Journal of Young Scientist, Volume II, 2014
ISSN 2344 - 1283; ISSN CD-ROM 2344 - 1291; ISSN Online 2344 - 1305; ISSN-L 2344 – 1283

ASPECTS OF ACHIEVING PRECISIONS IN MINING PENETRATIONS

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Abstract

The present papper deals with the aspects of precision, obtained in the case of front and contra-front projects and in cases in which the mining project has to get to other existing subteranian projects. From an economic perspective it is very important that the piercing to be done properly to avoid additional work to correct the deviations that occurred.

***Keywords**: mining penetrations, precision, deviations, topography*

INTRODUCTION

Deposits of useful minerals beneath the earth's crust open mining is placed according to some projects should contain all the necessary surveying their land materialize. In this context, we can say that precede surveying mining in that their projects is based on data from surveying. Also present in surveying mining and location measurements and control so that they fit into the project, and finally ending mining reception measurements (Dima, 1996).

Continuity and consistency of topographic work surface and underground at a mine shall ensure the existence of a common reference name topographic system. One such reference system is determined by the bond is between the work surface topography and underground, it materializes the elements as it is known, coordinates a project materialized toprografic mining work performed at a particular horizon and orientation of directions also materialized on that mining work (Popia, 2008).

MATERIALS AND METHODS

Consider an open deposit by two vertical wells including underground mining work are carried horizontally.

If the surface where the mining work is transmitted horizontally by two F_{309} and F_{300} ballasted wire coordinates of two points 309 and 300, then between them can be achieved poligonaţie (non-mining) whose points P_3 intermediates are denoted by P_4, P_1, N.

Solving this polygonal route aims to determine the coordinates of waypoints, which is possible by knowing the following quantities:

-coordinates X_{309}, Y_{309}, X_{300}, Y_{300} of the points 309 și 300 – which are known;

- angles β_1, β_2,..., β_n and distances D_{P3}, D_{P4}, D_{P1}, D_N – which are measured.

It is obvious that the determination of the coordinates of the points P_3, P_4, P_1, N of the reference system can be embodied in various ways other than those required.

It is considered, however, topographic features (coordinates of a point and a direction orientation) evidenced by two stable points in the ramp of one of the two wells (eg points P_3 and P_4).

We consider separately two polygonal route with two fixed points used for reference system transmission.

Route points can be related to two Cartesian reference systems: the general and the particular system 309_{xy} $309_{x'y'}$. The latter has an axis along the first side of the polygonal path, the other perpendicular to the side in point 309 (Figure 1).

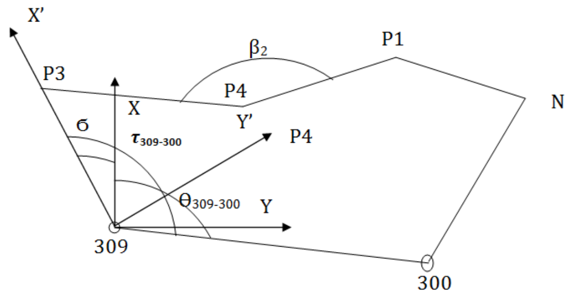

Figure 1. Polygonal route

RESULTS AND DISCUSSIONS

Orientations calculation in the particular system:

In particular the reference system can be calculated guidelines τ sides of the route as follows:

$\tau_{309\text{-}P3} = 0$

$\tau_{P3\text{-}P4} = \tau_{309\text{-}P3} + \beta_1 \pm 200$

$\tau_{P4\text{-}P1} = \tau_{309\text{-}P3} + \beta_1 + \beta_2 \pm 2*200$

$\tau_{P1\text{-}N} = \tau_{309\text{-}P3} + \beta_1 + \beta_2 + \beta_3 \pm 3*200$

$\tau_{N\text{-}300} = \tau_{309\text{-}P3} + \beta_1 + \beta_2 + \beta_3 + \beta_4 \pm 4*200$

Coordinates calculation in the particular system:

Also, the orientations values set out above, can be calculated the coordinates X', Y' of the polygonal route points:

$$X'_{P3} = X_{309} + D_{P3} \cos \tau_{309\text{-}P3}$$
$$Y'_{P3} = Y_{309} + D_{P3} \sin \tau_{309\text{-}P3}$$

$$X'_{P4} = X'_{P3} + D_{P4} \cos \tau_{P3\text{-}P4}$$
$$Y'_{P4} = Y'_{P3} + D_{P4} \sin \tau_{P3\text{-}P4}$$

$$X'_{P1} = X'_{P4} + D_{P1} \cos \tau_{P4\text{-}P1}$$
$$Y'_{P1} = Y'_{P4} + D_{P4} \sin \tau_{P4\text{-}P1}$$

$$X'_{N} = X'_{P1} + D_{N} \cos \tau_{P1\text{-}N}$$
$$Y'_{N} = Y'_{P1} + D_{N} \sin \tau_{P1\text{-}N}$$

$$X'_{300} = X'_{N} + D_{300} \cos \tau_{N\text{-}300}$$
$$Y'_{300} = Y'_{N} + D_{300} \sin \tau_{N\text{-}300}$$

In this way the coordinates of the points 309 and 300 are known in both reference systems. Consequently, one can determine the orientation Θ_{309}-300 $\tau_{309\text{-}300}$ of the two systems using the equation:

$$\mathrm{tg}\boldsymbol{\tau}_{309-300} = \frac{Y'_{300} - Y'_{309}}{X'_{300} - X'_{309}} \Rightarrow \boldsymbol{\tau}_{309-300}$$

and:

$$\mathrm{tg}\boldsymbol{\theta}_{309-300} = \frac{Y_{300} - Y_{309}}{X_{300} - X_{309}} \Rightarrow \boldsymbol{\theta}_{309-300}$$

the rotation angle б is:

$$\delta = \tau_{309-300} - \theta_{309-300}$$
$$\theta_{309-300} = \tau_{309-300} - \delta$$

The polygonal route forms a rigid system, as a result the relation is valid for any of the sides of them.

The point coordinates in the general system are:

$$\begin{cases} (x_{P3}) = x_{309} + D_{P3} \cos \theta_{309-P3} \\ (y_{P3}) = y_{309} + D_{P3} \sin \theta_{309-P3} \end{cases}$$

$$\begin{cases} (x_{P4}) = (x_{P3}) + D_{P4} \cos \theta_{P3-P4} \\ (y_{P4}) = (y_{P3}) + D_{P4} \sin \theta_{P3-P4} \end{cases}$$

$$\begin{cases} (x_{P1}) = (x_{P4}) + D_{P1} \cos \theta_{P4-P1} \\ (y_{P1}) = (y_{P4}) + D_{P1} \sin \theta_{P4-P1} \end{cases}$$

$$\begin{cases} (x_{N}) = (x_{P1}) + D_{N} \cos \theta_{P1-N} \\ (y_{N}) = (y_{P1}) + D_{N} \sin \theta_{P1-N} \end{cases}$$

$$\begin{cases} (x_{300}) = (x_{N}) + D_{300} \cos \theta_{N-300} \\ (y_{300}) = (y_{N}) + D_{300} \sin \theta_{N-300} \end{cases}$$

The compensation is realised on coordinates:

$$x_{P3} = (x_{P3}) + k_x D_{P3}$$
$$x_{P4} = (x_{P4}) + k_x (D_{P3} + D_{P4})$$
$$x_{P1} = (x_{P1}) + k_x (D_{P4} + D_{P3} + D_{P1})$$
$$x_{N} = (x_{N}) + k_x (D_{P3} + D_{P4} + D_{P1} + D_{N})$$
$$x_{300} = (x_{300}) + k_x (D_{P3} + D_{P4} + D_{P1} + D_{N} + D_{300})$$
$$y_{P3} = (y_{P3}) + k_y D_{P3}$$
$$y_{P4} = (y_{P4}) + k_y (D_{P3} + D_{P4})$$
$$y_{P1} = (y_{P1}) + k_y (D_{P4} + D_{P3} + D_{P1})$$
$$y_{N} = (y_{N}) + k_y (D_{P3} + D_{P4} + D_{P1} + D_{N})$$
$$y_{300} = (y_{300}) + k_y (D_{P3} + D_{P4} + D_{P1} + D_{N} + D_{300})$$

where: $k_x = \frac{f_x}{[l]}$; $k_y = \frac{f_y}{[l]}$

$$f_x = x_{300} - (x_{300})$$
$$f_y = y_{300} - (y_{300})$$

Errors before and after the coordinates compensation:

In the following are analised the errors of the sides orientations due to errors of angles and sides measurement of the polygonal route (Popia, 2008). Errors of the mining polygonal route sides are determined by the measurement errors of the angles and sides.

