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INVESTMENT ACTIVITIES FOR THE RESTORATION OF THE MAIN PRODUCTION FUNDS SUITABILITY IN RESPECT TO DEEPENING MINING OPEN PITS ZONE

V. I. Prokopenko, D.E., Prof., «National Mining University», prokopenko_vasil@ukr.net
O. O. Timoshenko, post-grad. st., «National Mining University», aatymosh@ukr.net

Components of constantly renewed cycle of the investment formation on maintaining productivity of production fixed assets and the mechanism of ensuring environmental and economic efficiency while exploiting iron ore deposit are substantiated. The methodological fundamentals for investing into extended reproduction of fixed assets at the mining enterprise for increasing completeness of using the operational stocks of raw ore materials are developed.

Keywords: mining enterprise, investments, extra income, cost of fixed assets, capital produc-

tivity, extended reproduction.

Statement of problem. Production parameters of any enterprise which show the capacity of its output and production costs are determined by available production potential in which the important role is given to the basic mechanical facilities. These mechanical facilities comprise technological complex of the enterprise and determine the level of its advancement and economy. Maintenance of ore mining and processing enterprise capacity is related to investment ensuring suitability of fixed assets to mining and processing of crude ore.

In the process of using, the production funds are subjected to wear. The basic equipment of Kryvyi Rih Mining Complex is 50% worn out, though lately some complexes (North Mining Complex and Central Mining Complex) renewed a definite part of their funds and that lead on the average to the reduction of their wear and tear level [1, p.30]. Increasing the depth of deposit exploitation results not only in wear and tear of the principal equipment, largely of technological equipment, but also in the worsening of production processes conditions which causes the reduction of production capacity and growth of production cost. At the same time nowadays powerful mining and metals production sector is the basis of Ukrainian economy. Iron-ore deposits and adjacent metallurgical enterprises form up to a fourth of domestic GDP.

Analysis of recent papers. When coming to a decision about investment suitability of a definite action, the significant role is played by the opportunity to assess effectiveness assessment and risk of this decision. The authors of the scientific paper [2, p.55] point out that an investor should have the information about possible contingencies or extra profit [2, p.56]. This risk will be reduced if the investments for the rational usage of natural resources are accomplished in a system in terms of time and space. According to Fedchak O. M. [3], if there are preventive investments, further even significant investments that are aimed to eliminate the consequences are low-effective and in general cause the problems accumulation and worsening of nature restoration [p.214]. In the work [4, p.8], it is mentioned that creation of investment activity managing system on the basis of scientific suspended prediction of its directions and forms ensures the realization of the main aims of the enterprise development and adapts it to the conditions of changing environment of its functioning. Thanks to the appropriate investment support the steady state of the enterprise in the market and its economic development in the long term are ensured. The essence of investment activity as the principled important direction of the coal mines durable equipment technical level growth is tacked in the article [5, p.4]. This paper describes a method of investment project planning of technological reequipment of coal production and preparation of new mining extracted areas for exploitation.

It is also noteworthy that the capacity of necessary investments for the restoration of the main mining funds is set according to their state which is characterized by the factor of wear, suitability, outdating and increase of these funds [6, 7]. In the authors' view, it is more reasonable to define the investments volume in terms of yield on capital investment of funds that should be assessed considering its suitability factor taking into account partial ousting of the durable equipment and its partial renewal during the current period of exploitation.

Present research demonstrates that a lot of enterprises, first of all mining and metals production sector, which nowadays has well-worn main assets, require investment activities. Relevant scientific base is developed enough on the level of general approaches to defining the volume and order of investment taking, into account changing enterprise environment. In general, the deeper the working zone of pit and the longer deposit exploitation time, the harder for the enterprises to overcome the difficulties in maintaining the production capacity and competitiveness. The solution for the problem stated, in the first place, is related to innovative activities based on the newest achievements in science. So, in the course of operational activity ore mining and processing enterprise has to carry out constantly renewable cycle of creating investment costs on maintaining the main production funds.

Aim of the paper. As for open-pit mining the investing costs must concern not only

expended reproduction of the main enterprise funds in proportion with the open cuts mining zone but also ensure ecological and economic during ore reserves exploitation. The object of this article is to offer solution to the above-stated problems by taking as an example of Kryvyi Rih Mining Complex.

Materials and methods. In the cycle of forming the investment costs for the production processes realization there are four stages: 1) obtaining extra profit from the operational activity; 2) investing the development of the production potential; 3) forming the internal environment of the enterprise; 4) production and realization of metallurgical raw materials. At large, these cycles comprise the mechanism of forming the investments for the reproduction of the durable equipment.

