УДК 5.51.519.2.519.254
https://doi.org/10.47533/2023.1606-146X.36

A. ZH. SAYAZHANOVA*, ZH. SAILAUKYZY, M. M. KOKKOZ, T. YA. KATSAGA, G. DANENOVA

*Abylkas Saginov Karaganda Technical University,
Karagandy, Kazakhstan
sayazhanova@gmail.com, s_k_zhuldiz@mail.ru, makhabbat_k@bk.ru,
tkatsaga@itasca.ca, guldan72@mail.ru*

RESEARCH FOR A WEB SERVICE TO ANALYZE WAYS AND MEANS OF FORECASTING AND PREVENTING SUDDEN EMISSIONS OF COAL AND GAS IN COAL MINES

The mining industry plays an important role in the economic development of many countries. However, it is also associated with high risks to human life and the environment. One of the most significant dangers in coal mines is the sudden emissions of coal and gas, which can result in accidents and loss of life. In this article, we present the results of our research on a web service to analyze ways and means of forecasting and preventing sudden emissions of coal and gas in coal mines. The web service provides an efficient and reliable tool for mine operators to manage the risks associated with coal and gas emissions and ensure the safety of their employees.

Keywords*: mining, machine learning, python, analysis, forecast.*

Introduction. The mining industry has always been associated with high risks to human life and the environment. Coal mining is one of the most significant contributors to the global energy sector, providing fuel for power generation and industrial processes. However, coal mining is also associated with high levels of risk, including accidents, injuries, and fatalities. One of the most significant dangers in coal mining is the sudden emissions of coal and gas, which can result in accidents and loss of life. Therefore, there is a pressing need for an efficient and reliable tool for mine operators to manage the risks associated with coal and gas emissions and ensure the safety of their employees.

The relevance of research methods for predicting areas of coal seams that are dangerous due to sudden emissions of coal, rock and gas consists in a relatively high probability of incidents and accidents associated with gas-dynamic manifestations of rock pressure. In the history of independent Kazakhstan, there have been 12 accidents at domestic mines. They claimed the lives of 160 people.

It is believed that one of the most important factors in the occurrence of a sudden release of coal and gas is a change in the structure of the formation and the structure of coal in the formation. Analyzing the data on coal and gas emissions that occurred in the mines of the Karaganda basin, it can be noted that in 91% of cases coal seams with a capacity of 3.5 m and above were exposed to emissions. Such emission-hazardous formations as k_{10}, k_{12} and d_6 have an average capacity of 5.2 to 8.3 m at the emission sites.

Underground geophysical monitoring at the sites of ongoing mining is carried out according to the schemes of longitudinal electro-profiling and dipole electromagnetic

* E-mail корреспондирующего автора: sayazhanova@gmail.com

sounding. Monitoring is carried out on hazardous formations and formations exposed to the threat of sudden emissions, with the frequency prescribed by the instructions on sudden release of coal and gas. [1].

Data analysis using the Python programming language. The information system makes it possible to forecast coal production for a given period, and also allows you to prospectively evaluate working and newly commissioned mines according to the level of manufacturability of coal mining, including in typical conditions according to the characteristics of the destructible and the features of the geological structure of the layers. The full list of forward-looking estimates is as follows:

– forecast for coal production in general and broken down by brand across the industry and individual regions for the specified year;

– forecast on the level of technological efficiency of mines throughout the industry and in individual regions;

– forecast of mine layers by typical operating conditions;

– forecast of closure of existing mines due to mining of coal reserves.

The developed database functions under the management of a DBMS, so storing and making changes to the database will be much easier. In addition, by storing data in a DBMS, we can connect it to any application programs. In our case, the Python programming language was used for the DBMS client shell and the service for predicting results.

Together, the database and the application software package that implements the interface to the database and performs forecasting function according to the scheme shown in Figure 1.

