

Development of Requirements for a Basic Standardized Mathematical Model of Geokhod

V V Aksenov, V Yu Beglyakov, A A Kazantsev, I V Doroshenko

Yurga Institute of Technology, TPU Affiliate, 26, Leningradskaya Str., 652050,
Yurga, Russia

E-mail: 55vva42@mail.ru, begljakov@rambler.ru, ak_uti@rambler.ru

Abstract: The article revealed the shortcomings of existing mathematical models geokhods, the necessity of a new approach to modeling the processes of internal and external geokhods interaction, formulated the task of building flexible mathematical models.

1. Introduction

Yurga Institute of Technology, TPU Affiliate has been currently engaged in development of a new generation of geokhods in collaboration with Kemerovo research center of the Siberian Branch of Russian Academy of Sciences [1]. In 2015-16 it is planned to manufacture and test a pilot model of geokhod for tunneling mine workings 3.2m in diameter [1]. Test results will be referred to when taking the decision of a full-scale production.

A number of companies and agencies are interested in developing geokhods with other configurations for tunneling mine workings in various mining geological and technical conditions. Technical orders for research and development have been already formed to design geokhods meeting special technical requirements.

Geokhod is a substantially new tunneling machine. Operation of main geokhod systems and their standards differ essentially from similar systems of all available tunneling machines [1]. Physical configuration and structure of main geokhod systems have been changed, functionality of systems and ways of their interaction have been varied, new layout and design decisions have been constantly made. Substantiating characteristics of available and newly developed design decisions is a burning issue. Mathematical models of force interaction are to be developed for reasoning force, power and design characteristics of geokhods and their systems of various standard sizes and purposes, moreover, interaction of elements, systems and modules, as well as their contact with geological environment are to be studied.

2. Results and Discussion

Various mathematical models describing contacts of geokhod main systems with each other and the geological environment are provided in papers [2...4]. The models are developed for geokhods «ELANG-3» and «ELANG-4» and their particular design characteristics are taken into account (Figures 1 and 2), among them: the structure and geometrical characteristics of a rotation mechanism, types and characteristics of function agents of the main face, technique of building peripheral canals and other particular features. Models presented in papers [4] also involve various characteristics of the geological environment; mining geological and technical conditions are taken into consideration, i. d.



they are intended to solve problems of various force interaction. However, geometrical characteristics of peripheral elements, their function agents and peripheral canals are not considered in those models etc.

