UDC 622.2:001.18

Prof., PhD Litvinsky Garry G.
(DonSTU, Alchevsk, LPR)

MINING EQUIPMENT AND TECHNOLOGY OF THE FUTURE

The retrospective analysis revealed the causes of stagnation and major deficiencies in mining engineering. The need to change the old conservative scientific doctrine to the progressive new was proved. Examples of new technical solutions and technologies of mining equipment (frontal roadheader, auger excavation aggregate, mine hoisting and drainage system) and the forecast of the mining development is made.

Key words: *analysis, forecast, mining equipment, mining technology, scientific doctrine, efficiency, roadheader, excavation unit, mine hoisting, mine drainage.*

Introduction

A retrospective analysis of the state and the historical development of the mining industry has shown that the first stage of its development is an advanced outpost of the science and technology development. However, so far in this industry there are clear signs of stagnation. Scientists of many countries considered the state of the mining industry from different perspectives and offer their predictions for its future development [1-5 etc.]. At the same time, most of these publications were devoted to discussion primarily organizational and economic problems. The concrete proposals were often neglected to change the base of the mining industry - its technology and equipment. Now the period of changing the technological structures of the world economy has come. It requires high-quality («jump») changes in the principles of mining production processes.

The aim of the article is to analyze the causes and to predict the perspective directions of mining machinery and technology development in the transition of global economy to a new (sixth) technological order. To do this, lets identify the technical contradictions responsible for the stagnation arising of the mining industry development, the main relics, outdated (relic) solutions inherent to mining equipment and technology and to develop ways their overcome on a new conceptual framework. Thus, complicated unresolved problem stands before mining industry on selecting alternative ways of development which, figuratively speaking; turn to uncompromising struggle of old and new scientific doctrines.

Struggle between old and new scientific doctrines

Looking at the technical side of the problem, we highlight the following main drawbacks of the mining industry:

- mining industry destroys the environment; pollute it with mine waters, methane emissions and gas and waste rock dumps, dramatically affects the water balance of the territory;
- an unacceptably high level of danger and emergency operations because of the inefficiency of ventilation, heat, and dust disturbances regime, frequent rock collapses and the destruction of the lining, the dangers of fires, explosions of gas and dust, flooding, etc.;
- mining equipment and systems have a large mass and spending energy, do not meet the principles of automation, mechatronics, do not provide manless technology and work organization;
- technological schemes of opening, preparation and development of deposits are unnecessarily diverse and complex, require the use of a wide range of specialized equipment and a large part of manual work;
- miners are in extremely unhealthy conditions (temperature extremes, dust, noise, vibration, bad lighting, air and water pollution), labor operations belong to a high category of intensity, are carried out in a forced position of the body (often lying and crawling), in imposed by mining machines pace.

Overcoming major technical contradictions in the mining industry lies on the way-out of the inertia vector of thinking inherent in existing nowadays the old ***conservative*** doctrine of mining technology.

The old conservative doctrine of mining technology uses:

- inertia vector of thinking: the outdated ideas and principles of mining, relics of the techniques and technologies;

- the concept of the ***extensive*** development of individual elements of the technology and techniques (increase of power, weight, size, speed, power availability, etc.)

- incremental improvements in ***traditional*** technical solutions aimed at eliminating "bottlenecks".

The inertia of thinking still dominates among manufacturers, designers and scientists and contributes to the preservation of relics and technical solutions, technical snowballing accumulation of contradictions, making them irresistible. We believe such technical relics are: cutters for breaking rocks, rails underground transport, pipe for drainage and ventilation, ropes in the hoisting, cables in power supply and for communication, forced mining ventilation, a huge complex surface, cyclicality in technology, etc.

The history of the development of technical systems has proven that attempts to overcome the technical contradiction based on traditional approaches cannot succeed and are fateful. It should be "***flexible thinking***" as the key to success in rapid changing of industry environment, e.g. mining companies need new basic solutions.

Based on the analysis of status and trends of mining industry development, we offer a new scientific doctrine, which involves:

- identifying, understanding and ***overcoming*** a qualitatively new level of accumulated technical ***contradictions***;

- use of the concept of ***intensive*** development of mining machinery and technology, changing the ***essence*** of technology and design ***principles*** of the engineering;

- the rejection of the existing relics of technical solutions, a ***fundamental change*** in the existing conventional approaches and beliefs, to ***overcome*** the "***inertia vectors***" of thinking;

- the transition to using the ***mechatronics*** and ***automation*** principles in mining equipment, to providing secure, manless, in-line and environmentally friendly mining technologies.

