International Journal of Civil Engineering and Technology (IJCIET)
Volume 10, Issue 03, March 2019, pp. 3249-3258, Article ID: IJCIET_10_03_327
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=10&IType=03
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

INFLUENCE OF WORKING EXCAVATIONS ON EACH OTHER WHILE MINING OUT COAL LAYERS

Dmitry Aleksandrovich Potyomkin

Ph.D., Associate Professor, Saint-Petersburg mining university, Russian Federation, 199106, Saint-Petersburg, Vasilievski ostrov, 21 linia, 2

Vladimir Leonidovich Trushko

D.Sc., Professor, Saint-Petersburg mining university, Russian Federation, 199106, Saint-Petersburg, Vasilievski ostrov, 21 linia, 2

Olga Michailovna Smirnova

Ph.D., Associate Professor, Saint-Petersburg mining university, Russian Federation, 199106, Saint-Petersburg, Vasilievski ostrov, 21 linia, 2

ABSTRACT

The results of mathematical modeling of working excavations while mining out coal layers in one of the fields of the Kuznetsk coal-mining field are presented in the paper. Engineering-geological features of the coal-measure rocks, plan and mutual orientation in the space of working excavations are considered. Evaluation of the stress state of coal-measure rocks in the main stresses is given. Features of formation of stress fields under the mutual influence of working excavations in the period of 2016-2018 are given.

Key words: coal-measure rocks, coal layer, working excavation, rock mechanics survey, geomechanical forecast.

Cite this Article: Dmitry Aleksandrovich Potyomkin, Vladimir Leonidovich Trushko and Olga Michailovna Smirnova, Influence of Working Excavations on Each Other While Mining Out Coal Layers. International Journal of Civil Engineering and Technology, 10(3), 2019, pp. 3249-3258

http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=10&IType=03

1. INTRODUCTION

The mine field of mine named after S.M.Kirov is located within Leninsky coal deposit of Kuznetsk coal basin. Coal-bearing deposits with layer thickness more than 5,500 m take part in the geological structure of Leninsky deposit [1, 2]. The field of mine named after

S.M.Kirov and Kirovsky Glubokoye site are located within Leninsky coal deposit. Leninsky syncline is wide flat-bottomed fold with asymmetrical limb. Layer Boldyrevsky has complex structure and tends to increase thickness in the South-East direction. The superface of stratum is composed of fine-grained siltstones. Fine-grained siltstones interlay in soil formation as well as there are also sandstone, argillite and interbedding of siltstones. Polenovsky layer has simple structure. Carbonaceous silt one can mark in the soil and the roof of the formation.

The numerical simulation took into account the stage-by-stage room-and-pillar works in the period 2016-2018. The unification of stress distribution zones takes place in the layers at the time of completion of room-and-pillar works planned in 2018 that can lead to an increase of the level of stresses in the protective pillar of Polenovsky layer (the protective pillar in the immediate vicinity of the mining extraction zone on Boldyrevsky layer). The lavas of Polenovsky layer in the North and South are located between two elements of geological disturbances in the bedding of rocks and the discharge zone after room-and-pillar works in Boldyrevsky layer is located in the East. The elements of geological disturbances that are included in the model are located below both layers. The volume of excavation in Polenovsky layer is surrounded by discharge zones from the works in Boldyrevsky layer and zones of geological disturbances.

2. METHODS

The large size of the mine fields, the complex shape of coal layers with access to the surface, their variable depth, partial development of coal layers, their small thickness in relation to the size of the mine field, the presence of tectonic disturbances, etc. determine the need for numerical modelling in two stages: the development of a global model and the development of local models based on the global model [3, 4, 5].

The global numerical model of large size 9.5×8.6×1 km was developed at the first stage. It includes coal layers of complex configuration with averaged representation of host rock properties and simplified representation of tectonic disturbances. The modelling of step-by-step coal mining was not included in the global model. The mining area was modelled in simplified way in one step as shown in Figure 1. The main goal of the global model development is to obtain the output data for setting boundary conditions when creating local models [6, 7, 8, 9].

Elements of the second order – 10-node tetrahedrons were used in modelling. The minimum linear size of the element corresponded to the layer thickness equal to 1.6 m, the maximum size reached 170 m in the elements of the coal-measure rock at the model boundary. The total number of elements exceeded 1.0 million.

