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A method for improving the competences of personnel of electrical divisions in mines

Metoda podnoszenia kompetencji pracowników działów elektrycznych kopalń

Key words: information and communication technologies, main electricity, modelling, personnel training.

Słowa kluczowe: technologie informacyjno-komunikacyjne, sieć elektryczna, modelowanie, szkolenie personelu.

Streszczenie
Dynamiczny rozwój teleinformatyki znajduje zastosowanie w różnych dziedzinach życia, w tym w podnoszeniu kompetencji zawodowych pracowników. Szkolenia personelu kopalni, zwłaszcza dozoru elektrycznego odpowiedzialnego za dystrybucję energii prowadzone były do tej pory tradycyjnymi metodami. Ze względu na niemożliwość symulacji funkcjonowania kopalnianej sieci elektrycznej szkolenia dotyczyły sytuacji standardowych i były prowadzone tylko teoretycznie. Mając na celu poprawę kompetencji zawodowych pracowników kopalń oraz w celu stworzenia możliwości sprawdzenia podejmowanych działań w różnych warunkach, opracowano koncepcję wirtualnego systemu zarządzania siecią elektryczną kopalni.

Introduction

A computer methods play a significant role in creating of safe working conditions. The European Commission insists on the use of ICT tools in practical training [5]. Due to the high costs associated with the use of electricity in the mining industry and thus the need for responsible energy management, training of personnel from electrical divisions is extremely high important. Such training should allow for the acquisition of a specific knowledge, and most important – the skills. The training process, due to the large number of existing natural and technological hazards and the need to maintain continuity of work, should be carried out with the use of properly prepared training applications, mapping virtual environment [6, 7]. With these kind of applications, it is possible to simulate a variety of scenarios, often impossible to carry out without being exposed to danger, where efficient and rapid worker response can significantly reduce the resulting losses. Acquire of the ability to recognize danger, which results in reduction of the number of accidents at work, is significant too [9].

So, the basic condition for the successful conducting of rescue operations is the preparation and experience of people taking part in them [3].

The research presented in this paper is a part of a larger European project – M-SMARTGRID, which aims at developing and implementing of mining smart electric grids. A smartgrid is an electric grid that uses Information and Communications Technology to improve the efficiency of the production and sustainability of distribution of electrical energy [4]. The article presents the concept of software, based on idea of the smart electric grids, intended to support training of the personnel from electrical divisions in mines and the concept of such trainings.

Background of the problem

Electrical systems in mines are quite often over-designed, and as such have high energy consumption in an idling state and quite often having peak power values several times higher than the average power [2]. This is due to the intermittent nature of some major loads (extraction, hauling, water pumping, booster fans). Furthermore, the considerable distances underground, coupled with high power requirements impose increasing strains on the power network [12]. In response, a number of individual system developments have been introduced over the years with an objective of decreasing the cost of energy used, mainly in the fields of mine ventilation and pumping etc. However it is increasingly recognized that if significant gains are going to be made in this area, then it is necessary to fundamentally address the grid system as a whole, applying smartgrid technologies.

A trained employee should be able to properly redirect energy from and to the available switching stations in order to minimizing its consumption. In the case of emergency and extraordinary conditions, a set of actions should be done, i.e.: determining the location of emergency; cutting-off the power supply to dangerous areas, with the exception of equipment required during the rescue; and bypassing damaged power switching substation, using alternative energy sources (another plant). In a stress situation an employee can make a mistake at each previous task, which can lead to serious accidents.

In the proposed training application, including the simulation software, the employee will have to deal with selected staged situations. The simulation software will include an advisory expert module, which will be used to verify the employee's activities on a regular basis [8].

Concept of the software for virtual simulation

The simulation software is divided into 3 main modules: Grid Management Center (GMC); Decision Support System (DSS); mine electrical model. The main part of the software is the Grid Management Center. It is a power management application module, with its own GUI, to manage network power usage in accordance to the instructions of the user. It considers all the mine services, both underground and on the surface. The Decision Support System module is responsible for control trainees decisions and advising on how to perform power management in different operation conditions, including but not limited to incidents, accidents, partial breakdowns, etc. Advice from the DSS is not critical, the final decision on the actions to be taken always left in the hands of the human.

