Türkiye 16. Madencilik Kongresi / *16th Mining Congress of Turkey,* 1999, ISBN 975-395-310-0

DEVELOPMENT OF THE MINING WORKS IN TROYANOVO-1 COAL MINE

G. Konstantinov
University of Mining and Geology, Sofia, Bulgaria

St. Hristov
University of Mining and Geology, Sofia, Bulgaria

I. Markov
University of Mining and Geology, Sofia, Bulgaria

V. Ivanova
University of Mining and Geology, Sofia, Bulgaria

ABSTRACT: The basic characteristics of the development of the mining operations at the Troyanovo-İmine from their commencement to 1997 are presented. The average development rates and their geometric mean values have been calculated on the basis of the quantities of extracted coal and overburden. An analytical expression has been found for the time series of the rates of coal and overburden extraction for the studied period. It is a step function which describes the historical facts of the mine development and permits the prediction of the future development rates. The proved irregular development of the mining operations requires the choice of a proper strategy for the mine development under market economy conditions.

1. GENERAL CHARACTERISTICS OF THE FIELD OF THE MINE

The open pit mine for production of lignite "Troyanovo-1" is located in the central part of the Maritza East Basin.

The overburden with thickness ranging from 50 to 85 i"• is composed of grey-green, grey, grey-blue, yellow and yellow-rust clays with no distinct boundary between them.

The coal starts with sharp transition from grey-green or black clays to coal. Within the boundaries of the mine the coal thickness is between 30-35 m. The topmost I coal layer represents several coal bands deposited in black fat clays. The main mining layer-II coal with thickness varying in the boundaries of 16-25 m is situated under it. The interlayer from II to III coal layer is composed of thin-seam green and grey-green clays. The third coal layer is of thickness ranging from 2 to 5.5 m.

The undercoal is composed of grey-black clays with thickness up to several meters.

Overburden work is carried out by wheel excavators Rs 1200 and Rs 2000, dump formation is performed by stokers As 1600, As 5000, As 6300 and As 12500. Coal is mined by excavators Rs 315, Rs 710, K 800 and Rs 1200.

The overburden is transported to internal and external dumps by conveyors or railway haulage.

The coal is delivered to the consumers (power plant or briquette factory) entirely by means of railway transport.

2. ANALYSIS OF COAL MINING

During the almost half century period of the existence of Troyanovo-1 Mine have been accumulated sufficient quantitative and qualitative data related to its main activity production of coal and the inevitably accompanying removal of overburden.

The volumes of coal and overburden mined over the years (Table 1, columns 3 and 6) can be regarded as time lines. On this basis it is possible to calculate the development rates (growth or drop) entered in columns 4 and 7 respectively, as well as the geometrical mean of the development rates (columns 5 and 8).

Thus, for example, the geometrical mean of the rates for development of coal for 1962 is:

$$\sqrt{11.67 \times 3.09} = 6.01$$

while for 1998 it will be:

$$\sqrt[38]{11.67 \times 3.09 \ldots 0.92} = 1{,}11$$

The geometrical mean values for the rates of development of the overburden are calculated analogously.

On the basis of the data in column 5 the analytical expression of the time line for the production of coal can be found:

$$\left.\begin{aligned} Y &= A \times B^{T-1} \\ Y &= 0.12 \times 1{,}11^{T-1} \end{aligned}\right\} \quad (1)$$

where Y is the level of coal production for the year Ti, for example for 1960 T=l, for 1961 T=2, and for 1998 T=39.

The constant A equal to 0.12 billion t., is the initial level, when T=l.

The constant B, equal to 1. H is the mean quadratic of the development rates, or it is the average rate of growth in coal production. This constant shows that in the course of 39 years the production of coal has increased in average, yearly by 11% (over the same period it is 12% for overburden).

Let us consider the actual dynamics of the growth rate. For 1965 the average growth rate from the beginning of the line is 0.87, till 1973 it is 0.96, till 1983 - 0.97 and in the end of 1998 - 0.92. The lack of correspondence of the actual growth rates and the calculated average rate is a source of deviations and reduces the accuracy of formula (1). Therefore, it is appropriate in the place of the average growth rate of coal production to introduce a formula for the time line of the equation of rates. This equation will represent a step-type function, but as first approximation it can be written down in linear form.

$$B = C_0 + C_1 \times T \quad (2)$$

After expansion of the constant B the formula for the time line gets the following expression:

$$B = 0.04 \times (C_0 + C_1 \times T)^{T-1} \quad (3)$$

where C_0 and Cj are constant values.

