Formation Auger Equipment Reliability

DROZDENKO Yuri V.

Sub-Faculty of Mining Machines and Systems, T.F. Gorbachov Kuzbass State Technical University, 650000 Kemerovo,Russia

Abstract: This article contains information about determination of the parameters that affect the formation of failure auger equipment

Keywords: auger, horizontal well, communication, coefficient of concordance, χ^2 criteria

1.Introduction

Auger equipment operation can be described by multifactor model taking into account the equipment design features as well as the horizontal well construction processes (rock failure and transportation layout of the pipe casing, etc.). The choice of these parameters helps to define the rational field of auger equipment application.

2.Characteristic of the work

Based on the model proposed by prof. Posin E.Z. and prof. Linnik Y.N. [1, 2] for the description of functioning of the screw shearer executive bodies, The schematic diagram (Fig. 1) is offered for the collection and analysis of the factors affecting the auger equipment operation.

In accordance with the scheme shown in Fig. 1 the auger machine operation is characterized by a horizontal well construction process and the process of formation of failures that are in communication with groups of factors affecting the functioning of the entire technical system.

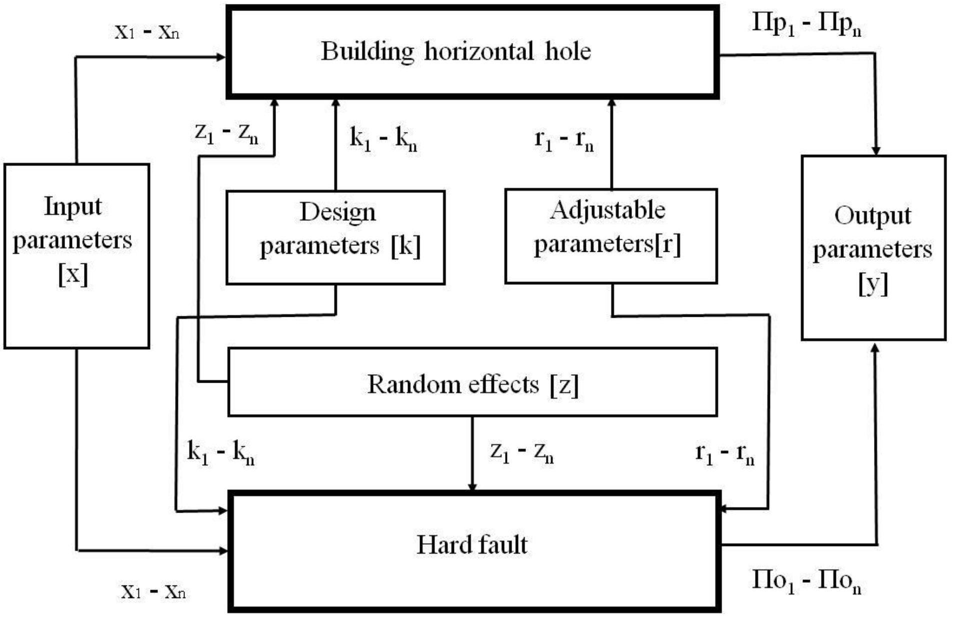

Fig. 1: Scheme of the auger machine reliability and efficiency formation

For descriptions of auger equipment **operation the following groups of factors** are used:

– input parameters (x) - characterize the properties of the soil in which it is supposed to construct a horizontal well (strength, moisture, structural heterogeneity) i.e. the parameters that can affect the formation of conditions for the occurrence of failures;

– output parameters (*y*) - characterize the actual state of the equipment and the constructed well conditions. These include the drilling process power consumption, the drilling speed, vibration level, matching a given direction, the hole diameter, the drilling flow chart, the bored mass volume;
– design parameters (*k*) - characterize the auger machine technical possibilities (geometric dimensions, the executive body design, the length and diameter of the screw section, equipment weight). This group of parameters is formed while designing the auger machine and is not changed during operation;
– adjustable parameters [*r*] - this group of parameters can to be changed during operation (rotational velocity, the pressure in the hydraulic system, power consumption, speed-power characteristics of the feed) for obtaining the optimal output parameters;
– random effects [z] - this group of parameters is random and cannot be the subject to any forecast. This primarily relates to the mass heterogeneity, in which is the well is constructed. Anthropogenic pollutions can significantly slow down the drilling process or stop it at all.