Extra profit from the operational activity is supposed to be received due to production capacity and quality increase by means of using upgraded iron ore which can be done by targeted managing of the mining operation mode. Herewith the enterprise firstly saves money on the development of production potential investing, namely, expended reproduction of the main enterprise funds, and then by these funds, it refines to low-grade ore reserves. The solution for this issue is based on the creation of technical funds and high-level technologies in respect to scientific and technological advance under the influence of time factor.

Thus, according to the cycle of reproduction of the main enterprise funds, during the first phase of the open cuts exploitation, the enterprise gets sufficient profit from mining and enrichment of high-grade ore and then, during the second and the third phases, it gains profit by using renovated and modernized production funds which produce output from the low-grade ore (Fig.2). During the initial stage of the open pit exploitation the production processes are performed with available technical and technological funds in favorable mining conditions, then – with improved funds that can adapt to the worth exploitation conditions because of the pit deeping.

The amount of durable equipment subject to reproduction because of wear is conditioned by its suitability for exploitation. Taking into account wearing out of a part of durable equipment and its partial renovation during the current period of exploitation (a year), suitability of its equipment for the planned period can be defined by the formula:

$$C_{n.o.э} = 1 - C_э = \frac{F_{n.2} - F_в + F_н - AD + E_м}{F_{n.2}}; \quad (1)$$

where $C_{n.o.э}$ – a coefficient of suitability of the durable equipment for exploitation, of share units;

$C_э$ – coefficient of wearing out of the durable equipment, share of units;

F_{n2} – planned cost of the durable equipment for the beginning of the year, UAH;

$F_в$, $F_н$ – cost of the durable equipment that were taking out of exploitation and introduced to exploitation during the current year, UAH;

AD – allocation for depreciation on reproduction of the durable equipment during the current year, UAH/year;

$E_м$ – enterprise expenses on the repair and modernization of the durable equipment during the current year, UAH/year.

Let us define how the suitability of the durable equipment will increase (or decrease) next planned year, depending on the amount of introduced and withdrawn funds. The change of suitability during the planned year compared with that during the current year is equal to the difference:

$$\Delta C_{n.o.э} = C_{n.o.э.к} - C_{n.o.э.п} = \frac{F_{к.2}}{F_{n.2}} - \frac{F_{к.1}}{F_{n.1}}; \quad (2)$$

where $\Delta C_{n.o.э}$ – the change (increase or decrease) of the suitability level of the durable equipment in the planned period compared with the current period, share of units;

$F_{к.1}$, $F_{к.2}$ – depreciated book value of fixed assets in the current and planned periods, UAH, accordingly;

$F_{n.1}, F_{n.2}$ – original value of fixed assets in the current and planned periods, UAH, accordingly.

The difference $(Ф_{n.2} - Ф_в - AB)$ in the formula (1) is a depreciated book value of fixed assets of the planned period without taking into account repair, modernization and renovation costs ($Ф_{э.2}$), and sum $(Ф_н + B_м)$ – costs that are unaccounted for by foregoing value $Ф_{э.2}$ (mark it $B_{в.2}$).

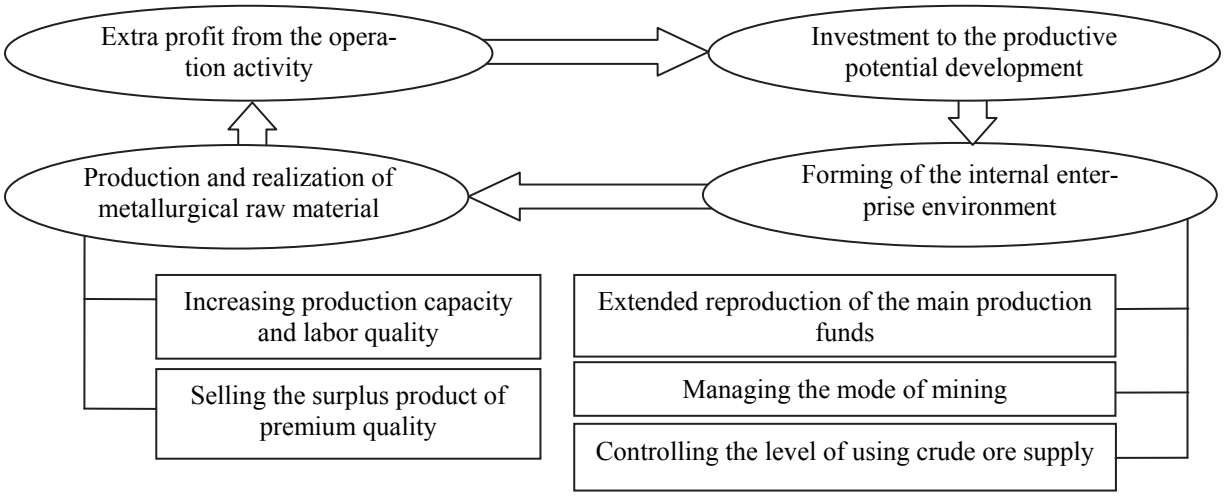

Fig. 1. The mechanism of ensuring ecological and economic efficiency of the iron-ore deposit exploitation