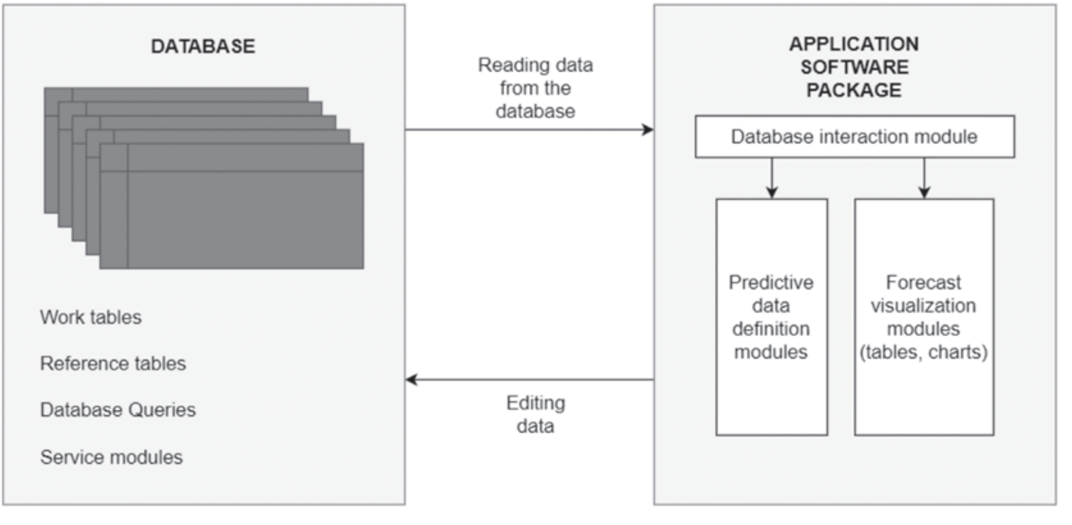

Figure 1 **–** The scheme of interaction between the database and the application package

The scheme consists of two main blocks: a database and an application package. There is a two-way communication between these blocks that implements the process of reading data from the database and transferring this information to an application package for further processing. In addition, the link implements the processes of editing records in the database, deleting records and creating new ones. This communication is implemented using the ODBC interface.

Neural networks are very powerful for performing predictive analysis and solving analytical problems. They are widely used to classify data to detect patterns and make predictions. Business cases range from classifying and protecting customer data to classifying text, consumer behavior, and many other tasks. To train a neural network model, we need to go through the process of loading data, determining the parameters of the model, the model and the loss function, training the model on the training set and verifying the model using the validation set. To do this, facilitate the conversion of model input data into tensors using PyTorch [2], using the torch package.Tensor PyTorch (Figure 2).

```
# Convert Input and Output data to Tensors and create a TensorDataset
input = torch.Tensor(input.to_numpy())      # Create tensor of type torch.float32
output = torch.tensor(output.to_numpy())      # Create tensor type torch.int64
data = TensorDataset(input, output)    # Create a torch.utils.data.TensorDataset object
```

Figure 2 – Converting model input and output data into tensor format

The Pytorch nn.Module neural network class provides an easy way to build a neural network. To do this, we only need to define the forward function, since the inverse function will be determined automatically (Figure 3).

Figure 3 – Learning process neural networks for predicting sudden emissions

Database queries are fragments of program code in a structured query language (SQL) and are necessary for performing intermediate queries to the database, such as searching in a reference table or searching for a related record. Such queries are not stored separately in the database in the form of saved code, but are stored together with service or work tables. The use of service requests and their storage separately from the program code implementing the interface to the database provides simplification of the source code, facilitates its understanding and support. In addition, if there is a need to adjust database tables in the future, the use of service queries stored together with database objects eliminates the need for appropriate editing of the program code of the program interface to the database, which facilitates the support of the entire system as a whole and reduces the possibility of mistakes by the programmer.

The forecasting module allows us to get a report on coal production, on the level of manufacturability of mines and on typical conditions for a period specified by the user. In addition, this module edits the list of existing and prospective mines. Editing consists in excluding mines from the list of existing ones and simulating the commissioning of promising mines. At the same time, in the database, the mine is marked as operational or decommissioned. [3]

The web service uses machine learning algorithms to analyze this data and provide accurate and reliable forecasts of coal and gas emissions. The web service also provides a dashboard that displays real-time data and alerts mine operators to any potential risks. Additionally, the web service provides tools for mine operators to implement preventative measures, such as ventilation systems, gas detectors, and other safety measures. The web service provides an efficient and reliable tool for mine operators to manage the risks associated with coal and gas emissions and ensure the safety of their employees.

Processing raw data into charts. The dynamics of sudden emissions of coal and gas in the Karaganda basin is shown in Table 1. Especially a lot of emissions (on average, almost 3 emissions per year) occurred in 1959-1968 [4]. This is explained by the fact that in the first years of emissions in the basin, hazardous formations were developed without an outlier forecast and often without the use of methods to prevent coal and gas emissions. In the future, with the accumulation of experience in emissions control, the development and implementation of methods for predicting emissions and ways to control emissions, their number decreased. However, the volume of coal discarded has increased.

