IMPACT OF IT APPLICATION TO MINING INDUSTRY DEVELOPMENT

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Abstract: *It's hard to imagine the mining industry without application of new IT solutions. Digitalization which includes the whole world has a huge influence on mining industry functioning. It concerns many sectors of a mining industry functioning, exactly in: work maintenance of underground part of extraction, assuring the supply of electrical power network or management with accordance to Corporate Social Responsibility (CSR) standards of the global mining company. Application of classical attitude has to be supported by new "intelligent" IT solutions. It assures not only more efficiency economically or social outcome, but assure achieving the high level of competitiveness. There are a lot of existing intelligent solutions. The article presents the possibility of appliance data mining techniques to the analysis of electric power and expert system for Computerised Maintenance Management Systems (CMMS) work maintenance data which proceed from the copper mining industry in Poland.*

Key words*:* IT solutions; mining industry; data mining; renewable sources of energy; competitiveness.

JEL Classification Codes: A10, C02, C38, C88.

1. INTRODUCTION – INDUSTRIAL REVOLUTIONS

Nowadays it's hard to imagine the world without computers and automation. All industrial revolutions caused the world which is addicted to new solutions. The present world is afflicted to the third industrial revolution which started in the late 1950s. The new approach concerns such aspects (Encyklopedia Wiem 2017):

- computerization,
- using the new sources of energy,
- automation of process,
- development of transport,
- development of telecommunication.

The main issue is that the computerization is noticeable everywhere. Personal life, the functioning of each industry or public services are based on computer solutions. Today even the information exchange is virtual e.g. e-mails. The approach to producing energy has changed too. New sources of energy were atomic energy and renewable sources of energy. Main technologies of renewable energy production are presented in figure 1. Process automation is based on using computer technology and software engineering. It assures supporting power plants and factories in industries as diverse as paper, mining and cement operate more efficiently and safely (ABB 2006). A new approach to transport is connected to the development of civil aviation and

popularise cars and trucks. Telecommunication especially wireless connection has changed a way of everyday life functioning.

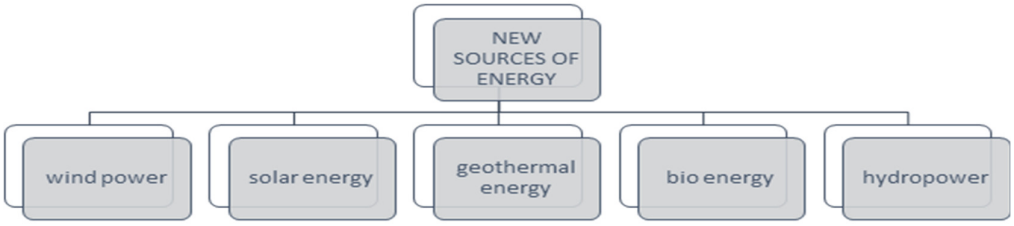

Figure 1. New (renewable) sources of energy

Nowadays in literature appeared the definition of fourth industry revolution called "industry 4.0". This new approach of automation and data exchange in manufacturing technologies that contains (https://en.wikipedia.org/wiki/Industry_4.0):

- cyber-physical systems,
- the Internet of things,
- cloud computing,
- cognitive computing.

Industry 4.0 in Macro Perspective is represented by following elements (Stock and Seliger, 2016): Smart Logistic, Smart Factories, Mining, Consumer, Water Reservoir, Smart Grid, Smart Home and Renewable Energies connected by product lifecycle. The Mining is connected directly to Smart Grid and indirectly to Smart Factories by Smart Logistic. Mining is very important part of Industry 4.0 because it's stated at the beginning of Product Life Cycle in Raw Material Acquisition part.

2. COPPER MINING INDUSTRY IN POLAND

The beginning of functioning copper mining industry in post-war Poland is dated to 1950 when the "Lena" mine started extraction but the highest speed development started in 1957 when Wyżykowski discovered the copper deposit. The need of discovering deposits of copper was pointed by Government Resolutions as a support to the national economy. (http://kghm.com/en/about-us/history). This discovery has a huge impact on local development (Jasińska, et. al 2010).

