Wind regime on the waste dumps

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Received May 22.2014: accepted June 13.2014

S u m m a r y . The articles describes the wind regime on waste dumps. The performance of Donbass wind regime and possibility of their maximum use in terms of WPP installation on the surface of coal mines waste dumps were investigate.
K e y w o r d s : wind energy, coal mines waste dumps, wind regime.

INTRODUCTION

Wind energy is one of the alternative [12-15]. While in Western Europe this type of energy is extensively used and wind power plants (WPP) are the active suppliers of electricity, in Ukraine this kind of energy is just being developed [1-4]. One of the most windy regions of Ukraine is Donbass, but using of wind energy is accentuated by high relief and lack of space to accommodate a wind power plant [5-7, 11]. These disadvantages can be compensated by using the surface of coal mines waste dumps [8-10, 16, 17].

However, based on a special shape of these objects, study of the wind regime which is mandatory to locate the WPP on their surface, is problematic [18-20, 23].

The aim of this work is to study the wind regime on waste piles. To achieve this goal the following problem was solved: to investigate the performance of Donbass wind regime and possibility of their maximum use in terms of WPP installation on the surface of coal mines waste dumps.

OBJECTS AND PROBLEMS

To solve this problem on a typical for Donbass example of Luhansk region, the factors of wind regime were analyzed. After all, to use the wind turbines on the waste dumps the frequency analysis of winds of different directions is required [21, 22]. According to the detailed wind diagram based upon long-term average annual data for Luhansk region (Fig. 1), the prevailing wind is easterly.

Since Donbass is characterized by rugged terrain, the waste dumps are most commonly located on the braced slopes of different aspects.

To estimate the "advantages" of the location of each waste dump we have proposed and designed the factor varying from 1 to 5 points (according to quality increase). When the coincidence of the dominant points of the compass directions

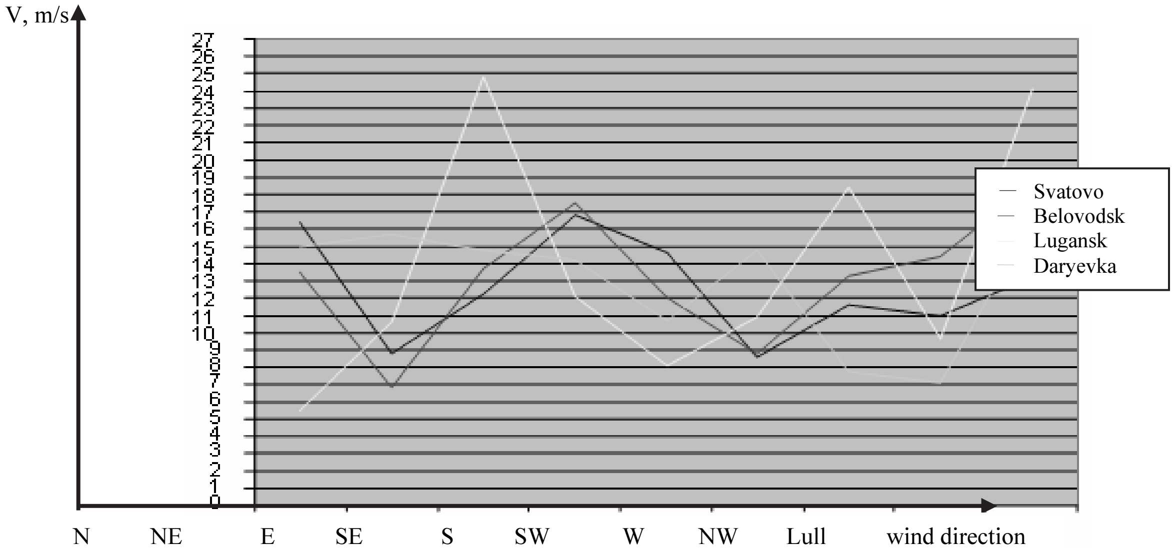

Fig. 1. Long-term average annual detailed wind diagram of Luhansk region

Fig. 2. Geomorphological analysis of site location dumps on satellite images (Lugansk region, a sample of 42 pieces)

