EFFECT OF ARTIFICIAL FACTORS ON FOG DISPERSAL PRACTICED IN LIGNITE MINES IN SERBIA

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ABSTRACT. Research and operational dispersal of super cooled fog has been practiced at the „Kolubara" open - pit coal mines for a number of years now. This activity is now being commenced also at other open – pit lignite mines in Serbia. The paper includes some of the knowledge acquired from the mathematics model presentations.

Key words: SUPERCOOLED FOG, OPEN-PIT MINING, VISIBILITY, MATHEMATICAL MODELS, MINING

ПРОУЧВАНЕ НА ВЛИЯНИЕ НА ТЕХНОГЕННИТЕ ФАКТОРИ ПРИ РАЗПРОСТРАНЕНИЕ НА МЪГЛАТА В ЛИГНИТНИТЕ МИНИ В СЪРБИЯ

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РЕЗЮМЕ. През последните години в открита въглищна мина „Колубара" се извършва проучване на разпределението супер охладена мъгла. Тази дейност в момента започва и в други открити мини за лигнитни въглища в Сърбия. Докладът включва познанията получени при математическото моделиране на процесите.

Ключови думи: Суперохладена мъгла, открит добив, видимост, математическо моделиране, минно дело

1. INTRODUCTION

The hitherto experience in lignite mining at „Kolubara" open pit mines has shown that the highest output in lignite is registered under winter operating conditions are producing an adverse effect on production processes: low air temperatures, heavy fog, heavy precipitation and strong gusts of wind.

The problem of their adverse effect on the overall pit operations was dealt with reliably by selecting a method involving the action of liquid propane on supercooled fogs.

Liquid propane is sprayed using accurately positioned stationary and mobile diffusers. Visibility can be improved in certain areas (e.g., coal system) or in the whole open pit mine.

2. CLASSIFICATION OF FOG

Fog consists of a large number of water droplets or ice crystals, whose weight is so small that they hover in the air. Oversaturation with steam and a sufficient number of condensation and crystallization are necessary for the formation of fog.

According to the way of their formation, fogs can be divided into those which are formed inside air masses and frontal fogs. The fogs inside air masses can be:

- radiant
- adjective
- orographic
- evaporation fogs
- and town fog

From the aspect of artificial influence, fogs are divided into:

- warm
- supercooled
- icy

3. SUPERCOOLED FOGS

Supercooled fogs are formed at temperatures from 0^0C to -29^OC. They consist mostly of supercooled water droplets whose concentration depends on temperature. Under natural conditions, a very small number of droplets freeze at temperatures exceeding -4^0C.

The most common freezing temperature of large droplets is -12^0C and that of the small ones, -20^0C. A remarkably important process taking place under natural conditions, on which the possibility of acting on supercooled fogs artificially is based, is Fyndeyson process. The consequence of the difference between the pressure above water and ice is the creation of a steam density gradient from liquid droplets to ice crystals, which causes the water droplets to evaporate and increases of crystals.

4. COOLING REAGENTS

Cooling reagents are gasses kept in liquid state under very high pressure. When these substances are introduced into supercooled fog at normal pressure, they evaporate instantly, taking heat energy from the surroundings for their phase transition.

One of the more suitable cooling reagents is liquid propane, a gas which is sprayed into the fog in the form of tiny droplets whose evaporation cools the surroundings and causes the supercooled droplets to crystallize.

The evaporation of a gram of liquid propane in the temperature range from -5^{0C} to $-10^{0}C$ results in the formation of 10^{11} crystals which grow to the size at which they precipitate.

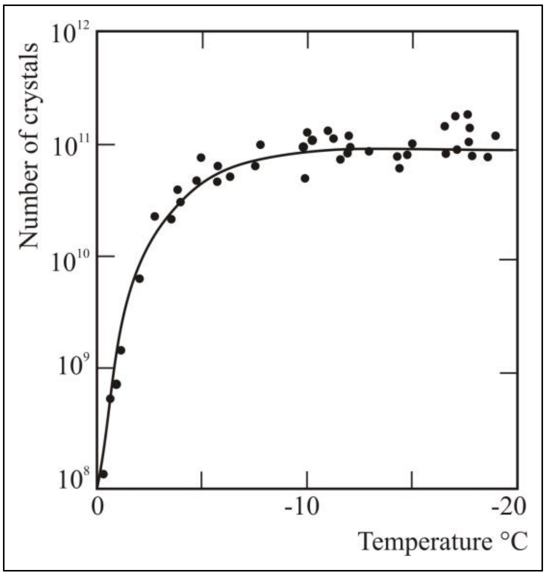

Fig. 1. Model of the dependence of the number of crystals per gram of liquid propane on temperature