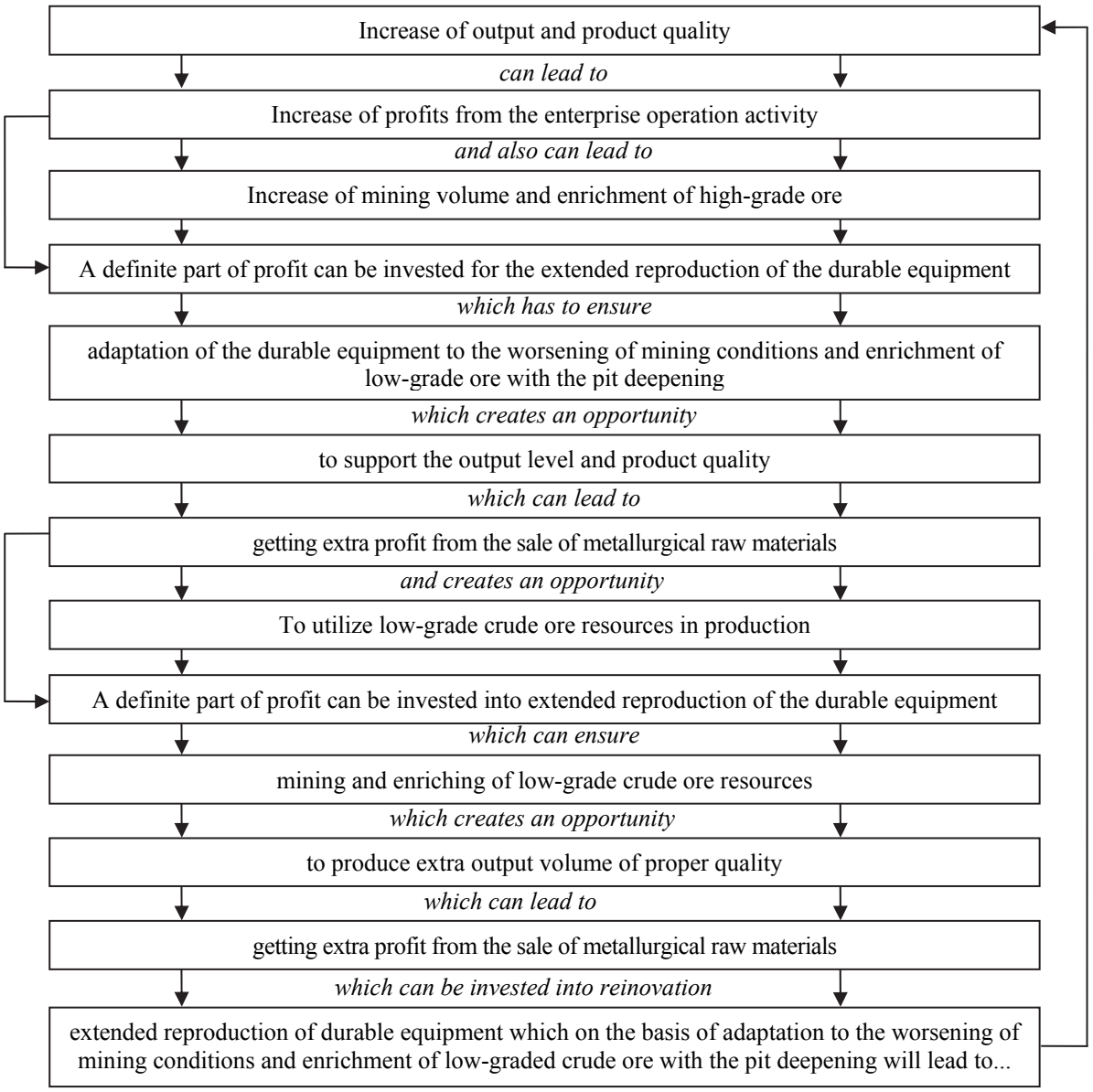

Fig. 2. The scheme of investing to the extended reproduction of the durable equipment for the more complete exploitation of crude ore deposit

It means that the figure $Ф_{з.2}$ will reflect the straight value of fixed assets directly remaining from their current exploitation period, and the figure $B_{в.2}$ – sum of costs, that will be allocated to restoring lost suitability of fixed assets in the planned period. Thus the authors mark out straight depreciated book value of fixed assets and their incidental value, that is formed by adding to the latter sum the costs needed for maintaining and developing production power of fixed assets next year. The environmental factors of the durable equipment exploitation that produce influence on their depreciated book value and the areas of assets suitability reproduction are given in the Fig. 3.

