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AIR FLOW ASSESSMENT IN TYPICAL VENTILATION NETWORKS IN ROMANIAN COLLIERIES USING AUTOMATED VELOCITY TRANSDUCERS

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ABSTRACT. As it is known, a precise estimation of a mine ventilation system's efficiency highly depends on the accuracy of airflow measurements. The airflow and speed of air are also basic aerodynamic parameters to be considered when establishing the power required to carry out the ventilation process. The passing, from mean velocity measurements in a cross-sectional area of working, using hand - held anemometers, to point like measurements - with automatic devices - imposes to establish the demands providing a correspondence between the two types of measurements, at the same accuracy degree. Consequently, the aim of the present paper is to solve two objectives: establishing the distribution of velocity lines for different profiles and support types; determining a rational positioning point for velocity - monitoring transducers and values for the correction factors used in obtaining a mean velocity. Within this scope, detailed measurements were carried out in collieries from Valea Jiului coal basin. Some major conclusions were emphasized, as a result of analyzing work made on the achieved data. The paper was a compulsory stage, and the results obtained were integrated in the action of automatically surveying of ventilation, in the collieries from Valea Jiului (Romania) coal basin.

ИЗМЕРВАНЕ НА ВЪЗДУШНИЯ ПОТОК В ТИПИЧНИ ВЕНТИЛАЦИОННИ МРЕЖИ В РУМЪНСКИТЕ КАМЕНОВЪГЛЕНИ МИНИ ЧРЕЗ ИЗПОЛЗВАНЕ НА АВТОМАТИЧНИ СКОРОСТНИ ПРЕОБРАЗУВАТЕЛИ

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РЕЗЮМЕ. Както е известно, точната оценка на ефикасността на вентилационните системи в мините зависи от точното измерване на въздушния поток. Въздушния поток и скоростта на въздуха са основни аеродинамични параметри, които трябва да се имат предвид при определянето на мощността на вентилационната система. Преминаването от измерване на скоростта в напречни райони чрез ръчни анемометри към измервания с автоматични приспособления налага установяването на съвместимост между двата метода и една и съща точност. Целта на настоящото изследване е решаването на два проблема: установяване на разпределението на скоростните линии при различните профили и поддържащи типове; определяне на рационална точка за скорост – мониторингови трансформатори и оценяване на точността на факторите, използвани при определяне на получената скорост. Направени са основни измервания в въглищния басейн на каменовъглена мина Валеа Джулиу. Като резултат от направения анализ са обосновани някои основни заключения. Изследването има задължителен характер и установените резултати са обстойно прегледани във вентилационната система на каменовъглената мина Валеа Джулиу (Румъния).

Introduction

As the airflows cannot be directly measured it is needed to measure their physical effects induced by air displacement or - when tracer gas techniques are applied - resorting to chemical analyses.

The most common device for underground measurements is the anemometer. As air velocity is considerably altered in the cross-sectional area of any mine working, hand-held anemometer based measurements has to be performed in such a manner which covers the whole area, allowing the determination of mean air velocity.

The passing from mean velocity measurements in a cross-sectional area of mine working, using hand - held anemometers, to pointlike measurements - with automatic transducers - impose to establish the correspondence between these two measuring techniques, at same accuracy degree.
Consequently, the research was directed to solve the following main issues:

- -assessment of velocity distribution patterns for different mine working profiles and support types;
- -determination of a rational positioning point for velocity monitoring transducers and correction factor values employed in order to obtain the mean velocity values.

Assessment of air velocity distribution patterns in different mine workings

Measurements were carried out, using four different methods - based on hand-held anemometers - in 43 mine workings from Dâlja, Petrila, Aninoasa and Livezeni collieries, in view of establishing the air velocity distribution patterns in:

- intakes and returns;
- mine workings traversed by a wide range of air flow quantities;
- mine workings with high and low levels of technological operations.

temperature differences.

The results obtained revealed the following findings:

– the mean velocity values determined through all the employed methods were considerably close, airflows being steady enough during a two hours period and affected only by minimal errors;

– the ratio between the mean velocity V_m and the maximum velocity V_M has ranged from 0,65 to 0,93, values which proves the unsymmetrical character of velocity profiles; this finding indicates that profiles can be unequally developed and the maximum velocities area is not necessarily placed in the mine working's center;

– at air velocities higher than 0,5 m/s, the average value of measured velocities in the upper third of the mine working is closely equal to the mean velocity in the entire section.