Local models with the size of elements from 1.0 m in the area of working excavations and local models with the size of elements up to 70.0 m at the border of the model with total number of elements exceeding 4.6 million pieces were created at the next stage taking into account the stage-by-stage development of individual sections of mine fields.

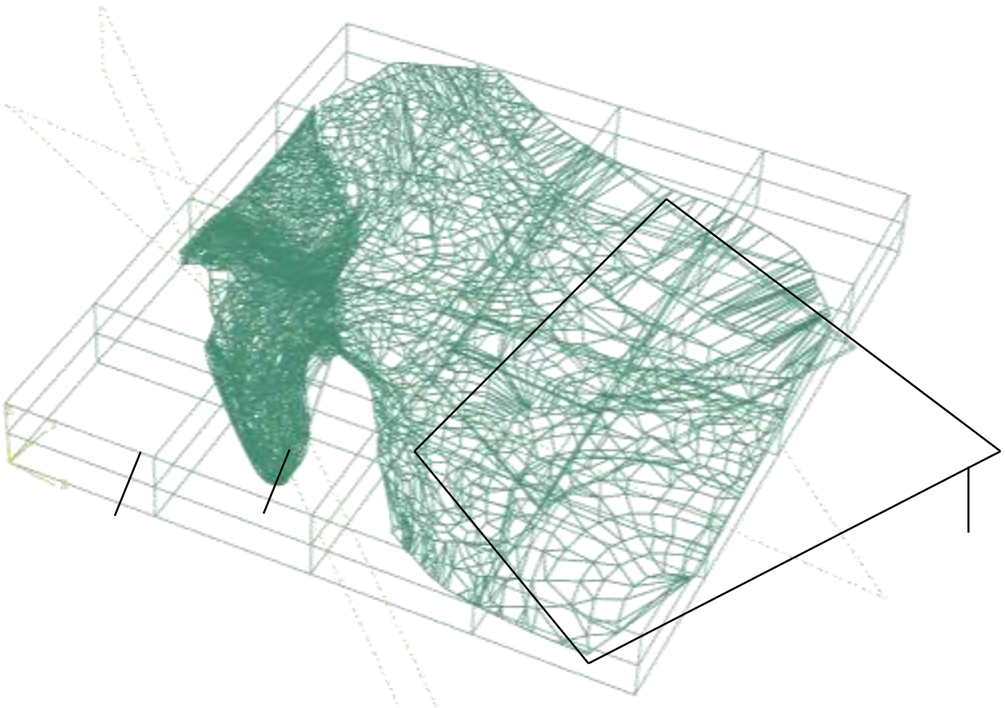

Figure 1. General view of the model with location of the coal layers of complicated configuration:

1 – coal-measure rocks; 2 – coal layers; 3 – general area of mining Boldyrevsky and Polenovsky layers

The real scheme of tectonic disturbances was significantly simplified due to existing limitations of computing power and scale of the developed model according to Figure 2. Tectonic disturbances extending beyond the boundaries of the coal layer mining zone were discarded (sections 2 in Figure 2). Three tectonic disturbances (sections 3, 4, 5) get to coal layer mining zone. Two tectonic disturbances are located almost horizontally (sections 3, 4). One tectonic disturbance crosses the layer vertically (section 5).

