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FORMATION DYNAMICS OF THE VOLUMES OF THE SUBSTANDARD MACHINES AND EQUIPMENT OF GENERAL ENGINEERING DESIGNATION IN UKRAINE

Industrial scrap, substandard machines and equipment of general engineering designation as types of solid industrial waste can be widely used in the construction sphere for obtaining valuable materials: for the manufacturing of the construction materials with protective properties against electromagnetic radiation and static electricity, for the production of the anodic earthings, etc. That is why, determination of the regressional dependence, describing the dynamics of the volumes of the substandard machines and equipment of general engineering designation formation in Ukraine is an important scientific-engineering problem.

Aim of the research is determination of the regressional dependence, describing the dynamics of the volumes of the substandard machines and equipment of general engineering designation formation in Ukraine and can be used for the forecast of these volumes. In the process of studies method of the regressional analysis of the results of single factor experiments and other paired dependences with the selection of the rational type of function from sixteen most widely used variants by the criterion of maximum value of the correlation coefficient was used.

Regression was carried out on the base of linearised transformation, enabling to reduce non-linear dependence to linear one . Determination of the coefficients of regression equations was performed, applying the least-square method by means of the developed computer program "RegAnaliz", the program is protected by the Certificate of the State Registration of the rights to the copyright object.

Adequate regression power dependence, describing the dynamics of the volumes of substandard machines and equipment of general engineering designation formation in Ukraine is obtained, it can be used for the forecast of such volumes. Graphic dependence, describing the dynamics of the formation of the volumes of the substandard machines and equipment is constructed, it enables to illustrate this dynamics and show the sufficient coincidence of the theoretical results with actual ones. It is established that in Ukraine in the period of 2017 – 2019 volumes of the substandard machines and equipment of general engineering designation formation decreased according to linear dependence.

Key words: dynamics, volumes of formation, solid industrial waste, substandard machines and equipment of general engineering designation, regressional analysis.

Introduction

As compared with the municipal waste in Ukraine which are buried at the landfills and dump sites, polluting the environment [1 – 5], solid industrial waste can be recycled comparatively easy [6 – 10]. Solid industrial waste is waste, unfit for the manufacturing of certain products types of raw materials, residues, not - used or substances, emerged as a result of technological processes, which can not be undergone to the recycling in the given production. This list includes 90 % of the total volume of the solid industrial waste, which are main sources of anthropogenic pollution of the global environment, they are the inevitable result of the consumer-oriented and low coefficient of resources usage. For instance, in the former-USSR enterprises of colour metallurgy annually mined approximately 2 bil. tons of rock formation and obtained finished products was nearly 1%. In Ukraine almost 80 – 85 % or 20 – 30 mil. tons of the processed raw materials represent waste, annual increment of the waste is within the limits of 2 mil. tons in mining industry, metallurgy, chemical and fuel-energy branches. More than 200 mil. tons are toxic and other hazardous waste. Annual growth of areas, occupied by the waste, is 50 thousand hectares [11]. At the same time, solid industrial waste, in particular metalworking waste, can be widely used in the construction sphere for obtaining such valuable materials: for production of the construction materials with the protective properties against electromagnetic emission [12, 13] and static electricity [14], for manufacturing anodic earthing [15]. This is explained by the fact that many mineral and organic

waste are close by their chemical composition and technical properties to natural raw materials. Promising sphere is also the application of finely dispersed metalworking waste for the minimization of the volumes of the immobilized liquid radioactive waste [16].

Problem setup

Among the strategic tasks, formulated in the Law of Ukraine of 28 February 2019 № 2697-VIII "On Main fundamentals (strategy) of the State ecological policy of Ukraine for the period until 2030" the return into business circulation valuable materials is pointes out [17]. That is why, the determination of the regressional dependence, describing the dynamics of the formation of the volumes of the substandard machines and equipment of the general engineering designation in Ukraine and be used for the forecast of these volumes formation is an important scientific-engineering task.

Analysis of the recent studies and publications

Work [18] is devoted to the problem of the ferrous scrap shortage at the domestic market of Ukraine. One of the reasons is that for the Ukrainian purchasing agents in recent years it was more profitable to sell the scrap abroad as the export prices were higher. In the paper [19] it was revealed and generalised main preconditions of the introduction of such mechanism of legal regulation of scrap export as the increase of the export duties to eliminate the shortage of this raw material at the domestic market and promote the development of national economy. The results of economic-mathematical modeling of maintaining the high rate of the export duties for metal scrap in the medium term period are presented. Economic-legal legitimation of the introduction of the increased duties for the ferrous scrap export and expediency of its further maintaining is substantiated. Effects of the introduction of the increased duties for scrap export in particular, its impact on the production, work places, tax revenues are studied.

