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Time Model of Quarry Power Consumption

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ABSTRACT: The paper presents the results of a study on finding the patterns of power consumption of mining enterprises, which is achieved by compressing information on electricity consumption, a mathematical description of trends in seasonal and annual electricity consumption and obtaining adequate temporary mathematical models of the systematic component of the process of power consumption of mining enterprises.

KEYWORDS: power consumption, productivity, factors affecting power consumption, correlation coefficients, factor models**..**

1. INTRODUCTION

In accordance with the methodology of analysis and mathematical modelling of power consumption, preparation and processing of initial information on monthly electricity expenditures at the mining enterprises of Navoi Mining and Metallurgical Company was carried out. The purpose of this research is to find the patterns of power consumption of mining enterprises, which is achieved by compressing information on power consumption, a mathematical description of trends in seasonal and annual electricity consumption and obtaining adequate temporary mathematical models of the systematic component of the process of power consumption of mining enterprises**.**

II. MATERIAL AND METHODS

The statistics of the monthly electricity consumption of «Muruntau» and «Tashkura» quarry (as% of annual consumption) are given in Table 1.

The values of monthly electricity consumption have a fairly strong concentration near the mean value, as evidenced by the small values of the standards. Close values of the mean, median and mode also confirm a sufficiently high statistical homogeneity of the monthly power consumption distributions at the mining enterprise.

Presenting interesting question is sampling accessories distributions monthly electricity consumption of individual plots to the same general population.

In accordance with the research methodology, the initial information on the electricity consumption, presented in a matrix form, was processed on a computer in order to obtain temporary models of power consumption.

As a result of the processing of statistical data, temporary mathematical models of the electric power consumption of the «Muruntau» mine, representing multiplicative functions reflecting the annual trend and seasonal variation during the year, were obtained in the form of:

$$W^*(T,t) = (a + bT)[c_0 + 2\sum_{k=1}^{2} c_k \cos(2\pi k f_1 t + \psi_k)] \quad (1)$$

where $W^*(T,t)$ - the values of monthly electricity consumption in a given year in relative units in relation to the annual power consumption of the base year; *a, b*- parameters of the regression equation ; T – year number, $T = 1,2,\ldots 9$; t – current month number, $t = 1,2,\ldots 12$; c_0 – the constant component of seasonal component; c_k - amplitude of the cosine component of seasonal component harmonics; ψ_k - phase of harmonic components; f_1 - frequency equal to the reciprocal of model schedule period, $f_1 = \frac{1}{t} = \frac{1}{12}$;

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Table 1. Statistics of monthly electricity consumption of the «Muruntau» and "Tashkura" quarry (in % of annual consumption)

Month number in a year	Average	Moda	Median	Standard	Dispersion	Asym metry	Express
quarry «Muruntau»							
1	9,09	9,59	9,59	1,57	2,48	-2,50	6,91
2	8,36	8,10	8,16	0,43	0,18	0,21	-1,72
3	8,86	9,43	8,92	0,67	0,44	-0,18	-0,81
4	8,05	8,28	8,28	0,77	0,60	-0,62	-0,50
5	7,84	8,20	8,10	0,49	0,24	-0,78	-0,72
6	7,58	8,20	7,70	0,55	0,30	-0,35	-1,36
7	7,89	7,69	7,69	0,80	0,65	0,08	-0,39
8	7,92	8,19	8,15	0,58	0,33	-1,23	1,39
9	7,57	8,60	7,40	0,87	0,75	-0,78	1,10
10	8,33	8,50	8,50	0,66	0,43	-1,60	3,37
11	8,78	8,47	8,53	0,76	0,57	0,16	0,84
12	9,60	9,80	9,80	0,80	0,64	0,19	-0,29
quarry «Tashkura»							
1	9,02	7,89	7,89	2,45	6,00	1,32	1,08
2	7,97	7,70	7,90	1,06	1,13	-0,27	-0,58
3	8,42	7,67	8,45	1,12	1,24	-0,28	-0,32
4	8,66	8,46	8,46	0,73	0,53	0,28	-0,02
5	8,06	6,80	7,87	1,31	1,70	-0,01	-1,51
6	7,72	8,80	8,19	1,40	1,95	-1,78	2,94
7	8,26	8,12	8,12	0,79	0,63	-0,17	-0,40
8	7,58	7,81	7,86	1,61	2,58	-1,71	3,25
9	7,60	7,76	7,76	0,94	0,88	-0,59	0,08
10	8,82	8,36	8,64	1,28	1,64	0,46	0,36
11	8,96	8,35	8,84	0,60	0,36	0,16	-1,69
12	9,00	8,60	8,85	0,70	0,49	0,25	-1,38

