SOME NEW SOLUTIONS FOR INCREASING THE SAFETY OF USE OF ELECTRICITY IN UNDERGROUND COAL MINES

Petar Kolev Petrov, *Technical University of Gabrovo, Gabrovo, BULGARIA*
Evtim Kartselin, *University of Mining and Geology "St. Ivan Rilski", Sofia, BG*
Dinko Gospodinov, *University of Mining and Geology "St. Ivan Rilski", Sofia, BG*
Vasile Cozma, *"Constantin Brâncusi" University of Târgu Jiu, ROMANIA*
Georgi Tsonev Velev, *Technical University of Gabrovo, Gabrovo, BULGARIA*
Nikolay Minekov, *Assarel-Medet JSC, Panagyurishte, BULGARIA*

ABSTRACT: The safety regulations regarding the safe use of electricity in underground coal mines illustrate big disproportions between the requirements that have to be met by the explosion proof electrical power equipment and the different kinds of cables, used r in underground mines' electrical power supplying systems. The present paper presents some new solutions for increasing the level of safety of electricity use in underground coal mines.

KEY WORDS: safety, electricity, underground coal mines, explosion-proof busbars, spark protection.

INTRODUCTION

The electricity has lots of advantages compared to other kinds of energy. It is used as a basic source of energy also in the underground coal mines for the all kinds of mining machineries, stationary equipment, lighting and signalization.

Along with that, it has to be notified that the safety requirements and conditions regarding the operation of electrical power equipment in the underground coal mines are seriously discriminated by the following reasons: hazardous concentration of gas Methane and coal powder in the colliery atmosphere, high humidity, limited space, limited visibility, periodical movement of part of the electrical equipment, constant rock pressure etc. These all reasons make the electricity in the coal mine one of the potential sources that can initiate fires and explosions

In order to gain high levels of safety regarding the use of electricity in the underground coal mines with increased concentration of gas Methane and coal powder, there are strong regulations and requirements that the mining electrical equipment must meet [1]. The results from year of experience have revealed that a lot of questions regarding the underground mines' electrical safety don't have the necessary quality solutions.

The paper describes the variety of requirements and regulations' documents regarding the safe use of explosion-proof mining electrical power equipment, different kinds of electrical cables and basic elements of electrical mining power network in the contemporary underground coal mines.

RESULTS AND PROBLEMS RELATED WITH THE OPERATION OF ELECTRICAL CABLE NETWORKS IN THE UNDERGROUND COAL MINES. TECHNICAL REQUIREMENTS

The basic principle for gaining a reliable protection against explosions in the electrical power mining equipment (starters, electrical motors etc.) in potentially explosion-hazardous environment consists of explosion-proof metal housings. In case of internal explosion, the blast is limited in the inner of

the electrical equipment housing, and the hazardous environment is protected securely.

The mining cables, used for electrical power supplying in the collieries do not have protection against explosion, compared to the other explosion proof equipment. As a result their safety and reliability is lower.

Cables armoured with steel stripes and outer lead sheath are widely used for main power supplying lines, also for power supplying in vertical mining shafts, inclined mining workings. Such cables are relatively protected against mechanical impacts.

The flexible cables that are widely used near by the coal production front and the technological machinery don't have sufficient mechanical impact protection, which is a serious safety issue.

The years of experience regarding operation of explosion-proof equipment in underground coal mines shows that the electrical power cables are the most vulnerable part of the overall electrical mining equipment mostly as a result of mechanical cable damage, caused by fallen rock pieces, mining transportation, pulling out cables directly from the cable terminations or joints etc.(up to 70 % of all cable failures).

A lot of studies [2, 4] prove that mechanical impacts and insulation breakdown are the main causes for failures of medium voltage armoured mining cables (table 1). The low voltage flexible cables are mostly affected by mechanical damage.

The main resources for increasing the mining cables' reliability and safety in association with improving of their construction seem to be very limited. The rate of mechanical failures of mining cables is almost not dependant on the quality of the cable joints also.

From the other side the installation of main power cables in mining productions without rail transportation is a very expensive operation. Along with that the high price of armoured power cables is mostly due to the world deficiency of copper and its alloys, expensive materials for the cable insulation , armouring and shielding (lead sheathe and steel armour).

NEW WAYS FOR INCREASING THE RELIABILITY AND SAFETY OF ELECTRICAL POWER SUPPLYING OF UNDERGROUND AUTHOMATED MINES FOR PRODUCTION OF COAL

The specific mining conditions requires new kinds of power supplying and current carrying devices, that are comparatively cheaper and mechanically better protected compared to the presently used armoured mining cables.

One alternative option is the implementation of a new kind of power supplying explosion-proof technical means – the so called busways [8, 9].

