Research and Design of the Coal Mine Energy Saving Type Pneumatic Low Temperature Magnetization Water Dust Removal Device

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Abstract

According to the requirement of high safety underground coal mine, we choose pneumatic motor as the power source to replace the traditional motor. Using magnetized water reduces the surface tension, dynamic viscosity and improves the wettability of dust and other characteristics, so as to achieve the dual objectives of high temperature working surface cooling and dust removal, and water utilization rate has been greatly improved as well. This equipment can not only improve the working environment and the work efficiency, but also protect the underground safety production.

Keywords

Mine; Pneumatic motor; Magnetized water; Cooling and dust removal; Underground safety.

1. Introduction

With the rapid increase of coal production and the improvement of mine production mechanization, the mine dust quantity is increasing and has become one of the most serious disasters in coal industry. At present, the main measures and methods of coal dust control in China and abroad are also varied. To the coal seam pre wet and water dust [1], To strengthen the dust management in mining [2], digging the working surface. The use of physical and chemical dust prevention technology and individual protective measures [3]. But the surface tension of the water of the above measures is too large, and the effect of catching dust is poor. According to statistics, the state-owned key coal mine average annual increase is 9 m, mining depth greater than 700m of the mine has more than 50, the deepest mine has more than 1000 m. High temperature has great influence on the work efficiency, safety and health of the workers in the underground [4-7].

In view of the above problems, we propose the technology of reducing the temperature of the cooling water in the air. We combine magnetized water dust technology with mine air-conditioning system, and take effective use of pressure duct in the wind with pneumatic motor to provide power for the whole system. This technology will largely reduce the dust diffusion in the working face and reduce the working surface temperature.

2. Experimental

2.1. Overall design of the device.

We detect the dust concentration in the workplace by dust concentration sensor, and then control the switch of the wind pipe according to the change of the concentration. When the wind line is connected, the compressed air (0.5-0.6 MPa) in the wind pipe is driven by the pneumatic motor, and the pneumatic motor drives the compressor and the magnetization. At this point, the water temperature in the water pipe in turn goes through the compressor, condenser, evaporator and throttle valve to form a refrigeration system into a low-temperature water, and then after the magnetization, it turns into a strong adsorption capacity of magnetized water, and finally the low temperature magnetized water is sprayed by the spray nozzle. The system design scheme is shown in Fig. 1.

2.2. Pneumatic motor selection.

Pneumatic motor is a pneumatic actuator, which converts the energy of compressed air into the mechanical energy of continuous rotary motion. We take into account that the pneumatic motor is used as the original motivation of the compressor, demand the higher speed, so the choice of blade type pneumatic motor is considered. Its structure is simple, explosion-proof performance is good, at the same time, the impact of high temperature and vibration is very small. This system chooses EMY250 type pneumatic motor; the parameters are shown in Table 1.

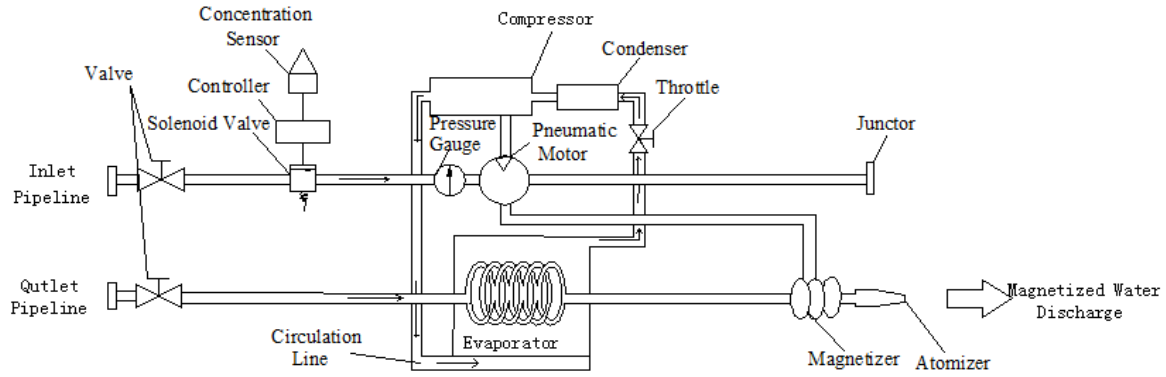

Fig. 1 Design diagram of low temperature and water cooling system

Table 1 Pneumatic motor parameters

Model	Rated Horsepower /*hp*	Rated Speed /*r.p.m*	Rated Torque /*N.m*	Gas Consumption /*L/min*	Working Pressure /*MPa*	Weight /*Kg*	Output Axis
EMY250	2.5	1400	12.5	3000	0.6	12.8	*Φ*20

2.3. Atomization nozzle design.

We designed a spiral nozzle, shown in Fig. 2, it can produce umbrella water curtain, or rotating jet. The expansion of the rotating jet can be faster than that of the corresponding non rotating jet, and the attenuation of the entrainment ability, the mixing effect, and the axial velocity of the jet is larger than that of the ordinary jet. The main difference between this kind of jet and conventional round jet is that its shape is trumpet shaped, so it has a strong ability to spread and absorb the surrounding medium and can form a large impact area and produce good atomization effect.