In an aspect of the future development of computer support to mining industry functioning, it's important to describe many aspects of it's functioning before the computer world come real. (Jasińska et. al. 2016_b). The main of them are:

- exchanging information was written (letters or notice-board) or spoken (direct convey and later by phones);
- book-keeping was paper;
- calculations or transactions settlement were handwritten;
- documentation related to working maintenance was paper separately for each underground machine;
- dispatcher registers of electrical power network where kept on paper and separately for each station.

It's important to notice that documentation related to working maintenance consisted of many registers so enlisting information or knowledge from so huge number of books written in non-standardised form was difficult (Jasiński and Janik 2015). The same situation was with

information of the power grid from dispatcher registers. The registers weren't used for detailed analysis due to an amount of it.

Nowadays approach to the everyday functioning of the mining industry is based on:

- exchanging information via a company's email;
- the book-keeping in the mining company is made with the support of a computer program;
- documents, information or reviews are stored in digitally way and more in on-line way of storing;
- controlling machines is with using a computer with installed software prepared by a producer of machines exactly to control the machine;
- controlling electrical power network is based on computer programs and dispatcher program is in everyday order.

The development was made in an accordance to economic issues (Jasińska, et. al. 2010_b) to assure for the global mining industry a high level of functioning and competitiveness (Jasińska, et. al. 2016_a) in the "new" world.

3. SELECTED APPLIANCES OF NEW APPROACH IN COPPER MINING INDUSTRY IN POLAND

This article contains only selected appliances of a new approach which has changed mining industry in Poland. The selected ones are:

- Computerized maintenance management system (CMMS system);
- Power quality (PQ) monitoring and storing this data;
- Equipping school labs with modern workstations which contain software e.g. typical to mining machines.

CMMS system in is a software which contains a computer database of information about maintenance operations. (Ashraf, 2008) Such systems have been applied in many different industrial companies (Žilka, 2013). Also in mining, the use of CMMS as an support to maintenance strategy is a common practice (Biały and Bobkowski, 2009, Konderla, et. al. 2006). In copper mining industry the CMMS concerns working of each self-propel underground machine (Jasiński, et. al. 2015_a) and contains at least such information:

- Machine information under normal working condition:
  - type,
  - year of production;
  - date of authoring to run;
  - placement of working;
  - time (shift) of working.
- Reparation information:
  - when the reparation was made (start and end date);
  - where the reparation was made (which department, repair shop etc.);
  - who made the reparation (which person or unit);
  - which part or system of machine was repaired;
  - which element was exchanged by a new element;
  - information about producer of new element.

It's important to notice that CMMS system is a huge database which replaced a number of paper registers to one computer database to support working maintenance (Jasiński, et. al. 2017).

Our world is based on electric power. It's hard to imagine its functioning without it (Jasiński, et. al. 2017). Todays, an aim is not only to assure the presence of electric energy but to

assure energy on a required level in a represented period of functioning of electric power network of a company as well as in specific working condition (Jasiński, et. al. 2017c). Analysis of power quality level become a real need in each industry because of energy cost. If delivered energy doesn't keep on required level distributor of electricity must assure compensation. On the other hand, each non-linear load in a company has an impact on a local working condition of an electrical power network. So that customers demand high quality but at the same time they have to take care of it. Renewable sources of energy or distributed generation which impact to electrical power network became an important topic analysis due to the scale of presentence in companies networks. (Sikorski and Rezmer 2015) Analysis of power quality had become an everyday part of copper mining industry functioning. There's an observable expectation of energy on a demanded level to assure the continuous working of main mining machines like welding machines, conveyor belts or drainage pumps. Working of the above-mentioned machines enables an extraction which is a priority of mining industry. Power quality monitoring is possible because there are a lot of PQ recorders which are available and more popular. European standard EN 50160 "Voltage characteristics of electricity supplied by public distribution network" makes demands to power quality (Klajn and Bątkiewicz-Pantuła, 2015). All parameters are measured by power quality recorders which need computer and software to assure the outcome of power quality level. It's important to notice that if the analysis is continuous the amount of data is large so to analysis are difficult but very necessary. Power quality analysis is very useful in renewable sources of energy placement decision-making in the electrical power network because the energy sources an influence on local parameters of energy which must be at required level (Jasiński, 2017).