It also relates to consumables (fingers, drilling locks). The presence of defects associated with the quality of material and manufacturing, may cause failures leading to the auger equipment emergency shutdowns.

In order to quantify the auger equipment performance parameters it is possible to use a large number of indicators. According to [3], all the indicators are divided into the following groups:

– by the assessment completeness;
– by the significance;
– by the analysis field;
– by the expression method.

Each group of parameters describing the auger machine operation contains a significant number of indicators, the analysis of which will take a long time. Therefore it is necessary to single out such group of indicators that would most fully characterize the process of the horizontal well construction. To determine the most significant indicators the method of rank correlation may applied. It involves the choice of indicators and their ranking, ranking processing and determination of the most significant indicators[3], obtaining a generalized opinion based on multiple judgments of experts.

Processing method is universal and includes four main stages:

1) converting the results of expert assessments in a form suitable and convenient for processing (matrix of ranks);

2) conformity analysis of the expert opinions;

3) determination of highly conformed subgroups characterized by the proximity of views of experts included in those subgroups;

4) generalized opinion synthesis, consisting in combining of particular assesses into the overall total indicator or group of indicators.

On the base of on the survey of the experts the rank matrix for each group of factors describing the machine auger operation (Table 1-5) were composed, and each indicator has been assigned its own assessment.

Table 1: Rank matrix of input parameters

Specialists		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Indicators	P1-Strength	7	7	4	8	2	5	3	1	7	6
	P2- Hardness	2	4	1	4	7	3	7	4	5	4
	P3- Humidity	3	2	7	1	1	2	6	3	1	3
	P4- Abrasivity	1	3	3	2	8	1	4	5	4	1
	P5- Fracturing	4	5	6	3	4	6	2	6	2	5
	P6- Foliation	8	1	2	5	3	4	1	2	3	7
	P7- Rock drillability grade	6	6	5	6	5	8	5	7	8	2
	P8-Structural inhomogeneity	5	8	8	7	6	7	8	8	6	8

Table 2: Rank matrix of output parameters

Specialists		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Indicators	P1-Borehole axis accordance with the given direction	5	1	1	4	1	1	2	3	1	5
	P2-Energy intensity of well construction	3	7	6	7	7	6	7	6	6	7
	P3-Well diameter	4	2	2	2	2	3	1	4	4	4
	P4-Actual velocity of drilling	1	4	3	5	4	4	5	5	3	3
	P5-Vibration level	7	5	7	6	6	5	6	7	7	6
	P6-The bored mass volume	2	3	4	1	3	2	3	2	2	1
	P7-The drilling flow chart	6	6	1	3	5	7	4	1	5	2

Table 3 : Rank matrix of design parameters

Specialists		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Indicators	P1-Drive capacity	8	9	8	9	8	7	9	9	8	9
	P2-Pressure in the hydraulic system	3	4	4	2	2	3	5	4	6	4
	P3-Geometric dimensions	7	7	6	8	1	2	2	3	1	2
	P4-Quantity of feed cylinders	4	5	3	5	7	5	4	5	2	1
	P5-Kind of consumed energy	9	8	9	6	9	4	8	6	4	5
	P6-Executive body design	6	6	7	7	6	8	7	8	9	8
	P7-Screw section overall dimensions	1	3	2	4	4	6	6	1	5	6
	P8-Feed cylinder stroke length	5	2	1	3	3	9	1	2	7	7
	P9-Equipment mass	2	1	5	1	5	1	3	7	3	3