The software retrieve information from the virtual sensors of switching station, which are part of the network segment of the mine electrical model. Localization of equipment in the mine model will be defined according to the actual state, following the approval of the representatives of the mine, in which the training would take place.

Cooperation between the major software modules is shown in Fig. 1. „Measurements" means the network load signals, at the designated points of the substations, „Decisions" means control information on how to redirect energy in the network. In the case of non-standard and emergency conditions, GMC module is supported by the DSS module, which suggests the sequence of actions and verifies the decisions taken by the trainee.

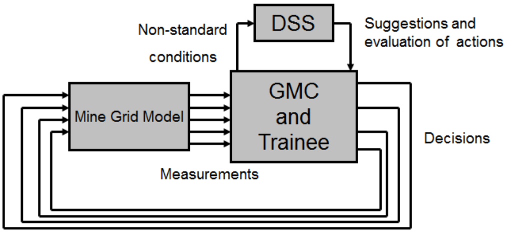

Fig. 1. Cooperation between the major software modules

Submodules of the GMC and the DSS: module for monitor and identify status of the network; module for energy consumption forecasting; expert module to support and control decisions made by the operator; database module.

Mine electrical model

The most important part of the software is general and systematic model of the structure of a mine power grid, which include information on the nature and timing of loads, on the possibility of disconnecting and re-timing of load connections, etc. The model comprise the various systems of a mine electric grid, including ventilation, pumping, transport, production, etc. Mine-specific model should be developed, taking into account the location of virtual (computer generated) test points. Primary data should be provided by mine operators and incorporated into the model. The first approximation of the model, the load model, created in the MATLAB environment, is presented in Fig. 2 [11, 12].

KOMAG Institute is in close cooperation with „KWK Ziemowit" mine during realization of „Mining Smart Electrical Grids" project. The model from Fig. 2 is currently under adaptation to the structure of Ziemowit's electric grid for testing purpose.

Database

It is necessary to constantly save the results of training, its progress, decisions of the trainee, types and time of occurrence of different emergencies, and rest of data necessary for functioning of the GMC and the DSS. Training software will be based on a SQL database server. For the purpose of the training software, MS SQL Server 2008/2012 has been selected as a database solution.

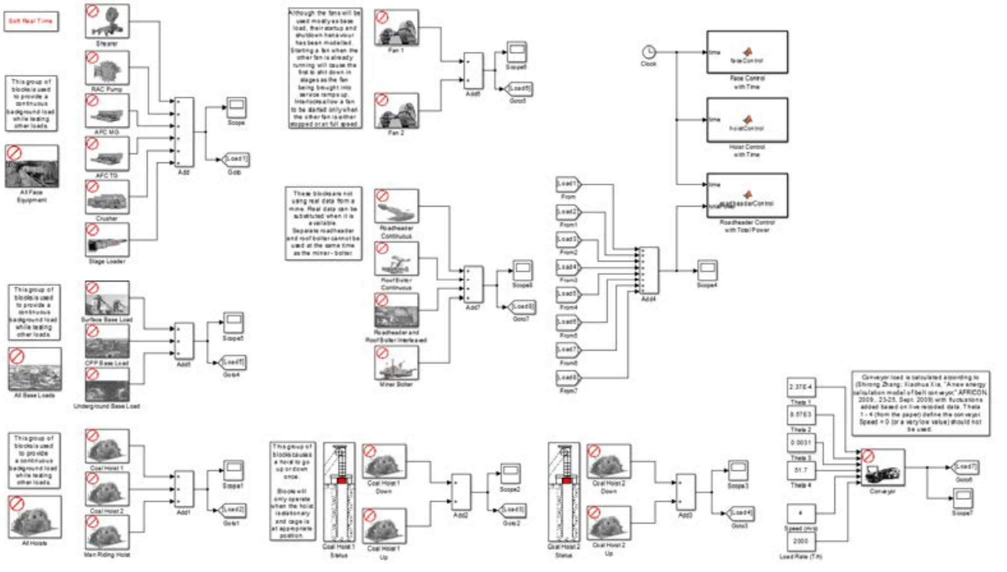

Fig. 2. Model of loads for different mine energy receivers [12]

Energy consumption forecasting

Forecasting module will be implemented based on mathematical prediction models behaviour, based on the load signal values [10][12]. Signals from each available measuring points of switching stations will be modeled independently. The ARMA, ARIMA and regression models structures will be used for energy consumption modelling [1]. To ensure correctness of the parameter estimation procedure, it is necessary to prepare the signals in advance. The signals should be smoothed and purified from noise. A special support software had to be designed to test different methods of smoothing signals.

