas sectioning by means of perspective teleoperation and commutation devices;
- the substantiation of effective control of intelligent active-adaptive power system structure with application of fast automatic standby activation devices, thyristor automatic standby activation systems and digital systems for reactive power fluxes control;
- the designing of means and methods for ensuring electromagnetic compatibility, power quality control and increasing at mineral-row objects;
- the designing of intelligent systems, which can control of power level and consumption at mineral-row objects;
- the designing of methodical support for informational and control communication between main elements of proposed intelligent active-adaptive power system.

C. The intelligent power system basic structure

The proposed intelligent active-adaptive power system includes following subsystems:

- subsystem of supporting and rising power quality and electromagnetic compatibility;
- subsystem of providing of reliability and uninterrupted operation of power supply, including alternative renewed energy sources applying possibility;
- subsystem of supporting of power supply stability with possibility of an operational administration of power system configuration, by automatic sectioning;
- subsystem of providing an optimum voltage mode;
- subsystem of providing the complex automated control of power consumption and efficiency level;
- subsystem of providing the structuring of consumers under possibility of loading control.

In Fig.1 the structure of proposed intelligent active-adaptive power system of mineral-row enterprise is shown. In fig.1: EPS – emergency power supply source; TS – thyristor switchboard; APS – automatic point of sectioning; FDC – filter device of compensation; SAF – shunt active filter; HARI – high-speed automatic reserve input; ARI - automatic reserve input; QF – breaker. Proposed structure was developed on the basis of results of numerous theoretical and experimental researches, which had been spent by authors at various times, in electric networks of the oil-extracting enterprises. Proposed structure contains all key subsystems, which provides all declared above functions.

D. The main elements of proposed intelligent power system

During researches, the structure and parameters of multilevel system of power supply sectioning by means of perspective devices of telecontrol and remote switching is proved. The basic element of the given system is the automatic point of sectioning (APS) or recloser, providing change of power supply configuration, by switching of various

supply lines depending on damages and emergencies presence, and the thyristor switchboard (TS), intended for power streams control.

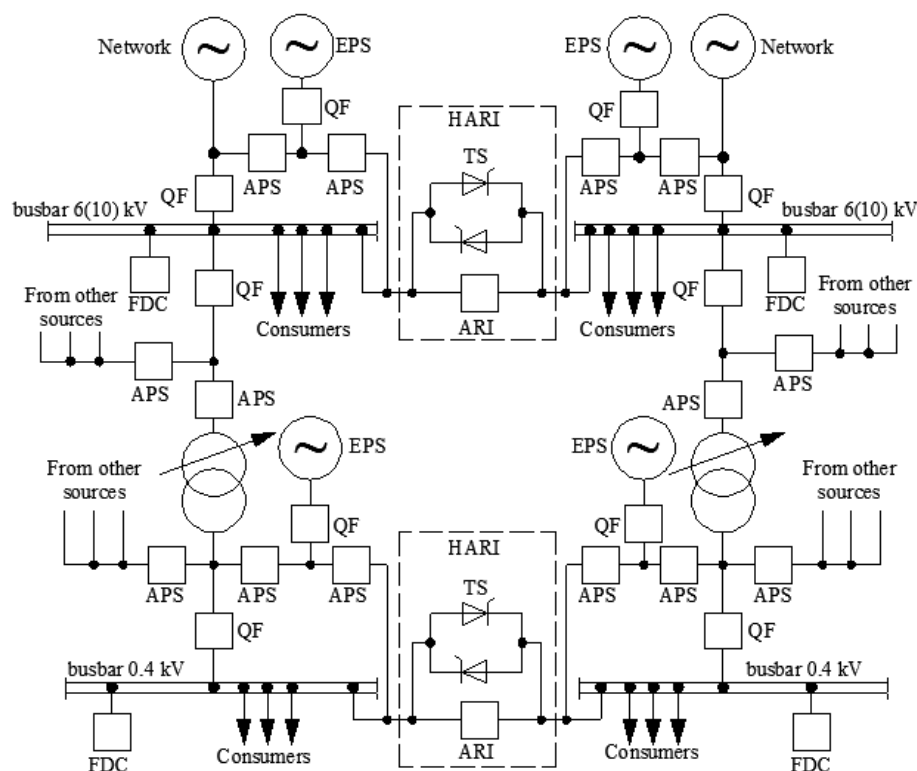


Fig. 1. The basic structure of proposed intelligent active-adaptive power system of mineral-row enterprise

During researches, means and methods of electromagnetic compatibility maintenance, power quality control and improvement are developed. Basic elements in this case are passive, active and hybrid filter devices of compensation (FDC), active systems of correction of current and voltage curves form on the basis of shunt active filters (SAF), the automated complex control system of power quality and consumption level [1].

