Process approach in the mining conditions

Štefan Markulik[1], ***Michal Cehlár***[2] *and* ***Róbert Kozel***[3]

The essential element of any system within an organisation is a process. The role of a process is to create values, which are generated by the transformation of inputs into outputs. Considering the fact that nowadays products are created on the basis of demand-management of the production, this transformation has to be managed in a way that the expected results are achieved at the output. It means the product will be in accordance with the specification (customer´s requirements). Without achieving this accordance, it is not possible to ensure customer´s satisfaction. The facts mentioned above are valid regardless of whether it is an organisation of production or non-production character. The application of the process management philosophy is possible also for the mining industry. The mining process is a process the realisation of which is financially very demanding. The most important part of process management is its planning. Planning activity determines 80% of the resulting effects. They are even more applicable to the mining process. Determining and selecting a suitable mining deposit is a strategic pillar for the planning of mining process. Understanding and application of process management is a necessary condition in order to achieve the success of mining organisation on the market.

Keywords: *Mining Process, Mineral Deposit, Process Approach, Process Control, Management.*

Introduction

Improving companies´ success means improving companies´ processes. Process approach in companies is nowadays a key to effectivity, economy and productivity. Conducting business process improvement (BPI) initiatives is a topic of high priority for today's companies. However, performing BPI projects has become challenging. This is due to rapidly changing customer requirements and an increase of inter-organisational business processes, which need to be considered from an end-to-end perspective. (Johannsen, 2017).

Organizations are increasingly concerned about business process model improvement in their efforts to guarantee improved operational efficiency. Quality assurance of business process models should be addressed in the most objective manner, e.g., through the application of measures, but the assessment of measurement results is not a straightforward task, and it requires the identification of relevant indicators and threshold values, which are able to distinguish different levels of process model quality. Furthermore, indicators must support the improvements of the models by using suitable guidelines (Sánchez-González, 2017). Improving the operational effectiveness and efficiency of processes is a fundamental task of business process management. There exist many proposals for process improvement patterns as practices that aim at supporting this goal. Selecting and implementing relevant process improvement patterns are therefore an important prerequisite for establishing process-aware information systems in enterprises (Lohrmann, 2016).

Creation of company processes management system has to be led in the sense of added value, which is created by these processes, to ensure their efficiency and effectivity with the aim of their continuous improvement. Process approach means adapting to customers´ requests and satisfying them, manufacturing products or providing services to customers, which is expected.

Material and methods

The application of process management philosophy depends on the process knowledge. It is important to know what activities are involved in the process, as well as what inputs are necessary for the implementation of the process in order to achieve the expected product. In the case of mineral extraction, the most basic inputs to this process are as follows:

- land (where mining will take place),
- amount of mineral raw material (bearing size)
- quality of mineral raw material,
- storage conditions,
- physical and chemical conditions,

[1] *Štefan Markulik,* Technical University of Kosice, Faculty of Mechanical Engineering, Department of Safety and Quality, Letná 9, 04200 Kosice, Slovak Republic, stefan.markulik@tuke.sk
[2] *Michal Cehlár,* Technical University of Kosice, Faculty of Mining, Ecology, Process Control and Geotechnology, Letná 9, 04200 Kosice, Institute of Earth Resources, Slovak Republic, michal.cehlar@tuke.sk
[3] *Róbert Kozel,* HAKOZ, s.r.o., Rozvojová 2, 040 11Košice, Slovak Republic, robo.kozel@gmail.com

- geology (such as flooding and cleavage);
- rock stability conditions,
- mining technology (machines and equipment),
- mining technique (availability of methods, mining procedures and practice);
- skilled workers,
- financial resources (credits, subsidies, co-financing by the customer, etc.).

All of the above inputs are the basis for a layout of the mining procedures, the individual activities by means of which the raw material will be mined. All this is an important assumption that the mineral raw material is of interest and that the output that will be formed by the extracted raw material is intended for a particular customer. The implementation of the process in practice is always based on the requirement of the customer's interest. Today there are no companies that would realise processes with uncertain sales of their products without knowing their customers. This is still more applicable in raw material mining because the implementation of this process is economically one of the most demanding processes at all. For this reason, the overall suitability of the mineral raw material deposit must be determined before the mining itself (Fig. 1).

