Assessmnent of the natural and energy resources utilization in the transportation flow chart of the industrial production

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Summary. There is a consideration on modeling of the assessment of the natural and energy resources utilization and losses of raw materials on the industrial transport of the blast-furnace production aiming to reveal the most unprofitable objects and processes of the transport as well as to protect the environment.
Key words: transport, energy resources conservation, ecology.

INTRODUCTION

One of the most important problems in the modern conditions of the technical, competitive and economic development of the industrial transport of metallurgical sector is the issues of reducing the costs of natural, energy resources and labor resources as well as the protection of the environment from its harmful influence [3].

It is discovered that in the total discharge of contaminants into the atmosphere by all anthropogenic sources the mass fraction of the transport is 60%, metallurgy – 13-20%, power engineering – 10-15%. Metallurgy and transport make more than 80 % in total [11, 19].

The transportation flow chart (TFC) of metallurgic raw materials transfer to the blast furnace (BF) and movement of the ready products and waste products of the blast-furnace production is one of the most energy consuming schemes in the complex structure of the metallurgic sector transportation system. The share of the transportation flow chart of the blast furnace production (TFC BFP) at the enterprises with the complete metallurgical cycle is 76% for energy consuming, 40% for water consuming, 70% for waste products by mass of the raw materials [2].

These conditions bring out the necessity of the adequate assessment [6] of natural and energy resources and labor resources (NE and LR) utilization at the stages and on the objects of the transportation flow chart of the blast furnace production.

It will facilitate to reveal the most resource-consuming processes and objects, reserves of resources conservation and reserves to increase the efficiency of energy utilization, to define the priority in improving the objects and processes of the industrial transport [9].

We present the blast furnace production as a cybernetic process constructed on the "black box" principle with the analysis of outputs and inputs according to the cybernetic scheme [12], fig. 1.

"The black box" is the blast furnace itself with physical and chemical process going in it and providing the required conditions and factors of its operation.

Transportation flow objects with their processes and operational outcomes which are to ensure the required conditions and required factors of the blast furnace operation are supposed as the input factors.

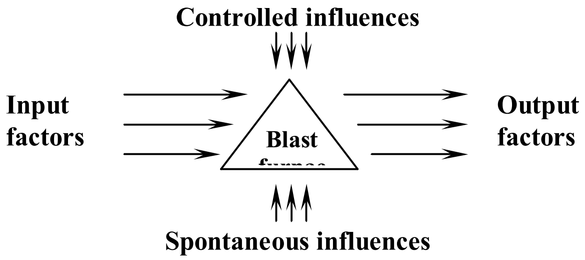


Fig. 1. Cybernetic scheme of the full blast furnace production cycle

The outcomes of the processes inside the blast furnace and the outcomes of the industrial transport operation with their processes and objects are supposed as the output factors.

Requirements to NE and LR, BF operation, its product – cast iron, etc., are treated as controlled influences. Natural factors of the environment, force-majeure circumstances, etc., are treated as spontaneous influences.

Life cycle of the objects and processes of TFC BF production can be presented as a dynamic graphic-topological model where certain natural, energy and labor resources are used variably at all of its stages (fig. 2).

Utilization of NE and LR in the transportation flows [Gabler 1983]on the preparation stage of the blast furnace production raw materials can be presented in the form of a matrix as a peculiar form of inter-object balance of NE and LR consumption [18].

NE and LR consumption indices per unit of the goods of the transported raw materials, ready products and waste products of the production are taken as the basis of the balance.

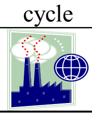
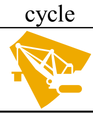
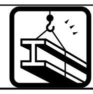
When analyzing the utilization of NE and LR in the transport flow chart of the industrial enterprises, three kinds of balances: active, passive and net-balance (estimated) are taken into account.

Net balance presupposes the acceptable levels of harmful influence (NE and LR utilization) of the transport flow chart of the blast furnace production on the environment which include the appearance of the human peril in the industrial region [7]: unfavorable environmental conditions [13].