Orientations errors are determined by the angles errors:

Are obtained using the general relation:

$$m_{\theta\beta}^2 = \left(\frac{\partial\theta}{\partial\beta_1}\right)^2 m_{\beta 1}^2 + \left(\frac{\partial\theta}{\partial\beta_2}\right)^2 m_{\beta 2}^2 + \left(\frac{\partial\theta}{\partial\beta_3}\right)^2 m_{\beta 3}^2 + \left(\frac{\partial\theta}{\partial\beta_4}\right)^2 m_{\beta 4}^2$$

In order to acheive the partial derivates we use:

$$\theta = \theta_{309-300} + \tau - \tau_{309-300}$$

So:

$$\frac{\partial\theta}{\partial\beta} = \frac{\partial\theta_{309-300}}{\partial\beta} + \frac{\partial\tau}{\partial\beta} - \frac{\partial\tau_{309-300}}{\partial\beta}$$

but: $\frac{\partial\theta_{309-300}}{\partial\beta} = 0$ and then:

$$\frac{\partial\theta}{\partial\beta} = \frac{\partial\tau}{\partial\beta} - \frac{\partial\tau_{309-300}}{\partial\beta}$$

In order to acheive the derivate $\frac{\partial\tau_{309-300}}{\partial\beta}$ we differentiate the expression: $tg\tau_{309-300} = \frac{y'_{300}}{x'_{300}}$ and we obtain:

$$\frac{d\tau_{309-300}}{\cos^2\tau_{309-300}} = \frac{x'_{300}\,dy'_{300} - y'_{300}\,dx'_{300}}{(x'_{300})^2}$$

$$x'_{300} = c\cdot\cos\tau_{309-300}$$
$$y'_{300} = c\cdot\sin\tau_{309-300}$$

$$\frac{d\tau_{309-300}}{\cos^2\tau_{309-300}} = \frac{c\cdot\cos\tau_{309-300}dy'_{300} - c\cdot\sin\tau_{309-300}dx'_{300}}{c^2\cos^2\tau_{309-300}}$$

or:

$$c\,d\tau_{309-300} = \cos\tau_{309-300}dy'_{300} - \sin\tau_{309-300}dx'_{300}$$

It goes from the derived differential:

$$c\frac{\partial\tau_{309-300}}{\partial\beta} = \frac{\partial y'_{300}}{\partial\beta}\cos\tau_{309-300} - \frac{\partial x'_{300}}{\partial\beta}\sin\tau_{309-300}$$

It is known that:

$$\frac{\partial y'_{300}}{\partial\beta} = R\cos\gamma \;;\; \frac{\partial x'_{300}}{\partial\beta} = -R\sin\gamma$$

$$c\frac{\partial\tau_{309-300}}{\partial\beta} = R\cdot\cos\gamma\cdot\cos\tau_{309-300} + R\sin\gamma\sin\tau_{309-300}$$

$$c\frac{\partial\tau_{309-300}}{\partial\beta} = R\cos(\tau_{309-300} - \gamma)$$

but: $R\cos(\tau_{309-300} - \gamma)$ - is the projection of the radius R on the line 309-300 and is noted with R'

$$\frac{\partial\tau_{309-300}}{\partial\beta} = \frac{R'}{c}$$

The general expression is:

$$\frac{\partial\theta}{\partial\beta} = \frac{\partial\tau}{\partial\beta} - \frac{R'}{c}$$

With this equality is determined:

1.The error of the first side:

In this case $\tau_{309\text{-}P3}$=0 and then:

$$\frac{\partial\tau_{309-P3}}{\partial\beta_1} = \frac{\partial\tau_{309-P3}}{\partial\beta_2} = \frac{\partial\tau_{309-P3}}{\partial\beta_3} = \frac{\partial\tau_{309-P3}}{\partial\beta_4} = 0$$

$$\frac{\partial\tau_{309-300}}{\partial\beta_1} = \frac{R'_1}{c} \;;\; \frac{\partial\tau_{309-300}}{\partial\beta_2} = \frac{R'_2}{c};$$

$$\frac{\partial\tau_{309-300}}{\partial\beta_3} = \frac{R'_3}{c}; \frac{\partial\tau_{309-300}}{\partial\beta_4} = \frac{R'_4}{c}$$