GUI

The training software will be implemented based on the use of C++ Builder, environment component of the RAD Studio XE5. The TMS and VCL graphic libraries will be used for visualization. Examples of the already available software windows are shown in Fig. 3 and Fig. 4.

Concept of a training

The software is only a tool in hands of the person responsible for training and gives him full potential of generating electric grid states. The number and order of specific faults of the grid and their location can be changed to create a scenario training. Suggested training program: (1) familiarize with the specific mine electric grid – acquire the ability to quickly identify the key elements of the system; (2) familiarize with the functions of the training application – acquire the ability to preview status of the switching station to find the location of areas cut-off from the system and to redirect energy between functioning switching stations; (3) tests involving balancing the network load as a whole, at normal conditions; (4) tests based on simulation of non-standard conditions: single fault of the grid, single fault of the mining or additional machinery, power breakdown in overall or in selective areas, higher than usual energy consumption; (6) – tests based on simulation of incident conditions: explosion, flooding, fire, crump, methane threat, risk of activating additional energy receivers, i.e. fan stations. The aim of the parts of training indicated in points 3-6 is acquire the ability to act properly when specific conditions occurs.

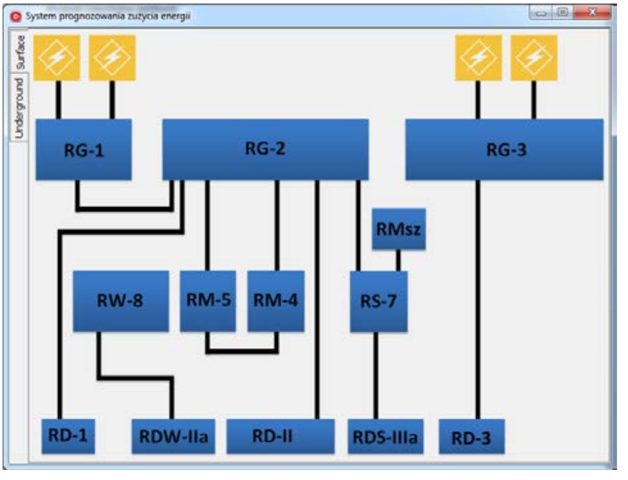

Fig. 3. Software window – a general diagram of surface power grid of the mine

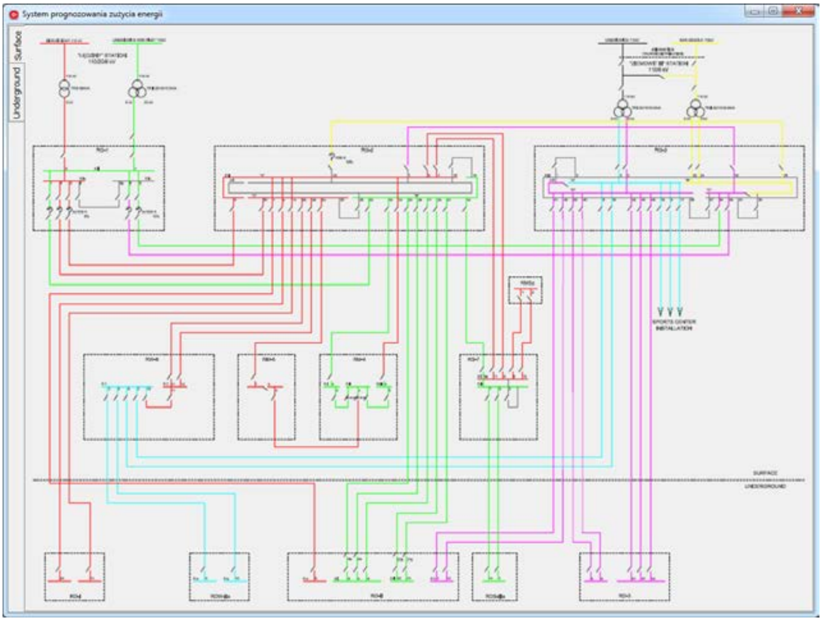

Fig. 4. Software window – a detailed diagram of surface power grid of the mine

The suggested training should be long-term. It is assumed that the trainee is employed and performs normal work under the supervision, but with the use of the proposed software. Two approaches are being considered: (1) fast training – training is independent of the current situation in the mine. Software has a built-in scenarios with all possible situations compliant with the training program. It means, that the employee is isolated from the real situation at work, he only monitors and coordinates activities simulated by the software. This type of training is the fastest one, but to realize training program, the employee cannot assist in regular work. It is possible to achieve when a full crew is present at work and it is lack of a very dangerous situations during mine functioning; (2) slow training – it is assumed that the employee coordinates energy redirection in the grid, takes strategic decisions, but the current situation in the mine is mapped in the software, with a specified approximation and delay. Of course, at this point, it is unlikely to map all the possible situations from a training scenario, even in a long time period (e.g. 3 months or more). In such type of trainin, it is also necessary from the technical supervisor of the software simulator to adjust software to the current situation and to correct carried out parts of the training, in accordance with the training program.

