50 years University of Mining and Geology "St. Ivan Rilski"
Annual, vol. 46, part III, Mechanization, Electrification and Automation in Mines, Sofia, 2003, pp.91-94

VENTILATION OF ZONES OF POTENTIALLY EXPLOSIVE GAS ATMOSPHERE
ВЕНТИЛАЦИЯ НА ЗОНИ С ПОТЕНЦИАЛНО ОПАСНА АТМОСФЕРА

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ABSTRACT

The need for guaranteeing the low concentrations of flammable substances in manufacture, where the formation of potentially explosive gas atmosphere is possible, requires development and use of special fans. Fans should be constructed with technical and maintenance characteristics, which do not allow ignition of the explosive gas atmosphere within the fan in both regular and accidental mode of operation.

The present article reports the construction of a fan with a system for stroke protection and bearing temperature control allowing the theoretical and experimental determination of the probability for ignition of explosive gas atmosphere within its casing. A fan performed in that construction is considered as a spark-free. fan

INTRODUCTION

In recent technologies of production, storage and use of flammable liquids, gases and powders, more and more efforts are devoted to involving approaches and methods, in which the release of flammable substances in the air will be reduced to the minimum.

Nevertheless, technological processes related to underground coal mining, production and chemical petroleum processing, painting and lacquering in both regular and accidental mode of operation are characterized with release of flammable gases, vapors or dusts.

Similar are the cases, when raw materials or products are flammable substances, which need to be transported, poured out, weighted or stored in warehouses.

Those technological processes require ventilation of premises with the aim of maintaining low concentrations of the flammable substance in the potentially explosive gas atmosphere. Fans, the technical and constructive characteristics of which do not allow them to cause fires and explosions, achieve the above objective.

There are requirements, within the regulations acting in Bulgaria and some other countries that those fans should be in a spark-free performance. However, there are no clearly defined criteria.

REASONS FOR THE ORIGINATION OF FRICTIONAL SPARKS AND LOCAL HEATNG IN THE FANS

Except for the electric motor, the explosion-proof performance of which is complied to the location of operation, sources of ignition of the explosive gas atmosphere might be frictional sparks or local heating, caused by strike or friction between movable or immovable parts of the fan. Reasons for the appearance might be as follows:

- falling of solid particles, carried by the air flow in the body of the fan;
- axial or radial displacement in the turbine, caused as a result of damages in the bearings.

Researches showed that frictional sparks, caused by stroke or friction between movable and immovable parts of the fan may bring to establishing of real conditions for ignition of the explosive gas atmosphere, passing though the fan.

MEASURES FOR PREVENTING THE ORIGINATION OF DANGEROUS FRICTIONAL SPARKS

Referring to resent fan construction for operation in explosive gas atmosphere, the measures applied for achieving safe operation of fans are reduced to the following:

- Use of bearing of rather high resource and improved wearing;
- Use of special lubrications;
- Use of special couple of metal for manufacturing of turbine and the inlet pipe, which are believed not to ignite the explosive gas atmosphere, passing through the body of the fan;
- Use of different plastics for the turbine and the inlet pipe.

The above constructions do not allow the determination of probability of ignition of explosive gas atmosphere neither experimentally nor theoretically.

Predicting of possible damages in the bearings of the turbine, which bring to operation of the fan in an accidental mode is also difficult. For that reason, up to now there is no unified statement or standardized requirement to define the constructive characteristic of fans for ventilation of hazardous zones, conditionally called "spark-free" (Regulation No 2).

That issue may be resolved by the introduction of a system for protection in the construction of fans, which allows theoretical and experimental determination of probability for ignition of explosive gas atmosphere. The system realizes a continuous control of the condition of fan and in case of some damages it work ceases. In that case neither dangerous sparks nor local heating is possible.

SYSTEM FOR PROTECTION AND CONTROL OF SPARK-FREE FAN CONDITION

The system for protection and control may be implemented in each ventilator, in spite of its construction. It consists of:

- Electrical switching of the feeding voltage of the electrical motor with the first possible stoke of turbine to any immovable part of the ventilator (confuser – the closest immovable part);
- Thermal control of bearing condition.

The electrical switching of turbine into immovable parts of the fan is done by a sensor (a metallic plate isolated from the casing of the fan), laid down between the turbine and the confuser.

In case of radial displacement of the turbine, an electrical contact takes place between the turbine and the sensor and it takes the potential of the earthening contour. This brings to switching off the electrical motor from the power supply. The number of dangerous frictional sparks, if admitted that they may originate is equal to the number of revolutions till the absolute stopping of movable parts (turbine, connecting coupling and rotor).

That system for protection by electrical switching off is analogous to the explosion-proof performance "increased safety – e", standardized for electrical appliances.

When the number of strikes is known then probability of ignition of the explosive gas atmosphere, passing through the fan, is predictable.

Thermal control of bearing is in fact a supplementary independent device for protection. It is used for continuous indirect monitoring of bearings in the period between repairs.

In case of random damages the electric motor switches off from the power supply and this prevents the long work of the fan under an accidental mode of operation.

Reasoned on specific requirements for appliances from group I and group II for operation in potentially explosive gas atmosphere, fans possessing the suggested system for protection and the additional independent device for monitoring of bearing temperature may be referred to category M1 for operation in mines and to category 1 – for the other industries (Directive 94/9/EC).

The construction of a fan, which implies the described system for protection and bearing temperature monitoring, is shown in figure 1.

