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The integrated development system of breakage faces power supply, training and knowledge assessment of staff of coal mines electromechanical services

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Abstract

The principles of the Internet-technologies use for ensuring operational safety of power supply of breakage faces of coal mines with a problems solution of design, training and employees' knowledge assessment of electromechanical services are considered.
The technology of the coal dredging from inclined and flat layers of average and above average power assumes that at the movement of a breakage face movements of electric equipment and recalculation of the power supply schemes will be required.
The new scheme of power supply is approved according to the regulations registered in safety regulation (SR) and operational regulation (OR).
Approach to creation a qualitative project of power supply of a breakage face as triune issue of the power supply development of breakage faces, training and assessment of staff's knowledge of electromechanical services of coal mines are considered and offered.
The algorithms analysis of power supply schemes calculation is carried out. On condition of the qualitative scheme of power supply the probability of possible energy saving is estimated and conditions of optimization of high-quality production are defined.
Research work on creation the automated system solution of the triune issue on the basis "cloud computing" use is analyzed.

Keywords: coal, mine, extraction, power supply, calculation, project, internet-training, expert, assessment, knowledge, issue, set, stream, information, automation, system.

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1. Introduction

On the coal mines developing flat and inclined layers of average and above-average power there is a need of relocating mobile transformer substations together with the distribution station in a breakage face progress process. Transfer process is preceded by the new project development of power supply.
The development project problem of the breakage face power supply (a mining site) is original because of identity: mining-and-geological conditions of coal layers bedding; existing systems of opening and mineral extraction, ventilation of the

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breakage face; mine categorizations according to gas and dust; structure of the electro- and electromechanical equipment in a face and in mine warehouses; the admissible, required and possible modes of the power consumption mining machines and installations. Practically there are no identical schemes of power supply both in one mine, and in different mines of the coal basin.

Taking into account a rigid algorithm of the statement and responsibility for quality of schemes project of power supply of the mining sites formalized in SR and OR [1, 2], the aim of schemes project of power supply of mining sites of coal mines can be solved only by qualified specialists.

There is a real problem of search and/or training of such experts which is offered to be united with process of qualitative project development of power supply of the mining site on the basis of the principles of the system approach consisting, first of all in a purpose, it is a creation of the qualitative project of power supply in conditions:

- multi-criteria of a design issue;
- existence of the determined and stochastic indignations;
- special algorithms of experts' knowledge an assessment;
- the adaptive methods of training allowing to solve a triune problem.

The obvious elements of unity which are available in the considered issues allow to assume that there are key moments crossing flows of information, criteria and approaches to the solution of problems of schemes design of power supply, training and an experts' knowledge assessment capable to create in the set terms and with necessary quality the project of power supply of the mining site.

From positions of system approach to the solution of the interconnected issues: 1. Design, 2. Training, 3. Knowledge assessment.

We will consider structure and components of information streams within a triune task.

In the figure 1 the considered issues are presented in the form of the crossed sets of various colour, equivalent by the size (weight). Let's say that it sets:

(i) design – red;
(ii) training – blue;
(iii) knowledge assessment – yellow.

Then subject of the subsequent analysis (in the real work) will be subsets: 1+2 - violet; 1+3 – orange; 2+3 – green; 1+2+3 – brown.

It is necessary to define the structure and value of each subset, rather solvable issues.

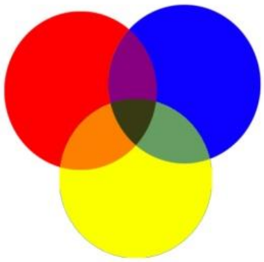

Figure 1. Crossing and union of sets of Design (D), Training (T), Knowledge assessment (KA)

2. Analysis of the task "Design"

The task "Design of the mining site power supply" is paramount (we classify it as a design task 1 – DT_1) within the considered problems. The structure and flows of information formed in this task exist also in two other tasks: "Training" and "Knowledge assessment" of electro-technical services personnel of coal mines (usually it is the staff of department of the chief mechanical engineer (sometimes power engineer) of the coal mine. Full calculation of the scheme of power supply of the mining site is carried out for the mining site put into operation. The probability of similar repeated calculation is very small as at trouble-free operation of the equipment and preservation of normal mining-and-geological conditions there is no need for replacement of machines and electric equipment.