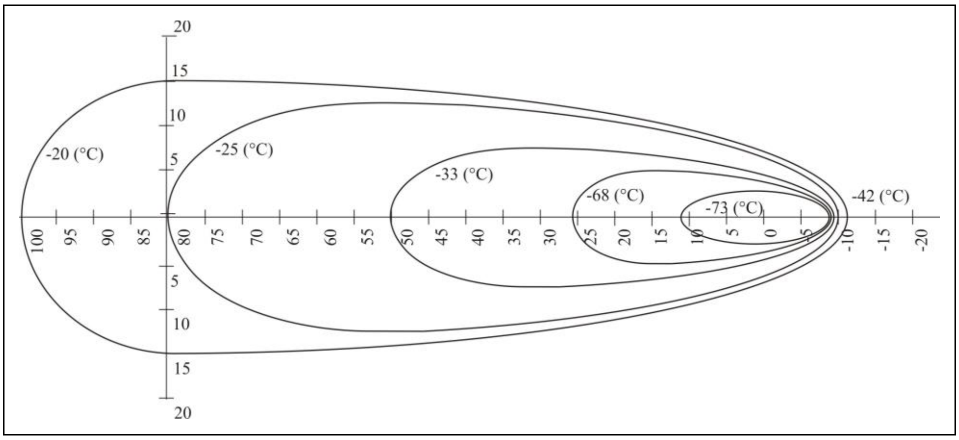

Fig. 2. Temperature distribution in a stream of liquid propane coming out of a nozzle at the rate of 28 (kg/h) (RHMZ, 1986.).

5. DISPERSAL OF SUPERCOOLED FOG

The purpose of dispersing fog is to improve visibility at open pit mines. Visibility is improved by spraying fog with liquid propane. Visibility is calculated in such cases from the following equation:

$$V = 3.912/SK_iN_ir^2 \quad i = 1 \text{ to } n \quad \text{where:}$$

N - water droplet or crystal concentration in fog
r - fog particle radius
K - fog particle contraction effectiveness

It arises from the equation that visibility is in an inverse proportion to the square of the fog particle radius.

The commencement of spraying and duration depend on:

- fog intensity
- air temperature
- prevailing flows (1)
- fog water content
- orography
- road network

Reagent proportioning should be varied depending on:

- fog type
- density
- temperature
- wind velocity

Using π theorem, it is possible to obtain the relations for calculating the width of crystallization:

$$l = C_l\, d^{1+\alpha} / v^{\alpha}\, t^{\alpha} \qquad (2)$$

where:
C_1 – constant
α – constant
v – wind velocity
t – dispersal duration

It has been experimentally determined constant that $\alpha \approx 1$ and $C_1 \approx 1/3$
For the thus determined constant, equation (2) becomes:

$$l = d^2/3vt \qquad (3)$$

It is possible to derive the relations for determining the reach over the other physical parameters:

$$d = C_d\, d^{1+\alpha} / v^{\alpha}\, t^{\alpha} \qquad (4)$$

In this case $\alpha \approx 1$ and $C_1 \approx 9$ so that we get

$$d = 9l^2/vt \qquad (5)$$

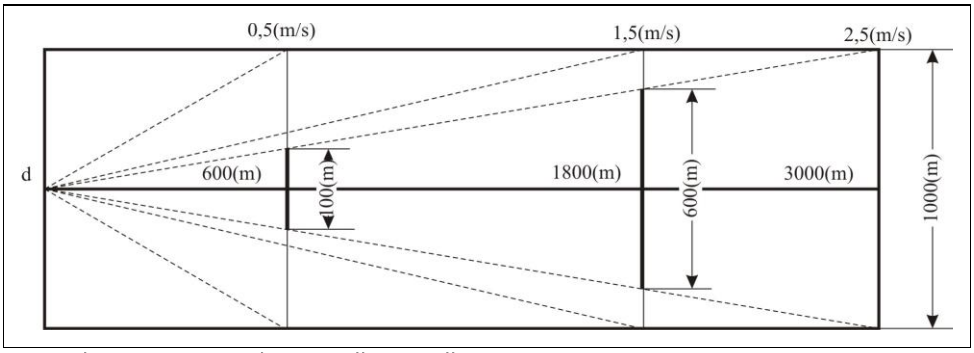

Fig. 3. Model of the spread of crystallization zone from one diffuser at different velocities and in moderate inversion (crystallization 20 min. From the commencement of spraying)

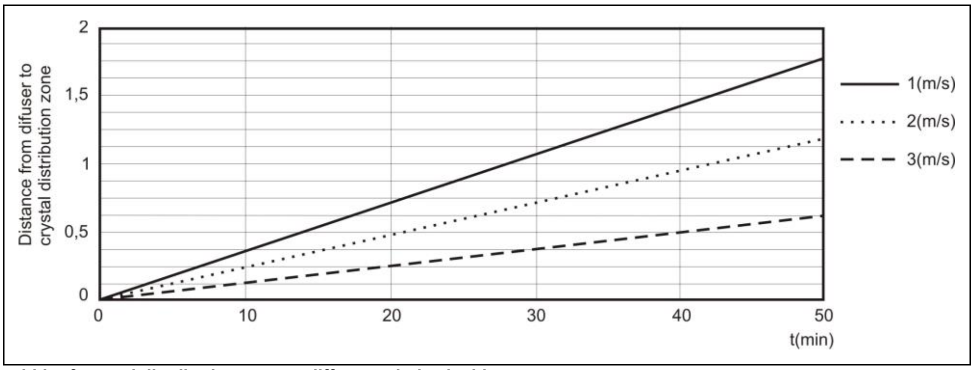

Fig. 4. Model of the width of crystal distribution zone at different wind velocities

6. DETERMINATION OF SUITABLE LOCATION FOR THE INSTALLATION OF STATIONARY DIFFUSERS

The determination of the most suitable locations for the installation of stationary devices for spraying supercooled fog depends on:

- prevailing flows
- position of equipment, excavators on the site
- temperature
- inversion intensity
- fog water content
- state of road network

For the sake of efficient dispersal, it is recommended that diffusers be positioned in a line down wind. The system consists of three diffusers positioned at the distance of 500-800 (m) (triangle system). Mobile units should be used in the situations when the prevailing flow directions are unfavourable in relation to the network of stationary diffusers.