The assessment of NE and LR utilization in the industrial transport of the blast furnace production concerning the environmental protection should be attributed to the passive balance as damaging the environment more than net balance.

Opposed to the passive balance, the active balance implies the reduction of natural, energy and labor resources consumption in comparison with the net balance and aims to the minimum utilization of the resources and maximum environmental protection [4, 14].

In this case the balance matrix can serve as a basis for modeling the inter-object utilization of the natural, energy and labor resources in the transport flow chart of the blast furnace production.

Stages and dynamics of the life cycle	1	2	3	4	5	6	7	8
	Produc tion	Keeping of the reserve fund	*i* –th operational cycle	Maintenance and overhaul	Keeping of repair stock	*i* –th operational cycle	Demounting	Renovation and utilization
								
Structure of NE and LR used (j):								
1. Atmosphere	+	+	+	+	-	+	+	+
2. Hydrosphere	+	+	+	+	-	+	+	+
3. Lithosphere	+	-	+	+	+	+	+	+
4. Territories	+	+	+	+	+	+	+	+
5. Phytosphere	+	-	+	+	-	+	+	+
6. Biosphere	+	-	+	+	+	+	+	+
7. Energy	+	+	+	+	+	+	+	+
8. Labor resources	+	+	+	+	+	+	+	+

+ NE and LR are used; - NE and LR are not used

Fig. 2. Graphic and topological model of the life cycle dynamics of the transportation flow chart objects of the blast furnace production and natural, energy and labor resources (NE and LR) utilization

The model is developed on the base of the prerequisites:

• flows of NE and LR utilization are defined and differentiated by their types and objects of TFC BF production [15];

• loading-discharging objects in TFC BF production are defined as the most consuming by the types of NE and LR [1];

• flows of NE and LR utilization are directed in accordance with the goods flow in TFC BF production.

Stages, their technological tools and processes, transport and technological logistic flows of the blast furnace production are taken as objects.

For each object we can write [8]:

$$\sum_{j=1}^{P} x_{ij}^{*} = X_i \text{ ; i=1...k,} \qquad (1)$$

where:

X_i - a generalized value of NE and LR consumption in conventional units approved for keeping records;

k – the amount of the used i –th NE and LR when transporting form one object to another;

i – an amount of the types of the used objects;

x_{ij}^{*} -the value characterizing the consumption of the corresponding natural, energy and labor resources when transporting goods from one object to another.

Taking into consideration the fact that the value x_{ij}^{*} represents the established and quite steady technical and economical links, we can assume that the ratio between the value x_{ij}^{*} and total natural and energy resources consumption, e.i., the value X_j^*, is a relatively constant value which can be named a coefficient of "the direct transition" [17]:

$$a_{ij}^{*} = \frac{x_{ij}^{*}}{\sum_{j=1}^{P} X_j^{*}}. \qquad (2)$$

Considering this ratio, the expression (1) can be transformed in the following way:

$$\sum_{j=1}^{P} (a_{ij}^{*} \sum_{j=1}^{P} X_j^{*}) = X_i \text{ ; i=1...k.} \qquad (3)$$

The values

$$x_{ij}^{*} = a_{ij}^{*} \sum_{j=1}^{P} X_j^{*} \text{ ; i=1..k; j=1...p} \qquad (4)$$

can be interpreted as the territorial "consumption functions" [17].

