Bulgakov Y., Moroz O.[*], Kavera A.[**], Gorbylyova E.[***], Borshch I.[****]

DEVELOPMENT OF A NEW METHOD OF INFLAMMATION PREVENTION

Abstract

Researches connected with influence of electric field on flame are analyzed. Dependence of tension value which leads to putting out of flame source are presented.

Introduction

Fire safety of available equipment is on indirect part when one develops new and more advanced equipment. According to statistics within period of 1991 to 2000, 50% exogenic fires refers to fires which appear as a result of cable coating inflammation (29,3%), conveyor belt (17,8%), coating in electrical machines (2,9%). The main problem is that there is a lack of anti-fire means to prevent inflammation of electrical equipment and conveyor belts. However, there are some methods of fire extinguishing which are not universal. For example, fire extinguishing by water is not allowed and while extinguishing by powder equipment damage occurs. In this connection there is a necessity to develop an absolutely new method of prevention and extinguishing of inflammation. The method is based on the ability of electric fields to influence flame.

The real state of the problem

For the first time, the plant for extinguishing flame was developed at ISRMP (Institute of Scientific Researches of Mine-Rescue Problems) in 1997. A range of researches on examining of electric field influence on process of conveyor belt combustion has been done. These researches are being continued at Don NTU. The plant,which was developed by the scientists of University, enables to generate electrical field with tension on electrodes up to 75 kv. A range of experiments to define optimal parameters for flame extinguishing has been carried out.

The plant consists of a power supply unit (risen transformator),a control unit and two electrodes. With the help of control unit the tension is gradually increased on electrodes and as a result an electric field appears between them. It facilitates movement of radicals and ions in the zone of combustion and

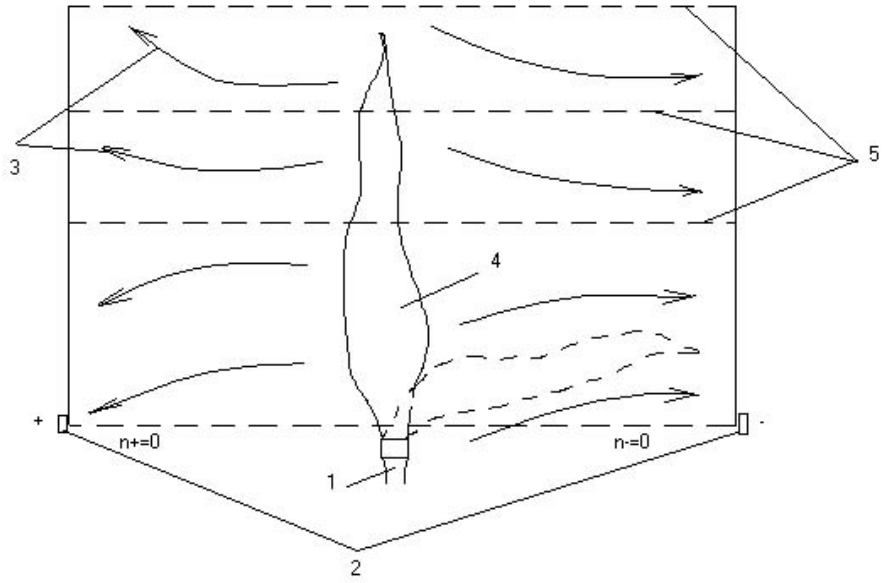
[*] Professor, Doctor of Technical Sciences, Donetsk National Technical Univerisy, Donetsk, Ukraine, Artemya street 58, 83000. E-mail: byf@mine.dgtu.donetsk.ua

[**] Post-graduate student, Donetsk National Technical Univerisy, Donetsk, Ukraine, Artemya street 58, 83000. E-mail: rex.@km.ru

[***] Senior teacher, Donetsk National Technical Univerisy, Donetsk, Ukraine, Artemya street 58, 83000