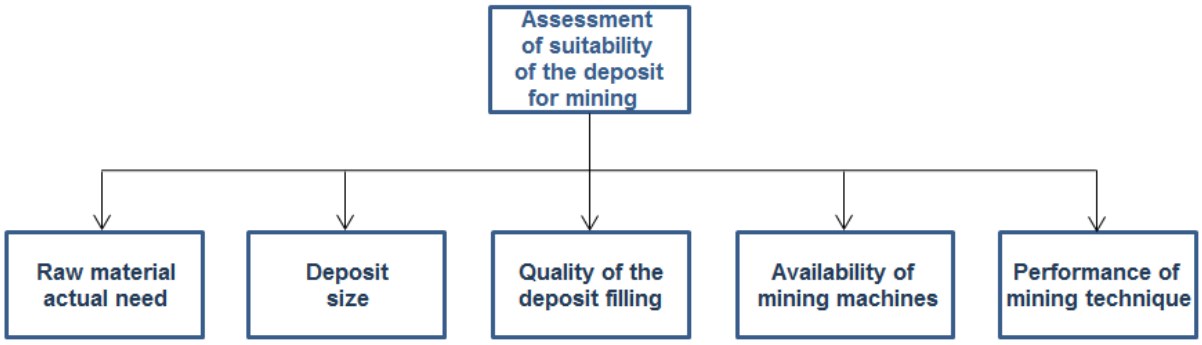

Fig. 1. Scheme of the deposit for mining assessment.

The deposit examination is the process by which the information on its usefulness is obtained. The deposit is basically located in the earth crust where the mineral raw material is extracted taking into account all economic and technological aspects. The earth crust is an earth surface cover the depth of 10-15 km. This range applies to the continents, in the place of the seas and oceans, the earth crust is known to the depth of 8 km.

Depending on this assessment, the individual mining procedures (activities) required to mining the raw material is also proposed.

It is also necessary to know the process of extraction from the point of view of each of the successive activities that make up it. These include, for example, the following activities:

- drilling works,
- blasting works,
- loading,
- transportation,
- crushing.

These activities are dependent on the input examination as well as on the knowledge of the customer specification related to the extracted raw material. This specification typically includes:

- amount of extracted mineral raw material,
- quality of raw material (fractions – individual representation).

Based on the above, the basic model of the mineral extraction process could look as follows (Fig. 2).

Figure 2 shows a basic model of the process that can easily map all the necessary inputs. These inputs can be grouped by affinity by applying the affinity diagram. This will result in a reduction in inputs, however not in terms of their total number, but in terms of the individual categories.