The model of relative assessment of natural, energy and labor resources [20] consumption in the transport flow chart of the blast furnace production can be presented as follows:

$$\begin{cases} a_{11}^{*} \sum_{j=1}^{P} X_j^{*} + a_{12}^{*} \sum_{j=1}^{P} X_j^{*} + \ldots + a_{1p}^{*} \sum_{j=1}^{P} X_j^{*} = X_1 \\ a_{21}^{*} \sum_{j=1}^{P} X_j^{*} + a_{22}^{*} \sum_{j=1}^{P} X_j^{*} + \ldots + a_{2p}^{*} \sum_{j=1}^{P} X_j^{*} = X_2 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \\ a_{p1}^{*} \sum_{j=1}^{P} X_j^{*} + a_{p2}^{*} \sum_{j=1}^{P} X_j^{*} + \ldots + a_{kp}^{*} \sum_{j=1}^{P} X_j^{*} = X_k \\ \dfrac{X_1 + X_2 + \ldots + X_k}{\sum_{j=1}^{P} X_j^{*}} = 1 \\ \sum_{j=1}^{p} \sum_{i=1}^{k} \dfrac{x_{ij}^{*}}{\sum_{j=1}^{P} X_j^{*}} = 1 \end{cases} \qquad .(5)$$

With limitations:

$$x_{ij}^{*} \geq 0 \Rightarrow a_{ij}^{*} \geq 0 \,; X_j^{*} \geq 0.$$

If natural, energy and labor resources are not utilized, the value of the corresponding member of the equation is:

$$a_{ij}^{*} \sum_{j=1}^{P} X_j^{*} = 0 \,. \qquad (6)$$

In case the system (5) is solvable, we get only relative values of a_{ij}^{*}, but not absolute ones.

Fig. 3 represents the example of a flow-diagram showing the model of loading the blast furnace with raw materials using a skip hoist (fig. 2, stage 6) where the utilization of the natural, energy and labor resources is assessed in the process of loading [10].

The process of loading the raw materials into the blast furnace can be shown as a large-scale dynamic system comprising several levels. Mathematical model is developed for each level and the optimum problems are made by the criterion binding them. NE and LR consumption can be criteria [5].

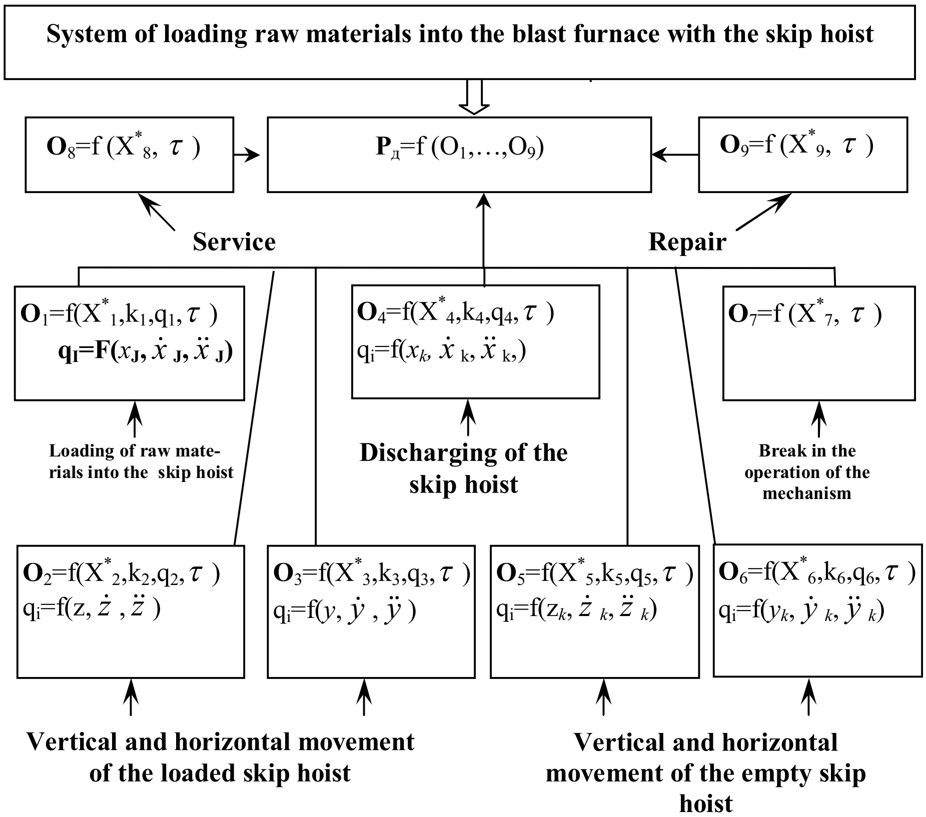


Fig. 3. The flow diagram of loading the blast furnace with the raw materials using the skip hoist