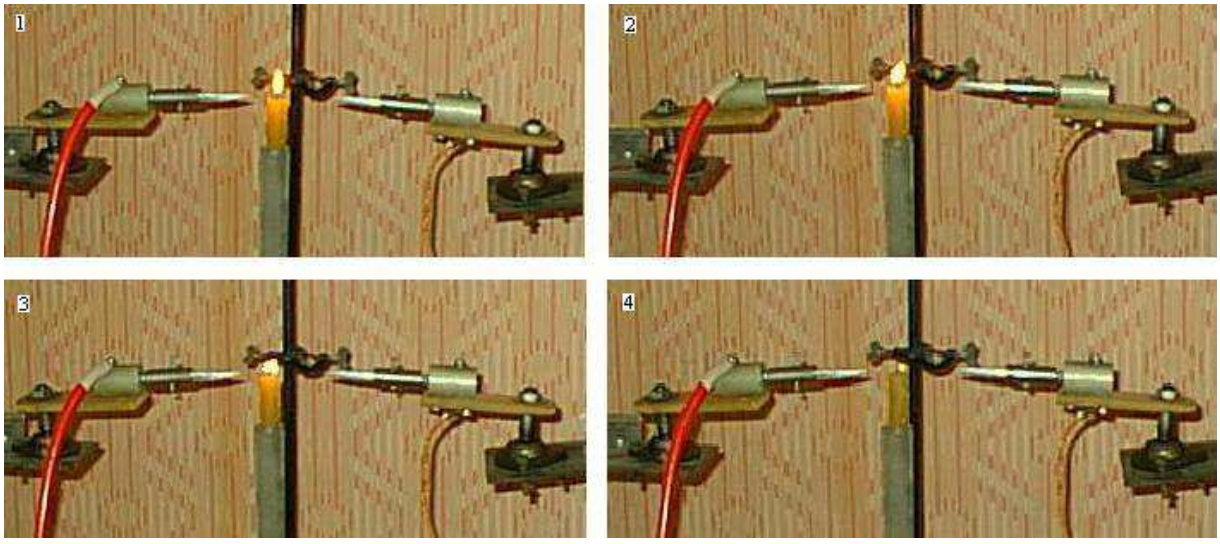
[****] Professor's assistent, Donetsk National Technical Univerisy, Donetsk, Ukraine, Artemya street 58, 83000

appearance of so called “ion wind” (picture 1). This “ion wind” leads to flame illumination from the surface of combustion (picture 2).



Picture 1 - Scheme of structure of the flame flow and its shape:

1- a burner;
2- electrodes;
3- lines of current;
4- flame;
5- lines of strength.



Picture 2 – Flame weakening in electrical field

The results of the experiments

With the help of voltmeter on control block the tension is fixed. With this tension flame which is between electrodes is fully extinguished. The programme of experiments was made to examine influence of electric field on the flame

source. Matrix of experiment planning was included in this programme. The range of experiments directed on examining of influence on the flame depending on the kind of electric field and the forms of electrodes and the material they are made of was supposed to be done in the frame of this programme.

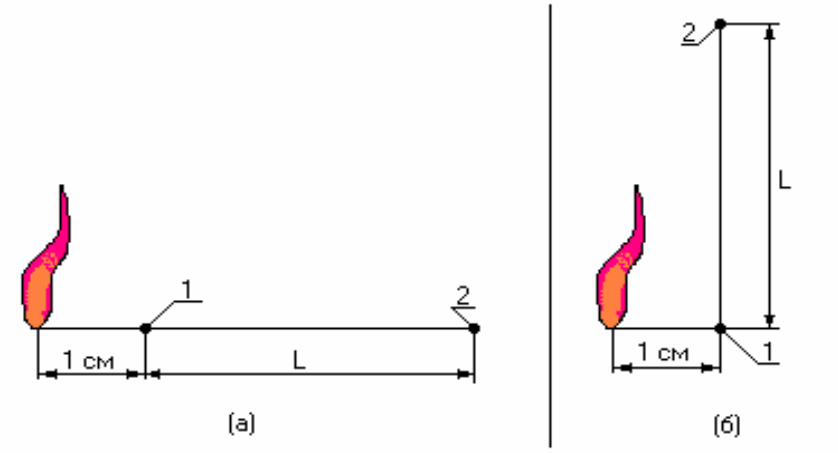
These experiments showed that a variable of the electric field influences the flame more sufficiently than a constant one.

One should mention that the tension value is lower in case of using variable tension. Having such tension, flame source set between electrodes is completely extinguished. Besides, if one uses the variable tension, the necessity to use tension rectifier is excluded, which simplifies the plant construction.

Material from which the electrodes are made didn't influence flame extinguishing but the shape of electrodes was of significant importance. These electrodes were made of aluminum and copper. 3 types of electrodes were made for the experiment:

1) needle-shaped electrode (point-sharpened);
2) flat round plate;
3) plate made of dielectric material with a set of tenens, each of which was attached by a separate cable.

The third type of electrodes was created to make volumetric field. However, as the experiment showed, the most efficient shape of electrodes for flame extinguishing is the first type of electrodes. For such a type of electrodes the range of experiments, which are described below, was carried out. The results are given in the form of graphs. The scheme is shown in picture 3.



Picture 3 - The scheme of experiments:
1-initial point;
2-final point;
L- changeable distance.