At conjunction of bearings of the prevailing wind direction and exposure of slope, bearing the waste heap, which takes place on the windward slopes, the location of the waste dump is estimated at 5 points. When the exact opposite points of the compass location estimated at 1 point. At complete antithesis of bearings, the location of the waste dump is estimated at 3 points. 2 points is the estimation of the situation, when the angle between exposure bearing and wind direction is 135°. If the angle is 45° – it is estimated at 2 points, if 135° – 4 points.

We have studied the location of 42 waste dumps of Luhansk region (Fig. 2, Table 1).

Table 1. Evaluating of efficiency of the waste dumps location on the slopes

Prevailing wind, bearings	Bearing of apparent wind	Slope exposure alternative	Angle between directions	Ball	Quantity of waste dumps	
					pcs	%
E	W	W	0°	1	20	47,62
E	W	SW, NW	45° , 45°	2	3	7,14
E	W	S, N	90° , 90°	3	9	21,43
E	W	SE,NE	135° , 135°	4	4	9,52
E	W	E	180°	5	6	14,29

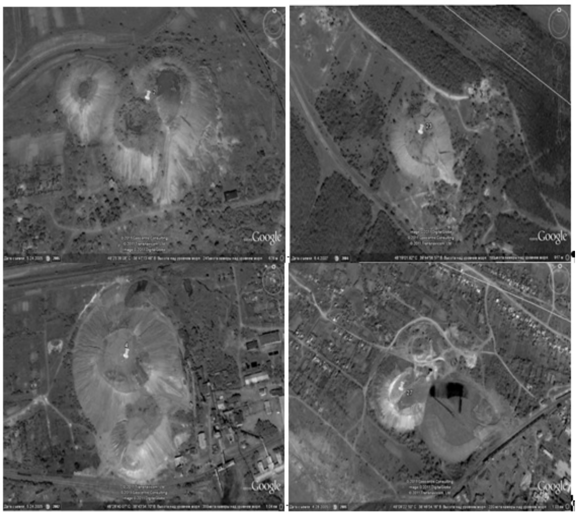

Fig. 3. Satellite imagery separate heaps of Luhansk region

Table 1 shows the distribution of the surveyed waste dumps over proposed scale.

The obtained results allow to choose waste dumps to place wind turbines on their tops more carefully.

Since the energy of the wind current is equal to half the product of the air density by the reference area of the standard wind wheel and weighted average windspeed raised to the third power, to determine it it's necessary to know the wind speed in a certain area. We analyzed the average wind speed in Lugansk region from 2005 to 2008 (Fig. 4).

We carried out detailing of the wind potential power (to construct WPS on the tops of the waste dumps) by taking into account changes in wind speed at different heights of Donbass coal mines waste dumps.

Were initially analyzed height of 42 coal mines waste dumps of Lugansk region above sea level (Table 2).

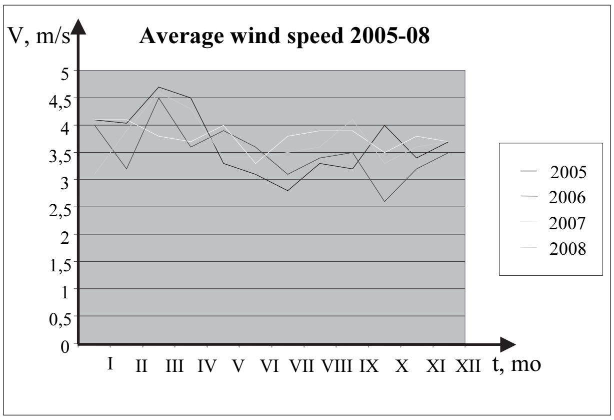

Fig. 4. Wind speed in Lugansk region

Table 2. Data check: disposition uniformity of 42 waste dumps

n	42	41
$\overline{X}$	233,048	237,195
S	73,2543	68,991
$X_{\max}$	351	
$t_{cp} = \dfrac{X_{\max} - \overline{X}}{S}$	1,61	
$t_{кр}(\alpha, \nu)$	2,00	
Derivation	H_0	
$X_{\min}$	63	110
$t_{cp} = \dfrac{\overline{X} - X_{\min}}{S}$	2,32	1,844
$t_{кр}(\alpha, \nu)$	2,00	2,00
Derivation	H_1	H_0