Another important aspect which is taking into consideration by the copper mining industry in Poland is to be social responsible. They functioning is in accordance with corporate social responsibly (CSR) standards (Jasińska, 2013). In agreement to the CSR standard education issues must be taken into consideration. This lead to that copper mining industry in Poland equipped the school labs with computers and software which assure the possibility to simulate real pneumatic, hydraulic and electric systems. Such operations assure that future workers, who come from local school (for miners, electrics, mechatronics etc.), are going to be well prepared to start work in the mining company so it's both profitable from industry and local society view (Jasińska and Janik 2009).

4. APPLICANCE POSSIBILITY OF ARTIFICIAL INTELIGENCE AND DATA MINING TO COPPER MINING INDUSTRY

Artificial intelligence has changed the world. There are many techniques of artificial intelligence in literature. One of them is those presented in figure 2. This article presents the opportunity of appliance selected technique - expert system to the mining industry maintenance process.

The expert system seems to be a support in decision making about working maintenance issues. The expert system consists of elements: knowledge base, database, interference unit, and solution (Sobierajski, 1994). The relation between parts of the expert system and is presented in figure 3. Additionally, Figure 3 presents the placement of CMMS in expert system of maintenance underground machines.)

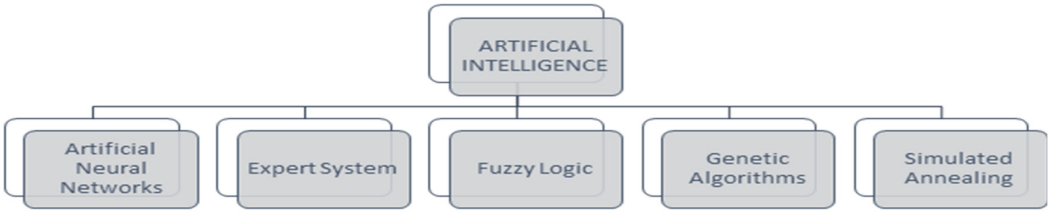

Figure 2. Techniques of artificial intelligence
(Source:Own elaboration based on Wilkosz, 2016)

The CMMS system would be a basement of the database in the expert system because it contains the most important information about underground machines. This database due to its structural and standardized form enables gaining information separately about each machine or for all groups of machines from each mine of KGHM. Information from CMMS may be used at the same time in year (e.g. 2016, 2017) analysis but also in the year of exploitation (e.g.1st-year, 2nd-year) analysis in an easy way because all important data are in CMMS. Another approach to analysis may be a comparison of machines which has the same mileage. CMMS assure possible appliances of much analysis which output may be useful for maintenance process exactly if reliability level would be indicated.

Preparation of the knowledge base in mining industry should be a priory task. Correct preparation of the base is in the basement of experienced workers knowledge. It's hard to find the experienced employee in the mining industry because work time before rental is shorter (25 years) than in other companies. Another aspect is that working conditions are adverse so rotation of workers is frequent. Therefore, the preparation of the database isn't an easy task and should become a priority.

