THE INFLUENCE OF INCREASING RELIABILITY OF BELT CONVEYORS UPON THE PRODUCTIVITY OF LIGNITE QUARRIES

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ABSTRACT: *At present belt conveyors have an important role in the mines of lignite quarries because they contribute decisively to achieving an optimum production. From this point of view the management of mines should be constantly preoccupied with ensuring, in optimal conditions, the operation of these elements of fixed capital and, if it is necessary they should maintain constant reliability. In this context, this paper has as theme the relation between the reliability of conveyors and the productivity within lignite quarries.*

KEY WORDS: *productivity; reliability; lignite quarries; open minnings; economic efficiency.*

JEL CLASSIFICATIONS: *L70; D20.*

1. ASPECTS REGARDING THE EXPLOITATION OF LIGNITE QUARRIES

The existence of coal deposits in Oltenia is known from ancient times due to exposures in the foothill areas or unveiled by the rivers Jiu, Tismana and Jaleş as well as by adjacent rivers, which made the inhabitants of villages on both sides of the rivers above to use lignite for household purposes.

The development of open mining of useful mineral deposits requires solving particularly important problems, related to:

- establishing rational exploitation limits;
- defining the extent of benches and analyzing their stability;
- determining production and the duration of activity of quarries; the opening, the preparation and the operation of the quarry;
- choosing the most rational and efficient technologies and equipment; organizing the activity within the quarry.

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The fact that open mining in Romania is relatively recent (in comparison with other countries) has created the possibility to choose the most modern equipment and has benefited from the experience of other coal basins in the world so that this equipment is realized according to the actual world technological level.

Open mining is now evolving worldwide, both in terms of production per exploitation unit, and in terms of the number of enterprises, increasing the production of raw materials extracted through quarries as compared to the total production of the same useful mineral.

The basic characteristics of open mining in present days are:

- applying effective methods of exploitation;
- comprehensive mechanization of production processes with the use of appropriate equipment of high productivity;
- possibility of rational planning and organization of work.

Surface working presents a series of advantages in comparison with underground working, requiring the analysis of its operation whenever possible.

Among the obvious advantages there are:

- full mechanization of working operations;
- obtaining greater production and much higher productivity as compared to the underground mining;
- the cost is much lower than in the case of underground mining;
- operating losses are about three times less than in the case of underground mining;
- open mining provides optimal working conditions and thus, it is safer than the underground mining;
- the operation of the quarries starts in a shorter period of time than the operation of underground mines.

Among the possible exploitation methods to be applied to a deposit one should choose the most rational one, which ensures great production and high productivity, few losses of useful mineral substances and the best safety conditions.

The mining method selected for exploitation influences the mechanical equipment within the technological flow, the size of the quarry, the number of benches/steps and the geometric elements of the quarries and also the technical-economic indicators obtained in the quarry.

The operating methods fall into four classes of methods, according to the system of transportation of mine dumps:

I. Operating methods with direct deposit of useless rock in heaps;

II. Operating methods with the transshipment of useless rock in heaps;

III. Operating methods with the transportation of useless rock in heaps;

IV. Combined operation methods.

Out of the Group of combined operating methods, the lignite quarries of Oltenia use the following methods of exploitation:

- the operating method with partial transport of waste to the inner dump and partial storage within the inner dump;
- the operating method with partial transport of waste to the outer dump and partial storage within the inner dump;

- the method of operation which transports a part of the useless rock to outer dumps, a second part of it to inner dumps and stores a third part within the inner dump;
- the method of operation which transports a part of the useless rock to outer dumps, a second part of it to inner dumps and partially transfers the third part of the stripping to inner dumps.

The belt conveyor is the most modern transportation system, which enables continuous transport from the work site over several kilometers. Remarkable progress has been made in building these transport facilities. Nowadays, high capacity conveyor belts are used in major quarries. Moreover, some strips hanging on cable are used, which ensure the translation movement, while the belt remains put.

Transportation systems within quarries consist of the following categories of conveyors: stationary conveyors, semi-stationary conveyors, non-stationary conveyors, conveyors with arms in the console, intermediate conveyors and overburden bridges.

2. GENERAL DESCRIPTION OF THE BELT CONVEYOR

The belt conveyor consists of a continuous loop of material, folded on two pulleys, one of which is the drive pulley being powered by an electrical motor through a gear assembly or a V-rope drive. The drive pulley is placed in front, at the discharge opening, in the direction of the belt. The unpowered pulley/the idler is also actuated by the belt and it plays the role of stretching the material.

Looping the belt around the pulley can be done by a stretching device composed of a trolley with four wheels that move on a metallic frame under the action of weights. This can be obtained with two threaded rods.