Table 1 **–** Dynamics of sudden emissions in the Karaganda basin

Period of the year	The number of explosive mine layers being developed	Average depth of workings on hazardous formations	The number of sudden emissions of coal and gas		The amount of coal and gas emitted	
			absolute	per hazardous formation	coal/rock mass, *t*	gas, thousand m^3
1959-1968	10	360	27	2,7	1998	105,36
1969-1978	18	470	16	0,89	1997	158,1
1979-1988	24	503	5	0,21	885	47
1989-1998	24	560	5	0,21	3980	2113,2
1999-2008	10	553	1	0,1	1087	414,09
2009-2018	16	587	5	0,31	3114	301,41

Visualization in the form of diagrams is an important part of the data analysis process because it allows data to be presented in a way that is easier to understand and interpret. Diagrams, such as charts, graphs, and maps, provide visual representations of complex data sets that allow viewers to quickly grasp trends, patterns, and relationships. This can be particularly useful when working with large datasets or when trying to communicate complex information to others.

In addition to making data easier to understand, data visualization can also be used to identify outliers and anomalies in data that might be missed through other forms of analysis.

The dynamics of sudden emissions in the Karaganda basin from Table 1 can be transformed into Diagram 1. Thus, we have a visual representation of how the statistical data changed from 1959 to 2018. The amount of coal and gas ejected and the average depth of workings in hazardous formations have increased significantly, thereby harming the environment. The number of developed explosive mine layers increased sharply in the period 1979-1998, then slowly but evenly this value began to fall. The absolute number of sudden emissions of coal and gas began to decrease from 27 to 5, and also reached a minimum extreme in the period 1999-2008.

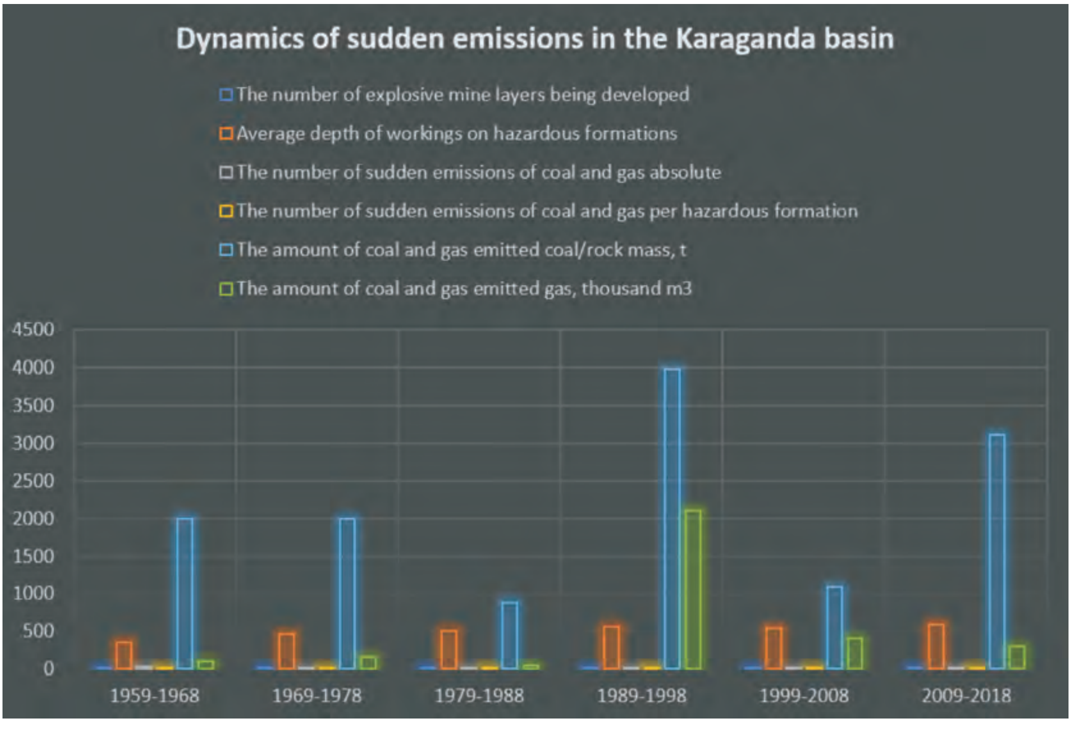

Figure 4 **–** Dynamics of sudden emissions
in the Karaganda basin

The reasons for all emissions that occurred at the mines of the Karaganda basin, in accordance with the accepted classification, are given in Table 2. According to these data, it is possible to make an analysis of individual layers during the opening of field workings [4].

