O. V. Bereziuk, Dr. Sc. (Eng.), Assistant Professor; I. V. Vishtak, Cand. Sc. (Eng.), Assistant Professor; M. S. Lemeshev, Cand. Sc. (Eng.), Assistant Professor

DYNAMICS OF SCAP VOLUMEFORMATION INCREASE IN UKRAINE

Solid industrial waste, in particular, metal working waste, can be widely used in the construction sphere for obtaining valuable materials for the production of the construction materials with the protective qualities against electromagnetic radiation and static electricity, for manufacturing of the anode earthing, etc. That is why, determination of the regression dependence, describing the dynamics of the scrap volume growth in Ukraine is an actual scientific-engineering problem. Aim of the research is determination of the regression dependence, which describes the dynamics of the scrap volume growth in Ukraine and can be used for the prediction of these volumes. In the process of the research the method of the regressive analysis of the results of the single factor experiments and other pairwise dependences with the selection of the rational type of the function from the sixteen most widely used variants by the criterion of maximum value of the correlation coefficient was applied. Regression was carried out on the base of the linearized transformations, which allow to reduce the non-linear dependence to linear one.

Determination of the coefficients of the regression equations was carried out applying the method of the least squares by means of the developed computer program "RegAnaliz", protected by the Certificate of the State Registration of the rights to the copyright object. Adequate regression power dependence is obtained, it describes the dynamics of the scrap volume formation in Ukraine and can be used for the prediction of these volumes. Graphic dependence, describing the dynamics of the scrap formation volume in Ukraine is constructed, it enables to illustrate this dynamics and show sufficient coincidence of the theoretical results with actual results. It is established that in Ukraine in the period of 2017 – 2020 volumes of scrap formation increased by hyperbolic dependence. Using the obtained dependence it is forecast that the volumes of the scrap formation in Ukraine in 2030 at present rate of growth will increase to 1132 thousand tons.

Key words: *dynamics, growth of the volumes of the formation, solid industrial waste, scrap, regression analysis.*

Introduction

Unlike solid municipal waste in Ukraine, which are mainly buried on the landfills and dump sites, polluting the environment [1 – 5], solid industrial waste can be rather easily recycled [6 – 10]. Some kinds of the raw materials, which can not be used for manufacturing of certain products, rest of the raw material or substances, emerging as a result of technological processes, which can not be disposed in this production are referred to solid industrial waste. About 90% of the volume of solid industrial waste falls on this group. That is why, solid industrial waste are main sources of the anthropogenic pollution of the environment in global scale. They emerge as the inevitable result of the consumer-oriented attitude and inadmissibly low coefficient of the resources usage. For instance, in the former USSR non-ferrous metallurgy annually mined approximately 2 bil. tons of rock formation and commercial production was nearly 1 %. In Ukraine almost 80 - 85 % or 20 – 30 bil. tons of the recycled raw material falls into the waste, annual increment is within 2 bil. of tons in mining industry, metallurgy, chemical and fuel-energy branches. More than 200 mil. tons are toxic and other hazardous waste. Annual increment of areas, occupied by the waste is 50 thousand ha [11]. At the same time, solid industrial waste, in particular, machining waste, can be widely used in the construction sphere for obtaining valuable materials, for the production of the construction materials with the protective properties against electromagnetic radiation [12, 13] and static electricity [14], for manufacturing of the anodic earthings [15]. This is explained by the fact that many mineral and organic waste by their chemical composition and technical properties are close to natural raw materials. Usage of the finely dispersed waste of the metal working is also promising for the minimization of the volumes of the immobilized liquid radioactive waste [16].

Problem set-up

In the Law of Ukraine of February 28 2019 № 2697-VIII "On main fundamentals (strategy) of the state ecological policy of Ukraine for the period until 2030" the return of the resource-valuable material into the production circulation is among the strategic tasks [17]. That is why, the determination of the regression dependence, describing the dynamics of the volume of scrap formation growth in Ukraine and can be used in the process of such volumes forecast is important scientific-engineering problem.

Analysis of the recent studies and publications

Research [18] is devoted to the problem of ferrous steel scrap shortage, one of the reasons of this shortage was that for Ukrainian purchasing agents in recent years it was more profitable to sell the scrap abroad, as the export prices were higher. The paper [19] revealed and generalized main preconditions of introduction of such mechanism of legal regulation of scrap export as the increase of the export duties to eliminate the raw material shortage at the internal market and promote the development of national economy. Effects of the introduction of the increased duty for scrap export, in particular, its impact on the production, work places, fiscal revenues are studied. Results of the economic-mathematical modeling of maintanining the increased rate of the export duty for the scrap in midterm perspective are presented. Economic-legislative legitimation of the increased export duty for the scrap export, introduced by Ukraine and expediency of its further maintaining is substantiated.