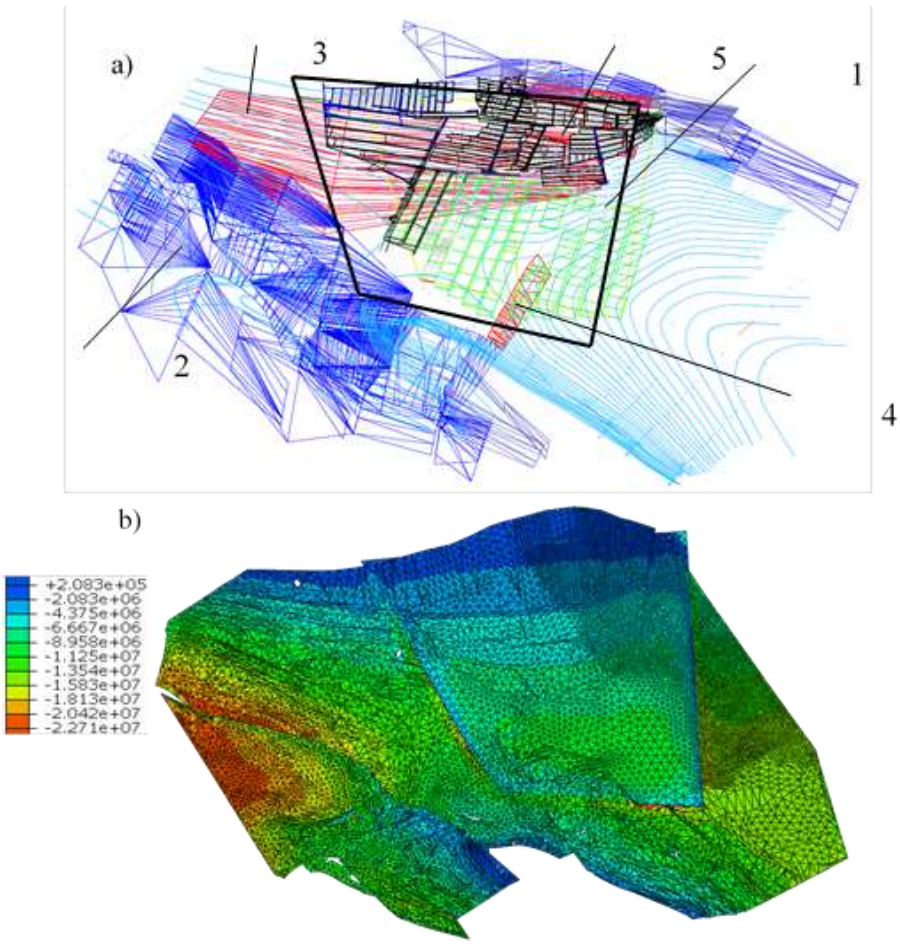

Figure 2. a) – Location of tectonic disturbances: 1 – mining zone; 2 – tectonic disturbances outside the mining zone (blue color); 3, 4, 5 – tectonic disturbances considered within the mining zone of two layers (red color), b) – Model fragment with location of tectonic disturbances and the main maximum stresses, Pa

The selected tectonically stressed and tectonically unloaded zones (indicated TSZ and TUZ, respectively) within the mine fields on the global model are conditional as shown in Figure 4. Since the assignment of the shear parameters of irregularities on the global model scale is complicated. A more exact location of the TSZ and TUZ was obtained on the local models.

Then qualitative and quantitative characteristics of the stress-strain state of the coal-measure rock were obtained on local models due to the significant simplification of the global model. In this case the main goal of the global model development – obtaining initial data for setting boundary conditions in local models was achieved. Frame of three-dimensional geological and structural model of mine field named after S.M. Kirov was created; the preliminary allocation of tectonically stressed and unloaded areas within the mining area in Boldyrevsky and Polenovsky layers was made on the basis of the results of the work.

3. RESULTS

The geometric dimensions of the local model were 7000m on the X axis, 6000m on the Y axis, 900m on the Z axis (vertical axis). The model included elements of Boldyrevsky and Polenovsky layers as well as three elements of geological disturbances, one of which is located in close proximity to the excavation areas of the period 2016-2018. The calculation was made on own weight and took into account the stage-by-stage room-and-pillar works in these layers in the period 2016-2018.

The calculated values of compressive stresses in protective pillars reach 13-15 MPa and are predominant. They cover most of protective pillar. The maximum values are 23-26 MPa. The presence of the discharge zone in the area of geological disturbance is noticeable as shown in Figure 5 on the right: the values of compressive stresses reach 1.0-1.5 MPa and are 2.5-4.0 MPa on average in layer.

The stress state of Boldyrevsky layer at the end of excavation works in 2017 is shown in the diagram of distribution of compressive stresses in Figure 6 in two angles. The calculated values of compressive stresses in protective pillars reach 20-23 MPa and they prevail since they cover most of the pillar. The maximum values are 35-40 MPa. In this case, the unloading zone begins to form over the place of excavation in underlying Polenovsky layer. The unloading zone with stresses of 1.0-1.5 MPa is available in the diagram on the left. It is framed by areas of increased stresses equal to 8.0-10.0 MPa, which means that there is the influence of stresses due to work in the lower layer.