As can be seen from table 2, the majority of emissions (38 out of 59, or 64.4%) occurred in workings in which anti-emission measures were not applied. These are 18 emissions that occurred for the first time on formations or mine layers that were considered non-hazardous, and 20 emissions occurred on hazardous formations mainly until 1967, when emission control methods were practically not used, and in subsequent years anti-emission measures were not applied due to various weak organizational, mining and other reasons.

Table 2 – Causes of coal and gas emissions during reservoir opening

Cause of emissions	Number of emissions	% of total emissions
For the first time on a seam, a mine layer	5	35,7
Without measures	3	21,4
Violation of parameters	2	14,3
Provoked by blasting	2	14,3
In the process of implementing measures	1	7,1
No events were required	1	7,1
TOTAL:	14	100

Taking table 2 as a basis, we can present a diagram that clearly clarifies the main causes of coal and gas emissions. To do this, we first need to analytically sort the data specified in these 2 tables. That is, the "raw data" must be processed before the "ready data".

Diagram 2 perfectly characterizes these "ready data" obtained from table 2. Here below we see the main causes of sudden emissions, as well as the amounts of these emissions are indicated vertically on the left, and percentage data on the right, which very clearly shows the growth of the emission hazard.

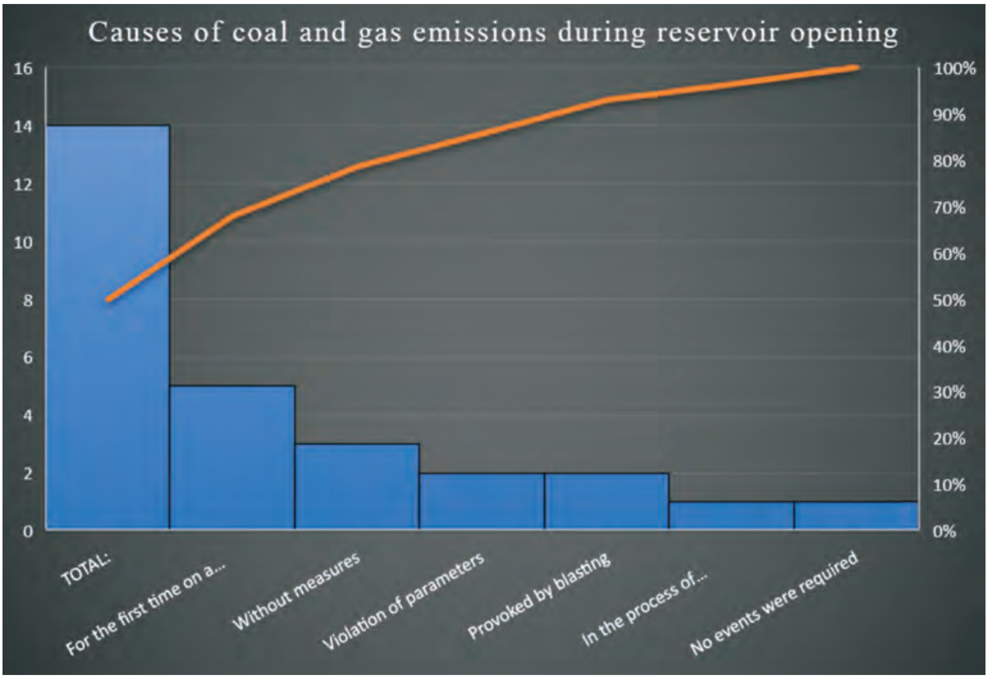

Figure 5 – Causes of coal and gas emissions during reservoir opening

All further forecasts are based on the lists of mines operated in a given year. When calculating, all mines closed before the specified year and promising ones put into operation after the year for which the forecast is being built are excluded from the list. The forecast is given to the user in tabular form or in the form of a graph.

Conclusion. Our research demonstrates the effectiveness of a web service to analyze ways and means of forecasting and preventing sudden emissions of coal and gas in coal mines. The web service provides an efficient and reliable tool for mine operators to manage the risks associated with coal and gas emissions and ensure the safety of their employees. The web service is a valuable addition to the toolkit of mining operators and will help to reduce the incidence of accidents and loss of life in coal mines. With further development and improvement, the web service has the potential to become a vital tool in the global efforts to improve the safety and sustainability of the mining industry.

REFERENCES

1 Wang Wei, Peng Lai, Wang Xiaochao Prediction of Coal Mine Gas Emission Quantity Based on Grey-Gas Geologic Method / Mathematical Problems in Engineering. 2018. Article ID 4397237. p.7.

