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Slovak University of Technology in Bratislava
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INNOVATIVE LIFECYCLE TECHNOLOGIES OF HOUSING, INDUSTRIAL AND TRANSPORTATION OBJECTS

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The monograph includes papers dedicated to the issues of energy-efficiency in construction and design of residential housing based on lifecycle, comfort parameters, sustainability, cost-effectiveness, as well as structural inspection and assessment, durability and reliability forecast, maintenance and renovation of buildings and structures in housing and utility sector, industrial and transportation construction.

It can be used as Urban Agenda for Sustainable Development of Regions. For researchers, university students, municipal administration, managers of business structures.

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2.4. FRACTAL APPROACH IN ASSESSING THE QUALITY OF STEEL 20

Volchuk Volodymyr, Parhomenko Olena

Introduction. To evaluate the influence of the structure and composition of the metal on mechanical properties, different physical methods and mathematical modeling are used [1-4]. This is due to the fact that the technology of production of rolled metal is a multicriterial technology. Therefore, many parameters influence the quality of metal rolling. The key parameters include the chemical composition of the metal and the elements of its structure. To establish a connection between the composition of materials and properties, often used the method of experiment planning.

The perspective direction of the study of the influence of structure on the properties of materials is the application of the theory of fractals and multifractals [5-9]. Fractal formalism helps to quantify the elements of the structure of materials with a complex geometric configuration of the form [10-13].

The paper considers the method for assessing the hardness of low carbon steel 20 based on the analysis of its chemical composition and fractal dimension of structural elements. The choice of this steel brand is due to the fact that it produces varietal and shaped rolling: sheets, strips, tapes, and pipes.

Materials and methods. Steel 20 was investigated in the state of the plant delivery. The chemical composition of the metal is given in Table 1.

Table 1. % content of elements of the chemical composition of steel

Content in % according to mass	C	Si	Mn	Ni	S	P	Cr	Cu	As
Steel 20	0,17-0,24	0,17-0,37	0,35-0,65	to 0,3	to 0,04	to 0,035	to 0,25	to 0,3	to 0,08

The hardness HB steel changed within the limits of 126 ... 131 in accordance with the normative documents. Investigated steel with a ferrite-perlite structure, which is most commonly found in the factory supply (Pic. 1).

Pic. 1. Structure of steel 20, ×200

Discussion of results. To determine the fractal dimension of the structure, a technique based on the convergence of dot and cell methods was used [14-17]. This approach allows you to increase the accuracy of determining the fractal dimension of structural elements. Since the structural component of perlite has a greater hardness than ferrite, the fractal dimension of perlite was calculated to establish a relationship between structure and hardness.

At the next stage of the research, the technique of planning experiments was used, when many factors simultaneously changed. This approach allows us to investigate the dynamics of the change of the function of purpose (hardness of HB), depending on the chemical composition and structure. The experiment scheduling matrix for 16 columns was implemented with the experimental indicators of the objective Yexp function and estimates of its Ydev prediction (see table 2), where **TL** is the total level of the values of the arguments (X_1 ... X_{10}); **LL** - lower level; **UL** - upper level and **IV** - interval of variation of arguments. Arguments of the function were carbon (X_1), silicon (X_2), manganese (X_3), nickel (X_4), sulfur (X_5), phosphorus (X_6), chromium (X_7), copper (X_8), arsenic (X_9), and fractal dimension of perlite (X_{10}).

During the experiment, a regression model for steel hardness prediction was obtained:

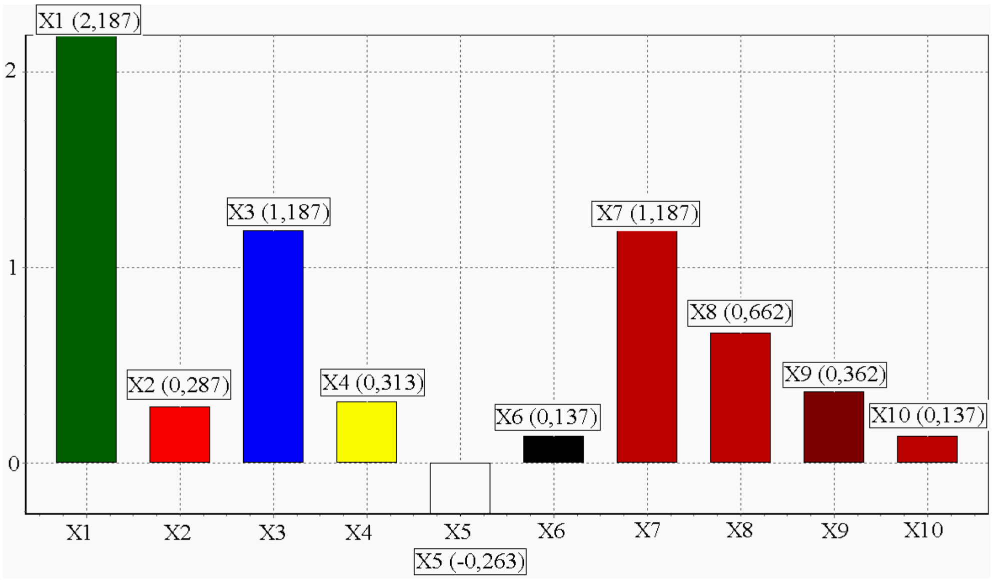
$$Y_{dev} = 115,329 + 41,375X_1 + 9,125X_2 + 3,958X_3 + 1,042X_4 13,125X_5 + + 6,875X_6 + 5,938X_7 + 2,208X_8 + 6,042X_9 + 0,404X_1 037,500X_1X_2$$

Coefficient of pair correlation was $R_2 = 0,86$.

Table 2. Matrition of plaining of the experiments for steel 20

TL		0,205	0,27	0,50	0,15	0,03	0,025	0,15	0,15	0,05	1,81	Hardness, HB	
IV		0,035	0,10	0,15	0,15	0,01	0,010	0,10	0,15	0,03	0,17		
UP		0,240	0,37	0,65	0,30	0,04	0,035	0,25	0,30	0,08	1,98		
LL		0,170	0,17	0,35	0,00	0,02	0,015	0,05	0,00	0,02	1,64		
№	X_0	X_1 (C)	X_2 (Si)	X_3 (Mn)	X_4 (Ni)	X_5 (S)	X_6 (P)	X_7 (Cr)	X_8 (Cu)	X_9 (As)	X_{10} D	Y_{exp}	Y_{dev}
1	+	+	+	+	+	+	+	+	+	+	+	131,0	131,3
2	+	+	+	+		+	+	+	-	-	+	129,0	130,0
3	+	+	+	-		+	-	-	+	+	-	129,5	128,7
4	+	+	+	-	-	+	-	-	-	-	-	128,4	127,5
5	+	+	-	+	+	-	-	-	-	+	+	130,0	130,9
6	+	+	-	+	-	-	-	-	+	-	+	130,5	130,8
7	+	+	-	-	+	-	+	+	-	+	-	128,7	128,3
8	+	+	-	-	-	-	+	+	+	-	-	128,6	128,4
9	+	-	+	+	+	-	-	+	+	-	-	128,0	129,2
10	+	-	+	+	-	-	-	+	-	+	-	127,7	128,4
11	+	-	+	-	+	-	+	-	+	-	+	127,5	126,8
12	+	-	+	-	-	-	+	-	-	+	+	127,0	126,2
13	+	-	-	+	+	+	-	-	-	-	-	127,5	127,6
14	+	-	-	+	-	+	-	-	+	+	-	128,0	128,3
15	+	-	-	-	+	+	+	+	-	-	+	126,0	125,5
16	+	-	-	-	-	+	+	+	+	+	+	126,5	126,2

Below is a histogram of the effect of arguments on the function of purpose (picture 2). On the histogram, the numerical values of the influence of each of the elements of the chemical composition and the fractal dimension of perlite on the hardness index are obtained by normalizing the coefficients of the regression equation.