During researches, the qualifier of mineral-row consumers by criterion of possibility of their participation in power consumption control is created.

During researches, the efficiency of reactive power streams control in mineral-row power systems by means of electromechanical complexes with synchronous engines and thyristor excitation is proved.

During researches, the complex comparative analysis of technical characteristics and functionality of mineral-row power systems of various structures is made. The result of this analysis allows making the information-operating interaction between elements of intelligent active-adaptive power systems.

During researches, the efficiency of intelligent power system structure control with use of means of high-speed automatic input of a reserve (HARI) on the base of thyristor systems of automatic input of a reserve (TSARI) and systems of digital control streams of reactive power is proved.

During researches, the complex system of relay protection and automatic on the basis of microprocessor devices with free-programmed logic is developed.

During researches, the technique of power systems neutral mode choice is developed for increase the efficiency of revealing and eliminating of various types of short circuits.

During researches, the methodology of information-operating interaction between main elements of proposed intelligent active-adaptive power system is developed.

During researches, the technique of power consumption control of mineral-row consumers in normal and extreme modes is developed.

During researches, the technique of uninterrupted power supply of mineral-row responsible consumers is developed and proved.

During researches, the complex of organization measures for providing information-operating interaction mode between power system and mineral-row consumers by optimization of operating modes of the equipment, modes of consumption of active and reactive power and voltage levels is proved and almost realized [2].

During researches, the structure and technique of key parameters choice of guaranteed power supply system of mineral-row consumers with use of sources of emergency power supply (EPS) is developed. The sources of EPS functions on the basis of the alternative renewed energy sources, which allow avoiding occurrence of emergencies and infringement of technological process continuity.

During researches, the functioning algorithm of the automatic control block (ACB) of power transformer transformation factor is developed for the voltage mode efficient control in mineral-row power systems. This algorithm is based on the choice of the power line, which defines the voltage mode of whole power system. This algorithm is realized by means of theory of indistinct logic methods, including processing of linguistically formulated expert knowledge, using the indistinct controller. Formation of the knowledge base on the basis of indistinct rules and expert estimations allows more effectively controlling and analyzing various parameters and factors characterizing the voltage mode of power system.

E. The practical application

In the leading Russian mineral-row enterprises the following basic elements of proposed intelligent active-adaptive power system, both in common, and separately are developed and introduced by authors over the last 10 years at various times:

- the automated monitoring systems and the power consumption account;
- the current and voltage form curves active correction systems on the basis of shunt active filters;
- the electromechanical complexes with synchronous engines as consumers-regulators;
- the control systems of power system configuration on the basis of methods and means of automatic sectioning;
- the guaranteed power supply systems on the basis of uninterrupted power supply with use of alternative and renewed energy sources;
- the automated system of voltage mode control with use of fuzzy logic theory.

Active correction systems of voltage and current form curves on the basis of shunt active filters and complex power quality monitoring systems are introduced on JSC «Orenburgneft» THK-BP [3]. The high-speed devices of automatic reserve input and the guaranteed power supply systems are developed on JSC «RN-Juganskneftegaz» «NK Rosneft». The automated power consumption monitoring and account systems and automated power supply control systems are introduced on JSC «Tatneft» and JSC «PO-

Kirishinefteorgsintez». A number of actions for the organization of regime interaction between power system and mineral-row consumers are introduced on JSC «Tatneft».

Economic benefit of application of the basic components of proposed intelligent power system averages from 300000 to 700000 \$ per year depending on quantity of the introduced elements and parameters of mineral-row enterprises electric networks.

The most significant results of working out and introduction of proposed intelligent active-adaptive power systems at the mineral-row enterprises will be:

- decrease in losses of mineral-row recovery by exception of power infringement of the basic responsible consumers defining the basic technological indicators of the mineral-row enterprises;
- minimization of additional capital investments on development of mineral-row enterprises power systems;
- decrease in losses of the electric power in distributive electric networks and power systems;
- increase of power savings and power efficiency level.

III. CONCLUSION

The basic structure of proposed intelligent active-adaptive power system for industrial enterprises on the example of mineral-row enterprises is created. The positive influence on power safety and efficiency level of proposed intelligent active-adaptive power system is proved. The main elements of proposed intelligent active-adaptive power system and their functions are defined. The most significant results of proposed intelligent active-adaptive power system applying are detected.

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