2 Egor Malykh PyTorch is your new deep learning framework / Machine learning. 2017. p.12.

3 Sailaukyzy Zh., Snitsar L.R., Klyueva E.G. BIG DATE technologies and infrastructure / Sailaukyzy Zh.: Publisher KSTU, Monograph, ISBN 978-601-315-415-2, 2021, p.7.25.

4 The Main Department of the Coal Department Joint Stock Company "ArcelorMittal Temirtau". Catalog of sudden coal and gas emissions that occurred at the mines of the Karaganda basin, Karaganda 2018.

5 Burkov Andrey Machine learning without unnecessary words. St. Petersburg, 2020. p.192.

6 Beazley David Python. Detailed reference guide. St. Petersburg: Symbol-Plus, 2010. p.864.

7 Yu. N. Tyurin, A. A. Makarov, I. R. Vysotsky, I. V. Yashchenko Probability theory and statistics - Moscow: JSC "Moscow Textbooks", 2014. p.256 .

8 K.E. Plokhotnikov, S.V. Kolkov Statistics: textbook. manual 4th edition. - Moscow: FLINT, 2012. p.288.

9 Thomas Nield Essential Math for Data Science. Take Control of Your Data with Fundamental Linear Algebra, Probability, and Statistics : detailed reference guide First Edition. - O'Reilly, 2022. p.323.

А. Ж. САЯЖАНОВА, Ж. САЙЛАУҚЫЗЫ, М. М. КОККОЗ,
Т. Я. КАЦАГА, Г. Т. ДАНЕНОВА

Әбілқас Сағынов атындағы Қарағанды техникалық университеті,
Қарағанды қ., Қазақстан

КӨМІР ШАХТАЛАРЫНДА КЕНЕТТЕН КӨМІР МЕН ГАЗ ШЫҒАРЫНДЫЛАРЫН БОЛЖАУ ЖӘНЕ АЛДЫН АЛУ ЖОЛДАРЫ МЕН ҚҰРАЛДАРЫН ТАЛДАУҒА АРНАЛҒАН ВЕБ-СЕРВИСКЕ АРНАЛҒАН ЗЕРТТЕУ

Тау-кен өнеркәсібі көптеген елдердің экономикалық дамуында маңызды рөл атқарады. Алайда, бұл адам өмірі мен қоршаған ортаға үлкен қауіп-қатермен байланысты. Көмір шахталарындағы ең үлкен қауіптердің бірі – кенеттен көмір мен газдың шығарылуы, бұл жазатайым оқиғалар *мен адам өліміне әкелуі мүмкін. Бұл мақалада біз көмір шахталарында кенеттен көмір мен газ шығарындыларын болжау және алдын алу жолдары мен құралдарын талдауға арналған веб-сервистің зерттеу нәтижелерін ұсынамыз. Веб-сервис шахта операторларына көмір мен газ шығарындыларымен байланысты тәуекелдерді басқарудың және өз қызметкерлерінің қауіпсіздігін қамтамасыз етудің тиімді және сенімді құралын ұсынады.*

***Түйін сөздер**: тау-кен өндірісі, машиналық оқыту, python, талдау, болжау.*

А. Ж. САЯЖАНОВА, Ж. САЙЛАУКЫЗЫ, М. М. КОККОЗ, Т. Я. КАЦАГА, Г. Т. ДАНЕНОВА

Карагандинский технический университет имени Абылкаса Сагинова, г. Караганда, Казахстан

ИССЛЕДОВАНИЕ ДЛЯ ВЕБ-СЕРВИСА ДЛЯ АНАЛИЗА ПУТЕЙ И СРЕДСТВ ПРОГНОЗИРОВАНИЯ И ПРЕДОТВРАЩЕНИЯ ВНЕЗАПНЫХ ВЫБРОСОВ УГЛЯ И ГАЗА В УГОЛЬНЫХ ШАХТАХ

Горнодобывающая промышленность играет важную роль в экономическом развитии многих стран. Однако это также связано с высокими рисками для жизни человека и окружающей среды. Одной из наиболее серьезных опасностей в угольных шахтах являются внезапные выбросы угля и газа, которые могут привести к несчастным случаям и гибели людей. В этой статье мы представляем результаты нашего исследования – веб-сервиса для анализа путей и средств прогнозирования и предотвращения внезапных выбросов угля и газа в угольных шахтах. Веб-сервис предоставляет операторам шахт эффективный и надежный инструмент для управления рисками, связанными с выбросами угля и газа, и обеспечения безопасности своих сотрудников.

***Ключевые слова**: добыча полезных ископаемых, машинное обучение, python, анализ, прогноз.*