Taking into account the resistance of the belts, the maximum length of a conveyor belt was capped at 250-300 m. If the product needs to be transported on greater distances, it uses a conveying system consisting of several serial powered conveyors.

The belt is supported by rollers along its path, being placed more often beneath the loading part to eliminate distortion under the weight of its cargo. The whole system is supported by metallic construction steel profiles.

The loading part (the drive) may be flat or gutter shaped, with rollers pitched at both sides.

Products are loaded on the conveyor with the help of a funnel which may be fixed or mobile, depending on the feeding place.

Unloading can be done exactly the same at the other end of the conveyor through the discharge hopper, or at various points on the sides of the belt with stoppers in the shape of metal blades sloping towards the direction of the belt or of the travelling trippers with funnel.

The residues that stick onto the belt are removed at regular intervals or continuously with cleaning devices.

Belt conveyors can be fixed in continuous processes or mobile, placed on wheels that can be moved from one place to another.

The products carried by using conveyors can be packed in bags, bales, boxes, and barrels or spilled in the form of powder, grains, lumps, etc.

Depending on the physical-chemical characteristics of the materials to be transported, belts can be made out of:

- hemp or cotton fabric, used for solid dry materials, without edges and resistant at temperatures below 80°C and tear-resistant up to 40MPa;
- fabrics made of camel hair resistant to materials impregnated with acids, but that does not support hot materials;
- rubber sheets and ply belting, which are most commonly used, as they are much more resistant to moisture, but the temperature of the material being conveyed must not exceed 65°C;
- tiles or laminated steel tapes which are used for hot and wet materials.

Transportation of materials is done both horizontally and making steep incline up to 26°, the inclination depending on the friction indicators between the cargo and the belt. A steeper inclination of the belt requires ribs to firmly contain the items being carried, the length of the conveyer being limited.

Roller belt conveyors are used in various branches of industry, such as mining, steel industry, construction materials, etc. This type of conveyor is used in industries where it is necessary to ensure a continuous flow of material.

3. THE RELATIONSHIP BETWEEN RELIABILITY AND PRODUCTIVITY IN LIGNITE QUARRIES

Forecasting reliability stands in the center of many reliability programs within the industry. The basic principle of forecasting reliability is to define the rate of failure for all key components in a system and then putting them together in order to get global failure rate of the system.

This process explicitly considers that all components are serial, which means that, if one element breaks down, the whole system will crash. The result gives an estimate of the time when a system, most likely will fail.

In recent decades, several standards have been developed to assist in carrying out this type of analysis. The standards define models for different types of components, based on test data. With few exceptions, the models assume a failure rate, which is constant in time, to address the life cycle of a component in case failures are seen as random.

The statistics indicators of reliability are:

- the average function time (t);
- the mean square deviation of the function times (σ_t);
- failure statistics;
- the experimental function of reliability [$R_N(t_i)$];
- the experimental rate of failure [$\lambda_N(t_i)$].

Because it employs working with installations, modern and complex tools and equipment, providing an efficient and safe use during their entire life cycle, is a main condition.

Through reliability we understand the use of the product at the projected parameters, its his secure and continuous operation, under stated conditions for a specified period of time.

According to the definition of the International Electro-technical Commission (I.E.C.), reliability is a characteristic of a fixed capital element, i.e. the probability with which it carries out a necessary task, under stated conditions for a certain period of time.

Reliability is also the synthesis of the four concepts:

- probability;
- performance and task;
- terms of functioning and operation;
- specified lifecycle.

Reliability is a synthesis parameter the assessment of which, in the context of costs and periods of implementation, can be graphically represented by an RCD triangle (reliability, costs, deadlines), as shown in Figure 1.

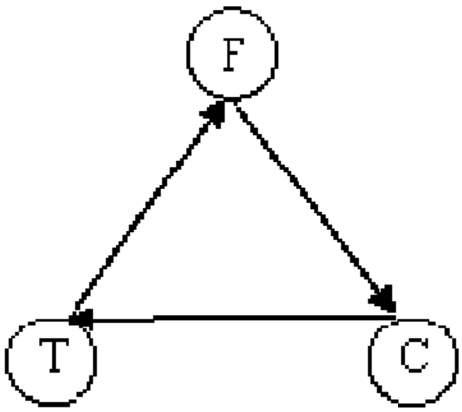

Figure 1. The RCD triangle

where:
R - reliability,
C - costs,
D – deadlines.

Reliability assessment is carried out in three phases:

I. In the design phase, based on considerations of reliability relating to the conception and design of the product as well as on the reliability of its components in specified operating conditions; in this phase we should consider the preliminary reliability (forecasted or designed).