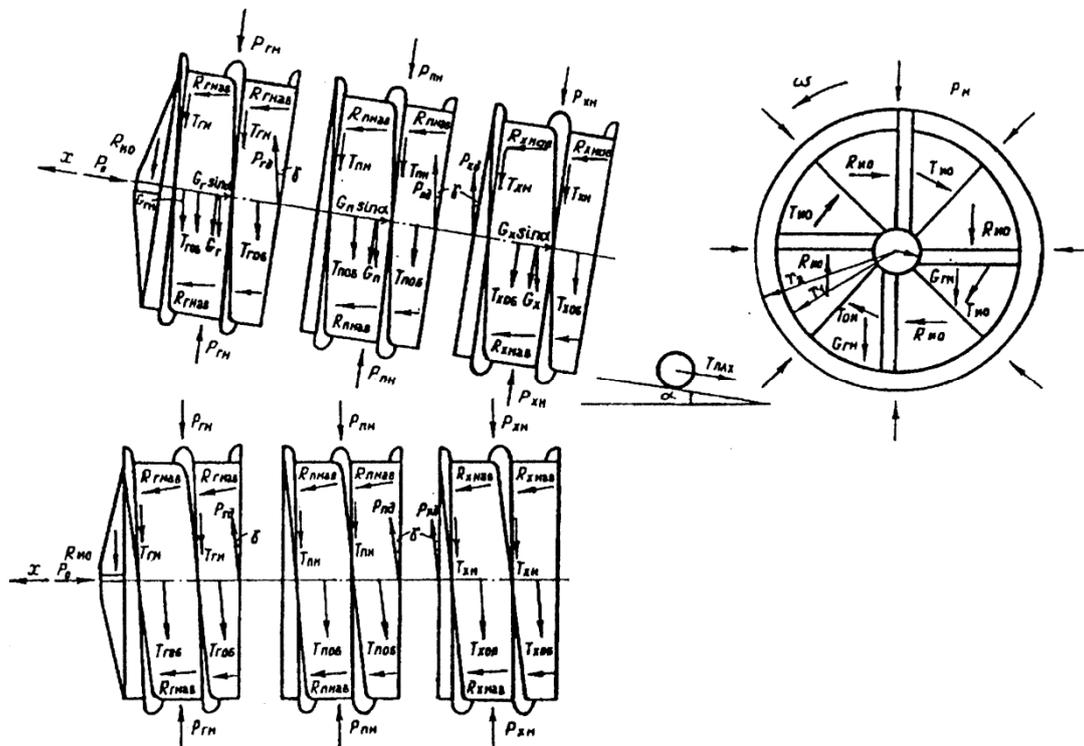


Figure 1 – Design diagram of available model of geokhod «ELANG-3»

The models consist of rather large undividable blocks. Moreover, these models have a significant nomenclature of various characteristics and variables. Characteristics and variables are chosen on the base of element designation and their design features (Figures 1, 2), as the consequence, they can hardly be systemized. When introducing a new variable a new designation being in line with designations of other variables and characteristics is to be created, and one should be convinced a newly created designation has not been used yet. This fact leads to restrictions and does not support team work of researchers, their groups and individuals.

A growing variety of layout and constructive decisions has determined the necessity of developing block-module and unitized machine. Composition and characteristics of geokhod modules make it possible to design diverse modifications on the general base.

In these conditions application of available models gets quite complicated because changing operation principle of one system or the way closely-related systems interact with each other can be reason for adjustment of the whole model. To be more precise, a prevalent approach requires for development of a new model, which will also rely on a certain layout or constructive decision.

A principle of modeling is to be revised when substantiating the characteristics of geokhod and its systems. A new flexible model is necessary, which will be able to take into account specifics of operation and interaction of the systems, make it possible to change their composition and sequence, add new systems or cut down their number, as well as change principles of their work and interaction. It is to be emphasized a particular system is to be changed independently on other elements of the model.

A mathematical model consisting of blocks is to be developed; each of them is a model of a particular system, module or interaction. And the general model is to be adjustable via replacing or changing the blocks. Moreover, adjustment of one block must not necessitate change in other blocks or rearrangement of connections in the model.