OAO "MEHPROM" (Donetsk, UA) develops and manufactures explosion-proof busway type SHPV-400

Table 1. Causes for failures of medium voltage armoured mining cables

Kinds of cable failures	Rate of failures of mining armoured cables, %		
	In vertical shafts	In productions with rail road transportation	
		Horizontal	Inclined
Mechanical failures	39,6	32,0	27,5
Mechanical failures due to power supplying of new mining productions	-	15,6	17,4
Insulation breakdown in transition and internal cable joints	41,8	20,4	24,6
Cable insulation breakdowns	18,6	19,7	18,9
Other causes for cable failure	-	12,3	11,6

It is used for transmission and distribution of electrical energy in stationary electrical power installations, supplied by three phase electrical system with insulated neutral of the power transformer for underground coal mines with hazardous concentration of gas

Methane and coal dust. The technical characteristics of explosion-proof busways type SHPV-400 are presented in table 2.

Table 2

№	Indicator	
1	Explosion protection rate	PB 3B
2	Rated voltage	
3	Rated current	
4	Current frequency	
5	International Protection Rating (by GOST 14254-80)	IP54

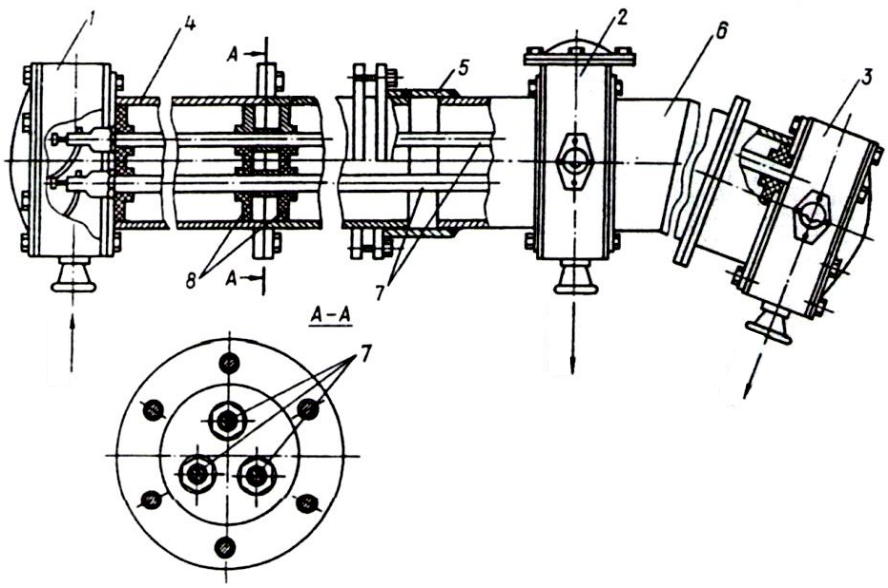

Figure 1. General setup of explosion-proof busway HPV-400

The general setup of an explosion-proof busway HPV-400 is illustrated in fig. 1 with the following indications: 1-internal termination box; 2-feeder (junction) box; 3-sectioning box; 4-linear sections.

The internal terminal box 1 is used to connect the power supplying cable to the linear section. The feeder box 2 connects external cable lines used for supplying of supplementary consumers, situated on the route of the busway. The sectioning box 3 is used for switching of a distribution device to the busway. The lin ear sections are designed to transmit the electrical energy trough the busway to the end electric power consumers.

The internal, feeder and the sectioning boxes are constructively unified as a welded metal construction with rectangular shape each with two internal devices (for flexible and armoured cables). The linear sections of busways 4, 5 and 6 are attached to the walls of these boxes. Explosion-proof caps are mounted to the unused terminals of the internal and sectioning boxes.

Each linear section consists of a pipe with side flanges that connects it with the rest elements of the busway. The busways uses metal pipes as current carrying conductors, since the electrical current flows mostly through the conductors' surface and less through its cross section area as a result of the effect of current displacement.

Main electrical power supplying realized with busways is significantly cheaper than the option with armoured power cables.

SPARK PROTECTION OF POWER CONTACT JOINTS IN MINING ELECTRICAL NETWORKS FOR VOLTAGE RATING UP TO 1000 V

There is information for new generation protection devices [1] that reacts upon loose and sparking detachable joint connections in the power supplying circuits of mining electrical equipment, intended for mining electrical networks up to 1000 V.

Loosened electrical bolt contact joints in the internal termination boxes of mining explosion-proof electrical equipment are a typical electrical source that could cause explosion or fire (sparking and inadmissible joint connection temperature increase).

An explosion could as a result of loosened and sparking electrical bolt contact joints in the internal termination boxes of electrical power equipment could occur if there is a coincidence in time and space of the following three cases:

There is a fault in the explosion proof system of the internal termination box of the

electrical power equipment (there is intolerable play between the flanges of the internal termination box);

There is presence of explosion hazardous environment in the mining production, where the electrical equipment is installed;

There are loosened detachable contact joints in the electrical power equipment circuit, accompanied by sparking.

As a result of the "breathing" explosion hazardous mixture penetrates inside the internal termination box and it will be a reason for an internal explosion. That explosion will be transmitted out in the mining gallery.