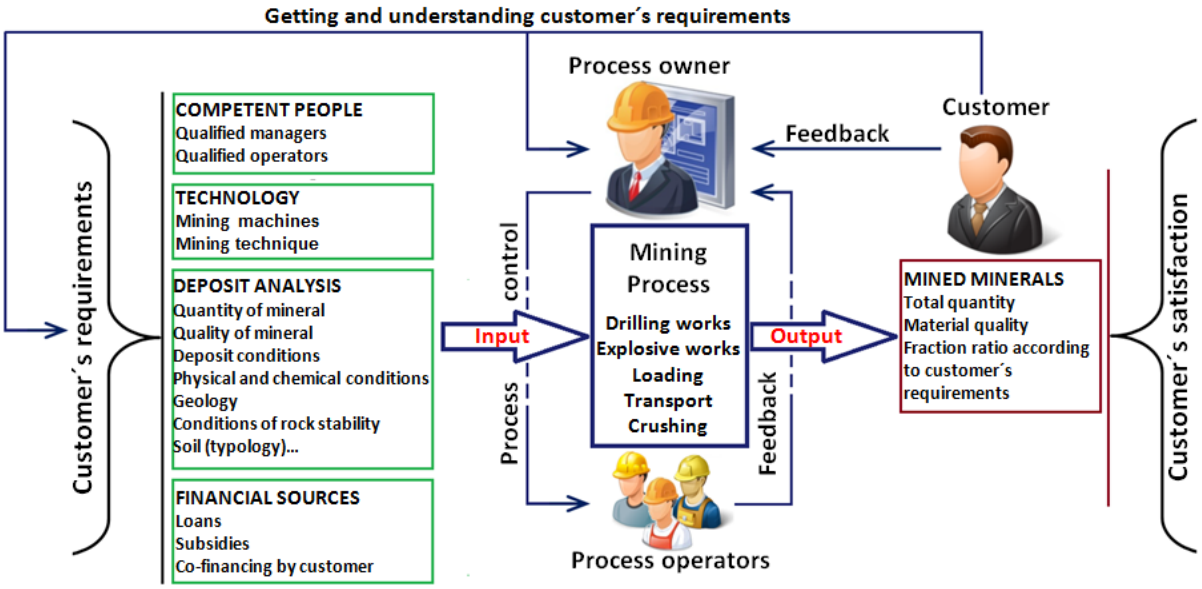

Fig. 2. Model of the mining process.

Results and discussion

The process modelling is based on the basic ideas, namely:

- the process has inputs (divided into several categories, the most commonly used in practice: people, machines, method, measurement, material, money, market, environment, information);
- the process consists of activities that are related or run simultaneously in order to achieve a transformation of inputs to outputs;
- the process has outputs (those represent products and/or services).

The input to the mining process

Referring to Figure 2, there are four basic groups of inputs that are essential to ensure the mining process. With the complexity of the mining process, the number of input categories may be too small. However, the purpose of categorising is to create a reduced number of inputs for easier management.

People

The basic input is presented by people. They are competent workers, starting with those who carry out individual activities at the extraction of raw materials, ending with the top managers responsible for the mining which should be in accordance with the customer specification, but also with the legislative requirements that apply to specific mining. In the figure, workers are illustrated directly above the process. It should be remembered that workers are one of the inputs to the process but hold the function of regulators, it means that they manage the process (individual activities) in the sense of approved mining procedures with respect to the customer requirements, legislation or land use planning in the region where raw material mining will be planned.

Today's business conditions are certainly characterised by rapid and unpredictable changes in both the environment and the company. In these business conditions, companies primarily need to remain flexible in order to manage to follow up changes in the environment, maintain their competitive advantage and remain competitive. Therefore, human resources in a company are strategically managed by defining a strategy of the development of human resources in the company, so it can be said that human resources in a company unquestionably become a part of the strategic management of the company (Karabasevic, 2015).

Machines

Another important input into the process of extracting raw materials are machines generally (in the picture as technology). This term is to be understood as technology, such as technical equipment for mining - machines and equipment such as, for example, loaders, bulldozers, excavators, conveyors, manipulators, etc. The second aspect of technology, as a category of input to the mining process, is technology - the mining technique chosen

to extract the raw material. The procedures and instructions that define the correct course of these activities should be developed for each mining work. The content of individual procedures and instructions is based on the mining project.

Material

Any process without financing cannot be functional. This is still more applicable to the raw materials mining. The mining is so complex and financially demanding that it is unrealizable without funding by credit, subsidies, or co-financing by the customer. Therefore, it is necessary to consider the possibilities of real financing of the mining process before the mining itself.

Money

Any process without financial cannot be functional. This is all the more so when mining raw materials are extracted. Mining is so complex and financially demanding that it is unrealizable without funding for loans, subsidies, or co-financing by customers. Therefore, it is necessary to consider the possibilities of real financial support of the mining process before mining itself.

Mining process

In defining the mining process, it is appropriate to identify all the necessary activities of which the process itself is composed or by which it is formed. From the point of view of the simplified illustration, Figure 2 shows the basic activities that characterise the mining process, such as drilling, blasting, loading, transportation, crushing. The management of the mining process is carried out by the management of each of its activities.