The stress state of Boldyrevsky layer at the end of excavation works in 2018 is following: the calculated values of compressive stresses in protective pillars reach 22-26 MPa and they prevail since they cover most of the pillar. The maximum values are 36-42 MPa. The diagram shows the general configuration of zones of high stresses and the configuration of adjacent areas as well as the "trace" of high and low stresses from the excavations of underlying Polenovsky layer.

Geological disturbances in the immediate vicinity of the working excavations and at distance from them leave their "trace" on the stress distribution diagram. Zones of reduced stress from 1.0 to 2.0 MPa at the intersection of the layer with the element of geological disturbance one can see.

Zones of increased compressive stresses in Polenovsky layer are formed at the end of the work in 2017. They have almost the same nominal values as for the Boldyrevsky layer since the working excavation is still far enough from the working excavation of Boldyrevsky layer and far enough from the element of geological disturbance. The influence of works in Boldyrevsky layer on the stress state of Polenovsky layer is noticeable in the characteristic of loaded and unloaded zones.

The unification of stress distribution zones occurs in both layers at the time of completion of room-and-pillar works in 2018 when the zone of room-and-pillar works in Polenovsky layer approaches the zone of room-and-pillar works in Boldyrevsky layer. This can lead to an increase in stress level of the protective pillar of Polenovsky layer, which is in close proximity to the working excavation of Boldyrevsky layer, made in 2016, up to 40.0-45.0 MPa. It should be noted that by this time the lavas of Polenovsky layer from the North and South are between the two elements of geological disturbances, it means, they are between the two unloading zones. It is clearly visible on the diagrams and the unloading zone after the room-and-pillar works in Boldyrevsky layer is in the East.

The geological disturbance elements included in the model are below both layers. It should be noted that the volume of excavation in Polenovsky layer are surrounded by unloading areas from works in Boldyrevsky layer and zones of geological disturbances. Protective pillars of Polenovsky will accumulate greater level of compressive stresses than protective pillars of the same layer in 2017 due to the lack of closely-spaced discharge zones. In general the most difficult situation in terms of stress distribution has developed in

Polenovsky layer in the zone of room-and-pillar works in 2018 due to the presence of close-located loaded and unloaded zones of different origin.

Modeling of development of the stressed state of coal-measure rock during the room-and-pillar works in 2019 has showed the strengthening of the previously noted patterns. The prevailing compressive stresses in the protective pillars of Boldyrevsky layer can reach 30.0-32.0 MPa and the maximum stress values reach up to 50.0-55.0 MPa. The growth of peak compressive stresses to such a level is recorded in the protective pillars in the areas of room-and-pillar works in Boldyrevsky layer in all calculation periods in 2016-2019. However, the increase of compressive stress peaks one can see in the pillars left in 2016 since the room-and-pillar works in Polenovsky layer approach them.

The prevailing compressive stresses in the protective pillars of Polenovsky layer can reach 25.0-30.0 MPa and the maximum stress values reach up to 55.0-60.0 MPa. Stresses of this level are fixed in the pillars that are in the vicinity of the pillars of Boldyrevsky layer that are left in the area of room-and-pillar works in 2016. This means that room-and-pillar works on Polenovsky layer are conducted in 2019 in the vicinity or directly into the undermined areas of Boldyrevsky layer. This, apparently, leads to the emergence of peak zones in the protective pillars of Polenovsky layer (Figure 3, 4).

4. DISCUSSION

Modelling of development of the stressed state of the coal-measure rocks in the area of room-and-pillar works on Boldyrevsky and Polenovsky layers in the period 2016-2019 allows us to draw the following conclusion.

The level of the stress state of the coal-measure rock estimated by compressive stresses gradually increases with the development of room-and-pillar works. At the same time, the most difficult situation in terms of stress distribution occurs in Polenovsky layer in the area of room-and-pillar works in 2018. This trend continues in 2019 due to the merger of the zones of increased stresses of both layers into common zone.