On measurement basis, velocity profile types were graphically represented for TH metal-arch supported and masonry and concrete lined workings (see figures 1 and 2). The majority of the obtained profiles are parabolic ones, regular or irregular.

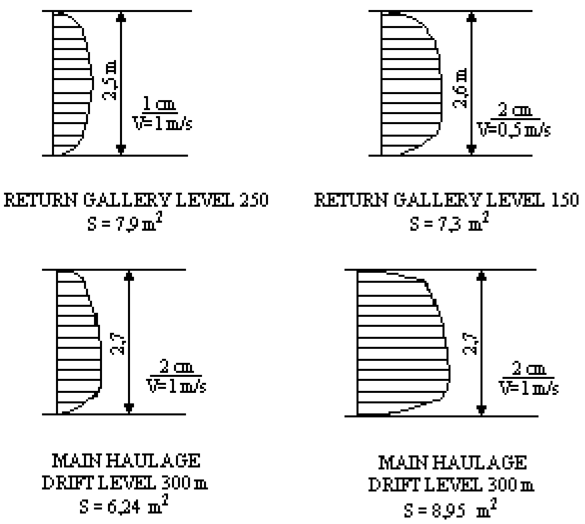

Fig. 1. Air velocity profiles in TH – arch supported mine workings, Petrila Colliery

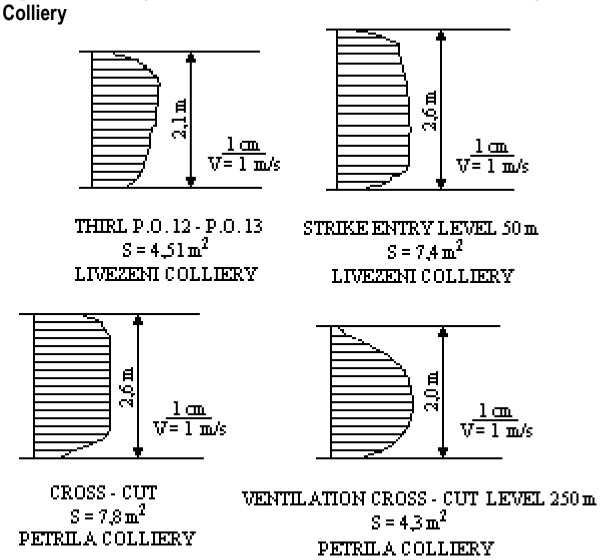

Fig. 2. Air velocity profiles in concrete supported mine workings, Livezeni and Petrila Collieries

Specific to intake workings are the profiles developed at the working's bottom and flattened at the top, as a consequence of temperature differences.

Assessment of velocity transducer rational positioning and correction factors to obtain the mean air velocity

For the flow in circular ducts, where Reynolds number Re=10^5, the velocity profile is entirely turbulently developed, the ratio between mean and central (maximum) velocities being:

$$\frac{V_{mean}}{V_{\max}} = 0{,}83$$

(1)

High rates of mean velocity increases or decreases do not change this ratio significantly (more than 5 percent). Therefore, it is assumed that knowing this ratio would allow direct mean velocity assessment, but only if measurement can practically be done in the central axis.

If measurement is carried out in any other point, it is required to assess another correlation factor, respectively a position factor FP, which multiplied by measured velocity value should give the mean velocity value:

$$V_{mean} = FP \cdot V_x \tag{2}$$

Hence, considering an "a" radius duct, having the maximum velocity V_M in the central axis, the symmetrical velocity profile can be obtained, based on the following function: $V_x = f(x, V_M)$, where $0 < x < a$.

Mean air velocity is given by:

$$V_{mean} = \frac{2}{a^2} \cdot \int_0^a x \cdot f(x, V_M) \cdot dx \tag{3}$$

and

$$FP = \frac{V_{mean}}{V_x} \tag{4}$$

Determining the ratio between mean velocity and velocities of various points placed on symmetrical profile curves, for 3 specific functios (circular, parabolic and irregular), the dependence position factor FP versus x/a ratio was obtained (see figure 3).

It can be seen from the diagram that for all the four profiles, a ratio $\tilde{x}$0,6 exists for which FP=1. It follows that measurement should not be necessarily done in the maximum velocity point, but in another one, and multiplying the measured value with a position factor the mean velocity will be obtained.