In picture 4a one can see the dependence between the tension of extinguishing and the distance between electrode on the right and the foot of flame source. When electrode is at the same horizontal level as the foot of the flame and the distance between them is 1 sm. it is considered to be the initial

position of electrodes. The distance gradually increases and the tension of extinguishing is measured every time.

Measurements are stopped when the flame stops extinguishing having maximum tension on electrodes.

In picture 4b the dependence between the tension of extinguishing and the distance between the electrode on the right and the foot of flame source is given. When electrode is at the same horizontal level as the foot of flame and the distance between them is 1 sm. it is considered to be initial position of electrodes. We change the position of the electrode gradually by rising it vertically. We set distance on the axle of abscissa starting with the initial point. Every time when we change the distance we measure the tension of extinguishing. We stop measurements when flame stops extinguishing having maximum tension on the electrodes.

While processing the given data a trend line was built (it is shown by a broken line in the graph). The equation of the link for the graph is calculated according to the following formula:

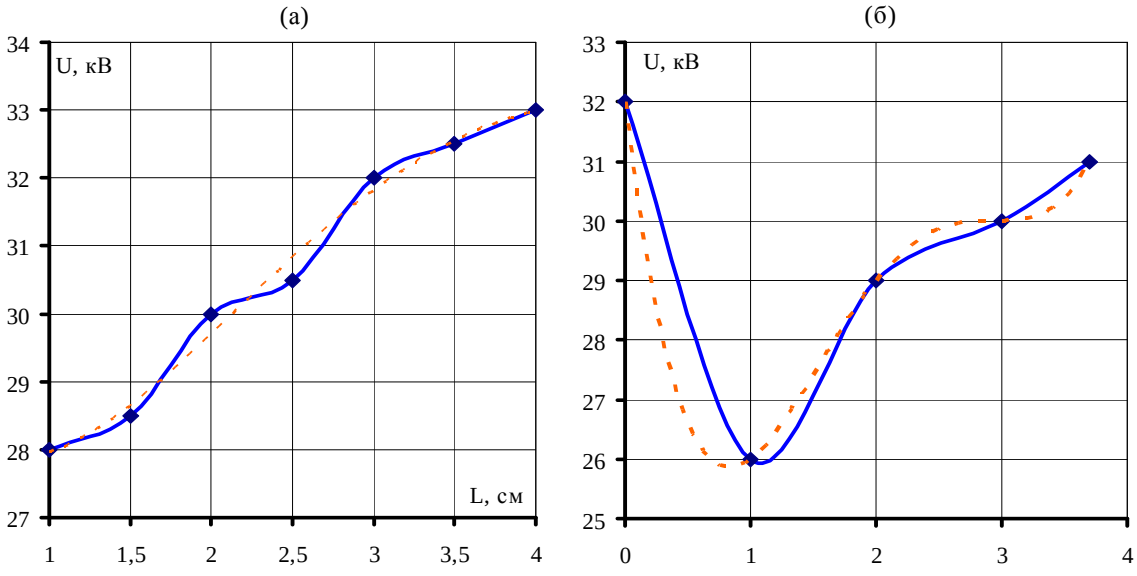
$$y = 0.0606x^4 - 0.8283x^3 + 3.6515x^2 - 4.3405x + 29.429,$$

and authenticity of approximation $R^2 = 0.9888$.

The trend line for the second graph is calculated as follows:

$$y = 0.6208x^4 - 5.5583x^3 + 16.829x^2 - 17.892x + 32$$

$$R^2 = 1$$



Picture 4 - The dependence between the tension of extinguishing and the distance between electrode on the right and the foot of flame source.