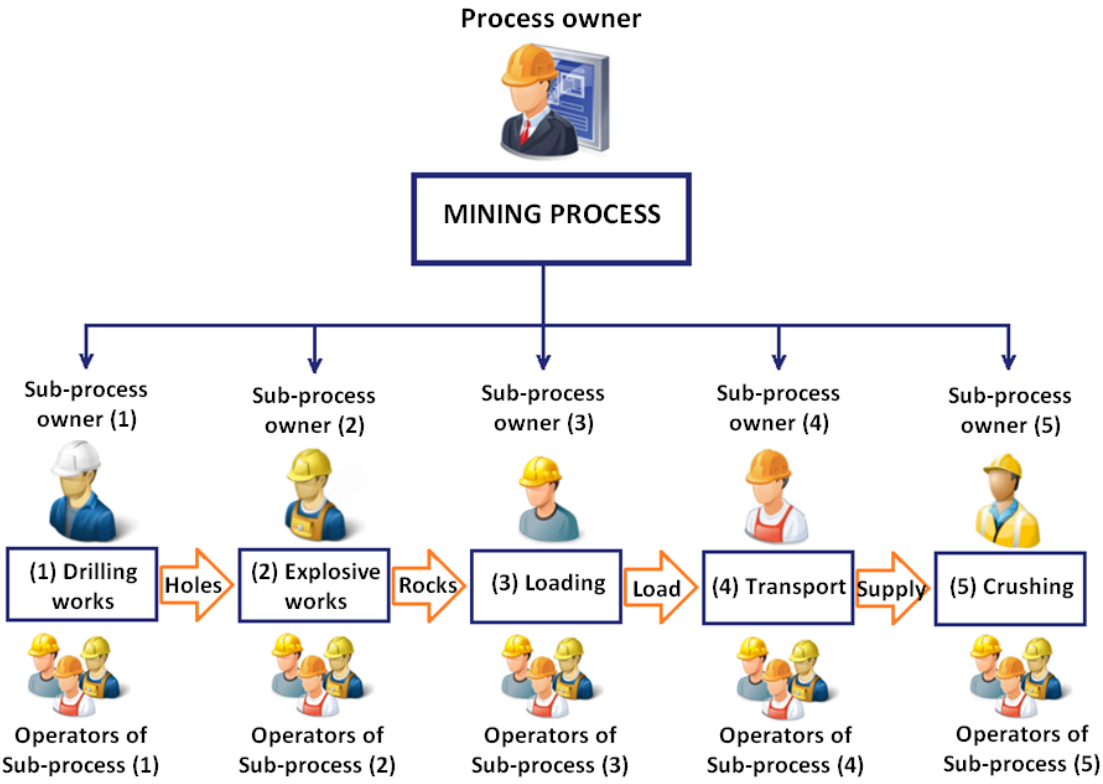

Fig. 3. Scheme of mining process management.

The basic condition of management of processes is the need to measure them. Unless the process is monitored through defined indicators, it is not possible to manage and subsequently improve this process. Therefore, it is very important for each activity to identify indicators that will give feedback to the process owner (process manager). The same principle can be applied to individual activities (Fig. 3). The operators of individual activities perform work according to the procedures and instructions while monitoring data within their activities. By their subsequent processing and analysis, they will serve for the responsible person to manage and improve it. The owner of X activity is responsible for his actions. Therefore, it is important to monitor and analyse data that provide him with information on its course and, if appropriate, give rise to action if the activity does not develop favourably with respect to the expected objectives. The same principle applies at the level of

the whole process where the owner - responsible for the mining process on the basis of indicators in individual activities can evaluate the mining process as a whole.

The output from the mining process

The basic idea of process approach is that output from the first process is the input for next process. In mining process it means:

- Outputs from first sub-process (drilling works) are all holes needed as inputs for next sub-process (explosive works).
- Outputs from second sub-process (explosive works) are all free rock preparing for next sub-process (loading).
- Outputs from third sub-process (loading) are all transported free rock preparing for next sub-process (transport).
- The output from fourth sub-process transport) is a supply of free rocks for next sub-process (crushing). Crushing is the final sub-process of the mining process. The output from this is the final product for the customer. A necessary condition is: the product must conform with customer requirements. It means the required quality and quantity of fractions (Fig. 3).

The basic condition of process management is the necessity of its monitoring and measuring. Unless a process is monitored based on defined indicators, it is not possible to manage and subsequently improve such a process. Therefore, it is very important to define indicators for particular processes, which will provide their owner with feedback about its course. It is possible to use the same system with particular sub-processes (Fig. 3). Operators of particular sub-processes do the work according to the processes and instructions while monitoring (collecting) data. These will, being subsequently processed and analysed, serve the sub-process owner for management and improvement. Based on various trends of monitored indicators in time, it is possible to take measures should the sub-process not develop favourably with respect to the expected aims. The same principle is valid on the level of the whole mining process when the owner – responsible for the mining process based on indicators in particular sub-processes can evaluate the mining process as a whole.