Obtaining of phosphogypsum ash cement and metalphosphate binders on the base of chemical industry and metalworking waste allow to solve urgent for Ukraine problem of energy and resources saving by means of creation new construction materials of polyfunctional designation [7]. As a result of the studies, carried out, presented in the paper [20], metal-ash-phosphate binder on the base of industrial waste is obtained.

Authors of the research [12] established that the application of betel-m (concrete electroconducting, metal-saturated, used as a special covering of the biological protection against ionizing radiation inside the buildings and structures) of the cellular variotropic and dense structure enables to reduce the level of electromagnetic radiation and decrease the hazard of radiation. The expediency of using finely dispersed sludge powders of steel ШХ-15 for the production of the special protective covering against electromagnetic radiation [13] is substantiated. In the research [14] it was suggested to use the covering of electroconducting concrete for the protection against static electricity, the technology of this concrete production is rather simple and does not require expensive materials and special equipment. In the paper [15] it is stated that betel-m can be used for the production of the electric conducting elements (anodic earthings) of the systems of anticorrusion cathode protection of the underground engineering grids. The expedience of the studies, dealing with the development of new type of matrix materials on the base of betel-m for the immobilisation of liquid toxic waste is substantiated in the paper [16].

In the study [21] regressional dependence, describing the dynamics of the scrap volumes formation in Ukraine, is determined.

In the paper [22] statistical data, regarding the waste formation according to the classification groups of the State classifier of waste in Ukraine, in particular, volumes of substandard machines and equipment of the general engineering designation in the period of 2017 – 2019, are published. But as a result of the analysis of the known publications, the authors did not reveal any specific mathematic dependences, describing the dynamics of the volumes of substandard machines and

equipment of the general engineering designation formation in Ukraine.

Aim and tasks of the paper

Aim of the given paper is construction, by means of the regressional analysis, regression dependence, describing the dynamics of formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine and can be used for the forecast of such volumes.

Methods and materials

For the determination of the regressional dependence, describing the dynamics of formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine the following methods are used: regressional analysis of the results of single-factor experiments and other paired dependences, computer modeling.

Results of the research

Table 1 shows the dynamics of formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine in 2017-2019 according to the data of the State statistical agency of Ukraine [22]. On the basis of the data of the Table 1 it was planned to obtain paired regressional dependence, describing the dynamics of formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine.

Table 1

Statistics of the volumes of formation of the substandard machines and equipment of general engineering designation in Ukraine [22]

Year	2017	2018	2019
Volumes of formation of the substandard machines and equipment of general engineering designation, t	130.8	95.028	62.708

Regression was performed on the base of linearized transformations, which enable to reduce non-linear dependence to the linear one. Determination of the coefficients of the regression equations was carried out, applying the method of the least squares [23] by means of the developed computer program "RegAnaliz" [24], protected by the Certificate of the State Registration of the right to the copyright object, and is described in details in the works [25, 26].

Program "RegAnaliz" allows to perform regressional analysis of the results of single-factor experiments and other paired dependences with the selection of the rational type of the function from 16 most widely-used variants by the criterion of the maximum correlation coefficient, saving the results in MS Excel and Bitmap formats.

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

Thus, by the results of the regressional analysis on the base of the data from Table 1, the following regressional dependence is taken as the most adequate

$$m_{\text{UMEMBD}} = 164,3 - 34,05(t - 2016) \text{ [t]}, \tag{1}$$

where m_{UMEMBD} − are volumes of formation of the substandard machines and equipment of general engineering designation, t.

Table 2

Results of the regressional analysis of the dynamics of the formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine

№	Type of regression	Correlation coefficient R	№	Type of regression	Correlation coefficient R
1	$y = a + bx$	0.99957	9	$y = ax^b$	0.97470
2	$y = 1 / (a + bx)$	0.98469	10	$y = a + b \cdot \lg x$	0.99271
3	$y = a + b / x$	0.96847	11	$y = a + b \cdot \ln x$	0.99271
4	$y = x / (a + bx)$	0.98199	12	$y = a / (b + x)$	0.98469
5	$y = ab^x$	0.99716	13	$y = ax / (b + x)$	0.89770
6	$y = ae^{bx}$	0.99716	14	$y = ae^{b/x}$	0.93715
7	$y = a \cdot 10^{bx}$	0.99716	15	$y = a \cdot 10^{b/x}$	0.93715
8	$y = 1 / (a + be^{-x})$	0.90646	16	$y = a + bx^n$	0.98514

Fig. 1 shows actual and theoretic graphic dependence, that describes the dynamics of the formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine.