III. RESULTS AND DISCUSSIONS

The values of time model coefficients and the reliability of the description of original statistical material in the form of the total contribution of harmonics in the model of power consumption are given in Table 2.

Table 2. Values of the coefficients of models of power consumption modes of the «Muruntau» and the «Tashkura» quarry

Plots	Coefficients of the model							
	Annual trend		Seasonal					Contribution of harmonics %
	$a\times10^{-1}$	$b\times10$	c_0	c_1	c_2	Ψ_1	Ψ_2	
Muruntau	8,30	0,0003	7,626	0,5263	0,0894	1,3	0,39	99,85
Tashkura	8,12	0,003	7,622	0,5386	0,0649	1,34	0,07	99,86

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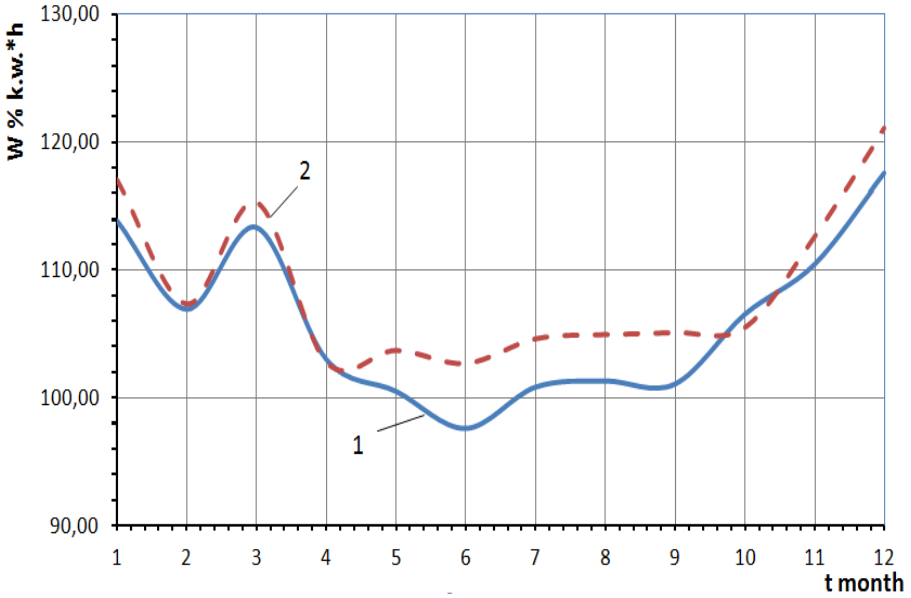
The first component model $(a+bT)$ represents annual trend, the second $[c_0 + 2\sum_{k=1}^{2} c_k \cos(2\pi k f_1 t + \psi_k)]$ reflects the power consumption within a year [5]. Models of seasonality of the power consumption modes of the «Muruntau» and «Tashkura» quarry are shown in Figures 1 - 2.