In a task "Calculation of power supply of the mining site in connection with a motion of a breakage face" (we classify a task as DT_2) the volume of unreliable information is minimum. New calculations of the scheme of power supply are made after advance of a breakage face on distance of 50-100 meters from initial situation. There is an existing scheme of power supply (we assume that the system of development by long columns on layer spread with advance of a breakage face reverse motion is used). In the new location of mobile substations and the figurative distribution station it is necessary to reduce length of the power cables powering electric equipment, length of the powering cables of transformer substations, feeders and actuators of the distributive site, to make new calculations of the currents of short circuit (CSC), losses of tension at start-up and settings of protection, to prepare the project for an assessment and the statement at the management of the mine.

Uncertain information is existence and characteristics of cable economy, and, perhaps, starting electric equipment which will be used in the new scheme of power supply.

We need the criteria reducing uncertainty of information and defining quality of new calculation for the solution DT_2 task. We will consider these criteria in the subsequent sections of the real work.

Separate problem which can be put in the scheme of power supply of a face, can be ensuring energy saving in the course of coal extracting (task DT_3).

In breakage faces of coal mines of the Republic of Kazakhstan (RK) electric energy is the basic of sources of machine actuating, mechanisms, control devices, protection, alarm systems and managements) *. An assessment of energy saving is possible in probabilistic statement as operating modes of the coal-mining machines (CMC), defined by the casual nature of change of strength properties of coal, and also firm inclusions existence in the coal massif, cracks and nature of their distribution. In A. I. Baron, E. Z. Pozin, U. D. Krasnikov, A. V. Dokukin, A. I. Kukhtenko's research works [3,…, 9] it was established that within a breakage face the coal resilience to cutting characterizing the massif is stationary normal process which properties are described by exponential or exponential-cosine correlation functions. Authentically, for conditions of the concrete developed coal layer (face) it is possible to specify the change range of coal resilience to cutting A [7]: Amin ≤ A ≤ Amax, where Amin, Amax is the maximum and minimum values of resilience of coal to cutting for the considered layer (face), N/m.

There is an opinion that the processes connected with destruction, loading and transportation of coal in a breakage face can be referred to stationary normal processes [6, 7, 8] too.

A. I. Beron, E. Z. Pozin's research [4, 5] established that to the minimum energy consumption and the best rating of coal correspond such control modes work CMC when the condition is provided

$$CF1 = \{V_{\Pi} / V_P = const, P_{ef} = const\}, \quad (1)$$

where P_{ef} is power consumed by the coal-mining car (CMC); V_{Π}, V_P is respectively, the linear speed of giving and cutting CMC.

The CMC adaptive control system creating a condition (1) provides high-quality coal mining in a breakage face. At the same time D tons of coal of the set quality [6] are extracted and the electric power is spent E, kilowatt-hour. D and E are random variables. We will use the probabilistic analysis of the economic effect of coal mining which is carried out in [6], and we will consider E estimates.

We characterize the saving energy ΔE as a random variable equal to a difference between the actual value E and an assessment $\overline{E}$. Then with probability λ value E is defined in some confidential interval I_λ

$$P((E - \overline{E}) < \varepsilon_e) = \lambda\,, \quad (2)$$

where $\overline{E}$ is displaced E assessment, defined as expectation value $M(E) = \overline{E}$.