Currently, there is a sharp struggle of these alternative scientific doctrines, the outcome of which depends on the development of the mining industry in the medium and long term. As examples, we present some solutions of mining equipment and technology to meet the requirements of the new scientific doctrine. These examples are special technical solutions in a number of design and technological researches carried out in the Donbass State Technical University.

Frontal mining intelligent roadheader «MIR»

Roadheaders [6] should be referred to as one of the basic types of mining equipment. Their extensive development has led to the emergence and consolidation of the following disadvantages: manual control and inability to being automated, absence of unification (a wide variety of types and modifications), poor adaptation to changing geological conditions, lengthy preparatory and final operations, low availability factor (0.5 ... 0.7) and time use index (0.2 ... 0.4). The cutting tools are outdated and have become one of the main brakes of roadheaders' improvement.

The main technical contradiction in this direction of mining machinery development was a functions discrepancy of executive cutting tool (equipped with incisors) and pressure (in the form of caterpillars) roadheader bodies carrying out the requirements of high-speed penetrations of the inclined and curved mining workings [6]. Existing roadheaders have been difficult to automate, they are not suitable for hard rock ($f > 5...7$) and inclined workings, heading rate is less than 200 ... 300 m / month. High dust content, noise and vibration are occurred in the workings face.

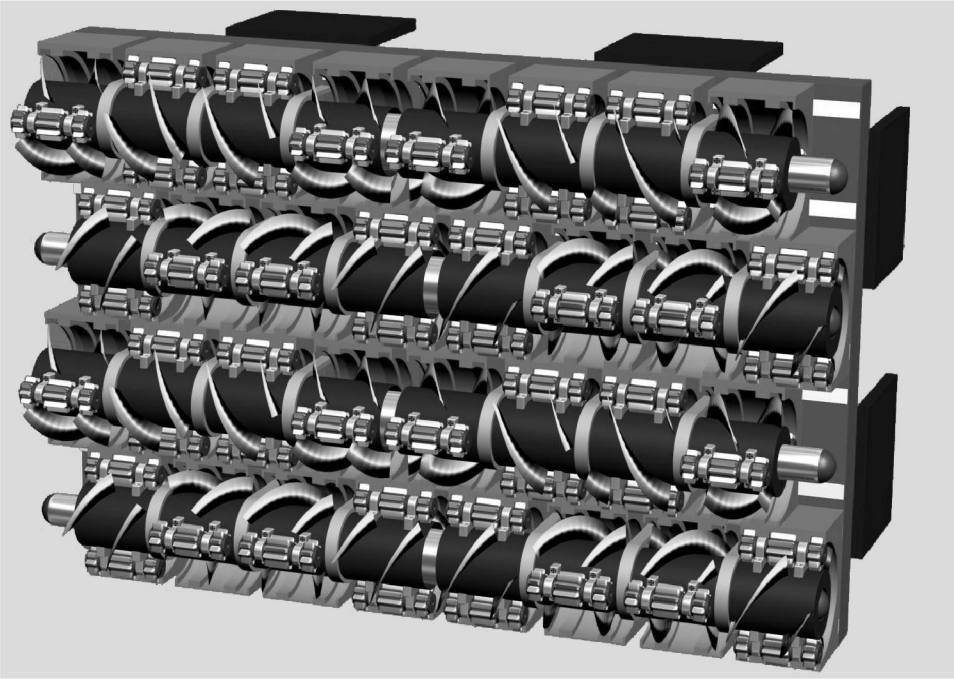

Figure 1 Frontal mining intelligent roadheader «MIR» (view of the working unit)

Based on the analysis of work and overcoming the inherent combines technical contradictions, we have developed the frontal mining intelligent roadheader «MIR» (Fig. 1) with a radically new arrangement for the streaming automated heading technology for horizontal and inclined (± 30º) workings in rocks of any hardness (up to f = 20 or more) with a rate of 50…100 m / day (1500 ... 2000 m / month.).

The main structural differences of the roadheader "MIR" are the working unit in the form of a base' diaphragm with the augers and running cutters. The augers are rotated by high-torque voluminous hydraulic motors on a "stator-wheel" scheme from the pumping station. Propulsion of the roadheader is made of a walking type hydraulic jacks and base plates. The roadheader operates automatically under computer control.