Comparison of the actual and theoretical data showed, that theoretical dynamics of the formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine, calculated by means of regression equation (1) does not differ greatly from the data, presented in the studies [22], this proves the sufficient accuracy of the obtained dependence determined previously.
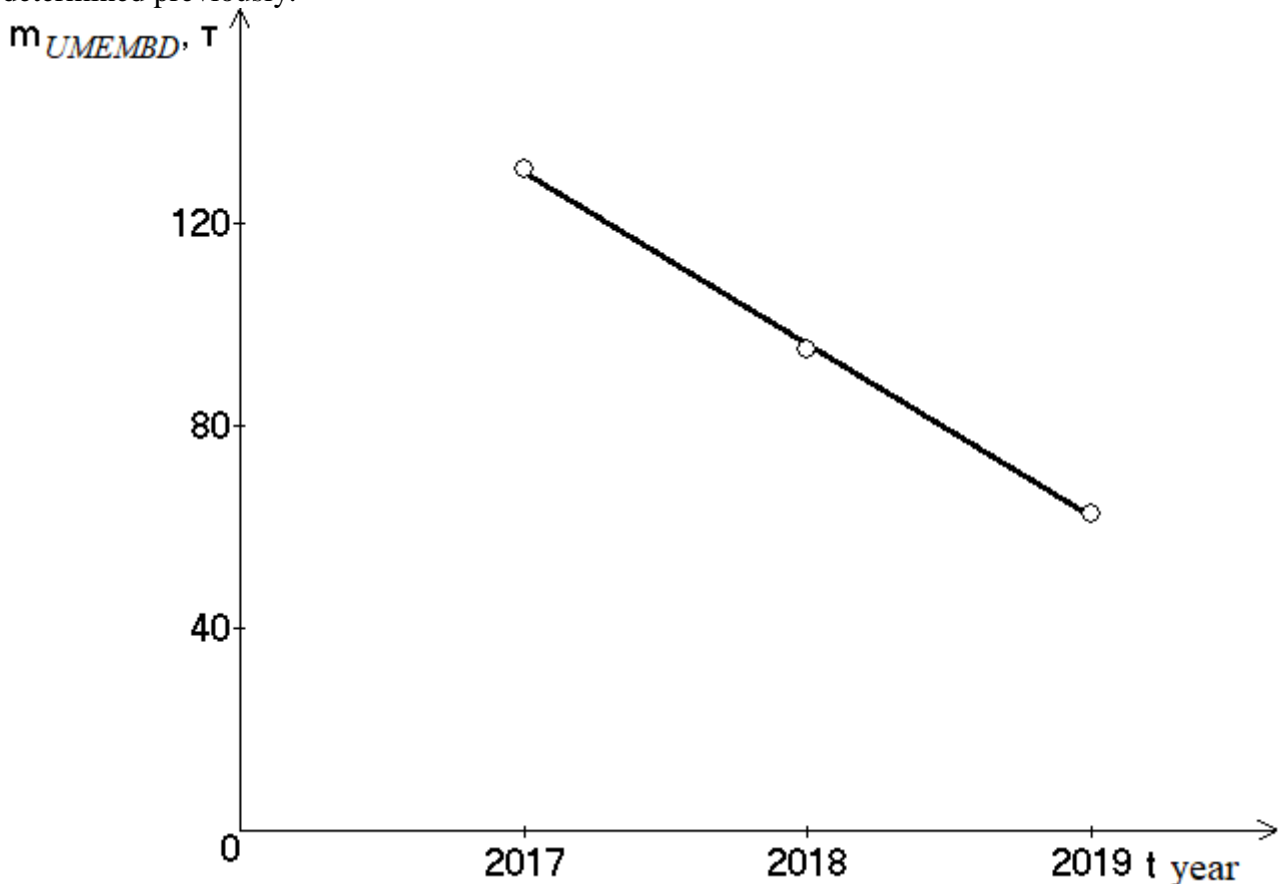

Fig 1. Dependence, describing the dynamics of the formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine during 2017-2019: actual ○, theoretical —

Conclusions

1. Regression dependence, describing the dynamics of the formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine is determined. The given regression can be used for the forecast of these volumes.

2. Graphic dependence that describes the dynamics of the formation of the volumes of the substandard machines and equipment of general engineering designation in Ukraine is constructed. The dependence illustrates this dynamics and shows the sufficient coincidence of the theoretical results with actual results.

3. It is established that in Ukraine during 2017 – 2019 volumes of the formation of the substandard machines and equipment of general engineering designation decreased according to linear dependence.

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