Table 4: Rank matrix of adjustable parameters

Specialists		1	2	3	4	5	6	7	8	9	10
Indicators	P1-Screw section rotational velocity	2	1	2	3	2	1	2	3	1	2
	P2-Possibility to change the pressure in the hydraulic system	5	5	4	5	5	5	4	5	5	4
	P3- Quantity of operating feed cylinder	3	2	1	2	3	2	1	2	2	1
	P4-Power consumption	6	6	6	4	6	6	6	4	6	6
	P5-Feed velocity	1	3	3	1	1	3	3	1	3	3
	P6-Feeding pressure	4	4	5	6	4	4	5	6	4	5

Table 5: Rank matrix of random parameters

Specialists		1	2	3	4	5	6	7	8	9	10
Indicators	P1-Mass heterogeneity	2	3	2	1	3	1	3	3	3	3
	P2-Presence of anthropogenic refuse	6	6	5	5	6	4	7	5	5	6
	P3-Connector quality	3	4	1	4	4	3	2	2	1	4
	P4-Presence of electricity source	5	5	4	3	5	2	5	4	2	2
	P5-Unaccounted communications	7	7	6	7	7	5	6	7	7	7
	P6-Hydro-geological conditions	4	1	3	3	1	6	1	1	4	1
	P7-Weather conditions	1	2	7	6	2	7	4	6	2	5

The coefficient of concordance characterizing the conformity of rankings carried out by experts is calculated for each matrix. The coefficient of concordance is the common rank correlation coefficient for the group consisting of *n* experts. Value range is 0 <*W* < 1. When all the experts give the same estimates, *W*=0. In the case of a complete lack of conformity the assessments are accidental and *W*=0. In other cases – the more W is, the higher is the conformity of expert rankings.

$$W = \frac{12S}{m^2(n^3-n) - m\sum_{j=1}^{n} T_j}, \qquad (1)$$

$$T_j = \frac{1}{12}\sum_{1}^{k}(t_j^2 - t_j);$$

k – the number of groups of the same ranks in each ranking (since, there are no indications of the same rank in the estimates of experts T_j=0);

$$S = \sum_{i=1}^{n} d_i^2$$

$$d_i = \sum_{j=1}^{n} q_{ji} - 0{,}5\ n(m+1)$$ - centralized rank value of each indicator;

$\sum_{j=1}^{n} q_{ji}$ - sum of the ranks for each indicator *n* – number of specialists;*m* – number of indicators.

The results of calculations of the coefficients of concordance for each matrix of the groups of parameters are presented in Table 6.

Table 6: Values of the coefficient of concordance

Groups of parameters	**Value of the coefficient of concordance, *W***
1. Input parameters	0,43
2. Output parameters	0,45
3. Design parameters	0,43
4. Adjustable parameters	0,78
5. Random parameters	0,41

The value of the coefficient of concordance W=0 means the inconformity of expert opinions; if W=0.40–0.50, the quality of assessment is considered satisfactory; when W>0,70 the quality of assessment is considered high.

To determine the significance of concordance criterion is possible with the use of χ^2criterion (Pearson criterion). The value of this criterion depends on the number of degrees of freedom (1.2) and confidence probability (confidence probability P=0.90 was adopted for calculations).

$$\nu = m - 1 \qquad (2)$$

$$\chi^2 = \frac{12S}{n \times m(m+1) - \frac{1}{m-1}\sum_{j=1}^{n} T_j} \qquad (3)$$

The results of calculation of χ^2 criteria values are listed in Table 7.

Table 7： χ^2 criteria values

Groups of parameters	χ^2	$\chi_{табл}^2$
Input parameters	23,26	2,83
Output parameters	38,6	2,20
Design parameters	39,20	3,49
Adjustable parameters	34,20	1,61
Random parameters	35,16	2,20

When comparing the obtained χ^2 criteria values with the table critical values it possible to see that the calculated values are much greater than the table ones. This suggests that there is full conformity of experts at ranking of the factors affecting the auger equipment operation [4, 5].