Electrical circuits for implementing the switching off in case of strike and thermal monitoring are in explosion-proof performance of individual protection (spark-free performance).

To discharge possible electrostatic charges toward the earthening contour is done by a high-resistivety resistor.

The temperature monitoring of bearings and lubrications done by means of thermal sensors in the bearing box.

The described switching off may easily be adapted to all centrifugal conventional fans and thus they may be adapted into a spark-free performance.

DETERMINING THE PROBABILITY OF DANGEROUS FRICTION SPARKS

The commissioning of a system for protection and monitoring the temperature of bearings may bring to determining the probability of origination of frictional sparks. This is possible because number of possible strikes between the turbine and the confuser depends on known values only.

It is admitted that displacement of turbine is possible during the fan operation. After the first strike, which means after implementation of an electrical contact between turbine and immovable parts of the fan, the switching off starts to act and the electrical motor switches off from the power supply. Then number of strikes will depend only on inertial masses of rotating parts (turbine, rotor, coupling and bearings). For each couple of fan – motor, they are known in advance and therefore, number of revolutions until complete stopping is determined by the formula:

$$n = \frac{E_{K(1)}}{(dM_{TP} + dM_A + M_{CП}).2\pi}, \min^{-1} \qquad (1)$$

$E_{K(1)}$ – kinetic power in the initial moment of stopping

dM_{TP} - moment of friction in bearings

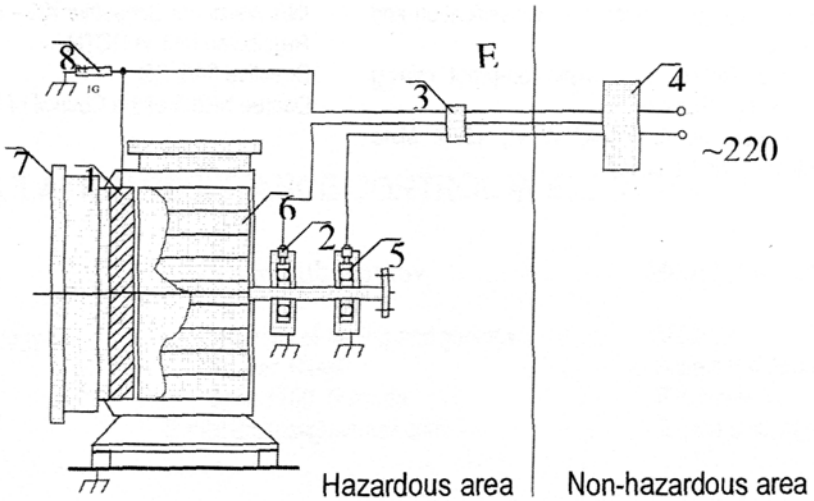
dM_A – moment, created by aerodynamic resistance, which depends on the construction of working wheel and its aerodynamic characteristics.

$M_{CП}$ – stopping moment, depending on force of contact between turbine and confuser

Then the probability of ignition ($P_{ВЗП.}$) of the explosive gas atmosphere in the fan is determined as a ratio of number of strikes **n** towards the number of realized ignitions **m**, or

$$P_{ВЗП.} = \frac{m}{n} \qquad (2)$$

Laboratory tests show that the probability is with the range of 10^{-8} to 10^{-11}.



1. Sensor
2. Thermal
3. Coupling box in explosion-proof performance
4. Automation to the system for protection and monitoring
5. Bearing body
6. Turbine
7. Inlet pipe
8. Resistor

Figure 1. Scheme of the switching off for spark-free fan

Not only possible ignition from hazardous frictional sparks, but also local heating is considered.

In consideration of possible damages in bearings within their resource, it is accepted that current of events is precisely enough subordinated to the law of Poisson and the probability ($P_{ПВР.ЛГ.}$), is determined by the expression:

$$P_{ПВР.ЛГ.} = 1 - e^{-\mu.t} \qquad (3)$$

μ – density of current of events from different damages (number of damages for a unit time);
t – duration of period between repairs

For roller bearings that probability in the period between repairs is within the range of 10^{-3} to 10^{-4} (INA Walzlager Schaeffler KG).

Based on the above, a system for protection and additional device for monitoring the temperature of bearings, which switches the electric motor off is adapted. The probability of ignition of the explosive gas atmosphere in its casing ($P_В$) is determined by the product of probabilities for appearance of hazardous frictional sparks ($P_{ВЗП.}$) and probability of damage of bearings ($P_{ПВР.ЛГ.}$):

$$P_B = P_{ПВЗ}.P_{ПВР.ЛГ.} \qquad (4)$$

Having in mind the above ranges of probabilities ($P_{ВЗП.}$) и ($P_{ПВР.ЛГ.}$), and in compliance to (4) the probability ($P_В$) acquires values within the range from 10^{-11} to 10^{-15}.

Applying the requirement for coefficient of resource κ=1.5, the probability ($P_В$) acquires values within the range from 10^{-6} to 10^{-10}.

In the case of those probabilities, a fan adapted according to the above approach, may be considered a non-damageable machine.

CONCLUSION

The discussed construction shows a new principle for implementation of spark-free centrifugal fans, based on principles analogous to standardized explosion-proof performance "improved safety – e".

Fans, adapted accordingly, have been applied into workshops of pharmaceutical industry and workshops for painting and lacquering for more than 6 years.

There have not been any damages and accidental situations since.

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Recommended for publication by Department of Electrical Engineering, Faculty of Mining Electromechanics