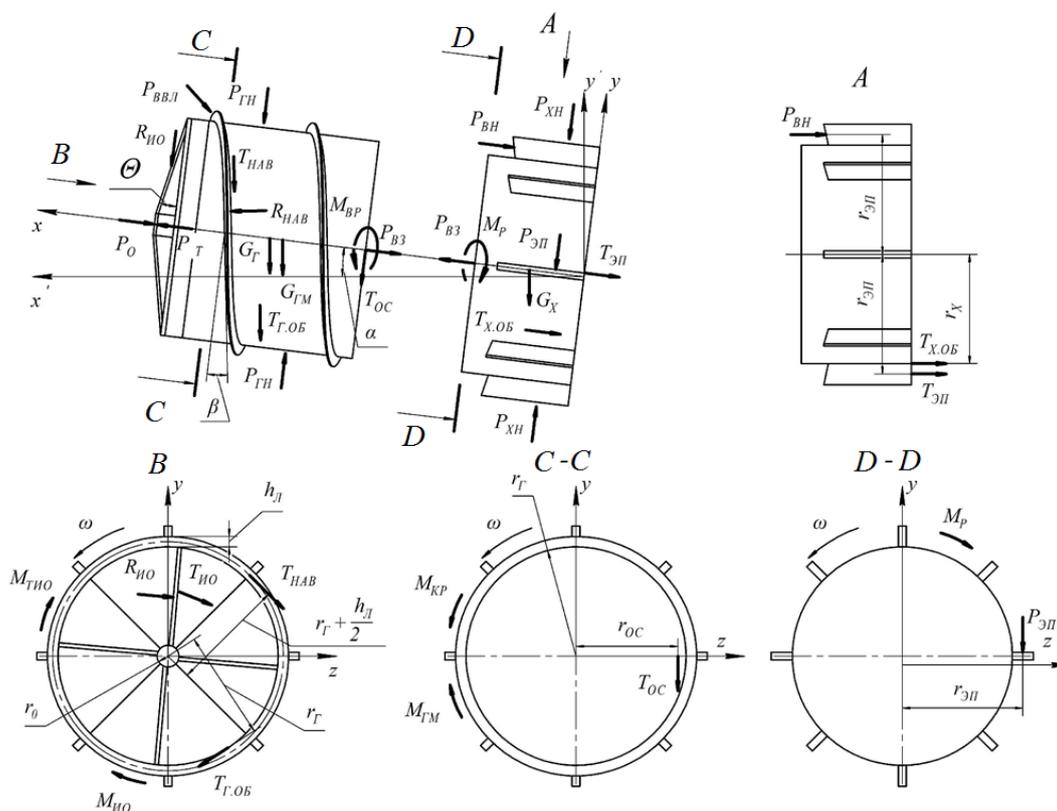


Figure 2 – Design diagram of available model of geokhod «ELANG-4»

To develop a mathematical model of this kind a number of issues are to be solved:

1) Geokhod is to be divided into systems and modules to create a wide range of layout and constructive decisions. The following requirements are to be met when dividing geokhod into modules and systems:

- both modules and systems are to be structurally and functionally independent;
- junctions are to be structurally similar and interchangeability level of systems and modules of the same name within one dimension size or a range of dimensions is to be acceptable;
- level of nesting sub-systems into the systems, units into modules is to be determined etc.

2) A structure, linking modules and systems is to be created when developing a general model of geokhod.

The structure of links is to provide standardized principles of forming input and output characteristics of various systems, modules and units of geokhod.

3) Standardized end connections are to be designed to join modules and systems.

Systems and modules of geokhod differ much in their structure and functions. Variants of geokhod units can be absolutely different. For example, single-thread screw blade and multi-thread propeller propulsive agents are available; principles of their interaction with geological environment and geokhod are significantly different.

Standardized end connections enable substituting various types of outer propulsive agents, function agents and other systems into the general geokhod system without changing the rest of the model. That is, changed or replaced module will be the reason of changes in the corresponding block of the mathematical model and affect the general results of modeling. 4) Principles of transforming each system (module) into an independent model, meeting the principles of the general model with input and output data are to be developed and be in line with standardized end connections between systems and modules.

Geokhod consists of more than ten structurally independent modules and systems with separate functions. A team of researchers and engineers working in groups and individually are involved in designing, estimating characteristics of geokhod, and developing its modules and systems.

To provide efficient group interaction agreements are to be done which support uniformity of designations, formulas, methods of design and modeling. Information discussed in groups and data transferred from one group or individual to the others are to be recorded.

5) Development of core of the model.

A core of the model – a constant unchangeable base like a main board in the computer or a tree for forming a 3D model is to be developed to modify the mathematical model of geokhod. In the core of the model there are blocks being models of systems and modules. System and module models will be developed according to the same principles, i.d. they will have their core consisting of models of sub-systems, units etc.

6) Development of “the first generation” flexible models.

Under assumption of extreme forms of model flexibility two opposite levels can be possibly defined:

- “zero flexibility” – model designed for a particular machine with constant characteristics;
- “absolute flexibility” – model, which can be used in any machine, i. d. a model of everything.

Obviously, the zero level is unacceptable. A model with absolute flexibility looks like a utopia, moreover, development of an unlimited flexible model requires a huge amount of time; however, these models are needed urgently. The lack of flexible models of geokhod and their systems is a constraint. If extreme forms of flexibility are not possible something average is required.

Therefore, some restrictions are to be determined:

- a limited number of structural decisions;
- a set of systems, modules and assemblies typical for geokhod etc.;
- a set of standardized connections (branching of the model core);
- a limited number of nesting levels (module/sub-module/unit/.../ element);
- etc.