Straight depreciated book value directly takes into account the cost of technological equipment that was withdrawn from exploitation and the sum allocated for depreciation. The number of technological machines, self-loading hauling units, wearing-out equipment depends on the operating life and working conditions, while the depreciation sum is determined by its standards set for each kind of equipment. According to the loss of fixed assets straight value, remaining by the end of the current period, the reproductive measures must be taken (in contrast to equipment exploitation, these measures suggest repair, modernization and renovation activities), the cost of which should be considered as incidental which is allocated as compensation for the loss of the depreciated value of the fixed assets. Such an approach to defining the structure of the durable equipment allows to determine the minimum amount of money, required for maintaining the open pits capacity in proportion to the time and depth of mining operations.

Thus the formula (2) can be introduced in the following way:

$$\Delta C_{n.o.з} = \frac{F_{з.2} + E_{в.2}}{F_{n.2}} - \frac{F_{з.1} + E_{в.1}}{F_{n.1}}. \quad (2a)$$

In the formula (2a) it is assumed that the original value of durable equipment is the cost of these for the beginning of the period, and the depreciated book value – for the end of the given period (current and planned periods). After the transformation of this formula, we obtain:

$$\Delta C_{n.o.з} = \left(\frac{F_{з.2}}{E_{в.2}} - \frac{F_{з.1}}{E_{в.1}}\right) \cdot 100\ \%; \quad (3)$$

where $E_{в.1}$, $E_{в.2}$ – accordingly, the expenses on reproduction of the durable equipment in the current and planned periods, UAH.

Analyzing the component of the formula (3) we can conclude that the change of suitability level of mining and building durable equipment during the definite period of the deposit operation is equal to the difference between the straight value of these funds and the sum of costs spent on their reproduction at the beginning and at the end of the planned period (Fig.3). If the suitability level changes, that is $\Delta C_{n.o.з} = 0$, then the reproduction costs of the fixed assets must be equal to:

$$F_{в.2} = \frac{F_{з.2} F_{в.1}}{F_{з.1}}, \text{ UAH.} \quad (4)$$

Taking into account that $F_в = F_н + E_м$, the formula (4) can be introduced in such a way:

$$E_{м.2} = \frac{F_{з.2}}{F_{з.1}}(F_{п.1} + E_{м.1}) - F_{н.2}, \text{ UAH.} \quad (5)$$

The value $E_м$ should be known for planning costs on maintaining the productive capacity of the open pit after its deepening. On the one hand, the rate of expenses on the reproduction and repair of the fixed assets will be known, on the other hand – we should take into consideration costs on maintaining the open pit productivity mining operations as go deeper. That is why we should add the value $B_{п.к}$ reflecting the increment of fixed assets due to the open pit deepening, to the value $B_{м.2}$, determined by the formula (5).

The formula (5) allows to plan the amount of costs for the renovation of fixed assets, their modernization and repair so that the assets suitability will not change (increase or decrease).

As the result, the cost amount depends on correlation of depreciated book values of fixed asses at the beginning and the end of the planned year, on the original value of fixed assets and also on the appropriated costs amount for the maintaining of the productive capacity during the current year.

The graphics given in Fig. 4 and 5, show the change in enterprise costs allocated on the installation of new equipment and capacity in planned year, depending on changes in the original value of this assets, which is related to the cost of their repair and modernization during the current year.