The obtained altitude above sea level data were checked for uniformity and authenticity. The Table below summarizes the test results of uniformity and authenticity of the altitude above sea level.

To confirm the authenticity of data on 42 waste dumps height above the sea level, a histogram and a polygon have been built (Fig.5).

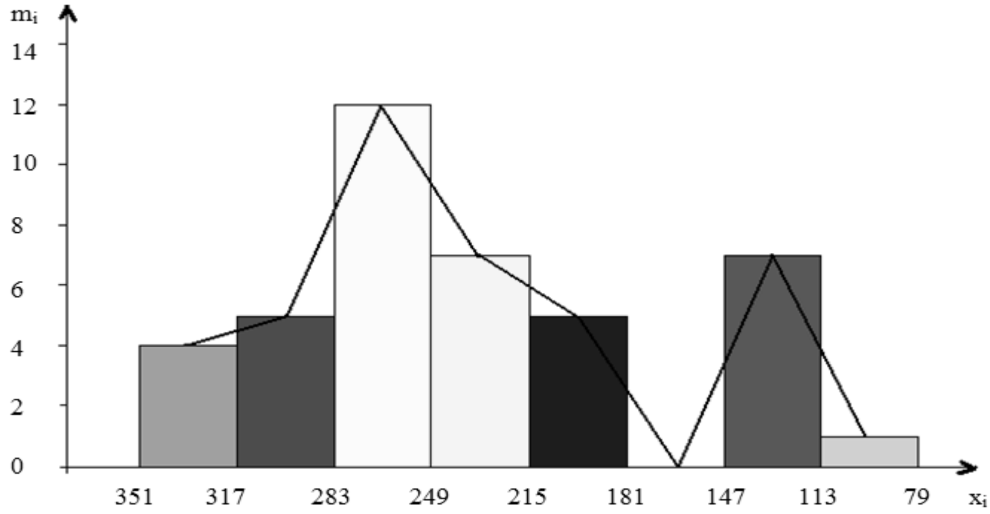

Fig. 5. The histogram and polygon of distribution in altitude0020of 42 waste dumps of Lugansk region above sea level

Table 3. Check of the heights uniformity of the conical waste dumps of Donetsk region

n	414,0	413,0	412,0	411,0	410,0	409,0	403,0	396,0	390,0	381,0	378,0
$\overline{X}$	48,7	48,2	48,0	47,9	47,7	47,6	46,8	45,9	45,3	44,4	44,1
S	24,7	22,4	22,1	21,8	21,7	21,5	20,7	19,9	19,3	18,6	18,4
X_{max}	260,0	124,3	117,0	111,0	104,0	103,0	96,0	89,0	86,0	81,0	80,0
$t_{cp} = \frac{X_{max} - \overline{X}}{S}$	8,57	3,40	3,12	2,89	2,6	2,57	2,38	2,16	2,11	1,97	1,95
$t_{кр}(\alpha, \nu)$	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96
Derivation	H_1	H_1	H_1	H_1	H_1	H_1	H_1	H_1	H_1	H_1	H_0
X_{min}	2	2	2	2	2	2	2	2	2	2	2
$t_{cp} = \frac{\overline{X} - X_{min}}{S}$	-1,89	-2,07	-2,08	-2,09	-2,11	-2,12	-2,17	-2,21	-2,24	-2,28	-2,29
$t_{кр}(\alpha, \nu)$	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96
Derivation	H_0	H_0	H_0	H_0	H_0	H_0	H_0	H_0	H_0	H_0	H_0

Further study was dedicated to the dumps height (without regard to their location above sea level). The analysed data below show the heights of the following objects: 210 flat and 100 conical waste dumps of Lugansk region, 414 conical and 182 flat waste dumps of Donetsk region.