The advantages of the roadheader «MIR» are safety and comfort working conditions (dust, vibration, temperature are excludied), continuous streaming technology, full automation of the work using the principles of mechatronics; versatility on any type of rock hardness and type of workings, simplicity and cheapness of construction; cutting of hard rock by cutters due to high (200-300 ton) thrust forces on the working face, the absence of expensive and bulky gears (no shafts and toothing); accuracy in keeping contour and predetermined heading route, high maneuverability (turning radius up to 10 m); a high heading rate (50-100 m / day), increase of labor productivity 7-12 times; reducing the cost of drilling 3-4 times, a payback period of less than 4-6 months.

The frontal aggregate of the screw coal mining (AFSM)

The main role in coal mining production on modern mines belongs to a shearer and a plow operating in a working face under the protection of the powered roof supports. The cutters are used as a cutting tool [6]. Disadvantages of this technique are much the same as that of the roadheaders with incisors.

To solve the problem of a manless coal mining with the help of streaming technology, we have developed the **frontal aggregate** AFSM (Fig. 2). It has excavation and delivery auger, working body with running cutters. The switchboards fence is fixed on augers. It eliminates the coal loss and the possible dilution by falling rock.

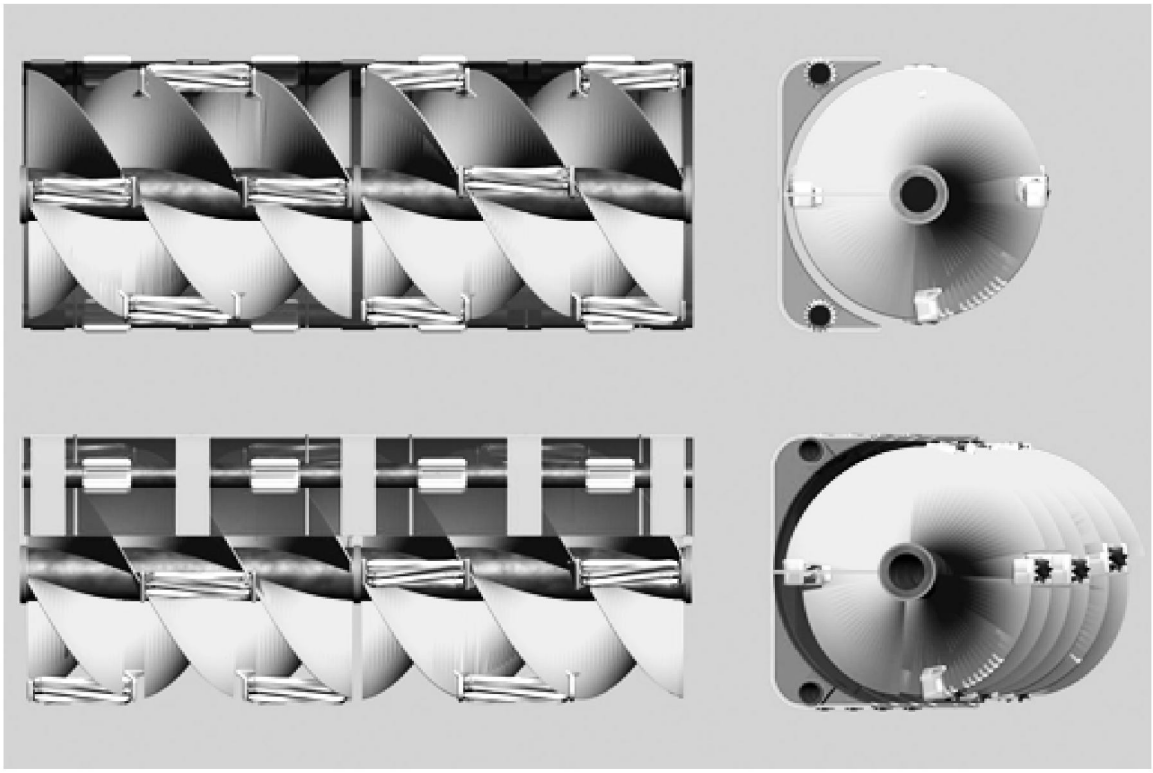

Figure 2 The frontal aggregate of the auger mining coal AFSM

The aggregate creates a thrust on the coal-face and is moved by thrust rollers. They can roll on the ground of a coal seam. Rolling cutters on augers produce effective frontal cutting of a coal face, at the same time reducing the resistance to rotation of the augers (rolling bearing effect).