In [7] it is shown that obtaining of phosphogypsumashcement and metalphosphate binders on the base of chemical industry and metal working production waste will allow to solve actual for Ukraine problem of energy and resources saving by means of creation of new construction materials of polyfunctional designation. As a result of research, carried out, which are described in the paper [20] metalashphosphate binder on the base of the industrial waste has been obtained.

In the work [12] it was revealed that the application of betal-m (concrete electro-conducting metal-saturated, used as a special covering of biological protection against ionize radiation inside premises, building and constructions) of the cellular, variotropic and dense structure allows to reduce the level of electromagnetic radiation and decrease the risk of radiation. In the paper [13] the expediency of usage of finely dispersed powders of IIIX-15 steel sludge for the production of the special protection covering against electromagnetic radiation is substantiated. In the research [14] it is suggested to use the covering, made of electric conducting concrete against charges of static electricity, the technology of such concrete production is rather simple and does not require expensive materials and special equipment. Authors of the work [15] state, that betel-m can be used for the production of electric conducting elements (anodic protection) systems of anticorrosion cathode protection of the underground engineering networks. In the paper [16] the expediency of developing of new type of matrix materials on the base of betal-m for immobilization of liquid toxic waste is substantiated.

The research [21 contains statistic data, regarding the waste formation according to the classification groups of the state classifier of waste of Ukraine, in particular, growth of scrap formation volume in 2017 – 2020 . As a result of the analysis of the known publications the authors did not reveal specific mathematic dependences, describing the dynamics of scrap formation growth in Ukraine.

Aim and tasks of the paper

Aim of the given paper is the construction by means of regression analysis the regression dependence, describing the dynamics of scrap volume formation in Ukraine and can be used for the prediction of this growth.

Methods and materials

For the determination of the regression dependence which describes the dynamics of scrap volume formation in Ukraine the following methods are used: regression analysis of the results of single-factor experiments and other pairwise dependences, computer modeling.

Result of the research

Table 1 shows the dynamics of scrap volume increase in Ukraine in 2017 - 2020 according to the data of the Statistical Agency of Ukraine [21]. On the base of the data from Table 1 it was planned to obtain the pairwise regression dependence which describes the dynamics of scrap volume formation in Ukraine.

Table 1

Statistics of the volume of scrap formation in Ukraine [21]

Year	2017	2018	2019	2020
Volumes of scrap formation in Ukraine, thous. tons	548.3	733.3	881.3	931.4

Regression was carried out on the base of linearized transformations which allow to reduce the non-linear dependence to linear dependence. Determination of the coefficients of the regression equations was performed, applying the methods of the least squares [22] by means of the developed computer program "RegAnaliz" [23], protected by the Certificate of the state registration of the rights to the copyright object and is described in details in the works [24, 25].

Program "RegAnaliz" enables to carry out regression analysis of the results of single-factor experiments and other pair -wise dependences with the selection of the rational type of function from the sixteen most widely spread variants by the criterion of the maximum correlation coefficient with the storing of the results in the format MS Excel and Bitmap.

Results of the regression analysis are presented in Table 2, where the cell with maximum value of the correlation coefficient *R* is marked with grey color.

Table 2

Results of the regression analysis of the dynamics of scrap volumes formation in Ukraine

№	Regression type	Correlation coefficient R	№	Regression type	Correlation coefficient R
1	$y = a + bx$	0.97302	9	$y = ax^b$	0.99457
2	$y = 1 / (a + bx)$	0.94069	10	$y = a + b \cdot \lg x$	0.99609
3	$y = a + b / x$	0.98025	11	$y = a + b \cdot \ln x$	0.99609
4	$y = x / (a + bx)$	0.99851	12	$y = a / (b + x)$	0.94069
5	$y = ab^x$	0.95862	13	$y = ax / (b + x)$	0.99712
6	$y = ae^{bx}$	0.95862	14	$y = ae^{b / x}$	0.99102
7	$y = a \cdot 10^{bx}$	0.95862	15	$y = a \cdot 10^{b / x}$	0.99102
8	$y = 1 / (a + be^{-x})$	0.99813	16	$y = a + bx^n$	0.91800

Thus by the results of the regression analysis on the base of the data from Table 1 the following regression dependence is finally taken as the most adequate.

$$msc = \frac{t - 2016}{0,00104 + 8,089 \cdot 10^{-4} (t - 2016)} \text{ [thous. t]}, \quad (1)$$

where m_{SC} – are volumes of scrap formation in Ukraine, thousand tons; t – year.