Duration of the training depends on the decisions of people responsible for the training of an employee and depending on their setups are prepared scenarios of the simulation, in accordance with the training program. They also decides about the number of repetitions of the selected scenarios and about assessment of whether the employee is properly trained yet or not. One of the stages of the test can be introduction of incorrect suggestions by the DSS on purpose, and then observation of trainee decisions.

Summary

The solution proposed in the article introduce a significant improvement in the work related to the training of personnel from electrical divisions in mines. By using the training software, it is possible to reduce number of professional personnel necessary to carry out the assessment processes, reduce time of training, in specific situations, and strongly increase the vocational competences of the employees. The results obtained during realization of the M-MARTGRID project formed the basis for the development of the training concept. Practicing activities that are dangerous or even impossible to complete in a real environment, causes that a person trained in a virtual environment can effectively and appropriately respond to a hazardous situation. Training in a virtual environment also positively affects of superiors and colleagues. What is important, such training has a direct impact not only on the safety of the employee, but also rest of the crew. It seems useful in further stages of research to refine the tools and use proposed concept for personnel trainings in different branches of industry.

References

1. Bielińska E.: *Prognozowanie ciągów czasowych*, Wydawnictwo Politechniki Śląskiej, Gliwice 2007.
2. Billewicz K.: *Smart metering – inteligentny system pomiarowy*, PWN, Warszawa 2011.
3. Grabowski A.: Sesje szkoleniowe górników w wirtualnej kopalni. Polish Journal of Continuing Education, 2014, 3(86), 113–123.
4. Keyhani A.: *Design of Smart Power Grid Renewable Energy Systems*, Wiley-IEEE Press, New Jersey, 2011.
5. Kupidura T.: *Technologie informacyjno-komunikacyjne w projektach międzynarodowych wpierających rozwój kompetencji cyfrowych*, Polish Journal of Continuing Education, 2014, 3(86), 123–131.
6. Łabędzka J.: *Współdzielenie zasobów cyfrowych w edukacji – platformy informatyczne*, Polish Journal of Continuing Education, 2014, 3(86), 132–142.
7. Michalak D.: *Innowacyjne formy szkolenia pracowników zakładów górniczych*, Polish Journal of Continuing Education, 2014, 2(85), 66–74.
8. Niedereliński A.: *Regułowo-modelowe systemy ekspertowe*, Jacek Skalmierski Computer Studio, Gliwice, 2006.
9. Ragan E., Sowndararajan A., Kopper R., Bowman D.: *The Effects of Higher Levels of Immersion on Procedure Memorization Performance and Implications for Educational Virtual Environments*, Presence, 2010, 19, 527–543.
10. Weron R.: *Modeling and forecasting electricity loads and prices*, John Wiley & Sons, Chichester, 2006.
11. www.mathworks.com.
12. The works carried out within the project „Mining Smart Electrical Grids" (M-SMARTGRID) supported by European Commission for Research and Innovation. Unpublished documents.

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