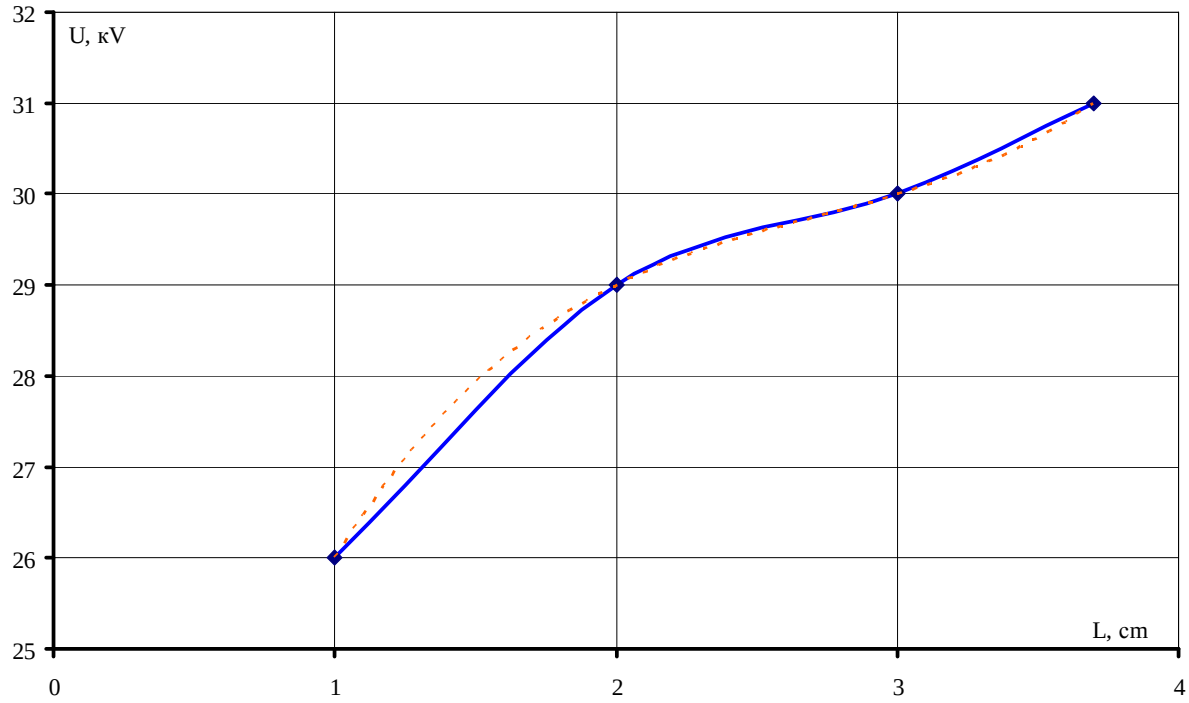
As one can see from the graph in picture 4a the tension value, which is necessary for extinguishing of flame, gradually increases while remoting the

electrode from the foot of flame source in horizontal direction. In graph 4b it is shown that the most efficient extinguishing can occur when the electrode is 1 sm above the level of the foot of flame. When one increases the distance the value of tension which is necessary for flame extinguishing increases proportionally as in the first case. The value of tension which is equal to 32kV when the electrode is at the same level as the foot of flame (where L=0) can have some inaccuracy. This inaccuracy can be explained by complexity of lines dislocation in the electrical field, lines being located very closely to the electrode. The mistakes are obvious because the initial points of the electrode dislocation in reference to the source in the 1-st and 2-nd parts of experiments are equal and in the 1-st part of experiments the tension value was equal to 28kV. Lets exclude this point from the value which was received while doing the experiments. Taking into consideration the above mentioned the graph previously presented by picture 4b can be viewed as follows.

In picture 5 we can see a trend line the equation of which can be calculated as follows.

$$y = 0.4637x^3 - 3.7824x^2 + 11.101x + 18.218$$

and authenticity of approximation $R^2 = 1$.



Picture 5 - Dependence between the extinguishing tension and the distance between the electrode on the right and the foot of flame source.

To make it sure that the flame is put out by “ion wind”, the following experiment has been done. The flame source was put into a glass cylinder with an opened top to let oxygen into and combustion products out. The cylinder prevented “ion wind” influence on flame of the burner. The flame was shaped as

a sphere. It is likely to be caused by the fact that the top of the cylinder was opened. It means that the extinguishing effect is achieved in the result of aerodynamic influence of a flow of the charged particles on the flame. Thus, the fact of flame extinguishing by the aerodynamic flow of the charged particles was proved by using experimental approach. This process is of a mechanical character. The determining factors in this processes are the shapes of electrodes forming electric field, the tension between electrodes and the distance to the source of burning.

Conclusion

Taking into account the results of theoretical researches and experiments it was suggested to use the given phenomenon for developing prevention methods of inflammation of different objects including the electrical plants, coating of electrical cables and conveyor belt.

Literature

1. Lyovkin N. B. ‘Prevention of accidents and injuries in coal mines of Ukraine.’ Makeyevka: Mak SRI, 202-392p.
2. Malinowski A. E. ‘The role of charged particles in burning explosive processes’. Socialist reconstruction and science. –1934, №7- p.24-37.
3. Bulgakov Y. F. Dikenshtein I. F., Zuykova S. N. ‘Report on scientific and research project’ – Donetsk: SRIMR, 1997. -25 p.
4. Bulgakov Y. F., Kavera A. L., Bershadski I. A. ‘Development of a new method of inflammation prevention of mine equipment' News of Donetsk Mining College, 2004, № 1.
5. Timoshenko G. M., Zima P. F., ‘The theory of engineering experiment’, the educational supply. - K: UMK VO, 1991-124p.