To determine the most significant factors it is necessary to determine the significance level for each group of parameters - this can be done using the method of proportional relations. The number of significant figures (h) is equal to the number of summands of proportional relationship numerator.

$$\frac{\sum_{i=1}^{h} V_i}{\sum_{k=h+1}^{n} V_k} \geq 1$$

where Vi = Kn – Ki; Vk = Kn – Kk – wights of i and k indicators;Kn , Ki , Kk - sums of ranks of n, k and i indicators.

The ranking histograms are created to determine the number of significant figures.

After determining the number of significant factors, the level of significance is determined by the following expressions:

$$K_{зн} = \begin{cases} K_h & \Delta\{K\}_1 > \Delta\{K\}_2 \\ K_i + \dfrac{K_n h}{n} & \Delta\{K\}_1 < \Delta\{K\}_2 \end{cases} \quad (5)$$

where $\Delta\{K\}_1 = \dfrac{K_h - K_i}{h}$ - average value of distribution amplitude of rank sums; $\Delta\{K\}_2 = \dfrac{K_n - K_{h+1}}{n-h}$ - average value of distribution amplitude of insignificant indicators.

The results of $K_{зн}$ calculations are presented in Table 8.

Table 8： The results of the significance level calculation

Groups of parameters	Number of significant factors ***h***	$\Delta\{K\}_1$	$\Delta\{K\}_2$	$K_{зн}$
Input parameters	2	2.5	6.50	46,75
Output parameters	2	5.0	7.75	40,07
Design parameters	3	7.3	4.15	48,3
Adjustable parameters	2	1.5	8.5	37.6
Random parameters	2	9.5	6.2	42,8

3.Conclusion

Comparing the obtained $K_{зн}$ values with the histogram values, we choose those factors the $K_{зн}$ values of which are above the designed values, they are the most important indicators.

4. References

[1] Dokookin A.V., Frolov F.G., Posin E.Z. Choice Parameters of Winning Machine // M.: Nauka, 1976.

[2] Linnik Y.N. Basis of Calculation of Reliability and Efficiency of the Winning Machine in Various Operating Conditions // M.: A.A. Skochinskiy Institute of Mining, 1991.

[3] Kvagenidze V.S. Diagnostics, Maintenance and Repair of the Career Mining Equipment at Low Temperatures // Kemerovo: KuzSTU, 2003/

[4] Karasev A.I. Theory of Probability and Mathematical Sstatistics // M.: Statistika, 1970.

[5] Rygev P.A. Mathematical Sstatistics in Mining // M.: Vishaya Shkola, 1973.

THEME

CHINESE COAL IN THE XXI CENTURY: MINING, GREEN AND SAFETY

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Foreword

Mining technology is an important issue on resource exploitation, which is related to mine production security and energy supply. In order to promote the scientific and technological progress and international exchanges of the mining technology, the Taishan Academic Forum – Project on Mine Disaster Prevention and Control is to be held on Oct. 17-20, 2014, in Qingdao, China. The aim of the symposium is to summarize the modern coal industry achievements, in safety green mining methods and the related fields. There will be experts and scholars to attend the meeting, from the coal industry enterprises, universities, research institutions and other related fields of China and Russia.

The main topics of the symposium include: safety green mining methods, mine construction and modernization, the mining theories, methods and technology, the construction safety of mining and underground engineering, the operation and management of mining and underground engineering, etc.

The symposium is organized by the Education Department of Shandong Province, Shandong University of Science and Technology, Coal Industry Bureau of Shandong Province. It is undertaken by Institute of Mining and Safety Engineering, Shandong University of Science and Technology and State Key Laboratory of Mine Disaster Prevention and Control.

We are convinced that the symposium is going to play an important role in the development of the coal mining technology and international communication. Heartfelt thanks are extended to domestic and overseas scholars who have given great supports to this conference and all the authors who have presented the papers.

Weijia Guo, China
Yunliang Tan, China
Yongjie Yang, China
Shasha Yan, China
Dongmei Huang, China

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