Range of possible values E at its replacement on $\overline{E}$ will be equal to $\pm\varepsilon_e$ and (2) it will be possible to present in the form [6]:

$$P((\overline{E} - \varepsilon_e) < E < (\overline{E} + \varepsilon_e)) = \lambda\,. \quad (3)$$

Equality (3) means that value E with probability λ is in an interval

$$I_\lambda = \{(\overline{E} - \varepsilon_e), (\overline{E} + \varepsilon_e)\}. \quad (4)$$

In the considered statement the size E is not casual, but I_λ interval is casual. The provision of an interval I_λ which is defined by the centre $\overline{E}$. Also the interval length is casual, equal to $2{\cdot}\varepsilon_e$. From here follows that when providing a condition (1), energy saving amount ΔE in the range $2{\cdot}\varepsilon_e$ can be equal to 0.607E, where E is instant expenses of electro-receivers of the breakage site during the periods of condition achievement (1).

Existence of energy-saving dependence ΔE from mining-and-geological, technological and organizational conditions for breakage sites of coal mines is obvious. Dependence on staff's qualification of electro-technical services of the mine (one more subtask – ST_4) though there are assumptions with algorithms of schemes calculation of power supply of mining sites of coal mines, they are not rigid, containing varied (in certain ranges) indicators and coefficients which admissible values can be accepted by the expert performing calculation for reasons of personal experience and knowledge at the choice of various versions of electric equipment and schemes of power supply is less studied. In extreme situations which possibility of emergence in the conditions of underground production isn't excluded essential value has "a human factor" [10]. There is a sense to consider critical situations like "power supply loss" by the certain consumer, group and/or all consumers of the breakage site.

And in this case losses of the enterprise are defined not by the probabilistic admission (4), but proportional size to time during which the breakage face stands idle and the mine loses profit proportional coal mining for idle time.

Task ST_4 consists in an assessment influence qualification of employees on quality of the making decisions on schemes designing of power supply in normal and extreme situations of a breakage face and possible at the same time size changes of energy saving ΔE.

Static schemes calculation of power supply of mining sites of coal mines is carried out on the known algorithms [11, …, 17] containing a large number of aprioristic settlement variables and parameters (changing from 10 to 40% of basic size), value of which is accepted by the employee of electromechanical service of the mine proceeding from qualification and personal experience. The operating mode of a breakage face during change doesn't remain constant and therefore loading of mobile transformer substations within a day and separate shafts is uneven and changeable. In some scientific and methodical and normative documents [11, …, 16, 18] the admissible error of calculation of schemes of power supply to 10% is accepted. In the dynamic modes change of separate parameters and variable schemes of power supply (for example, the inductive resistance of cables, reregulation of currents, the moments and speeds) reaches up to 50% and more values rather nominal and basic that significantly influences on energy consumption of machines and mechanisms of a breakage face.

Proceeding from the aforesaid we will consider a static algorithm fragment of the scheme calculation of power supply of the breakage site from a position of definition of the variables and parameters accepted from the range of possible values.

At the first stage of schemes calculation of power supply of mining sites of coal mines the scheme of arrangement of processing equipment is developed and the table of electro-receivers with their rating data is formed. There is a possibility of development of alternative options on the basis of a large number of the projects analogs which are available at the enterprise and in standard and help sources of information. It is obvious that already at this stage the prospect under certain conditions is put to have positive and/or negative value of energy saving amount ΔE.

The standard method of the power assessment S_p of electro-consumers of the mining site (breakage face) is the demand coefficient method [11, …., 14], according to which

$$Sp = k_c \sum Pi_{nom} / \cos\varphi, \qquad (5)$$

where k_c is the demand coefficient on the site considering loading of electric motors and non-simultaneity of their work; $\sum Pi_{nom}$ is a total rated capacity of electro-receivers of the site, Kw; $\cos\varphi$ is the conditional average power coefficient recommended by Centregipromine for breakage faces of mines with flat layers equal 0.6.

Dredging of coal from flat layers of average and above the average power of layers in RK mines is carried out by the mechanized extraction complexes with automatic blocking of launch sequence of their electric motors, in this case in [11, p. 474] coefficient of demand is recommended to determine according to dependence

$$k_c = 0.4 + 0.6 Pi_{max} / \sum Pi_{nom}, \qquad (6)$$

In a formula (6), taking into account use of multi-engine breakage combines, instead of Pi_{max} value is substituted

$$k_п \sum P_{CMC\,nom}, \qquad (7)$$

where: $\sum P_{CMC\,nom}$ is the amount of power ratings of the electromotors set by the coal-mining machine (combine); $k_п$ is utilization coefficient of electromotors power.