All the data were checked for uniformity and authenticity. The following table shows an example of checking the heights uniformity of the largest group - the conical waste dumps of Donetsk region.

The Figure 6 below shows the confidence test data on coal mines waste dumps obtained by using the rectified chart method.

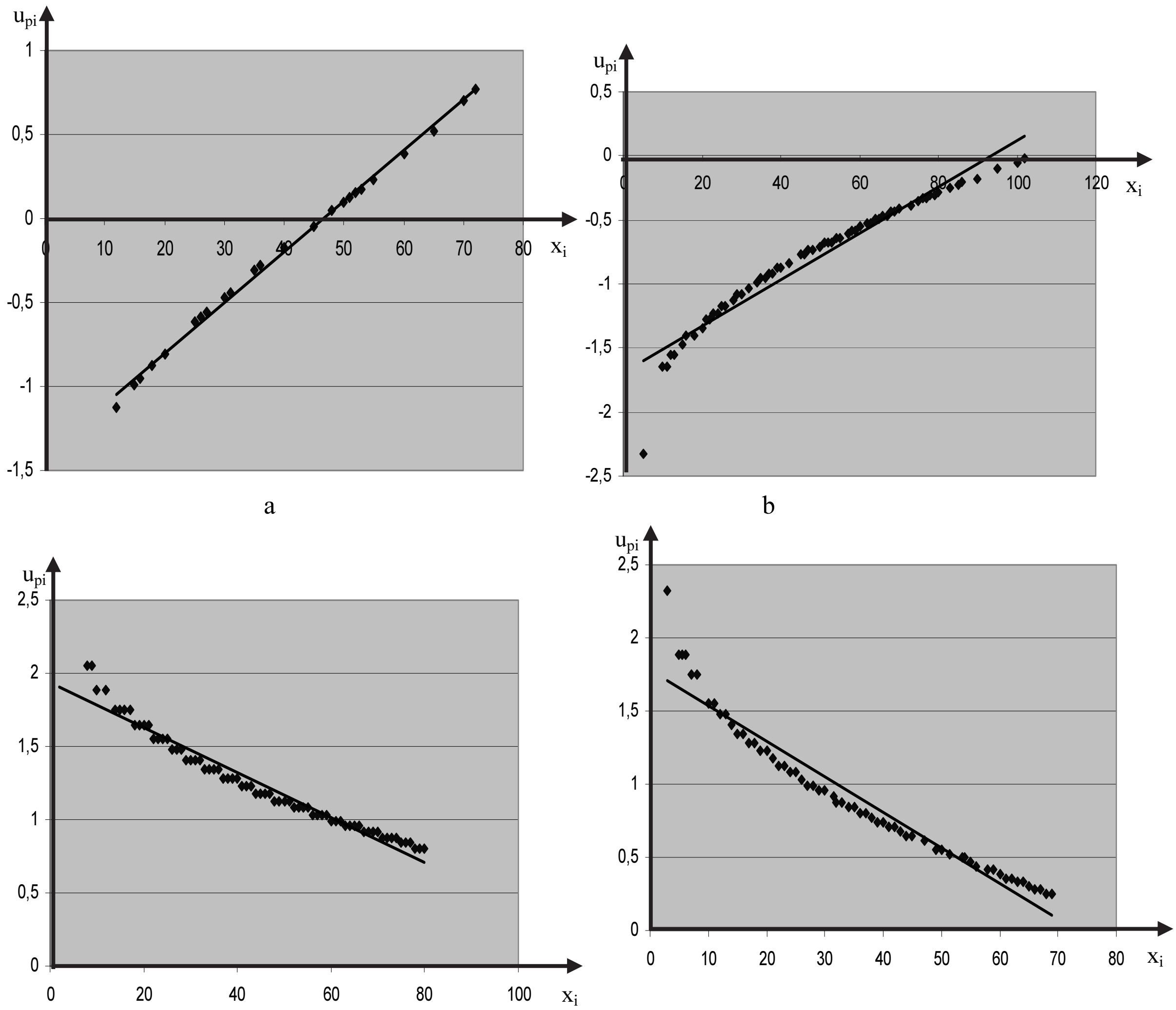

Fig. 6. Confidence test data obtained by using the rectified chart method: a – flat waste dumps of Lugansk region, b – conical waste dumps of Lugansk region, c – conical waste dumps of Donetsk region, d – flat waste dumps of Donetsk region.

The figure shows the obtained probability curves of height of the conical and flat waste dumps of Donetsk and Lugansk regions.

The conical and flat waste dumps of Donetsk and Lugansk regions were compared at first in pairs using Fisher-Snedecor test:

$$F = \frac{S_x^2}{S_y^2}, \quad (1)$$

$$t = \frac{|\bar{x} - \bar{y}|}{\sqrt{\frac{S_x^2(n-1) + S_y^2(m-1)}{n+m-2}\left(\frac{1}{n} + \frac{1}{m}\right)}}. \quad (2)$$

And then in block (using Kruskal–Wallis one-way analysis of variance:

$$Q = \frac{12}{N(N+1)} \sum_{\gamma=1}^{a} \frac{1}{n_\gamma} \left[\sum_{i \in S_\gamma} R_i \right]^2 - 3(N+1). \quad (3)$$

In each case, the heights of the waste dumps were found to be nonuniform.

Then the coal mines waste dumps of Donetsk and Lugansk regions were zoned according to height and therefore, according to their wind potential power.

To zone them, all the conic and flat waste dumps of Donetsk and Lugansk regions were checked for information content, pursuant to the procedure.