Moving speed of the frontal aggregate is about 0.05 ... 2 mm / s. Due to the compact of aggregate and its high speed (to 50 ...100 m / day) is not need for fixing the coal seam roof, which turns into a smooth descent mode. Miners are not required in the lava and ventilation is not necessary.

The advantages AFSM include: manless mining, streaming and continuity of the coal mining productivity, full automation, high capacity 150–200 t / h of coal from the lava, which has 100 meters in length, a neutral gas environment without ventilation of lava, simplicity and low cost of the aggregate construction, it is possible to extract thin coal seams from 0.4 m with angles of dip from 0 to 40–50 degrees, short the payback period of up to 1 month.

Ropeless hydrojack hoisting and pipless drainage (HJHD)

Modern mining hoist [7] has serious fundamental deficiencies that preclude its use for mining enterprises of the future: a large mass, insufficient carrying capacity and reliability of the rope; low efficiency factor (0.4 ... 0.5) and low productivity; cyclical operation, the complexity of automation.

Mining hoist problems can be resolved by eliminating the rope, which became the main vector of the thinking inertia [7]. To this end, we have developed an alternative and, at first glance, an unusual solution to this problem - ropeless hydrojack hoisting and pipless drainage. It includes (Fig. 3) lifting cans about 1 m^3 in the form of 2 columns of boxes and their propulsion system is a hydraulic cylinders. They stand at the reference stations in on the distance 120 ... 250 m along the shaft and move cargo and empty columns along the rails.

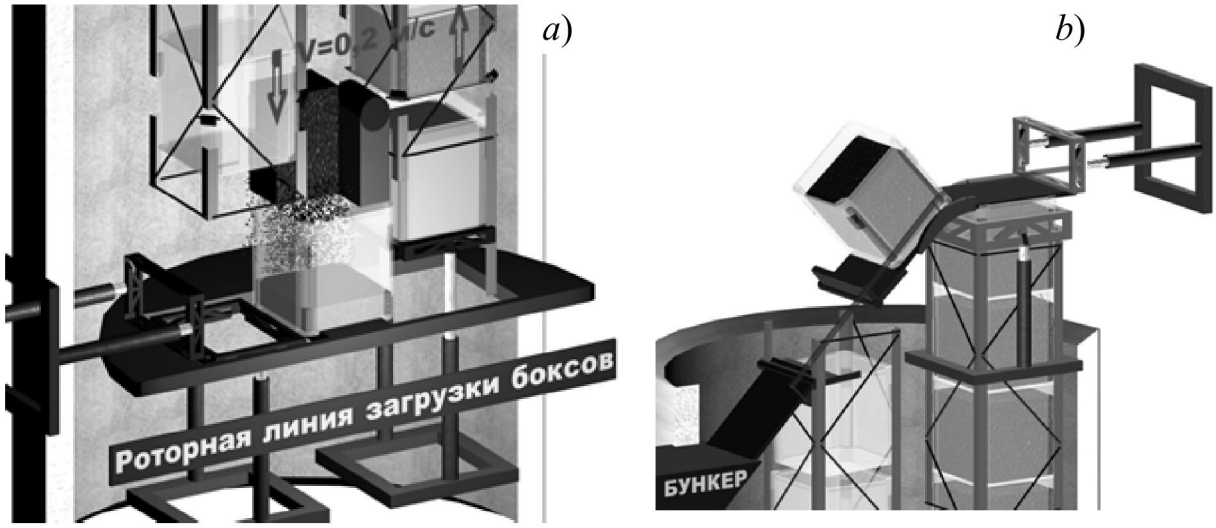

Figure 3 Ropeless hydrojack mining hoist and pipeless drainage: a rotary line
a) in the shaft when loading boxes by the ore or mine water, b) on the surface at their unloading

Hydraulic cylinders operate continuously and automatically. They are connected to the stationary pumping stations at the surface. The lifting boxes are filled with bulk water or coal on the lower horizon by an automatic rotary line (area about 3 m^2) and the cargo' column is lifted at a rate 0.2 ... 0.3 m / s at the mine surface where compact (area also 3 m^2) automatic rotary line unloads boxes. Columns of empty boxes are lowered down at the same rate. Productivity the new mine hoist only in one shaft exceeds 20 thousand t / day and does not depend on the depth of lift. It allows a fulfil drainage for mine and fully refusing pumps, pipes, sophisticated drainage equipment, underground pumping cameras and so on. Specific energy consumption 1.8 ... 2.2 times lower, hardware and maintenance is cheaper 3–4 times.