Letters in the figure show: $P_д$ – the functional of NE and LR expenditure at the stage of the object's life cycle; O_i – functional of NE and LR consumption of the corresponding element of the loading process; X^*_i – cost coefficients; k_i – constructive characteristics of the object including geometry, mass, efficiency coefficient, etc.; q_i – independent generalized coordinates, τ - time.

Cost coefficient X^*_i, including the consumption of the corresponding NE and LR as well as the consumption of c_{pi}: the energy $c_{эл}$, materials $c_м$, repair c_p, labor force $c_з$, wear-and-tear c_a, management $c_{упр}$ and other $c_{пр}$, makes:

$$X^*_i = \sum_{i=1}^{p} c_{pi} \,. \tag{7}$$

On the operational stage, when discharging the skip hoist, the following example of the functional of the consumption for vertical and horizontal movement of the loaded skip hoist can be presented:

$$O_2 = f\,(X^*_2,\ K_2,\ q_2,\ \dot{q}_2,\ \ldots,\ \tau\ ), \tag{8}$$

or in the particular expression:

$$O_2 = J_n + J_y + J_m + J_o, \tag{9}$$

where:

J_n, J_y, J_m, J_o – are the functional showing the consumption at the stages of the start, movement, braking and stops of the mechanism correspondingly.

Thus, the requirement for the *i*-th resource for the j-th process of loading can be defined [16]:

$$x^*_{ij} = \sum_{s=1}^{4} \frac{b_s^i}{C_i^{\,p}} \cdot d_s^{cn}, \tag{10}$$

where:

$C_i^{\,p}$ - are mean prices for the *i*-th resource;

b_s^i - the coefficient of the utility function of the *i*-th resource for the equipment of *S* group which is defined when identifying the model;

d_S^{cn} - financial assets for fulfilling the demand for the *i*-th resource of *S* group defined as follows [Richter 1975]:

$$d_s^{\,cn} = \alpha_{cn} \cdot d^{н}_{s\Sigma} + \beta_{cn} \cdot d_s, \tag{11}$$

where:

α_{cn}, β_{cn}- coefficients representing the shares of the financial resources accumulated and received after the sales of the product which are directed toward the consumption of the *i*-th resource and defined when identifying the model of demand for the *i*-th resource,

$d^{н}_{s\Sigma}$ - total financial resources intended for the consumption of the *i*-th resource of *S* group,

d_S - aggregated financial resources for the consumption of all *i*-th resources of all *S* groups.

CONCLUSIONS

The suggested approach to the modeling of the assessment of natural, energy and labor resources in the transportation flow chart of the industrial production allows to define the most consuming objects and processes of the chart, determine the priority for their improvement as well as to develop the corresponding environmental protection procedures.