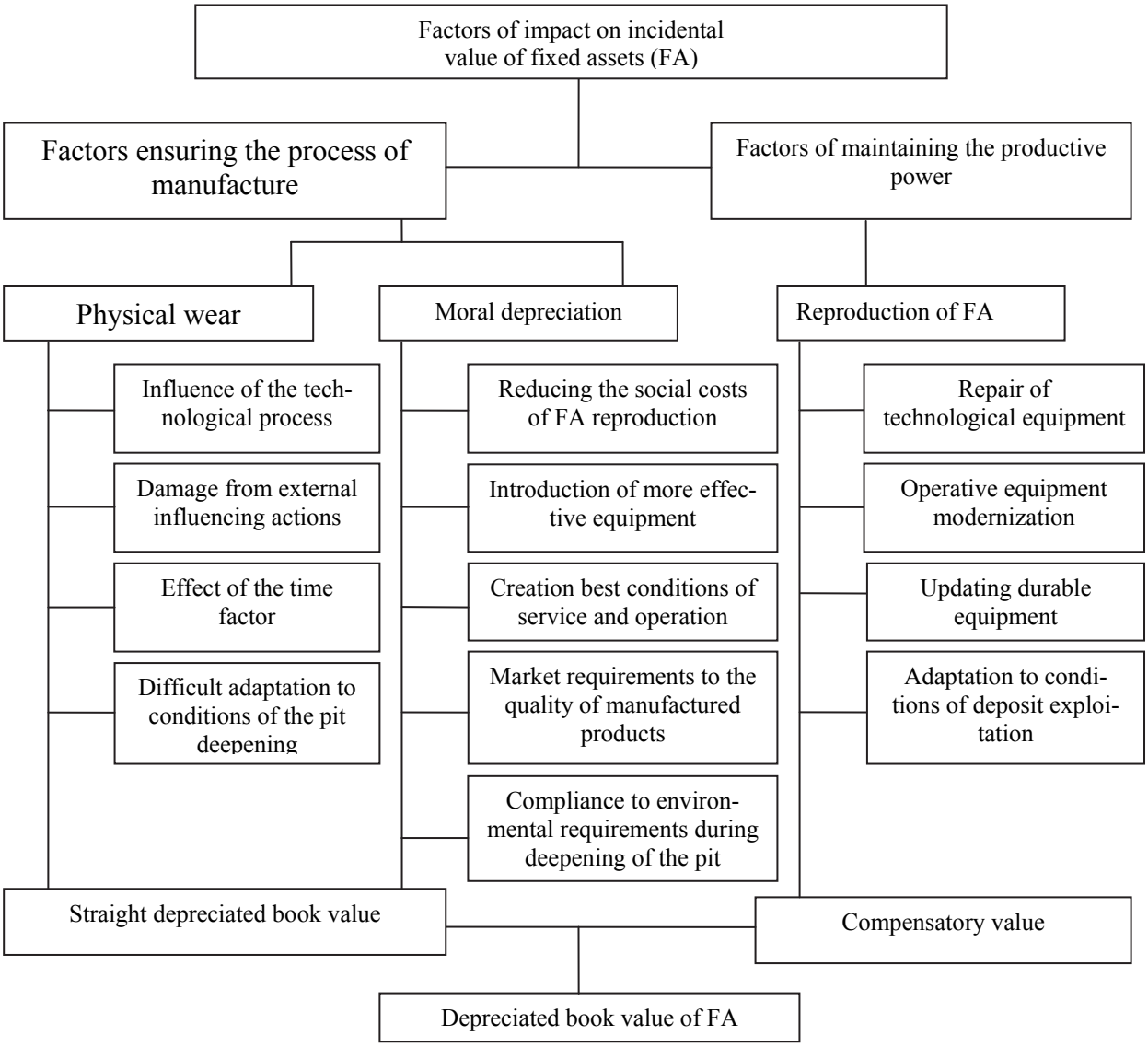

Fig. 3. Graphic presentation of the influence of environmental factors on their depreciated book value of fixed assets.

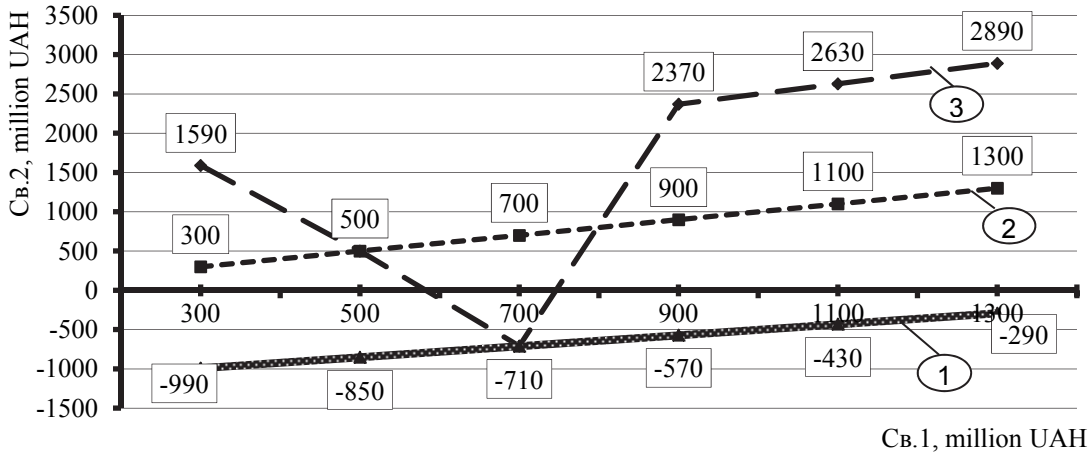

Fig. 4. Change of expenditure, necessary to ensure the suitability of fixed assets in the planned year depending on the expenses on repair, modernization and updating funds in the current year: 1, 2, 3 if $\frac{B_{з.2}}{B_{з.1}} = 0,7\ ;\ 1,0;\ 1,3$, accordingly.