The values in (1) are obtained in relative units. To translate their named units, you must perform a conversion:

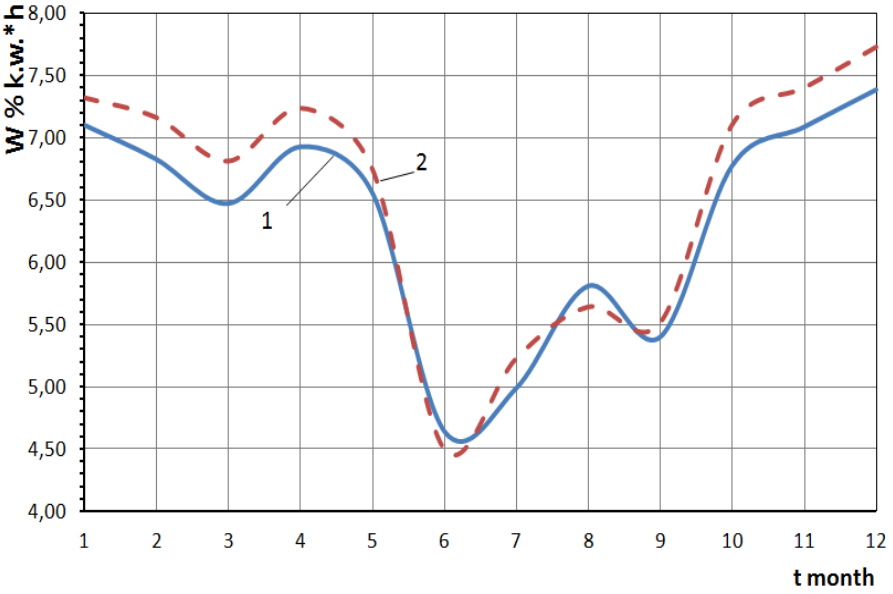
$$W(T,t) = W^*(T,t) \cdot W(1) \qquad (2)$$

where W(1) – base year power consumption.



1 – Experimental power consumption.2 – Seasonal component of the model of power consumption.

Figure 1. - The model of seasonality of the «Muruntau» power consumption regime.



1 – Experimental power consumption.2 – Seasonal component of the electricity consumption modelя.

Figure 2. - Seasonal model of the power consumption mode of «Tashkura» quarry.

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To confirm the adequacy of the time models, the simulation of power consumption process for the last year and comparison with the actual data were performed. The results are shown in Tables 3-4 and are presented graphically in Figure 3-4.

Table 3. Modelling results and actual values of electricity consumption of «Muruntau»

№	Year Month	Actual power consumption, kWh	Power consumption by simulated calculation, kWh	Forecast error	
				absolute, kWh	relative %
1	January	11710100	11391659	318440,5	2,72
2	February	10735976	10696434	39541,9	0,37
3	March	11532192	11338952	193239,9	1,68
4	April	10279704	10302721	-23017,0	-0,22
5	May	10372330	10050775	321554,6	3,10
6	June	10269967	9759083	510883,5	4,97
7	July	10463322	10084005	379317,2	3,63
8	August	10495794	10131863	363930,7	3,47
9	September	10512025	10108182	403843,4	3,84
10	Oktober	10550095	10655358	-105263,1	-1,00
11	November	11262119	11047844	214275,5	1,90
12	December	12104208	11756768	347440,2	2,87