Thus, numerical simulation helps to identify the following circumstance. The growth of stresses in the protective pillars occurs as well as the natural collapse of rocks in excavations occurs. Areas of bearing pressure move after room-and-pillar procedures. In the future, the spatial convergence of the zones of room-and-pillar works is possible in such a way that the protective pillars of the adjacent coal layers will have the mutual influence of increased stresses [10, 11] that can lead to premature uncontrolled destruction of these pillars.

a)

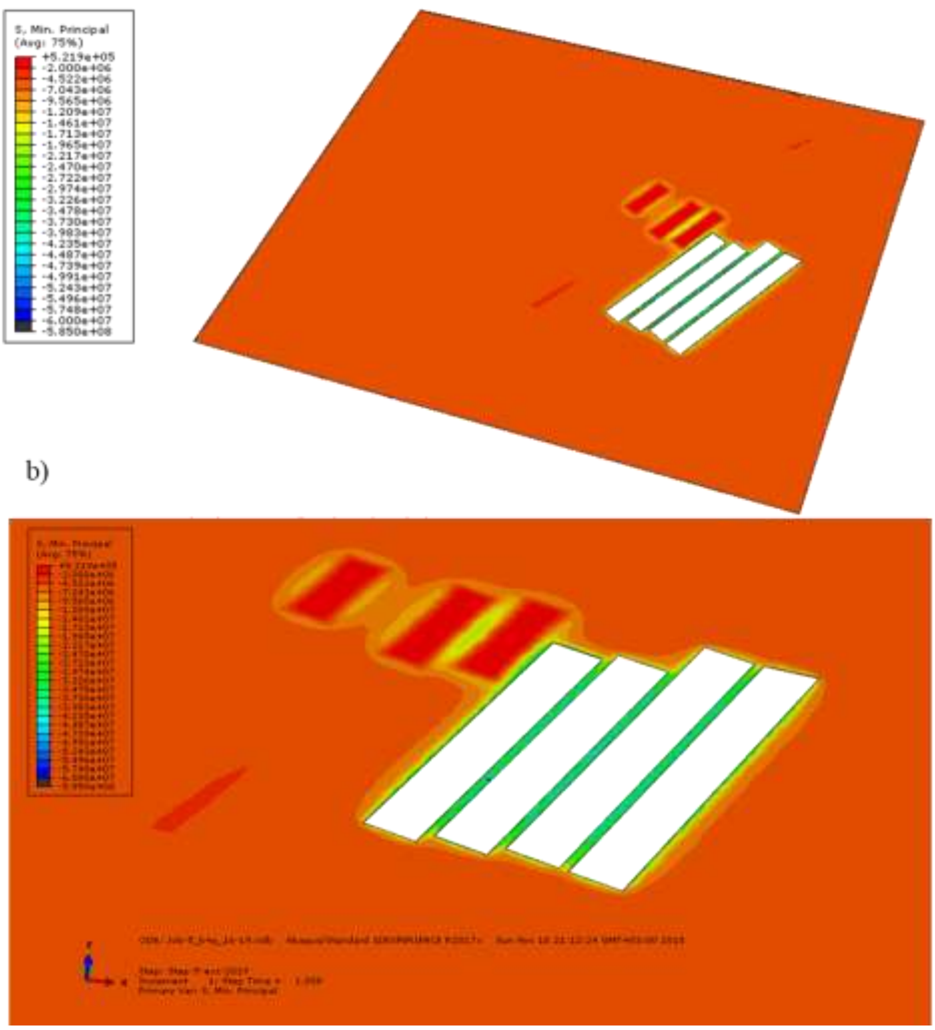

Figure 3. Stress state of Boldyrevsky layer at the end of excavation works in 2019

(a – in the model scale, b – fragment of the model in the enlarged scale)