Ratios (5) – (7) make Centregipromine algorithm [11] which became practically standard for the first stage of calculation of diagrams of electrical power supply of mining sections of coal mines [11, …, 14]. It is necessary to mark that the described algorithm and a calculation procedure still are regulating for coal mines.

Above, in the considered fragment, the alternative options connected to a possibility of a choice of electro-receivers with different tension and on selection of technological machines and mechanisms (in that case if at the enterprise there is such opportunity), in determination of number of substations and branches of the customers powering from one main cable are tracked.

Without considering an algorithm of diagrams calculation of electrical power supply, we will stop on the analysis of separate variables of an algorithm which can have the values accepted from the range of possible values.

In [11, p. 356-359] the coefficient of demand is defined as the relation of a steady maximum load (30 minutes) of receivers to their total associated power:

$$k_c = k_{odn} \cdot k_z / \eta_{dv} \cdot \eta_c, \qquad (8)$$

where: k_{odn} is a coefficient equal to the relation of power rating at the same time switched on in the considered moment with a receiver to total power of the receivers connected to the transformer; k_z – it is relation of the actual power given by the receiver to the considered time point to its power rating; η_{dv}, η_c is effectiveness factor of receivers and network.

Acceptance of values of variables in a formula (8) by the designer of the diagram of electrical power supply depends on experience and understanding of specifics of technology of the mechanized coal mining. Complexity of this process also led finally to Centregipromine's decision to recommend applications of a method simplifying calculation on the basis of an assessment k_c for formulas of (6) type and/or reference tables.

The following stage of the diagram creation of electrical power supply of a section is a calculation of a cable network for heating, the actual current of loading of the complete transformer substation (CTS) and/or a branch of the diagram of electrical power supply powering from substation is defined here:

$$I_f = \frac{k_c \cdot (\sum Pi_{nom})}{\sqrt{3} \cdot U_{nom} \cdot \cos\varphi}. \qquad (9)$$

In (9) rated voltage is accepted depending on CTS with which the cable is calculated. The subsequent choice of a cable is most often according to special tables, has to meet a condition:

$$I_{ld} \geq I_f, \qquad (10)$$

where: I_{ld} is long admissible current of the cable of the corresponding section on heating, A; I_f is the actual current of cable loading, A.

In reference tables [12, 14] the correction coefficients allowing to consider ambient temperature can be put (depending on actual and calculated, and also from the nominal temperature of cable vein. This correction coefficient changes in the range from 1.27 to 0.79), on mechanical durability, on a condition of economic density of current, on thermal firmness and loss of tension [12, p. 291-298]. Calculations on thermal stability are connected with an assessment of ability of cables to maintain currents of short circuit (s.c.) until operation of the devices of protection which are adjusted in s.c. currents. The correction coefficients considering loading of cables, various on a design, change from 1.00 to 1.30. Check of cable network of the mining site on loss of tension allows to estimate providing the set mode of powerful engines launch of the coal-mining car and remote engines of conveyors.

The factor allowing to rationalize schemes of power supply of mining sites is the design features allowing overloads of transformers and the taps allowing to change transformation coefficient.

The admissions in calculation algorithms considered above connected with a variation of correction coefficients and parameters of cables (for example, due to change of their resistance during the work under loading), were considered in scientific and methodical literature [11,12, 15, 16] and reference-standard documentation [13, 14] by development of a set of the offers recommendations allowing to provide performance of technological conditions of engines start and operation of settings system of devices of protection against s.c. currents. The engineering instructive claiming service of mines implements a control of documentation for the purpose of safety of systems operation of power supply of mining sites. There is no place left for receiving energy saving.