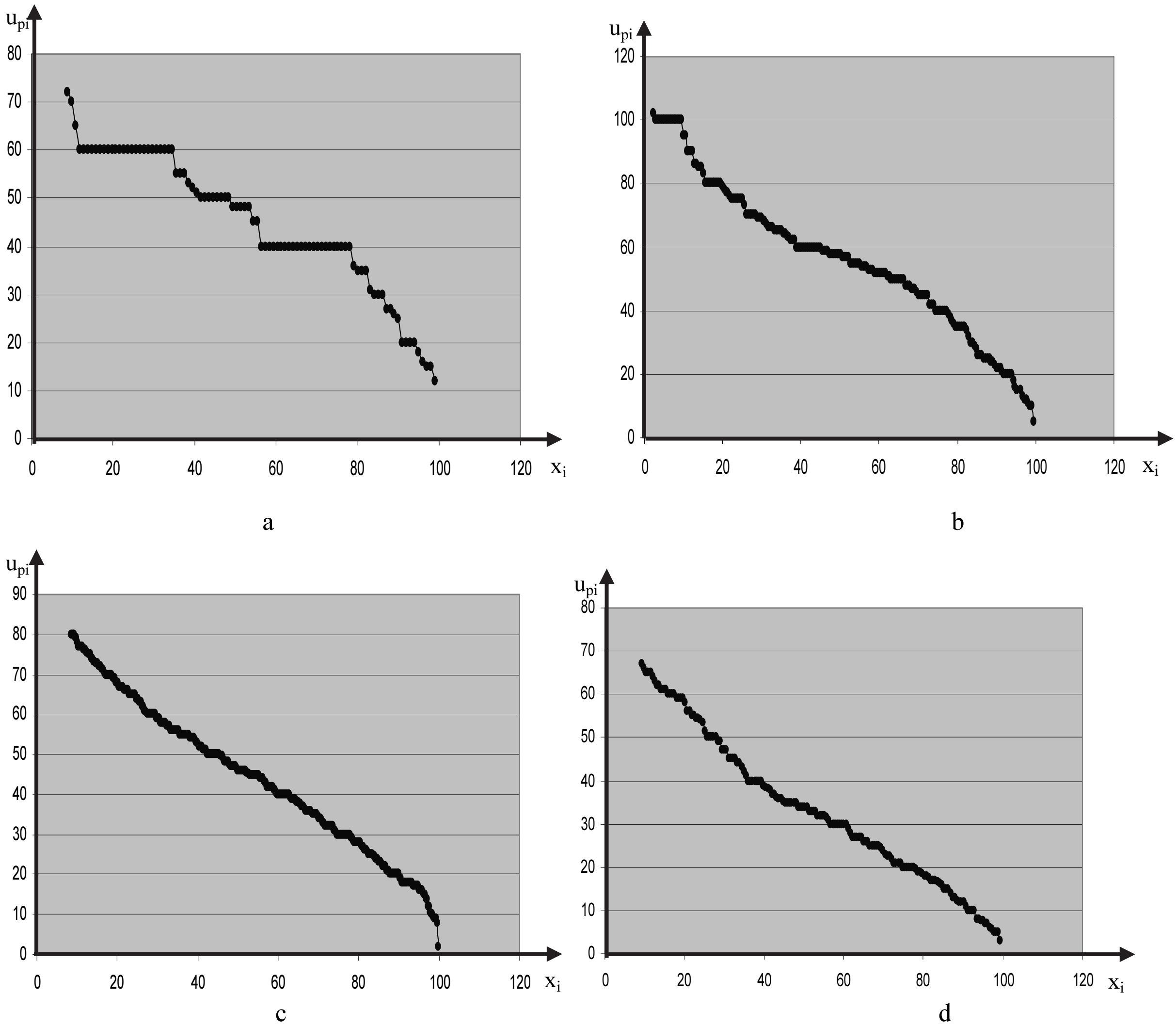

Fig. 7. Probability curves of height of the conical and flat waste dumps of Donetsk and Lugansk regions: a – flat waste dumps of Lugansk region, b – conical waste dumps of Lugansk region, c – conical waste dumps of Donetsk region, d – flat waste dumps of Donetsk region.

Determination of information coefficient and pooled results are shown in the Table below.

Table 4. Determination of information coefficient using the waste dumps height

Waste dumps dislocation (region)	Selection scope			Average value		Dispersion, S_2	Actual value of the informa-tion coeffi-cient, V^2	Tabulated value, χ^2	Condition of data informative: $V^2 \geq \chi^2$ informative, $V^2 < \chi^2$ not informative
	1st sub-matrix, n_1	2nd sub-matrix, n_2	Total, n	1st sub-matrix, $\overline{X}_1$	2nd sub-matrix, $\overline{X}_2$				
Lugansk region (flat waste dumps)	46,0	46,0	92,0	42,57	47,47	198,27	2,76	3,8	Informative
Lugansk region (conic waste dumps)	103,0	103,0	206,0	60,33	52,65	549,11	5,67	3,8	Informative
Donetsk region (flat waste dumps)	82,0	82,0	164,0	35,64	29,66	273,87	5,33	3,8	Informative
Donetsk region (conic waste dumps)	189,0	189,0	378,0	45,33	42,85	337,12	1,89	3,8	not informative

CONCLUSIONS

1. Heights 42 heaps of coal mines are investigated. All of them are in the Lugansk region above sea level. Results checked for uniformity and accuracy.

2. Results obtained by evaluating the effectiveness of the location on the slopes of the heaps of wind turbines. They allow more true dumps choose to be placed on top of their wind turbines.

3. Obtained expression for the energy of the wind potential for the changes in wind speed at different heights heaps of coal mines in the Donbas.

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ВЕТРОВОЙ РЕЖИМ НА ТЕРРИКОНАХ

Валерий Буняченко

А н н о т а ц и я . В работе проведено изучение ветрового режима на терриконах. Исследованы показатели ветрового режима Донбасса и возможности максимального их использования при установке ВЭС на отвалах угольных шахт.

К л ю ч е в ы е с л о в а : ветроэнергетика, породный отвал, ветровой режим.