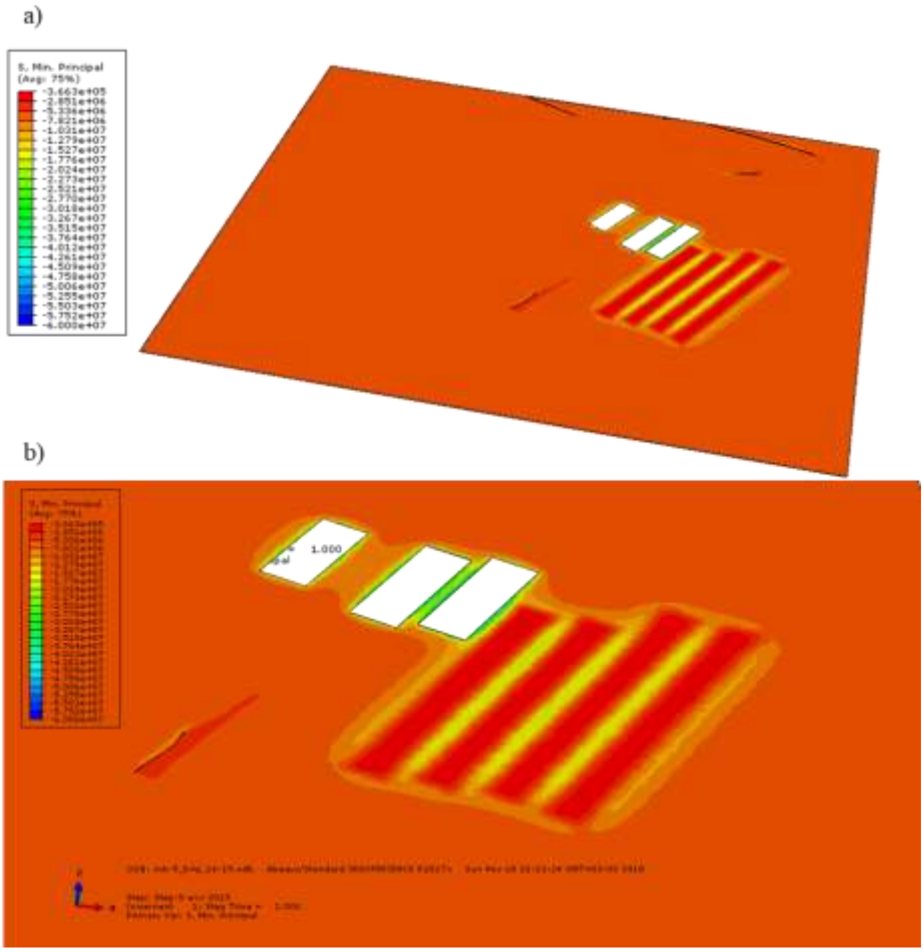

Figure 4. Stress state of Polenovsky layer at the end of excavation works in 2019

(a – in the model scale, b – fragment of the model in the enlarged scale)

5. CONCLUSION

Modern mining enterprises have extensive network of underground facilities. They tend to expand their activities through the introduction of new facilities and the reconstruction of existing facilities. The coal mining leads to formation of working excavations that affect each other not only within one layer, but also in adjacent layers. The sequence of room-and-pillar works in different layers may depend on a number of reasons including non-technical nature. There are various combinations of mutual positions and orientations of working excavations. Separate issue is the presence of large volume of broken-down rocks formed with room-and-pillar works. In particular, the physical and mechanical properties of broken-down rocks can change over time as a result of compaction. Also, the question of changing the gas-dynamic mode of operation of coal-measure rocks under room-and-pillar works requires a separate study [12, 13, 14, 15, 16, 17, 18, 19, 20]. The primary geomechanical factor of formation of the stress-strain state of coal-measure rocks containing sheet deposit was considered in the paper. Features of formation of stress fields under the mutual influence of working excavations were given.

REFERENCES

[1] The choice of the sequence of development of contiguous layers of the suites in the mines of JSC "SUEK-Kuzbass" Korshunov G. I., Paltsev A. I., Krotov N. In. F. P. Ivchenko, R. S. Istomin Mining information-analytical Bulletin No. 5, 2011, pp. 24-28.

[2] Ermakov, A. Y. Study of the mutual influence of remediation in concurrent mining of extraction pillars and formations baikaimsky Brewski in the mines of JSC "SUEK-Kuzbass"/ A. Yu., Ermakov, O. V. Vanaken// Energy security of Russia: new approaches to the development of the coal industry: proceedings of the XVI international scientific-practical conference on the 7-10 October 2014. – Kemerovo, 2014, pp. 109-111.

[3] Kazanin, O.I., Sidorenko, A.A., Sirenko, Y.G. (2018) Numerical study of the air-gas dynamic processes when working out the Mosshny seam with longwall faces. ARPN Journal of Engineering and Applied Sciences, 13 (4), pp. 1534-1538.

[4] Kazanin, O.I., Sidorenko, A.A., Vinogradov, E.A. Substantiation of the technological schemes of intensive development of gas-bearing coal beds (2017) ARPN Journal of Engineering and Applied Sciences, 12 (7), pp. 2259-2264.