The automated calculations of schemes of power supply of mining sites of coal mines [17, 19 - 23] in "Adviser" regime help to design schemes of power supply of mining sites of coal mines and to model the modes of normal and extreme operation of these schemes. It allows to assume that the choice of the varied coefficients can be carried out by methods of mathematical modelling in the best way. The best decision is creation of system of the automated monitoring by a power consumption in a breakage face.

Stochastic regularity of resilience change to cutting coal A (t) along the length of a breakage face (lava) of L=200m at the normal law of distribution and an interval of correlation $\tau_{kor} = 6\text{m}$ [6,…, 8] is followed by change of loading of the electric drive of the coal-mining machine not less than 33 times ($L / \tau_{kor} = 33$) and in this situation the system of power supply of the mining site has to remain efficient that is not always possible even at wide experience of the designers of the scheme of power supply balancing this scheme within variations of the coefficients were considered above, parameters of cables and types of electric equipment.

The system of monitoring together with a control system of the coal-mining machine of adaptive type allows to satisfy conditions (1) at which existence of energy saving in a breakage face is possible.

Conclusion

The operability of power supply system of a breakage face reached by the qualitative project promotes providing:

- safety of technological processes and production;
- production of necessary amount of coal;
- possibilities of receiving the required granulated composition (quality) of coal;
- energy saving in breakage faces of coal mines.

The effect of ensuring quality of coal and energy saving is achievable by means of monitoring system of a power consumption and an adaptive control system of electric drives of the coal-mining machine.

3. Analysis of the task "Training"

Specialists of chief mechanical engineers departments (power engineering specialists) of coal mines theoretically must have vocational education, earlier (in Soviet period, i.e. till 1900), they were engineers of specialty "a mining engineer-electrical-mechanic", "a mining engineer electrician".

Reforms in the higher education within the Bologna Process have led at first "engineer" specialization disappearance and then also special training of electricians and electrician-mechanics direction both on the first (bachelors) and at the second step (masters) of the higher education has disappeared. Bachelors in "Power industry" at mining specialization in the curriculum have no more than three disciplines like "Technological processes of mining", "Explosive works" and, perhaps, "Mining electro-mechanics" that it isn't enough for vocational training at the level of the expert on mining electrical equipment, electro-mechanics and automation of mining productions. In attempt to find a way out of a similar situation there are compelled schemes of finishing learning and certification, for example:

- receiving second higher education on mining specialty (option of training O_1);
- enrolling after a bachelor degree in "Power industry" magistracy on mining specialty (option of training O_2);
- training at special organizations courses having the license for the right of teaching, certification and issue of the certificate on mining disciplines, mining electrical equipment, mining mechanics and electro-mechanics, safety rules for coal mines, service regulations of electric equipment, the principles and rules of production and operation of explosion-proof miner electric equipment, mining machines, hydraulic and electric drives of mining machines, mine transport, automation of technological processes and productions at the mining enterprises, audit, adjustment and reliability of operation of machines and electric equipment of the mining enterprises (option of training T_3).