By means of formula (3) it is possible to describe sufficiently well the historical facts for the development of coal production. The projections on the basis of formula (3) can be successful for the near future. This fact is needed much for the work of the mine under market conditions.

An identical approach can also be applied for estimating overburden excavation.

3. QUANTITATIVE ESTIMATION OF THE REGIME OF MINING WORKS

The regime of mining works gives the most precise technological estimation for the volumes of poal and overburden excavation in time. It allows for planning the appropriate strategy of development of mining works.

Figure 2 shows the graph of the overburden volumes increasing by years (ΣV) as a function of the increasing tons of coal (ΣP). The different points of the curve give the number of the respective year for excavation of mining mass (Table 1).

For example, it can be seen in point 14 of the graph that till 1966 included a total of 30.67 mln. t. of coal (column 9 of the table) and 90.18 mln. m^3. of overburden (column 10) were excavated. The respective exploitation coefficients of overburden are given in column 11.

It can be seen from the graph that the period till 1960 can be considered as construction one, and the time from 1961 to 1963 as period for achieving the production capacity of the mine. Thus the period for normal operation of the mine starts from 1964.

The graph shows the low evenness of development of mining works over the years.

Quantitative expression of the evenness of the regime of mining works at n mean exploitation coefficients of overburden can be obtained from formula (Konstantinov, 1987).

$$k_p = \frac{k_1 \times P_1^2 + k_2 \times P_2^2 + \ldots + k_n \times P_n^2}{P \times V} \quad (4)$$

where P and V are respectively the tons of coal and the volumes of overburden; kj, k2 ••• k_n - the mean exploitation coefficients of overburden.

Using Table 1 and formula (4) we can estimate the coefficient of evenness of the regime of mining works from 1960 (point 8 of the graph) till 1973 included (point 21 of the graph):