Pic.2. Histogram of the influence on function (hardness HB)

The analysis of the above regression equation is confirmed by the fact that the strongest link is observed between the function of the target (the index of yield strength Y) and the arguments X_1 (carbon 2,187), X_3 (manganese 1,187) and X_7 (chromium 1,187). Sulfur (X_5) and phosphorus (X_6), as harmful impurities, reduce strength, as they contain more than 0.045% steel at elevated temperatures, made red and cold needle respectively. The connection is confirmed by the relatively high correlation coefficient (R_2 = 0,86), which is substantiated by physico-chemical interpretation of the influence of the composition of the metal on its properties. Carbon steel, usually in the form of a chemical compound Fe_3C (iron carbide), with an increase in its content to 1.2%, increases the hardness, strength and elasticity of steel and reduces its viscosity and its ability to weld. In turn, manganese contained in normal carbon steel in the range of 0,3 to 0,8% reduces the harmful effects of oxygen and sulfur, increases the hardness and strength of steel, its cutting properties, but it reduces the ability to withstand the metal to dynamic loads , in particular to drums. Chrome increases strength, hardness and heat resistance, cutting and tribological properties, but reduces the viscosity and thermal conductivity of the metal [1].

The insignificant influence of other elements: Si (the coefficient of influence according to the calculations is 0,287), Ni (0,313), Cu (0,662) and As (0,362) on the hardness of steel 20 is compensated partly by the action of more "weighty" elements of chemical composition, for example C (2,187). Additionally, these items may have a greater impact on other features than their intended purpose. So Si is introduced into the steel as an active deoxidizer and does not make a more noticeable effect on the properties [1].

To verify performance and adequacy, the obtained mathematical model was tested according to the Fisher and Cochran criteria [2]. According to Fisher's criterion, the model is adequate:

$F_{observation} = 1{,}589$; $F_{critical} = 2{,}400$.

According to the criterion, the Cochran model is also right:

$F_{observation} = 0{,}382$; $F_{critical} = 0{,}547$.

Conclusions. The method of estimating the quality of low-carbon steel is proposed based on the analysis of its chemical composition and fractal dimension of structural elements. A mathematical model for evaluating the hardness of steel 20 was obtained by implementing a matrix of experimental planning. It has been established that the hardness of a metal is sensitive to the change in the fractal dimension of perlite. It confirms the influence on the hardness parameters not only on the chemical composition, but also on the elements of the structure, which are described by fractal dimension.

REFERENCES

1. Bol'shakov V.I. *Substrukturnoye uprochneniye konstruktsionnykh staley* [Substructural strengthening of structural steels]. Toronto: Bazilian Press, 1998, 316 p.
2. Voznesenskiy V.A. *Statisticheskiye metody planirovaniya eksperimenta v tekhniko-ekonomicheskikh issledovaniyakh* [Statistical methods of experiment planning in technical and economic research]. Moscow: Finansy i statistika, 1981, 263 p.
3. Mishutn A., Kroviakov S., Pishev O.,Soldo B. Modified expanded clay lightweight concretes for thin-walled reinforced concrete floating structures. Technical Journal. 2017. vol. 11. no. 3, pp. 121–124.ISSN 1846-6168 (Print), ISSN 1848-5588 (Online).https://hrcak.srce.hr/186657.
4. Dubrov Yu. I., Volchuk V. N., Bol'shakov V. I. *Primeneniye ekspertnoy informatsii pri formirovanii aktivnogo eksperimenta v materialovedenii* [Application of expert information in the formation of an active experiment in materials science]. The modeling and optimization in materials science. Proc. 40th Int. Conf. Odessa, 2001, pp. 25-26.
5. Volchuk V., Klymenko I., Kroviakov S., Orešković M. Method of material quality estimation with usage of multifractal formalism. Tehnički glasnik - Technical Journal. 2018, vol. 12, no. 2,