These restrictions will provide acceptable labor coefficient of model development, but won't support their possibilities. The limits of these restrictions are to meet near-term prognoses of geokhod-construction.

7) Development of plans (prognoses) to develop next-generation models.

First generation models will meet near-term plans, their development and maintenance enable accumulation of useful experience, reveal peculiarities, errors etc.

The team of researchers and engineers involved in designing geokhods already has plans for the nearest and far future. The range of structural and layout solutions in question includes both real ones which have been developed and “fantastic” issues.

Therefore, first generation models will need up-dating soon. So, one should think of developing new generation of models, work out principles and approaches to modeling geokhod and its systems.

8) Development of software.

Formation of new, expandable mathematical models relies on application of excessive mathematical tools, requiring for automated calculations and formation of models. Available CAE-systems are to automate the process of mathematical model formation, but they are multi-purpose tools or software, which can be used to solve a wide range of problems.

To develop mathematical models of geokhods taking into account requirements, restrictions and agreements mentioned above special-purpose software based both on available CAE-systems and on independent platform are necessary.

Conclusion

- 1) Available mathematical models of geokhods do not solve the issues arising when designing geokhods of new generation.
- 2) A flexible model capable for expanding and modification is required.

- 3) Block and module principle of the structure enables development of flexible models, which can be modified and expanded.
- 4) A system of rules (agreements) to provide independent but coordinated modeling of various systems and modules of geokhod.
- 5) Models of the first generation, as well as principles of formation models of further generations are required.
- 6) Special software is necessary for mathematical modeling the interaction process of geokhod with the geological environment and its systems with each other.

References

- [1] Aksenov V.V., Khoreshok A.A., Beglyakov V.Y. Justification of creation of an external propulsor for multipurpose shield-type heading machine - geo-walker // *Applied Mechanics and Materials*. 2013. T. 379. C. 20-23.
- [2] Aksenov V.V., Khoreshok A.A., Efremenkov A.B., Timofeev V.Yu. Development of mathematical model of geokhod interaction with geological environment // *Mining Informational and Analytical Bulletin (Scientific and Technical Journal)*. Mining machinery / M.: Publishing «Gornaya Kniga» – 2011.– OB № 2. pp. 79-91.
- [3] Blaschuk M.Yu., Dronov A.A., Mikheev D.A. Mathematical model to calculate forces necessary for geokhod movement // *Actual problems of present day mechanical engineering: Proceedings of International Scientific and Practical Conference / Yurga Institute of Technology*. – Tomsk: TPU Publishing, 2014. pp. 134-139.
- [4] Sadovets V.Yu., Beglyakov V.Yu., Efremenkov A.B. Simulation of geokhod movement with blade actuator // *Applied Mechanics and Materials*. 2015. V. 770. pp. 384-390.
- [5] Koperchuk A.V., Murin A.V. 2012 *Mining Informational and Analytical Bulletin* Improvement of locked up hydrodynamic coupling for drives of mining machines **OB3** 300-305.
- [6] Murin A.V., Koperchuk A.V. 2011 *Mining Informational and Analytical Bulletin* Reduction of energy losses by locked up hydraulic coupling in drives of mining machines **OB2** 337-343.
- [7] Efremenkov A.B., Timofeev V.Y. 2012 7th International Forum on Strategic Technology (IFOST) Determination of necessary forces for geohod movement (IEEE) pp 1–4.
- [8] Koperchuk A.V., Murin A.V. 2014 *Applied Mechanics and Materials* Influence of geometrics of synchronization devices of fluid coupling on loading capability **Vol. 682** 499-503.
- [9] Koperchuk A.V., Murin A.V., Dortman A. A., Filonov V. V. 2015 *Applied Mechanics and Materials* A change in mechanical behavior of safety fluid couplings when the lockup device is used in its construction **Vol. 770** 279-282.
- [10] Methodology instructions. Boom-type roadheaders. Calculation of operation loading of actuating device transmission. Guideline document 12.25.137-89. – Moscow: Ministry of coal industry of the USSR, 1989. – 51 p.