The option of T_3 training is perspective from a position realization on the basis of modern Internet technologies including Cloud.
The last list has included the disciplines defining qualification of the specialist of department of the chief power engineer of the coal mine. The employee of department of the chief power engineer, the mining and/or driving site who doesn't have the document confirming knowledge as the specialist in a set of professional disciplines shouldn't be allowed to development of power supply projects of breakage faces.
If the similar document is available, then there is a question of quality of the available knowledge. And it is already the task of a subsystem "Knowledge assessment (KA)". Task analysis of a KA subsystem will be realized in the following section of the real operation.
Process "Training" in any option (T_1, T_2, T_3) can't be realized while listening lectures course both on several, and on a set of disciplines. This trivial statement reinforced by long-term experience of students' training and undergraduates in technical university [11, 12, 16, 17, 19,…., 23]. But here are normal set, working in "normal" conditions: "lectures - a practical training - laboratory researches - term papers and projects", specifics of mining can demand adding of the special methods of training connected to operation of the expert in extreme conditions of origin of techno genic alert conditions and catastrophes. Trainings in the environment of the virtual and/or physical trainers can be in such methods. We will designate the process of training by means of the virtual trainer as — T_4, and on a physical trainer – T_5.
There can be many trainers and a sequential training on everyone, it must improve skills of the expert. An important educational point on a trainer is step-by-step approximation to the possible extreme situations arising in a breakage drift under the influence of the determined or stochastic external perturbations. Terminal phase of the specialist's education of department of the chief mechanical engineer (power engineering specialist) of the coal mine can be proof testing on the complex trainer which is most displaying conditions of real and abnormal operation system of electrical power supply and an electric equipment of a breakage drift.
Technologies of development of the virtual trainers not much more differ from procedures of scheme creation and hardware-software support of SCADA systems. Here dispatchers of production (in mines – mining dispatchers), chief mechanical engineers and power engineering of coal mines become screenwriters and directors. Experience of trainers creation of electrical power systems shows that the perfect constructions turn out in the form of hybrid virtual and physical exercise machines [24].
The amount of the mastered professional necessary disciplines; number of the credits on all forms of education on each discipline; the estimates received in training activity on all forms of education for each discipline; complex translated coefficient of GPA. can be criteria in the tasks "Training" by options T_1, T_2, T_3 for applicants for operation by the specialist of department of the chief mechanical engineer of the coal mine. GPA (Grade Point Average) is an arithmetic average from the estimates received for all passable courses taking into account time spent for them.
Criteria when training at exercise machines are time of task performance; value judgment of performance quality of a task by each member of the estimated commission; resultant assessment of performance quality of a task by the estimated commission.

Conclusion
The system of the higher technical education of the Republic of Kazakhstan does not train the experts who are professionally trained for work in departments of the chief mechanical engineer (power engineering specialist) of coal mines. Admissible options of training within higher educational institutions (T_1, T_2) and the training centers of mines and/or associations (T_3) partially allow to solve a problem of professional specialization.
The option of T_3 training is perspective from a realization position based on modern Internet technologies including cloud.

4. Task analysis of the "Knowledge assessment"

"The knowledge assessment" (KA) within the triune task connected with mining gets the weight and value incomparable with similar tasks in educational institutions. The reason is in consequences to which incorrectness of the project of power supply of a breakage face can lead. There is a sense to mention the fundamental regulating documents — safety regulation (SR) and operational regulation (OR). [1, 2], and also [13, 14, 18].
It is necessary to begin checking his professional availability for the coal mine service with the employee's knowledge assessment of service of the chief mechanical engineer (power engineering specialist) within SR and OR [1, 2]
The options of methods and algorithms of the knowledge assessment, developed in fundamental works [25-30] and realized in the automated system of training [19-24] do not exhaust a set of possible approaches.
We will consider basic statements, tasks "Knowledge assessment".
The aim which "checking person" pursues is a definition of employee's readiness (we will call him further "examinee") for performance at the high professional level of schemes calculations of power supply of the mining site, and in the subsequent assessment of ability to overcome difficulties which can arise in a breakage face at emergency and catastrophic situations.
Knowledge assessment is carried out in the test way, and hardly someone will try to disprove this statement. A question of algorithms development and admissions remains open, allowing to approve positive and negative result of an assessment of knowledge. Responsibility in made decision

practically excludes stochastic approach to knowledge assessment of "examinee". It is necessary to recognize the requirement to consider a necessary 100% assessment of affirmative answers for all questions and tasks of any control test impossible, from the accounting of psychological and physiological features of the person [10]. Here very complex challenges appear 1. Selection of the command C_1 of the qualified experts for drawing up the list of disciplines of control tests; 2. Choice of the command C_2i of the qualified experts for making up the list of questions of control tests in concrete (i) disciplines; 3. Development of a heuristic algorithm EA_1j by which the team of experts of each discipline will determine positive assessment and tolerances on each question and/or on the amount of questions by each discipline of the control test; 4. Development of heuristic algorithm HA_2j on which the team of experts will determine the positive assessment and tolerances by the control test; 5. Determination of the checking person CP, and having the right decision-making, on "examinee’s destiny". Some tasks solutions C_1, C_2i, creations of algorithms HA_1j, HA_2j and a choice of CP are given in operations [17, 19, …., 23].
In the modern integrated systems of the technological control process and production to which to some extent it is possible to apply a considered triune task. The integrating factor is the uniform database [32, page 37]. Tasks of knowledge assessment acquire a sense from control tests creation, which are a part of the similar database for the triune task. Components of information flow tasks P, T and KA are structured in the database. Subsequent sections of operation are devoted to the analysis of these flows