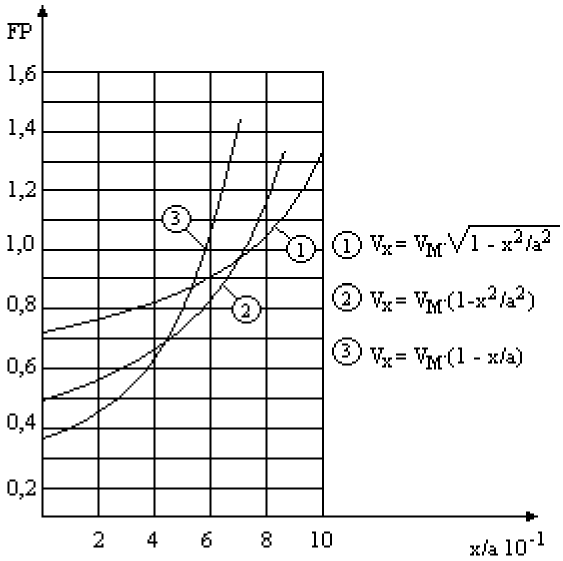

Fig. 3. Air velocity profiles (1 – circular profile; 2 – parabolic profile; 3 – irregular profile)

For "a" radius circular ducts, measuring in a point x/a=0,6 gives directly the mean velocity, while FP equals the unit.

Similarly was approached the case of mine workings, but giving consideration to the unsymmetrical pattern of velocity profiles and to the need of placing the transducers in a way which could not affect them by the technological operations.

Consequently, as a function of the real unsymmetrical velocity profiles obtained, the correlation between the correction factor (denominated by position factor FP) and pointlike velocities measured in the upper third of the cross-sectional area of mine workings was assessed.

These correlations were established for TH - arch supported (figure 4) and concrete supported mine workings (figure 5), considering that the V_{mean}/V_x ratio approximates the unit in points placed in the upper third of the mine workings. This area allows an easier placement and safer operation from the technological point of view.

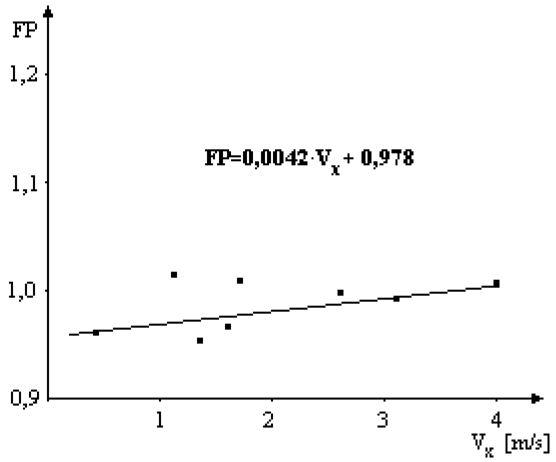

Fig. 4. The correlation between the position factor FP and pointlike velocities established for TH - arch supported mine workings

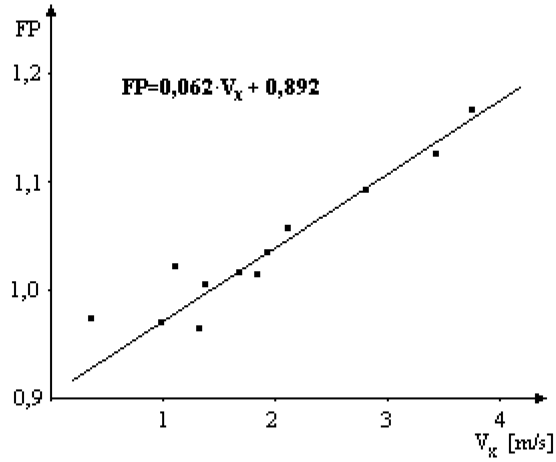

Fig. 5. The correlation between the position factor FP and pointlike velocities established for concrete supported mine workings

Measurements were carried out in two workings at Aninoasa Colliery, in the range of 0,6-1,8 m/s velocities (Priboi Station) and 4-6 m/s (Piscu Station) using the ATM-689 automatic velocity transducers connected to the central telemetry mine system.

A linear relationship was obtained between the position factor FP and the air velocity for both measuring stations (see figures 6 and 7), and FP=1 was found stable, with maximal variations from -3 % to +7 %,when the transducer was centrally located at h/6 distance from the working's top.

b.The computation of air quantities in workings not provided with transducers, based on Khirchhoff's first law ($\sum Q_i=0$).