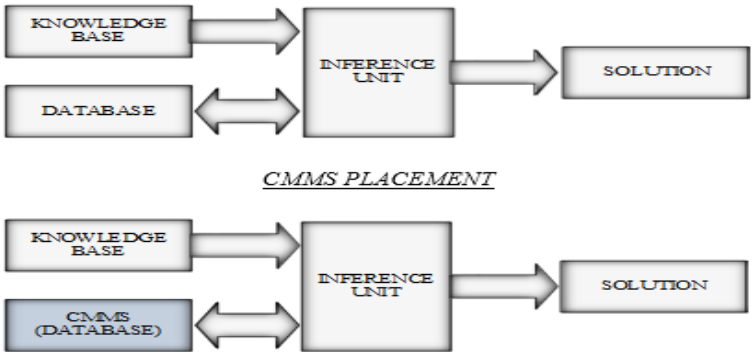

Figure 3 Structure of expert system and structure with the placement of CMMS
(Source: Own elaboration based on Rebizant, 2012)

Mining industry functioning begins to be based on a large amount of data in each part of it. A large amount of data requires a tool to support the analysis of it (Lee, et al. 2014). One of the solutions may be using data mining. The definition of data mining is "Data mining is the analysis of (often large) observational data sets to find unsuspected relationships and to summarize the data in novel ways that are both understandable and useful to the data owner". (Hand, et. al. 2001) That means that data mining supports the analysis of a large amount of data. There are a lot of data mining techniques. Selected one chosen by Conseil International des Grands Réseaux Électriques (CIGRE) is presented in figure 4.

Figure 4 Data mining techniques according to CIGRE
Source: Own elaboration based on (CIGRE 2006)

Selecting tool to support analysis is based on the aim which must be achieved. Classification is led to finding differences between classes of object. The difference is based on the data descriptions of these objects. It differs from classification in clustering the properties of groups aren't predefined but the output is an identified group on its characteristic. Regression is aimed to find a description of data in terms of some mathematical function. Association rules are led to identifying rules that tend to apply to items in data (CIGRE 2006).

Authors suggest using data mining techniques to the analysis of power quality in the electrical power network of mining industry due to (Jasiński, 2017):

- One week power quality data for each parameter consist of 1008 10-minute data;
- Numbers of parameters which should be take into consideration is at least 53;
- Into analysis, there are often took more than one measurement point.

E.g. one-week power quality measurement in the mining industry which consist of at least 3 transformer substation so gives 6 measurement points. For each point at least 53 parameters (do not consider line-line values only as one value to calculations) are recorded so we have 318 parameters from 6 measurement points. If we count the number of 10-minute data, the outcome is a database consist of 320 544 10-minute values. Analysis of such database requires a tool to support it. There's a need for reduction of data without loss of its feature but the groups are unknown at the beginning. Cluster analysis (CA) seems to be a solution because it gives representatives of data with saving its futures. CA found appliances in PQ issues. The examples are presented in (Morais et al., 2009), (Jasiński et al., 2016), (Jasiński et al., 2017_a), (Jasiński, et al. 2017_b). Exactly interested is using CA to automatic flag system for PQ data in the mining industry (Jasiński, et al., 2017_a). Out of this process is 2 groups of data: 1 – data that must be taken into consideration during assessment of PQ level, 2 – data which must be omitted for analysis. With analysis of PQ level is connected cost of energy consumption in the industry. CA of long-term power quality data may lead to find specific working conditions or indicate the impact of distributed generation on electrical power network of the mining industry. So cluster analysis may be a tool to support decision making about using renewable sources of energy in mining industry network.

5. CONCLUSIONS

Nowadays mining industry cannot function without the solutions which were implemented with development of computers and automation of process. Future will be based on the new artificial solution which would help to everyday functioning of mining company. CMMS which support working maintenance would be a useful part of further expert system to assure the more efficiency working maintenance process. It's essentially important in rotation of workers is frequency increasing on actual labour market to support new employees of mining industry.

Due to increasing amount of data in each part of mining company functioning, data mining will be a useful tool to support each analysis, especially to power quality data. The data mining

solutions will be recommended when the smart grid will be a reality in the mining industry as a tool to support analysis of huge databases. Additionally, CA can be a tool to indicate the impact of distributed generation for the local working condition of the network and facilitate a decision making about renewable sources of energy installation in the mining industry.

Described approach of mining industry assure not only more efficiency economically or social outcome but assure achieving the high level of competitiveness which is and always should be important for the global mining industry.

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