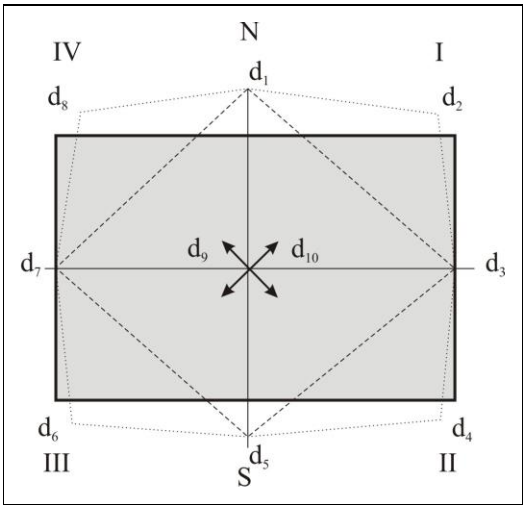

Fig.5. Model of setting up the network of stationary diffusers

7. INVESTIGATION RESULTS IN THE PERIOD UNDER OBSERVATION

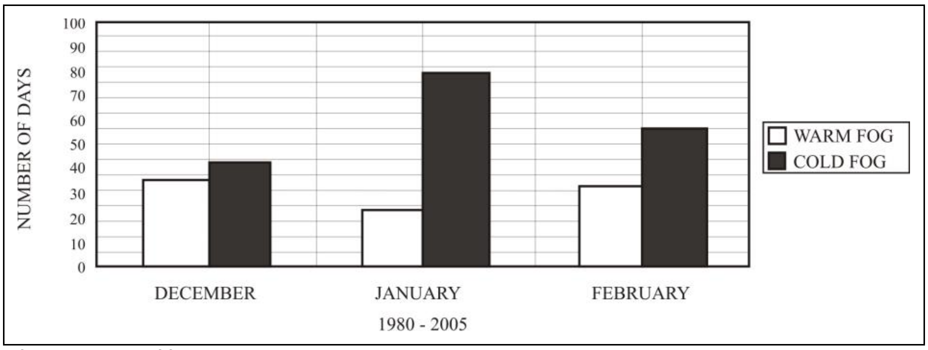

Fig. 6. Discrete model of the incidence of fog in the period under observation

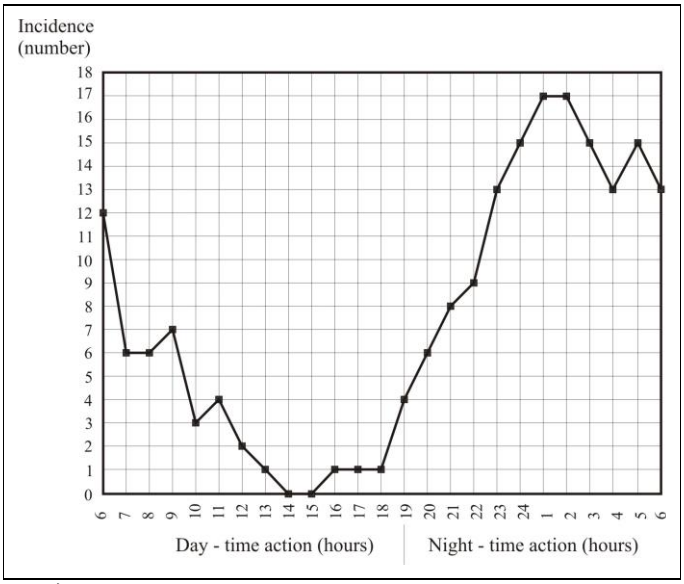

Fig. 7. Incidence of acting on supercooled fog in the period under observation

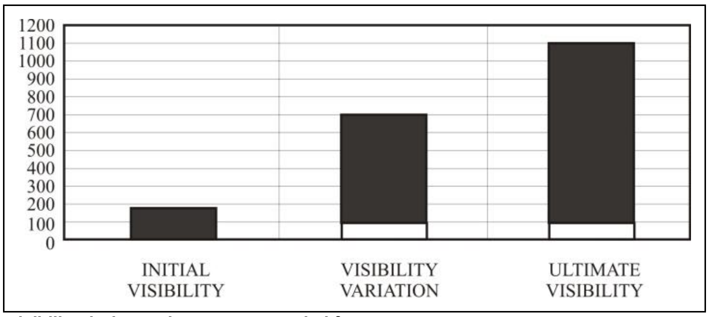

Fig. 8. Discrete model of improving visibility during action on supercooled fog

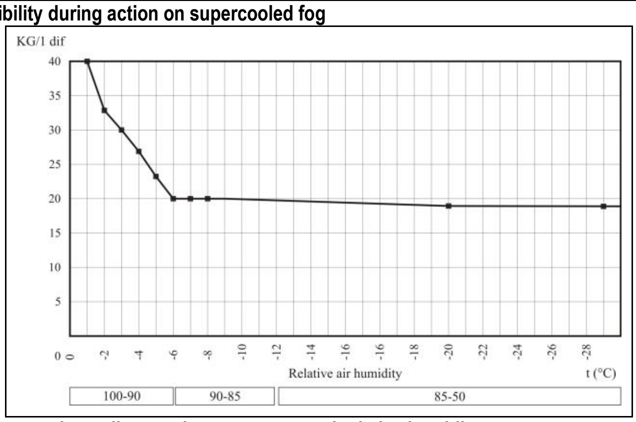

Fig. 9. Model of proportioning liquid propane depending on air temperature and relative humidity

8. CONCLUSION

Adequate application of systems for dispersal of super cooled fog shows positive results in terms of time utilization of open pit mines mechanization, higher safety at work and other effects considering energy savings and ecology. It is very important to keep in mind that these systems could be installed at the aero ports in order to achieve greater safety when the visibility is smaller than allowed, for the road infrastructure and cities in which super cooled fog appears frequently.

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