Conclusions

As part of the new scientific doctrine, we offer new design solutions for achievement of energetically self-sufficient and environmentally "clean" mining companies:

- new models of mining equipment and underground transport (methanol diesel trucks, gravity hydraulic transport of coal, leaving the empty rock in the mine);
- universal opening schemes, preparation and development systems of coal seams;
- energy supply (energy system of the free-piston methane-diesel engines); ventilation (to creat 100% CH_4 the neutral gas underground environment) and surface structure of mine (in the form of a compact closed block), and others.

The implementation of new and promising research results, united in a uniform technological mining industrial system allows the mining of domestic mining and engineering go to its rightful place in the global division of labor and competition, to solve the problem of the economy to ensure the country's energy and raw materials, significantly improve the socio-economic level people and society.

Reference

1. Deutch J. The Future of Coal / John Deutch. — http://breakingenergy.com/2013/12/04/

2. Litvinsky, Garry G. Problem eksploatacji cienkich pokladow w ukrainskich kopalniach wegla kamiennego Zaglebia Donieckiego. / Garry G. Litvinsky // Proc. of the School of Undergr. Mining 2002 : Intern. Mining Forum. Polish Acad. of Science. — Krakow : Nauka-Technica, 2002. — pp. 343–363.

3. Plakitkina, L. S. Analysis of the status and outlook for the coal industry of Russia until 2035" / L. S. Plakitkina // Mining journal. — 2015. — № 7. — pp. 11–14.

4. Puchkov, L. A. Underground mining / L. A. Puchkov, Yu. A. H. Zhezhelevskiy. — M. : Gornaya kniga, 2009. — 624 p.

5. Shmatko, C. I. On measures for the integrated development of the coal industry of the Russian Federation / C. I. Shmatko. — Ugol, 2011. — № 1. — pp. 4–10.

6. Gorbatov, P. A. Mining machinery for underground mining / P. A. Gorbatov, G. V. Petrushkin. — Donetsk : Nord Kompyuter, 2006. — 669 p.

7. Bezhok, V. R. Mine rise / V. R. Bezhok, V. I. Dvornikov, I. G. Manets, V. A. Pristrom. — Donetsk : Yugo-Vostok Ltd., 2007. — 623 p.

Recommended for publication by Doctor of Science, head of Chair CUS&M DonNTU Bohchevskii S. V., PhD, ass.prof., chair DMD DonSTU Melezhyk A. I.

The date of submission 28.02.17.

д.т.н. Литвинский Г. Г. (*ДонГТУ, г. Алчевск, ЛНР*)

БУДУЩИЕ ГОРНЫЕ МАШИНЫ И ТЕХНОЛОГИИ

Ретроспективным анализом выявлены причины технического застоя и основные недостатки горной промышленности. Показана необходимость замены старой консервативной научной доктрины на новую прогрессивную доктрину. Даны конкретные примеры новых технических решений и технологий для горной промышленности: проходческий комбайн, лив. шнековый агрегата для добычи угля, шахтный бесканатный подъем и беструбный водоотлив.

Ключевые слова: *технология добычи, горные машины, научная доктрина, проходческий комбайн, шнековый агрегат для добычи угля, шахтный подъем, шахтный водоотлив.*

д.т.н. Литвинський Г. Г. *(ДонДТУ, м. Алчевськ, ЛНР)*

МАЙБУТНІ ГІРНИЧІ МАШИНИ І ТЕХНОЛОГІЇ

Ретроспективним аналізом виявлено причини технічного застою і основні недоліки гірської промисловості. Показана необхідність заміни старої консервативної наукової доктрини на нову прогресивну доктрину. Дано конкретні приклади нових технічних рішень і технологій для гірничої промисловості: прохідницький комбайн, шнековий агрегат для видобутку вугілля, шахтний безканатний підйом і безтрубний водовідлив.

Ключові слова*: технологія видобутку, гірські машини, наукова доктрина, прохідницький комбайн, шнековий агрегат для видобутку вугілля, шахтний підйом, шахтний водовідлив.*