[5] Kazanin, O.I., Sidorenko, A.A., Vinogradov, E.A. (2017) Choosing and substantiating the methods of managing gas emission in the conditions of the Kotinskaya mine of JSC Suek-Kuzbass. ARPN Journal of Engineering and Applied Sciences, 12 (6), pp. 1822-1827.

[6] Kazanin, O.I., Sidorenko, A.A. Interaction between gas dynamic and geomechanical processes in coal mines (2017) ARPN Journal of Engineering and Applied Sciences, 12 (5), pp. 1458-1462.

[7] Kazanin, O.I., Sidorenko, A.A. The best available technologies for horizon mining of flat-lying gaseous coal seams: Prospects for development in Russian mines (2017) ARPN Journal of Engineering and Applied Sciences, 12 (1), pp. 227-234.

[8] Kazanin, O.I., Sidorenko, A.A., Vinogradov, E.A. (2018) Assessment of the influence of the first established and identification of critical steps in main roof caving. ARPN Journal of Engineering and Applied Sciences, 13 (10), pp. 3350-3354.

[9] Meshkov, S., Sidorenko, A. (2017) Numerical Simulation of Aerogasdynamics Processes in A Longwall Panel for Estimation of Spontaneous Combustion Hazards (2017) E3S Web of Conferences, 21, статья № 01028.

[10] Potemkin D.A., Popov M.G., Trushko O.V. Examination and analysis of actual stability of mine workings at the Yakovlevsky iron ore deposit. ARPN Journal of Engineering and Applied Sciences (ARPN J. Eng. Appl. Sci.), 13 (7), 2018, pp. 2490-2499

[11] Potyomkin D.A., Trushko V.L., Trushko O.V. The stress-strain behaviour of the protective pillars of a subarrier zone using the ore deposits mining combined system. International Journal of Mechanical Engineering and Technology (Int. J. Mech. Eng. Technol.), 9 (3), 2018, pp. 1046-1052

[12] Kovalsk, E. R., Karpov, G. N., Leisle, A. V. (2018). Investigation of underground entries deformation mechanisms within zones of high stresses. International Journal of Civil Engineering and Technology, 9(6), 534-543

[13] Kovalski, E.R., Karpov, G.N., Leisle, A.V. (2018). Geomechanic models of jointed rock mass. International Journal of Civil Engineering and Technology. 9. 440-448

[14] Sidorenko, A.A., Ivanov, V.V. Underground mining of multiple seam of coal (2016) ARPN Journal of Engineering and Applied Sciences, 11 (7), pp. 4448-4454.

[15] Trushko V.L., Protosenya A.G., Trushko O.V. Stress-strain behavior of the workings during the rich iron ores development under the confined aquifers. International Journal of Applied Engineering Research (Int. J. Appl. Eng. Res.), 11 (23), 2016, pp. 11153-11164

[16] Trushko V.L., Trushko O.V., Potemkin D.A. Provision of stability of development mining at yakovlevo iron ore deposit. International Journal of Applied Engineering Research (Int. J. Appl. Eng. Res.), 11 (18), 2016, pp. 9248-9255

[17] Trushko V.L., Protosenya A.G., Ochkurov V.I. Prediction of the geomechanically safe parameters of the stopes during the rich iron ores development under the complex mining and geological conditions. International Journal of Applied Engineering Research (Int. J. Appl. Eng. Res.), 11 (22), 2016, pp. 11095-11103

[18] Trushko V.L., Trushko O.V., Potemkin D.A. Efficiency increase in mining of highgrade iron ore deposits with soft ores. International Journal of Mechanical Engineering and Technology (Int. J. Mech. Eng. Technol.), 9 (3), 2018, pp. 1038-1045

[19] Trushko V.L., Protosenya A.G., Verbilo P.E. Predicting strength of pillars in fractured rock mass during development of apatite-nephelinic ores. ARPN Journal of Engineering and Applied Sciences (ARPN J. Eng. Appl. Sci.), 13 (8), 2018, pp. 2864-2872

[20] Trushko O.V., Potemkin D.A., Popov M.G. Ensuring sustainability of mining workings in development of ore deposits in complex geological conditions. ARPN Journal of Engineering and Applied Sciences (ARPN J. Eng. Appl. Sci.), 13 (7), 2018, pp. 2594-2601