II. In the production phase, on the basis of experimental testing of products within laboratories, testing stations, trial stands; at this point we

should take into consideration the technological or experimental reliability
III. In the operation phase, on the basis of information relating to the behaviour of products for a certain period of time; in this phase we are dealing with operational reliability.

The nominal reliability is also mentioned, and it represents the dependability of a product stipulated in the specifications (standards, internal rules, conditions of contract etc.).

A notion which can no heard very often when speaking about reliability is the notion of breakdown, meaning failure (fault, malfunction, shutdown, incident) which prevents the product to fulfill one, more or all of the basic functions provided. That is to say that not every malfunction of a product constitutes a breakdown.

Breakdowns may fall into the following categories:

- partial failures that cause the termination of one or more functions of the product without leading to a total shutdown;
- total failure which paralyzes all functions of the product and leads to complete shutdown

According to their occurrence failures may also classify in:

- instant failures which occur accidentally and are based on hidden flaws of the product,
- progressive failures determined by wear and tear caused by pushing the parameters of the product off limits.

Allowing for the theoretical considerations presented above, we consider that in the case of belt conveyors used in lignite quarries the determination of reliability is a basic premise in order to increase or at least maintain steady productivity and hence general effectiveness of the economic unit.

In general, through **economic efficiency** one can highlight and measure the complex relationship between the effects, i.e. the results of economic activities and the efforts (expenses) made to obtain them. Efficiency is higher if the same amount of production factors turns out a higher production value, or when a specified amount of results is achieved with a minimal consumption of production factors.

Economic efficiency expresses the ratio of the useful effects (outputs) to the efforts made to get there (expenditures) or vice versa, the ratio of consumption of production factors to the results obtained.

$$E = \frac{efect}{efort} = \frac{R}{C}; \qquad E = \frac{efort}{efect} = \frac{C}{R}$$

where:
E = economic efficiency
R = result (profit)
C = expenditures or consumption of production factors

In terms of productivity, it is generally defined as the ratio of the measured volume of production to the measured volume of the inputs (production factors). Each input can be associated with a measure of productivity, as there are results which cannot be directly linked to any of the production factors. According to the theory of economic growth, productivity is measured as a result which shows the excess of production obtained which cannot be explained by the increased of the production factors used (capital and labor).

Generically, we shall tackle further on the problem of capital productivity (yield).

Capital productivity (yield) refers to the efficient use of capital and designates the ratio of total production volume to the amount of capital being consumed.

Due to the impossibility of measuring the capital, the capital coefficient is used as a tool for economic analysis of the economic efficiency of capital.

Capital coefficient expresses the capital requirements for getting economic effects; the smaller this parameter, the higher the efficiency of using the capital. It can be determined as an average or as a margin.

The average capital coefficient (K) shall be calculated by relating the amount of used capital (K) to the production volume (Q) obtained over a certain period of time.

$$\bar{K} = \frac{K}{Q}$$

The marginal coefficient of capital (Kmg) can be calculated by relating capital variation (ΔK) to production variation (ΔQ) over a certain period of time.

$$Kmg = \frac{\Delta K}{\Delta Q}$$

This reflects the increase in capital necessary for obtaining an additional production volume, on condition the other factors of production should not change.

In our case the productivity of a belt conveyor can be determined according to the relation:

$$\mathrm{W}=Q \times v \times q \times k \times B$$

Where:
W=productivity (yield) of the fixed capital element de capital fix
Q= quantity conveyed
v = speed
k= the fall (flow) of the materials conveyed
B= the width of the belt

Therefore, we believe that the optimal operation of a piece of equipment such as a belt conveyor is influenced by the following factors: the speed of transport, the quantity transported and the width of the belt.

4. CONCLUSIONS

In terms of equipping lignite quarries from Oltenia Coal Basin with modern equipment one may observed the aging of machinery, a situation that can be recovered through a better reliability of these installations, which leads to higher productivity; higher productivity means higher income for the economic unit, which ensures a better remuneration of human labor, thus leading to increased economic comfort of employees.

In the same train of ideas there has been observed a deficiency in innovation and competitiveness of lignite quarries. These are critical impediments for the increase of reliability.

In future, the lignite sector should take into account the following:

• the increase of the technological level within quarries as a result of:
  - rehabilitation of technological lines for quarries and dumps;
  - monitoring the operation of equipment within the quarry and the consumption of electricity;
  - switching to the inner dump in all the lignite quarries;
  - extending the technology towards direct dumps;

• improving the infrastructure of quarries as a result of:
  - easy and secure access to all equipment and technological works;
  - ensuring secure communication facilities and performances;
  - setting up of premises with building in good condition, with access roads and well maintained platforms.

• optimal and reliable management of fixed capital assets, and in particular of belt conveyors, in order to increase economic efficiency of the unit.

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