If we consider a mine ventilation network with "m" branches and "n" junctions, the total number of necessary transducers is given by the number of independent meshes:

$$\gamma = m - n + l \tag{5}$$

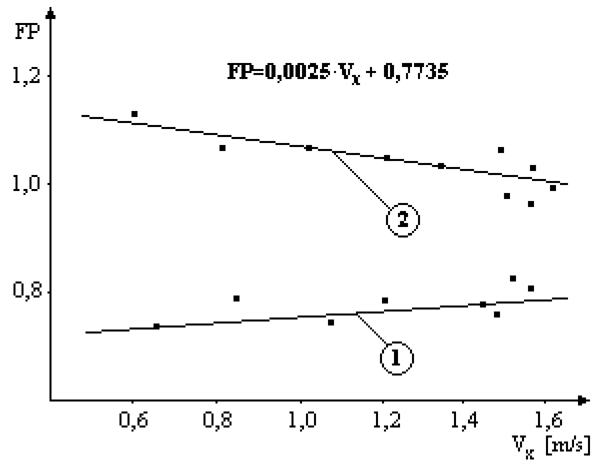

Fig. 6. The correlation between the position factor FP and the air velocity for both measuring stations (1 - placement at h/6 from the entry top and wall; 2 – central placement at h/6 from the entry top)

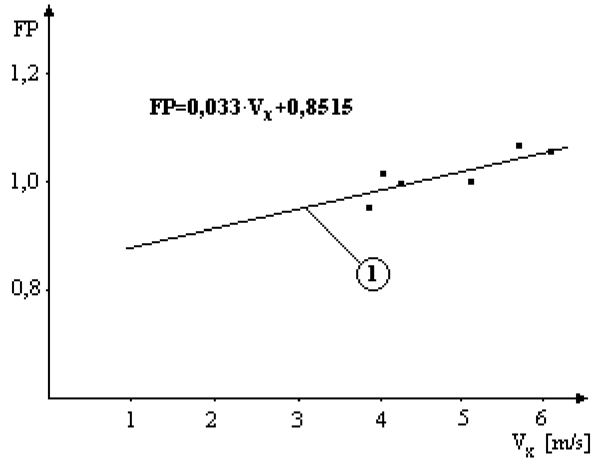

Fig. 7 The correlation between the position factor FP and the air velocity for both measuring stations (1 – central placement at h/6 from the entry top)

As an example, Livezeni colliery having a ventilation network with 73 branches and 43 junctions would necessitate at least 33 transducers (73-41+1). This number can be diminished by eliminating the branches with less than 100 m^3/min. air quantities.

In workings ventilated by means of auxiliary systems, transducers will be placed at h/6 from the working's top, or at the auxiliary ventilation duct's end.

Conclusions

The results of experimental research regarding the feature of converting pointlike air velocities into mean velocities, allowed to emphasise the following conclusions:

- in any subsurface mine working, the mean velocity being greater than 0,013 m/s and Reynolds number greater than 2500, the flow occurs in turbulent conditions, excepting areas just nearby the walls, where it is laminar;

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- air flow in circular ducts for Reynolds number $Re=10^5$ is turbulent and velocity profile is symmetrical and entirely developed,
- the ratio between mean and maximum the velocity being 0,83;
- results of the measurements carried out at Dâlja, Livezeni, Petrila and Aninoasa collieries and in an experimental aerodynamic tunnel revealed that air velocity profiles are parabolic, regular or irregular; in TH - arch supported and concrete or masonry supported mine workings, the unsymmetrical velocity profiles are developed either in the upper or the lower half of the workings, the ratio between mean and maximum velocities varying in a wide range (0,65 – 0,93);
- for velocities higher than 0,5 m/s the average value of measured velocities in the upper third is approximately equal to the mean velocity;
- the established correlation between the position factor FP and the pointlike measured velocities in the upper third (h/6 from the working's top) allows the determination of mean air velocity;
- actually verifications of the rational transducer placement point,carried out in Aninoasa colliery with ATM - 689 transducer spotlighted a close to unit value of FP, with a deviation range from -3 % to + 7 %.
- the minimum number of branches equipped with air velocity automated monitoring devices, is given by the number of independent meshes contained within the network (γ=m-n+1). As an example, for Lupeni colliery it was determined that complete control of air flows could be achieved by using only 33 transducers.

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