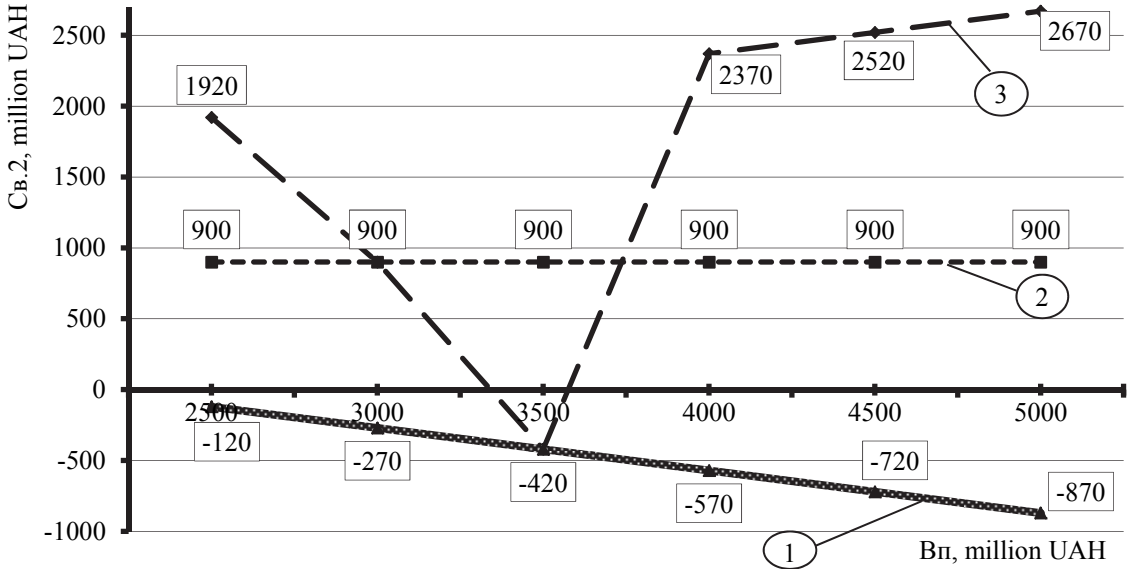

Fig. 5. Change of expediture necessary to ensure the suitability of fixed assets in the planned year depending on their original value: 1, 2, 3 if $\frac{B_{з.2}}{B_{з.1}} = 0{,}7$; 1,0; 1,3, accordingly.

From the graphs it follows that the volume of expenses on the renewal of fixed assets, their modernization and repair is determined by the ratio of residual values of assets at the end of the planning year and the beginning of this.

Table 1 gives the approximate data of Poltava MPP concerning the volume of fixed assets, which ensure its production capacity, efficiency of using funds in general and their individual kinds. Typically, the intensity of funds using in terms of capacity is characterized by capital productivity ratio, for open pit depth $H_{к.t}$ in t –th year of the deposit exploitation is:

$$\Phi_{от} = \frac{O_{пт}}{O\Phi_t}, \text{ t/(UAH per year)} \qquad (6)$$

where $O_{пт}$ – amount of extracted crude ore in the pit, tons / year;

$O\Phi_t$ – the total amount of the pit funds, UAH.

Table 1

Capital productivity ratio of fixed assets in terms of purpose

Kind of fixed assets	Depreciated book value, million UAH/year		Economic capacity, million t/year		Capital productivity ratio, t/1000 UAH	
	2011	2012	2011	2012	2011	2012
Total	3297,8	5247,4	9,811	9,69	2,98	1,85
production facilities:	3241,4	5193,7			3,03	1,87
buildings and structures	1118,8	2235,7			8,77	4,33
machinery and equipment	975,8	1120,5			10,05	8,65
Vehicles	1101,7	1778,8			8,91	5,45
Other	45	58,7			218,02	165,08

With deepening of the pit, productivity of fixed assets of extracting crude ore is reduced. If at the beginning of the year the pit depth was $H_{к.п}$, and at the end of the year it was $H_{k.k}$, the capital productivity ratio as a function $\Phi(H_к)$ of this depth will decrease

$$\Delta \Phi_{от} = \Phi(H_{к.п}) - \Phi(H_{к.к.}).$$

In oder to find the value $\Delta \Phi_{от}$, it is necessary to know the relation between the productivity of the technological equipment and the open pit depth.

Pit productivity will determine the equipment that is used in four main production processes: 1) rock preparation for extraction by drill and blast tunneling method; 2) extraction-and-loading works, performed by shovel excavator; 3) rock delivery by conveyor transport to the processing plant; 4) rock storage. The

amount of works, that are performed by the pit equipment, machinery, self-loading hauling units, are a function of open cuts depth. This function can be represented for the i-th process in the following general form:

$$Q_{pi} = f_i(H_к), \text{ t/year.}$$

As follows from the analysis performed, deepening of the pit causes decrease in productivity of production means and this leads to the reduction of mining ore output; but, according to equation (6), decrease in ore output brings about reduced capital productivity ratio of the pit fixed assets (it should be noted that the value of assets due to wear and tear is not reduced, because the repair and restoration were allocated by the funds defined by the sum ($B_{м.2}$ + $B_{п.к}$)).This reduction of capital productivity ratio must be set off by the introduction of additional funds specified by the capacity and the cost of extracting ore production processes into operation.