A loosened and intolerably overheated detachable contact joint in the internal termination box of an electrical power equipment is possible to result in cable insulation inflammation i.e. fire. Such a fault regime could be a reason also for intolerable overheating of coal dust, deposited over the internal termination box of the electrical power equipment reaching its autoignition temperature i.e. causing a fire in the mining production. A fire could be ignited if there is a coincidence in time and space of the following events:

There is a loosened, sparking and overheated power contact joints of the internal termination box of the electrical power equipment;

Presence of flammable material over the overheated equipment termination box (coal dust, oil, cloth pieces etc.)

Under durability in the electrical power engineering normally is understood the property of an object to be resistant of disturbances, not allowing their cascade appearance to result in total failures in the electrical power supplying of consumers [11].

Under durability of electrical power contact joints must be understood the ability of the protection system and the personnel maintaining the electrical power supplying system to prevent events that could cause intolerable overheating and arcing of electrical power contact joints.

Up to now the mining electrical networks doesn't use protection devices that reacts upon arcing and sparking of electrical power contact joints in the internal termination boxes of the mining electrical explosion-proof power equipment. The conventional switch gear equipment and protection systems do not detect faults such as continuous sparking and arcing of loosened power contact joints in the protected electrical power network.

In [8, 9] has been developed a new principle for a protection system that detects arcing and spark in loosened electrical power contact joints. Its block diagram is illustrated in fig. 2. The principle of operation is as follow. When a sparking and arcing in loosened power contact joint occurs it is accompanied a high frequency current component is superimposed over the base sine wave current with system frequency of 50 Hz. Both signals are obtained by the secondary winding 1 of a current measuring transformer (CT). The CT cores envelopes the three phase conductors A, B, C of the line. Resistors 2 are connected on the CT's secondary windings and are used to obtain diagnostics signal with system frequency and the superimposed to it high frequency signal.

The principle of operation of the protective device is explained in [10].

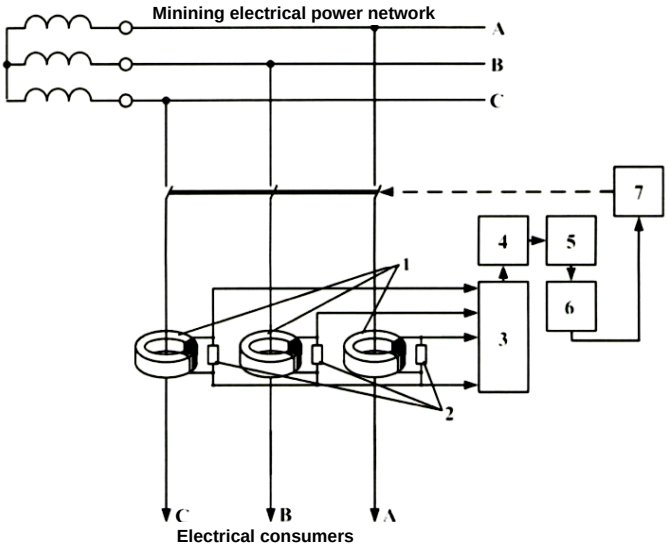

Figure 2. Block diagram of device for protective disconnection of the electrical power network in case of hazardous sparking and arcing in electrical power contact joints.

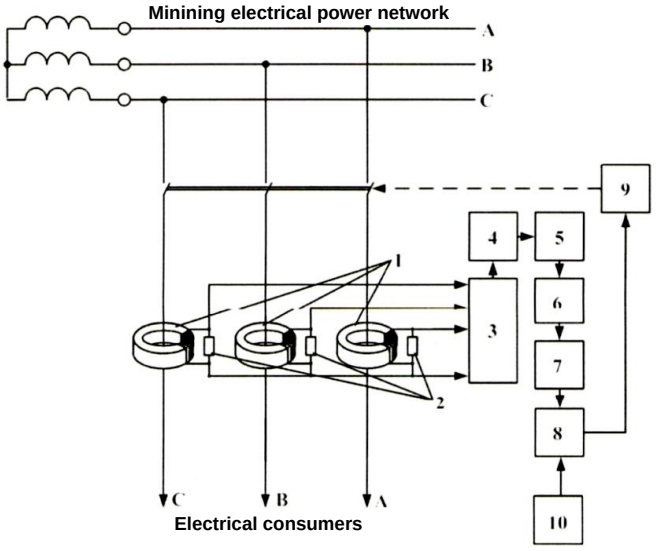

Figure 3. Block diagram of protection system with auto selection function, implemented in mining residual current device, where: *1* – current measuring transformers; *2* – resistors (current sensors) connected to the CTs' secondary windings; *3, 5* – signal amplifiers; *4* – high-frequency filter; *6* – detection-selection device; *7* – auto selection block; *8* – logical elements „OR"; *9* – automatic disconnection system; *10* – mining residual current device.

CONCLUSIONS

The flexible and the armoured power cables in the underground mining electrical power supplying systems have a relatively low operational reliability as a result of failures caused mainly by mechanical damage and insulation breakdown.

Replacement of main armoured power cables with cheaper explosion-proof busways increases the reliability and safety of mining electrical power supplying systems. Along with that financials savings are achieved.

There are presented new variants of protection devices that detect sparking and arcing in loosened detachable electric power contact joints in the internal termination boxes of the electrical mining power equipment.

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