REFERENCES

1. **Berestovoy A.M., 2002.:** Synthesis of processes and objects in the material transportation flows of solidifying liquids: diss. …Doct. Tekhn. Science. Lugansk, EUNU, 542.
2. **Bretschneider B., Kurfurst J,. 1989.:** Air pollution control technology. Trans. from English, Leningrad, Khimiya, 288.
3. **Danilecki K., 2007.:** Application of the time density characteristics in optimisation of parameters of an engine with sequential turbo-charging. TEKA Commission of Motorization and Power Industry in Agriculture, OL PAN VIIA, 23-34.
4. Environmental Policy in Europe: Industry, Competition and the Policy Process,1996.: Edited by F. Leveque, Cheltenhem UK, Edward Elgar, 218.
5. **Erofeev N.M., Orlov L.A., 1973.:** Automatics and automation of port cargo handling processes. Moskow, Transport, 269.
6. **Filho F., 2001 E-Business:** The Challenger of a new Business Strategic Model for the Brazilian Companies. Proceedings of the 21th conference of the Production and Operations Management Society, POM-2001, March 30-April 2, Orlando Fl.
7. **Fischer M., 1994.:** Ökologische Dimension der Logistic: evolutorisch-entropische Systemanalyse Ökonomischer Prozesse. Miteinem Geleitw. von Peter Klaus, Wiesbaden, Dt. Univ., Diss.,ISBN 3-8244-6132-3, 173.
8. **Gabler Lexikon Materialwirtschaft&Einkauf, 1983.:** Wiesbaden, 420.
9. **Khlestova O.A., Berestovoy A.M., 2000.:** Methodological approach to the ecological assessment of the stages of the transport flow processes of the blast furnace production, Metals of Ukraine, № 3,4, 48-49.
10. **Khlestova O.A., Berestovoy A.M**., **Chernyshov N.V., 2004.**: Methodolgy of ecological and energy assessment of transportation flow systems of the metallurgical production. Bulletin of Priazovskiy State Technical University, scientific articles, Mariupol, Iss. № 14., 347-352.
11. **Khlestova O.A., Berestovoy A.M., Kapustin E.A., 2001.:** Monitoring of environmental and energy mathematical economics of transport flow cycles of the industrial production. Environment and resource conservation. - №1. – 48-52.
12. **Kobrinskiy N.E., Maiminas E.Z., Smirnov A.D., 1975.:** Introduction into the economic cybernatics, Ekonomika, 343.
13. **Kuranc A. 2005.:** A continuous measurement of CO, CO2, HC and NOX at the work of a combustion engine fed with petrol in nstable thermal conditions. TEKA Commission of Motorization and Power Industry in Agriculture, V, 107-115.
14. **Oosterhuis F., Rubic F., Scholl G., 1996.:** Product Policy in Europe: New Environmental Perspectives, Dordrecht, the Netherlands, Kluwer Academic Publishers, 306.
15. **Parunakjan V., Sizova E., 2008.:** Increase of efficiency of interaction of production and transport in the logistic chains of material traffic of enterprises, Problemy Transportu, Katowice, T.3, Z.3., 95-104.
16. **Ponosov Yu.K., Savushkin S.A., 2002.:** Modeling of Russian transportation system development (economic and production aspect). Moskow, VINITI RAS, 112.
17. **Richter R.-J., 1975:** Kybernetische Analyse verkehrsokonomischer Systeme-Verkehrsoko-nometrie 1-.2., uberarbeitete Auflage. Transpress VEB Verlag fur Verkehrswesen, Berlin, p.
18. **Richter** R.**-J. 1982.**: Transport mathematical economics. Transl. from German, Moskow, Transport, 317.
19. **Suravegina I.T., Senkevich V.M., 1995.:** How to teach ecology. Teacher's book, Moskow, Prosveshchenie, 96.
20. **Weidema B.P., 2009.:** Using the budget constraint to monetarise impact assessment results, Ecological Economics, 6(68), 1591-1598.

ОЦЕНКА ИСПОЛЬЗОВАНИЯ ПРИРОДНЫХ И ЭНЕРГЕТИЧЕСКИХ РЕСУРСОВ В ТРАНСПОРТНО-ТЕХНОЛОГИЧЕСКОЙ СХЕМЕ ПРОМЫШЛЕННОГО ПРОИЗВОДСТВА

Ольга Хлестова, Иван Берестовой

Аннотация. Рассматривается моделирование оценки использования природно-энергетических ресурсов и потерь сырьевых материалов на промышленном транспорте доменного производства с целью выявления наиболее затратных объектов и процессов транспорта, а также защиты окружающей среды.
Ключевые слова. транспорт, энергоресурсосбережение, потери сырья, экология.