pp. 93–97. ISSN 1846-6168 (Print), ISSN 1848-5588 (Online). https://doi.org/10.31803/tg-20180302115027.
6. Bolshakov V.I., VolchukV.M., DubrovYu.I. *Osnovy organizatsii fraktal'nogo modelirovaniya* [Fundamentals of fractal modeling]. Kiev: Akademperiodika, 2017, 170 p.
7. Zhuravel' I.M. *Vybir nalashtuvan pid chas obchyslennya polyafraktal'nykh rozmirnostey zobrazhennya* [The choice of parameter swhen calculating the fractal dimension of the image]. *Naukovyy visnyk NLTU Ukrayiny* [Scientific Bulletin of UNFU]. 2018, vol. 28, no 2,pp. 159-163.ISSN 1994-7836 (Print), ISSN 2519-2477 (Online). https://doi.org/10.15421/40280230.
8. Bolshakov V., Volchuk V., Dubrov Yu. Fractals and properties of materials. Saarbrucken: Lambert Academic Publishing, 2016, 140 p.
9. Bolshakov V., Volchuk V. and Dubrov Yu. *Puti primeneniya teorii fraktalov* [Ways of applying the theory of fractals]. Saarbrucken: Palmarium Academic Publishing, 2016, 146 p.
10. Bolshakov V.I., Volchuk V.M., Dubrov Yu.I. *Fraktal'nyy podkhod pri identifikatsii slozhnykh sistem* [Fractal approach to the identification of complex systems]. *Dopovidi Natsionalnoi akademii nauk Ukrainy* [Reports of the National Academy of Sciences of Ukraine]. 2017, no. 6, pp. 46–50.ISSN 1025-6415. https://doi.org/10.15407/dopovidi2017.06.00
11. Bolshakov V. I., Volchuk V. M., Dubrov Yu. I. *Topologicheskiye i fraktal'nyye invarianty struktury dlya otsenki kachestva metalla* [Topological and fractal invariants of a structure to assess the quality of a metal]. *Dopovidi Natsionalnoi akademii nauk Ukrainy* [Reports of the National Academy of Sciences of Ukraine]. 2017, no. 4, pp. 42–48. ISSN 1025-6415. https://doi.org/10.15407/dopovidi2017.04.042.
12. Bolshakov V.I.,Volchuk V.N. *Materialovedcheskiye aspecty primeneniya veyvletno-mul'tifraktal'nogo podkhoda dlya otsenki struktury i svoystv malouglerodistoy stali* [Material science aspects of the use of wavelet and multifractal approach for assessing of the structure and properties of low-carbon steel].*Metallofizika i noveyshiye tekhnologii* [Metal Physics and Advanced Technologies]. 2011, vol. 33, no 3, pp. 347-360.
13. Volchuk V.M. *K primeneniyu fraktal'nogo formalizma pri ranzhirovanii kriteriyev kachestva mnogoparametricheskikh tekhnologiy* [On the Application of Fractal Formalism for Ranging Criteria of Quality of Multiparametric Technologies]. *Metallofizika i noveyshiye tekhnologii* [Metal Physics and Advanced Technologies]. 2017, vol. 39, no 3, pp. 949-957. ISSN 1024-1809. http:// DOI: 10.15407/mfint.39.07.0949.
14. Bolshakov V.I., Volchuk V.N. and Dubrov Yu.I. *Osobennosti primeneniya mul'tifraktal'nogo formalizma v materialovedenii* [Features of the multifractal formalism in materials]. *Dopovidi Natsionalnoi akademii nauk Ukrainy* [Reports of the National Academy of Sciences of Ukraine]. 2008, no. 11, pp. 99–107. ISSN 1025-6415. http://dspace.nbuv.gov.ua/handle/123456789/6255.
15. Bol'shakov V. I., Dubrov Yu. I., Kryulin F. V. and Volchuk V. N. Sposib vyznachennya fraktal'noyi rozmirnosti zobrazhennya [Method for Determining the Dimensionality of Images]. Patent product no. 51439A, UA. MPK 7 G06K9/00, bulletin no. 11, 2002.
16. Volchuk V.M. Rozroblennia i doslidzhennia metodu vyznachennia yakisnykhk harakterystyk metalu na osnovi analizu fraktalnoi rozmirnosti yoho mikrostruktury. – Manuscript:05.02.01 – Materials Science / V.M. Volchuk. – Dnipropetrovsk, 2003. – 186 p.
17. Bol'shakov V.I., Volchuk V.N., Dubrov Yu. I. *Razrabotka i issledovaniye metoda opredeleniya mekhanicheskikh svoystv metalla na osnove analiza fraktal'noy razmernosti yego mikrostruktury* [Development and study of the method for determining the mechanical properties of a metal based on an analysis of the fractal dimension of its microstructure]. *Metallovedenie i termicheskaya obrabotka metallov* [Metall Science and Heat Treatment of Metals]. 2004, no. 1, pp. 43–54.
18. Bol'shakov V.I., Volchuk V.N., Dubrov Yu. I. *Fraktaly v materialovedenii* [Fractals in materials]. Dnepropetrovsk: PGASA, 2005, 253 p.

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