To produce the planned amount of ore $O_п$ due to lower performance of the pit equipment by the value $\Delta O_п$, equal to the difference of

$$\Delta O_п = O_п(H_н) - O_п(H_к), \text{ t/year,} \quad (7)$$

additional amount of funds can be estimated by the equation:

$$\Delta \Phi_{о.п} = \frac{\Delta O_п}{\Phi_о}, \text{ UAH/year.} \quad (8)$$

In equation (7) amount $O_п$ is considered as function of depths $H_н$ and $H_к$ at the beginning and the end of the planned year. These are taken as the smallest values of the performance of technical equipment for the main industrial processes of mining pit operations in general.

Let us consider solution to the present problem. If the performance of the i-th equipment at the initial phase of the operation time is Q_{eo}, but in t-th year – Q_{et}, the decline in productivity will be $(Q_{eo} - Q_{et})$. To compensate this reduction in *t*-th year, additional equipment should be installed in the amount equal to $(Q_{eo} - Q_{et})/\Phi_{oi}$, where Φ_{oi} is capital productivity ratio of *i*-th type of equipment. It is necessary to allocate funds for mining and processing ore equipment to offset decline in its performance with deeper pits in the amount determined by the equation:

$$\Phi_{д.t} = \sum_{i=1}^{m} \frac{Q_{oi} - Q_{ti}}{\Phi_{oi} K_{ф.it}}, \text{ UAH/year, (9)}$$

where $\Phi_{д.t}$ – value of fixed assets, which have to be additionally put into operation in *t*-th year of exploitation, UAH/year;

$K_{ф.it}$ – coefficient, for the rise-fall in prices of i-th type of process equipment in the t-th year of its exploitation.

Productivity of drilling rigs, excavators and open-pit dump trucks changes with pit deepening from 300 m to 390 m. On average, with the deepening from 300 m to 330 m productivity is reduced by 20%, to the depth of 360 m - by 40%, to the depth of 390 meters – it is more than a half. At the same time, productivity of open-pit dump trucks in the specified deepening of mining operations is reduced by 10, 30, 40%, but for shovel excavators it is 10, 20, 35% (Fig. 6). It means that the largest decrease in operational productivity under the influence of depth and time factor is related to drills: productivity of machines is reduced by more than 2 times with deepening of the working area from 300 m to 390 m over 12 years, the productivity of excavators and dump trucks dropping by 1.6 times. Thus production capacity in mining ore pits must be primarily provided, depending on the values of drilling equipment productivity at different depths. Additional number of drilling rings must be installed and commissioned considering degree of reduced productivity as for other types of quarry equipment (dump trucks and excavators), its additional amount should be introduced taking into account the decreased volume of mining works in the related processes (extraction-and-loading of rock formation and hauling).

Using equations (7) – (9), we calculated the investment costs required to restore the pit fixed assets at different depths , departing from the data presented in Table 1. According to the authors' estimations, the cost of the pit fixed assets is from 852.7 thousand UAH to 3392 2 thousand UAH which must be compensated as a result of wear and tear under the influence of environmental factors operation at a deeper pit (Fig. 3). The amount of investment

funds to be allocated for restoring funds suitability, should compensate this wear, on the one hand, and to provide renovation and modernization of production means, on the other; which will support planned capacity of the mining ore pit at deeper zones of mining operations. To determine the estimated capability for accumulation of funds at Poltava MPP, we investigated profit from operating activities, which can be used for the reproduction of fixed assets in different modes of ore excavation.

Table 2

Comparison of the needs and opportunities of mining and processing plant for the extended reproduction of the fixed assets

Items of comparison	Open cuts depth, m					
	315	330	345	360	375	390
The sum of investment, needed to reproduce the FA, millions UAH	852,7	1011,5	2011,8	2259,3	2874,1	3392,2
Accumulated sum of MPP profit, thousands UAH						
version 1	2868,0	5221,7	6330,6	7257,1	7665,9	8058,0
version 2	1585,6	2935,4	4044,2	4970,8	5756,8	6431,0
version 3	438,9	888,7	1997,6	2924,1	4126,7	5111,0

The results listed in Table 2 (percentage shows the ore quality at different periods of the pit exploitation), indicate that the plant will be able to allocate the required investment capital, if it excavates ore reserves by mining operations modes with a reduction of quality (version 1 in accordance with Fig. 1) or average ore quality (version 2). As follows from Table 2, total profits from the sale of mining operations product at all depth in the specified modes by far exceed the investment needs for the extended reproduction of the pit fixed assets.