The output from the mining process is a mined raw material that has to meet customer requirements. These relate in particular to the quantity and quality of the mineral raw material. The amount is determined by conventional weight or volume units (such as a tone or m3). The quality indicator of the extracted raw material refers to its fractions (grain size). This means that the representation of the individual fractions, as well as the amount of raw material used in the individual fractions, is assessed. When looking at the simplified scheme of the related activities of the mining process (Fig. 3), it is obvious that each of these activities contributes to the resulting perceived quality of the extracted raw material. Looking at the model of the mining process (Fig. 2), it can be seen that the whole mining process begins with the exploration of the deposit. In particular, it is a geological examination which includes an assessment of the physical and chemical conditions. Just on the basis of this examination, the process of individual mining activities can be chosen. The deposit examination is, therefore, the first and very important step that provides information on the fact which drilling method will be right. Although the geological examination is very important in terms of setting up other procedures related to the extraction of raw materials, the information from it can be compared to the statistically processed data obtained from serial production. In either case, the data does not give a 100% picture of the facts; it is still just sampling. This means that the image of the whole complex (condition of the deposit, or the manufactured parts) is only assumed on their basis. From this point of view, it is very important to determine the parameters that affect the resulting quality of the extracted raw material.

Conclusion

The management of any organisation has to be built on the management of its processes. In reality, it means clearly specified processes, which means knowing the inputs into the process, activities the process will consist of, and outputs. A very important factor is getting feedback which will provide information whether there are expected inputs at the input, whether the process is realised by planned activities and whether at the output, there is a product which meets customer´s requirements.

Mining of raw minerals differs significantly from other industrial processes. Each deposit is unique; it means that it is characterised by other geological conditions and an organisation that decides to exploit the mineral raw material cannot change these characteristics. They have to be simply respected, and their potential influence in planning the mining process must be taken into account. These are the conditions created by Mother Nature itself. In the case of other industrial processes, the organisation itself creates the conditions for their implementation.

The basic geological characteristics that make up the initial input into the mining process are mainly:

- the concentration of mineral raw material in the rock,
- quality of mineral raw material,
- conditions of rock stability,
- storage condition,
- physical and chemical conditions,
- flooding,
- cleavage and others.

Looking at the geological characteristics of a potential mineral deposit, they can be divided into two groups, namely:

- characteristics with an impact on the course of the exploitation (such as flooding, the presence of gases, stability conditions, etc.),
- characteristics with impact on the resulting quality of raw material used (concentration of mineral raw material, quality of mineral raw material, grain size - mineral raw fractions, etc.).

The impact of flooding or the presence of various impacts can significantly affect planning as well as the actual course of the mining process. However, the presence of water or gas does not have an impact on the resulting quality of the extracted raw material. Therefore, the mining organisation must take into account their impact on the process in order to ensure working conditions that comply with safety regulations in accordance with the legislation applicable to mining work. Although these geological characteristics do not affect the quality of the raw material, their impact on the process must also be seen in terms of financial costs, since the potential deposit should, in that case, be rid of excess water that may have a negative impact on the overall stability of the rock. Similarly, this also applies to the occurrence of gas, which can either be discharged from the deposit or the workers are equipped with breathing apparatus. The financial costs associated with the occurrence of the above geological characteristics of the deposit should be understood both as a part of providing a different technique minimising the negative impacts on the course of the mining and its overall prolongation in terms of time.

The influence of the grain size of the mineral material present in the deposit has a significant effect on its final quality. If the grain size of the mineral raw material in the deposit is greater than required, in such a case its treatment can be assured by crushing process to achieve the desired size.

If the grain size is smaller, there may be a situation that the customer's interest will not be satisfied. In this case, the chance is to offer this raw material to the same or another customer, but at a lower price.

The impact of the mining processes is in strong interaction with the input geological characteristics of the deposit since the individual mining processes are planned and subsequently implemented. As stated above, the grain size is one of the characteristics that significantly influence the resulting quality of the output - the raw material, but from the exploitation of the deposit potential to obtaining the resulting mineral raw material of the required quality, it is necessary to mine it. It is just the initial mining processes that are crucial in determining the final quality. This is primarily about drilling and blasting work. In case the mineral raw material is in the desired grain size, it is crucial to choose the correct procedure for the following processes as they can significantly affect the resulting quality of the raw material.

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