But: $\frac{\partial\theta}{\partial\beta} = \frac{\partial\tau}{\partial\beta} - \frac{R'}{c}$ so:

$$\frac{\partial\theta_{309-P3}}{\partial\beta_1} = -\frac{R'_1}{c} \;;\; \frac{\partial\theta_{309-P3}}{\partial\beta_2} = -\frac{R'_2}{c} \;;$$

$$\frac{\partial\theta_{309-P3}}{\partial\beta_3} = -\frac{R'_3}{c}; \frac{\partial\theta_{309-P3}}{\partial\beta_4} = -\frac{R'_4}{c}$$

$$m_{\theta 3\beta}^2 = m_{\theta 1\beta}^2 + \left(1 - \frac{2R'_1}{c}\right) m_{\beta 1}^2 + \left(1 - \frac{2R'_2}{c}\right) m_{\beta 2}^2$$

Substituting the formula error, we have:

$$m_{\theta_1\beta}^2 = \frac{(R'_1)^2}{c^2} m_{\beta_1}^2 + \frac{(R'_2)^2}{c^2} m_{\beta_2}^2 + \frac{(R'_3)^2}{c^2} m_{\beta_3}^2 + \frac{(R'_4)^2}{c^2} m_{\beta 4}^2$$

2. The error of the scond side:

In this case we have:

$$\tau_{P3-P4} = \tau_{309-P3} + \beta_1 \pm 200^g$$

from which:

$$\frac{\partial \theta_{P3-P4}}{\partial \beta_1} = 1 \ ; \ \frac{\partial \tau_{P3-P4}}{\partial \beta_1} = \frac{\partial \tau_{P3-P4}}{\partial \beta_2} = \frac{\partial \tau_{P3-P4}}{\partial \beta_3} = \frac{\partial \tau_{P3-P4}}{\partial \beta_4} = 0$$

then:

$$\frac{\partial \theta_{P3-P4}}{\partial \beta_1} = 1 - \frac{R'_1}{c} \ ; \frac{\partial \theta_{P3-P4}}{\partial \beta_2} = 1 - \frac{R'_2}{c} ; \ \frac{\partial \theta_{P3-P4}}{\partial \beta_3} = 1 - \frac{R'_3}{c}$$

$$m_{\theta_2\beta}^2 = \left(1 - \frac{R'_1}{c}\right)^2 m_{\beta_1}^2 + \left(\frac{R'_2}{c}\right)^2 m_{\beta_2}^2 + \left(\frac{R'_3}{c}\right)^2 m_{\beta_3}^2$$

Comparing the obtained expressions we have:

$$m_{\theta_2\beta}^2 = m_{\theta_1\beta}^2 + \left(1 - \frac{2R'_1}{c}\right) m_{\beta 1}^2$$

If the polygonal route is long enough then:

$$\frac{2R'_1}{c} > 1 \ ; \ so \ \ m_{\theta_2\beta}^2 < m_{\theta_1\beta}^2$$

3. The error of the third side (Table 1):

In this case:

$$\tau_{P4-P1} = \tau_{309-P3} + \beta_1 + \beta_2 \pm 2 \cdot 200^g$$

Analogously to the previous case we obtain (Table 2):

4. The error of the "i" side:

$$m_{\theta i\beta}^2 = m_{\theta 1\beta}^2 + \left(1 - \frac{2R'_1}{c}\right) m_{\beta 1}^2 + \left(1 - \frac{2R'_2}{c}\right) m_{\beta 2}^2 + \ldots.$$
$$+ \left(1 - \frac{2R'_{i-1}}{c}\right) m_{\beta i-1}^2$$

Table 1 -Mining Polygonal route (general system)