5. The structure analysis and information streams in "Violet" subset

Let us see a figure. We see combining "Red + Blue = Violet", that is a subset "violet" is a key questions of the task of circuits design of electrical power supply of mining sections and training activities of the experts professionally ready to the decision of the task of creation of the qualitative project. As a first approximation flows of tasks P and T completely cover with each other. There is nothing unusual in it. It is necessary to select only the information entering a violet set. There is no definite answer and an expert’s expressed opinion will be subjective (including authors of the real operation). Nevertheless, some possible structural options can be performed — Vi and lists of information flows — LIFij with a purpose of a motion start on a "violet" subset creation.
The first structural unit of V1 shall be connected to SR and OR [1, 2]. It is obvious from the analysis of section 3. LIFij information streams will contain rigidly formalized data (j = 1,2 ….) and requirements for diagrams of electrical power supply of a breakage drift.
The second structural unit can be connected with actually algorithms of schemes calculation of power supply of a breakage face. Some fragments of these algorithms are described above, in section 1. Perhaps, it is necessary to place a set of the conditions anyway received from operating experience and design of schemes of power supply of breakage faces in separate structural unit.
A criterion of the choice can be combinations of events like "… .if so, then there is a sense to execute it later …. (to accept, to calculate ….) following action ….".

6. The structure analysis and flows of information in "Orange" subset

Let us see a figure. We observe the association of "Red + Yellow = Orange". "Orange" is a key questions of the design issue of schemes of power supply of mining sites and knowledge assessment. Taking into account the analysis in the previous section we will define some (unambiguously subjective) structural options — O_i (an orange subset) and lists of information streams — LIFOij (lists of flows of information of orange subsets).
Here structural units O_2 have to be connected with contents of control tests and algorithms of a heuristic assessment of knowledge mentioned in section 3. Structural unit of O_1 on the separate disciplines chosen as C_2i and questionnaires formalized in the form of texts, and codes of answers — LIFOij. Other structural unit of O_2 it is offered to define algorithms HA_1j, HA_2j (see above section 3).
It is possible that the "orange" subset can be limited to O1 and O_2.

7. The structure analysis and information flows in "Green" subset

Training + knowledge assessment = "green" subset. There is a sense to enter different levels of the analysis. For example, "green subset" on level of training in a bachelor degree, structural unit —GS GMi (see above — T_3) (see above — T_1), is similar in a magistracy — GMi (see above — O_2), and further on special courses — SCKi (see above — T_3). Information flows and the forms of the knowledge assessment in various levels can have coinciding names with close contents, but with a different depth of approach to the required knowledge of professionally trained specialist of department of the chief mechanical engineer (power engineering specialist) in the coal mine. The following structural unit of GKTi is a "green" subset of control tests.

8. The analysis of structure and information streams in "Brown" subset

It is offered to include information, which will allow the person making the decision — PMD (see section 3), to execute its functions in this area of the triune issue and uniform database.

9. Conclusion

The triune system of electrical power supply development of breakage drifts, training and staff's knowledge assessment of electromechanical services of coal mines realized as the integrated automated system with the uniform database, together with a power consumption monitoring system in a breakage drift and system of the adaptive control by electric drives by the coal-mining machine will provide on the coal mines developing oblique and slanting layers of average and above average power, necessary technology of calculation and circuits design of electrical power supply, qualified specialists and will create a basis for high-quality and energy saving coal mining.

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