Table 1. Development rates of coal production in Troyanovo-1 mine

No.	Years	Coal, mln. t.	Development rate	Geometrical mean of the development rates	Overburden mln. m^3	Development rate	Geometrical mean of the development rates	ΣP mln. t.	ΣV mln. m^3	K m^3/t.
1	2	3	4	5	6	7	8	9	10	11
1	1953	-	-	-	0.11	_	-	-	0.11	-
2	1954	-	-	-	0.31	2.82	-	-	0.42	_
3	1955	-	-	-	0.80	2.58	2.70	_	1.22	-
4	1956	-	-	-	1.06	1.33	2.13	-	2.28	_
5	1957	-	-	-	1.29	1.22	1.85	-	3.57	-
6	1958	-	-	-	1.82	1.41.	1.75	_	5.39	-
7	1959	-	-	-	2.81	1.54	1.72	-	•8.20	-
8	1960	0.12	-	-	3.97	1.41	1.67	0.12	12.17	33.08
9	1961	1.40	11.67	-	4.86	1.22	1.61	1.52	17.03	3.47
10	1962	4.32	3.09	6.01	9.68	1.99	1.64	5.84	26.71	2.24
11	1963	4.58	1.06	3.37	11.33	1.17	1.59	10.42	38.04	2.47
12	1964	6.94	1.52	2.76	16.16	1.43	1.57	17.36	54.20	2.33
13	1965	6.06	0.87	2.19	16.95	1.05	1.52	23.42	71.15	2.80
14	1966	7.25	1.20	1.98	19.03	1.12	1.49	30.67	90.18	2.62
15	1967	7.54	1.04	1.81	21.05	1.11	1.46	38.21	111.23	2.79
16	1968	8.02	1.06	1.69	23.42	1.11	1.43	46.23	134.65	2.92
17	1969	7.78	0.97	1.59	19.69	0.84	1.38	54.01	154.34	2.53
18	1970	8.34	1.07	1.53	20.68	1.05	1.36	62.35	175.02	2.48
19	1971	7.29	0.87	1.45	19.29	0.93	1.33	69.64	194.31	2.65
20	1972	6.59	0.90	1.40	20.95	1.09	1.32	76.23	215.26	3.18
21	1973	6.35	0.96	1.36	21.06	1.01	1.30	82.58	236.32	3.32
22	1974	5.49	0.86	1.31	22.51	1.07	1.29	88.07	258.83	4.10
23	1975	5.96	1.09	1.30	18.88	0.84	1.26	94.03	277.71	3.17
24	1976	5.78	0.97	1.27	17.87	0.95	1.25	99.81	295.58	3.09
25	1977	5.36	0.93	1.25	18.41	1.03	1.24	105.17	313.99	3.43
26	1978	6.72	1.25	1.25	18.66	1.01	1.23	111.99	332.65	2.78
27	1979	6.84	1.02	1.24	16.95	0.91	1.21	118.73	349.60	2.48
28	1980	7.86	1.15	1.23	16.09	0.95	1.20	126.59	365.69	2.08
29	1981	7.79	0.99	1.22	17.71	1.10	1.20	134.38	383.40	2.27
30	1982	8.02	1.03	1.21	19.05	1.08	1.19	142.40	402.45	2.38
31	1983	7.77	0.97	1.20	22.32	1.17	1.19	150.17	424.77	2.87
32	1984	7.50	0.96	1.19	24.03	1.08	1.19	157.67	448.80	3.20
33	1985	5.98	0.80	1.17	22.32	0.93	1.18	163.65	471.12	3.73
34	1986	7.24	1.21	1.17	23.71	1.06	1.18	170.89	494.83	3.27
35	1987	7.56	1.04	1.17	28.02	' 1.18	1.18	178.45	522.85	3.71
36	1988	7.08	0.94	1.16	30.76	1.10	1.18	185.53	553.61	4.34
37	1989	6.79	0.96	1.15	28.06	0.91	1.17	192.32	581.67	4.13
38	1990	6.85	1.01	1.14	24.30	0.87	1.16	199.17	605.97	3.55
39	1991	6.77	0.99	1.14	19.06	0.78	1.15	205.94	625.03	2.82
40	1992	7.67	1.13	1.14	23.71	1.24	1.15	213.61	648.74	3.09
41	1993	7.54	0.98	1.13	25.29	1.07	1.15	221.15	674.03	3.35
42	1994	6.82	0.90	1.13	22.17	0.88	1.14	227.97	696.20	3.25
43	1995	7.81	1.15	1.13	17.40	0.78	1.13	235.78	713.60	2.23
44	1996	7.77	0.99	1.12	17.92	1.03	1.13	243.55	731.52	2.31
45	1997	7.15	0.92	1.12	17.85	1.00	1.12	250.70	749.37	2.50
46	1998	6.58	0.92	1.11	18.16	1.02	1.12	257.28	767.53	2.76
Total:		257.28	-	-	767.53	-	-			

Note: **ΣP** - increasing amounts of the coal, mln.t.
ΣV - increasing volumes of the overburden, mln. m^3
K - exploitation coefficient of overburden, m^3/t.

$$k_p = \frac{k_8 \times P_8^2 + k_9 \times P_9^2 + \ldots + k_{21} \times P_{21}^2}{P \times V} =$$

$$= \frac{33.08 \times 0.12^2 + 3.47 \times 1.40^2 + \ldots + 3.32 \times 6.35^2}{82.58 \times (236.32 - 8.20)} = 0.082$$

From the beginning of operation of the mine, including during the construction period till 1973 included

$$k_p = \frac{k_1 \times P_1^2 + k_2 \times P_2^2 + \ldots + k_{21} \times P_{21}^2}{P \times V} = \frac{1538.5}{19515.1} = 0.079$$

For the period 1953 till 1993:

$$k_p = \frac{k_1 \times P_1^2 + k_2 \times P_2^2 + \ldots + k_{41} \times P_{41}^2}{P \times V} = \frac{9167}{149061.7} = 0.061$$

For the whole period of existence of the mine from 1953 till 1998 (point E of the graph) the evenness of work is 5%.

CONCLUSION

The studies carried out show that the unevenness has always been going along with the development of mining works. This fact requires the development of an appropriate strategy for work under the dynamic conditions of market economy.

REFERENCES:

1. Konstantinov, G. Quantitative estimation of the regime of mining works in the open pit mines. *Mining Magazine*, issue 10, Sofia, 1987.