Fig. 1 shows actual and theoretical graphic dependences, which describe the dynamics of scrap volumes growth in Ukraine.

Comparison of the actual and theoretical data showed that theoretical dynamics of scram volume

formation in Ukraine, calculated by means of the regression equation (1) does not differ significantly from the data, presented in the works [21], that proves the sufficient accuracy of the previously obtained dependence.

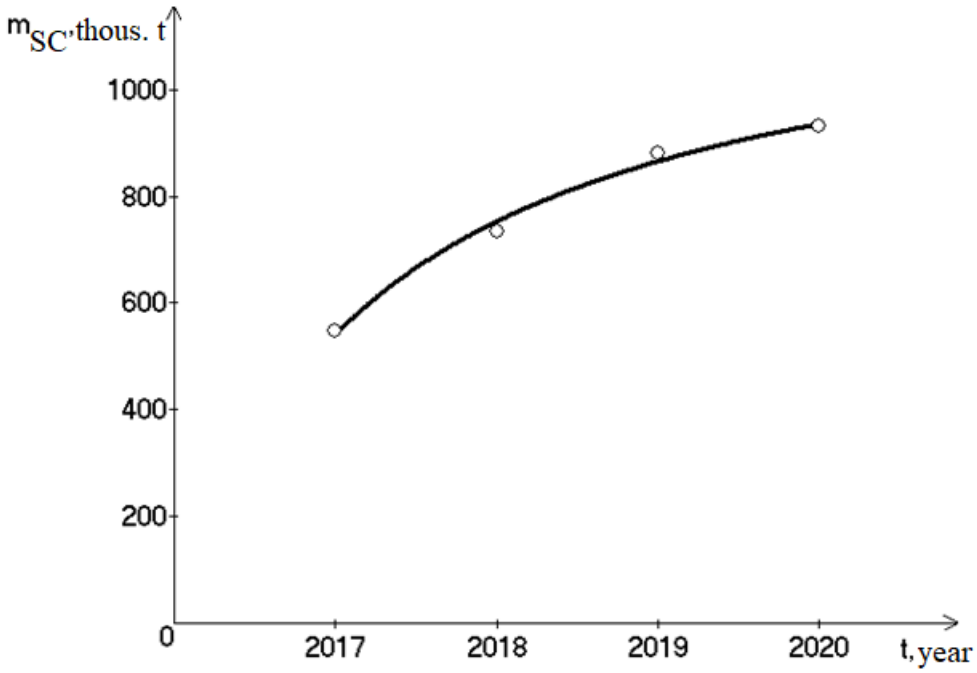

Fig. 1. Dependence, which describes the dynamics of scrap volume formation growth in Ukraine in the period of 2017 - 2020: actual ○, theoretical —

Using the dependence (1) it can be forecast that the volumes of scrap formation in Ukraine in 2030 at present growth rate, will increase to 1132 thousand tons.

Conclusions

1. Regression dependence, which describes the dynamics of scrap volume formation in Ukraine is determined and can be used in the process of these volumes forecast.
2. Graphic dependence, which describes the dynamics of scrap volume formation in Ukraine and allows to illustrate this dynamics, show sufficient coincidence of the theoretical results with actual results has been constructed.
3. It is established that in Ukraine in the period of 2017 – 2020 volumes of scrap formation increased by hyperbolic dependence.
4. It is predicted that the volumes of scrap formation in Ukraine in 2030 at present rate of growth will increase up to 1132 thousand of tons.

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Bereziuk Oleg – Dr. Sc. (Eng.), Assistant Professor with the Department of Health and Safety, Pedagogy of Safety.

Vishtak Inna – Cand. Sc. (Eng.), Assistant Professor with the Department of Health and Safety, Pedagogy of Safety.

Lemeshev Mykhailo – Cand. Sc. (Eng.), Assistant Professor with the Department of Civil Engineering, Municipal Management and Architecture.

Vinnytsia National Technical University.