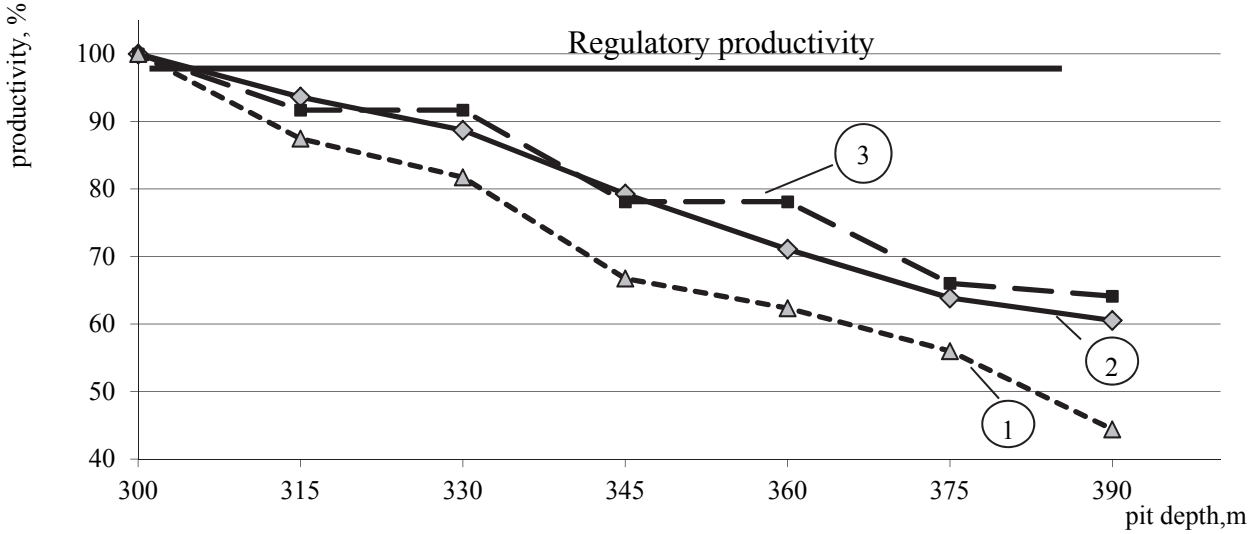

Fig. 6. Decline in productivity of technological equipment due to increase in pit depth ,% : 1 – drilling rings; 2 – open-pit dump trucks; 3 – excavators.

Conclusion. In general, the study resulted in scientific and methodological principles of investing costs into reproduction of fixed assets suitability in mining and processing industries, taking into account deterioration of operation conditions at deeper horizons of pit works, which provides a complete extraction of mineral ore reserves. The main conclusions consist in the following:

1) increase in economic capacity and cost of metallurgical raw materials production using rich iron ore (high grade), achieved through a targeted control of the pit mining mode, allows the mining plant to receive additional profit from sale of products;

2) reasonable structure of constantly recovered cycle of funds investment is aimed at supporting the company's facilities through the introduction of new technologies due to the additional income from operations. By this, the

company first collects money for investing into the development of production capacity, namely the extended reproduction of fixed assets, and then, using these assets, it refines low-grade ore stocks;

3) it is recommended to consider the recovery measures costs (repairs, modernization and updating of equipment) not like straight costs but collateral ones which seek to compensate the loss of the residual value of fixed assets. This allows to determine the minimum amount of investment necessary for maintaining the pit capacity depending on the degree and time of its deepening;

4) assessment of Poltava MPP capability to accumulate profits from operations for the extended reproduction of fixed assets indicates that if it develops low grade ore reserves, the plant will be able to allocate the necessary investment funds because the amount of profit is 2–3 times higher than the investment needs for reproduction of fixed assets;

5) further research should be focused on the motivation of mining enterprises to establish investment funds based on the approach proposed by the authors for the reproduction of fixed assets that will provide high degree of ore extraction in the pit.

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Обґрунтовано складові постійно відновлюваного циклу формування інвестицій на підтримку продуктивності основних засобів підприємства і механізм забезпечення еколого-економічної ефективності експлуатації залізорудного родовища. Розроблено методичні основи інвестування розширеного відтворення основних фондів гірничого підприємства для підвищення повноти використання експлуатаційних запасів рудної сировини.

Ключові слова: гірниче підприємство, інвестування, додатковий прибуток, вартість основних фондів, фондовіддача, розширене відтворення.

Обоснованы составляющие постоянно обновляемого цикла формирования инвестиций на поддержание производительности основных средств производства и механизм обеспечения эколого-экономической эффективности эксплуатации железорудного месторождения. Разработаны методические основы инвестирования расширенного воспроизводства основных фондов горного предприятия для повышения полноты использования эксплуатационных запасов рудного сырья.

Ключевые слова: горное предприятие, инвестирование, дополнительная прибыль, стоимость основных фондов, фондоотдача, расширенное воспроизводство.

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