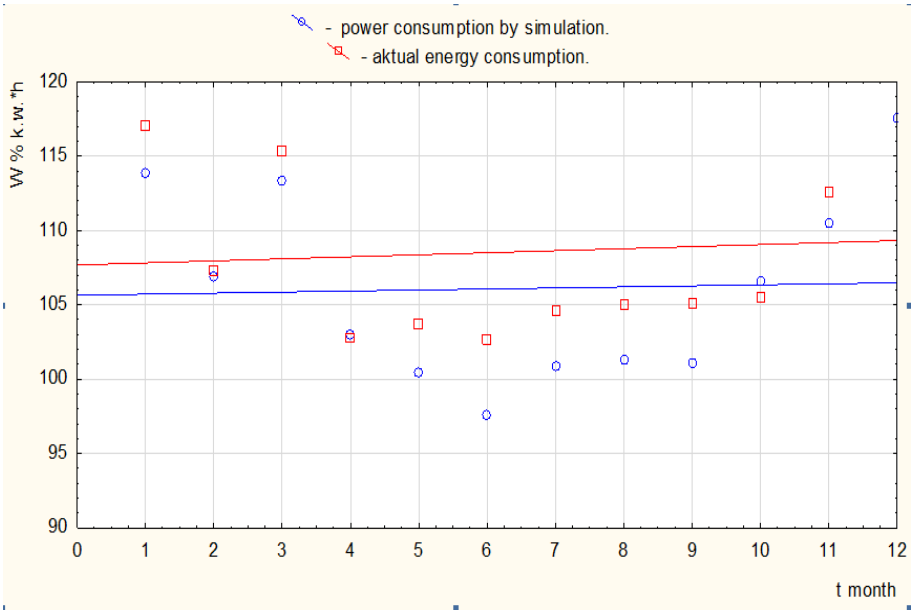

Figure 3. Actual and calculated values of the temporal model of power consumption of «Muruntau».

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Table 4. Results of modeling and actual values of power consumption of «Tashkura» quarry

№	Year Month	Actual power consumption, kWh	Power consumption by simulated calculation, kWh	Forecast error	
				absolute, kWh	relative %
1	January	731937	710193,8	21743,15	2,97
2	February	716050	682732	33318	4,65
3	March	681074	647115,8	33958,25	4,99
4	April	723606	692648,8	30957,22	4,28
5	May	675064	656033	19031,01	2,82
6	June	450281	464562,9	-14281,9	-3,17
7	July	523014	498890,2	24123,8	4,61
8	August	564330	580940,1	-16610,1	-2,94
9	September	551654	540083	11571,03	2,10
10	Oktober	710410	677514,5	32895,54	4,63
11	November	739873	708668,2	31204,81	4,22
12	December	772516	738418,5	34097,48	4,41

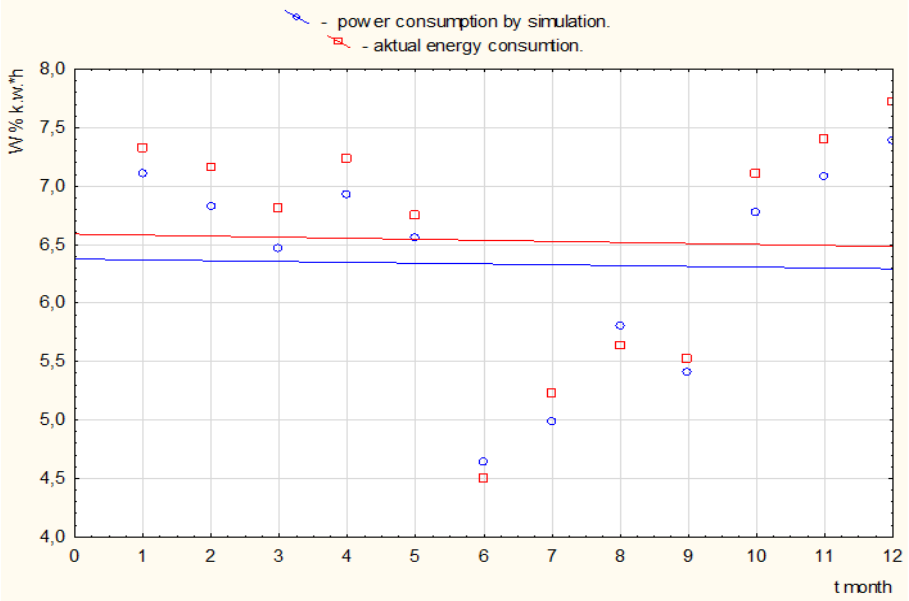

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Figure 4. Actual and calculated values of the temporary model of power consumption of «Tashkura» quarry.

IV. CONCLUSION

The adequacy of the temporary mathematical models obtained is justified by a small percentage discrepancy (for «Muruntau» mine, the maximum discrepancy is within 4.95%, for the Tashkura quarry, the maximum discrepancy is within 4.99%).

The dependencies obtained reliably describe the regime of electric consumption of mining enterprises and can serve as forecast predictors when planning the power consumption regimes at mining enterprises.

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