PS	PV	β	Cadran	L	D	ΔΞ	ΔΨ	ΔZ	
		θ	Sign	φ	cos q	X'	Y'	Z'	Point
		c q	θχ	cos j	sin q	Cx	Cy	Cz	
		g. c. cc.	θ	sin j	[D]	X	Y	Z	
						585590.473	391005.560	356.850	300
	309		0.0000			585570.980	390938.250	356.180	309
	300			25.526	25.460	23.989	-8.531	-1.830	
1.363				104.5671	0.942198	585594.969	390929.719	355.613	
309				-0.07168	-0.33506	-0.00177	-0.00612	-0.00791	0.1
	P3		378.2490	0.997428	25.460	585594.967	390929.713	355.605	P3
	309			33.798	33.758	14.642	30.417	-1.652	
1.465				103.1123	0.433733	585609.610	390960.136	355.327	
P3				-0.04887	0.901042	-0.00412	-0.01423	-0.01840	0.1
	P4		71.4393	0.998805	59.218	585609.606	390960.122	355.308	P4
	P3			25.161	25.119	12.310	21.895	-1.457	
1.373				103.6873	0.490084	585621.921	390982.032	355.143	
P4				-0.05789	0.871675	-0.00587	-0.02027	-0.02620	0.1
	P1		67.3933	0.998323	84.337	585621.915	390982.012	355.117	P1
	P4			39.44	39.418	9.305	38.304	-1.311	
1.263				102.1166	0.236059	585631.226	391020.336	354.995	
P1				-0.03324	0.971739	-0.00861	-0.02974	-0.03845	0.1
	N		84.8289	0.999447	123.755	585631.217	391020.306	354.957	N
	P1			43.327	43.324	-40.741	-14.736	0.528	

1.479				99.2245	-0.94038	585590.485	391005.600	356.902	
N				0.012181	-0.34013	-0.01163	-0.04015	-0.05191	0.1
	300		222.0943	0.999926	167.079	585590.473	391005.560	356.850	300
	N			70.138					
1.46				101.7988					
300									0.1
	309								309

τ =	103.8051	82.0541	21.7510
D=	70.11781	70.07601	0.04180345
Wx,y,z=	-0.012	-0.040	-0.052
C0=	- 0.000070	- 0.000240	- 0.00031070
Tx,y=	0.091582		
Tz=	0.070358		

Table 2 - Mining polygonal route (particular system)

PS	PV	β θ' c θ g. c. cc.	Cadran Sign θ^c θ	L φ cosφ sin φ	D cosθ sin θ [D]	ΔX X' Cx X	ΔY Y' Cy Y	ΔZ Z' Cz Z	Point
						0.000	0.000		
	309		0.0000			0.000	0.000	356.180	309
	300	0.0000		25.526	25.460	25.460	0.000	-1.830	
1.363		0.0000		104.5671	1	25.460	0.000	355.613	
309				-0.07168	0				0.1
	P3		0.0000	0.997428	25.460	25.460	0.000	355.613	P3
	309	293.1903		33.798	33.758	3.604	33.565	-1.652	
1.465		93.1903		103.1123	0.106763	29.064	33.565	355.327	
P3				-0.04887	0.994285				0.1
	P4		93.1903	0.998805	59.218	29.064	33.565	355.327	P4
	P3	195.9540		25.161	25.119	4.263	24.754	-1.457	
1.373		89.1443		103.6873	0.169696	33.327	58.319	355.143	
P4				-0.05789	0.985496				0.1
	P1		89.1443	0.998323	84.337	33.327	58.319	355.143	P1
	P4	217.4356		39.44	39.418	-4.067	39.208	-1.311	
1.263		106.5799		102.1166	-0.10317	29.260	97.527	354.995	
P1				-0.03324	0.994663				0.1
	N		106.5799	0.999447	123.755	29.260	97.527	354.995	N
	P1	337.2654		43.327	43.324	-33.449	-27.534	0.528	
1.479		243.8453		99.2245	-0.77206	-4.188	69.993	356.902	
N				0.012181	-0.63555				0.1
	300		243.8453	0.999926	167.079	-4.188	69.993	356.902	300

CONCLUSIONS

The process to establish the expressions of errors before and after compensation is similar to that presented in full polygonal routes except that in the mining polygonal routes the angular error W_β is missing so can not be determined only m_x, m_y and M_x, M_y of the points coordinates of the route. Established formulas are valid in this case.

In mining polygonal routes is very important to examine errors that form the sides of route. These errors are composed of errors for connection of the topographic surface features, plus the design errors, attachment errors, and measurement errors in the ground, and side angles of the mining polygonal route.

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