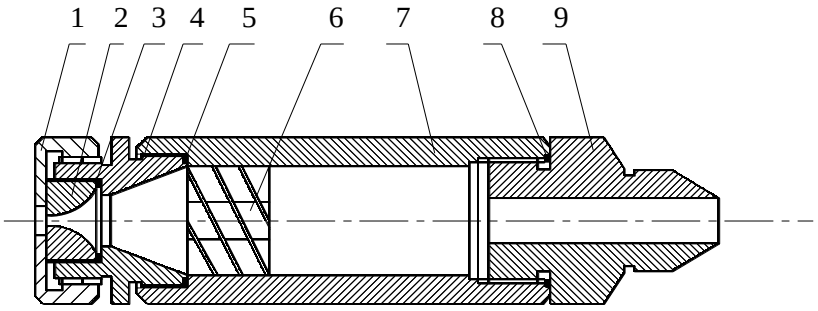

Fig. 2 Design of the spiral spray nozzle
1-Front Nozzle, 2-Nozzle, 3-O-Ring, 4- Conical Section, 5-O-Ring, 6-Add Spin Element, 7-Straight Section Tube, 8-O-Ring, 9-Nozzle Joints Base

2.4. Magnetizing device selection.

In this system, a strong magnetic field is chosen to carry on the magnetization of the water and the magnetic induction intensity is 170 mT, which is to ensure the best magnetization. The strong magnetic magnetization device has the characteristics of energy saving, environmental protection, high efficiency, stable performance, high grade explosion-proof magnetic shielding and so on.

3. Results and discussion

Water samples were selected as test materials, in order to eliminate the influence of gas impurities and temperature in the water surface tension and dynamic viscosity, we will store the tap water in the bucket, exposed in the air for 24 hours, and then test the water samples when with stable property. Specific experimental steps are as follows:

(1) The magnetic water device is arranged on the nearest water injection pipe of the distance nozzle, the magnetic water device to the outlet of the distance is 0 by default;

(2) Start the pump, the fixed flow rate is 1m/s;

(3) The magnetic induction intensity of the magnetic water heater was 0, 50, 100, 170, 240, 280, 330, 400, 500 mT, and then determine the surface tension. The surface tension was measured at 5 times in each magnetic induction intensity, and the average value was taken as the surface tension of the condition;

(4) The velocity of the flow is 0.6m/s and 0.2m/s, respectively, and the surface tension of the water at different flow velocity is measured.

3.1. Effect of magnetization treatment on surface tension of water.

From Fig. 3 and Fig. 4, it can be seen that magnetic treatment can reduce the surface tension of water, the lower the surface tension of the liquid, the need to overcome the surface tension required to overcome the surface tension is small, at this point, the more easily it will be broken, the droplets will be smaller, and the effect of dust trapping will be better. The surface tension of the magnetic induction intensity was decreased from 0 to 170 mT and 240 to 330 mT, and the magnetic induction intensity reached the lowest value at 170 mT. And the greater the flow rate, the farther outlet water magnetizer distance will be, and the surface tension of water drop is small.

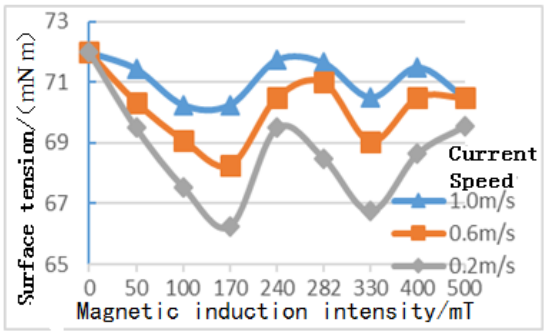

Fig.3 Relationship between surface tension and magnetic induction intensity of water

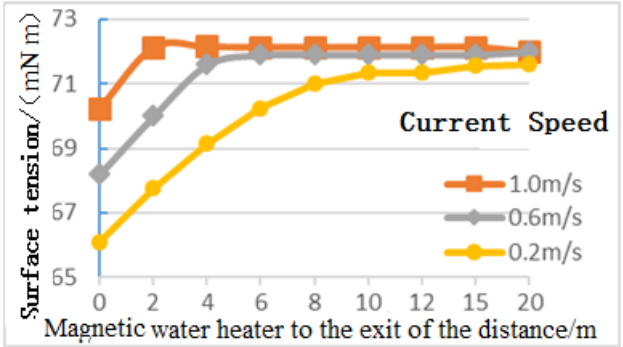

Fig. 4 Relationship between surface tension of water and the position of magnetic water heater

3.2. Effect of magnetization treatment on water viscosity.

From Fig. 5 and Fig. 6, it can be seen that magnetization treatment reduces the effect on the water dynamic viscosity, and the decrease of liquid viscosity increases the Reynolds number, accelerates the development of turbulent prompts the spray of the round jet or liquid jet fragmentation, it also decreases atomized droplet size, and the atomization effect be improved, fog particles evenly be distributed. A fine spray of particles can significantly increase the total surface area of the droplet, resulting in a substantial increase in the probability of contact with the dust, to catch the dust effect is better. Velocity and magnetic water device position on the viscosity of the hydrodynamic effect is similar to the surface tension, that is, the greater the speed is, the farther the magnetic water from the device to the position of a water outlet will be, and the dynamic viscosity of water reduced value will be smaller.

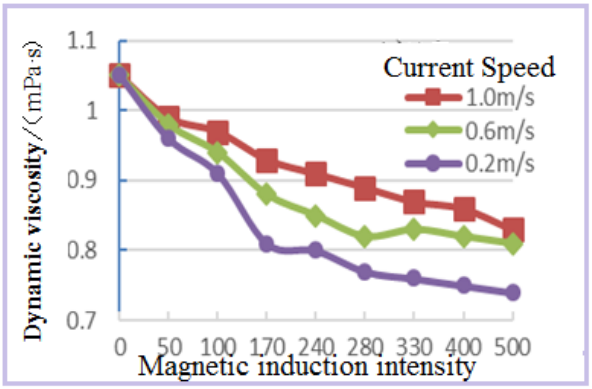

Fig. 5 Relationship between the dynamic viscosity and magnetic induction intensity of water

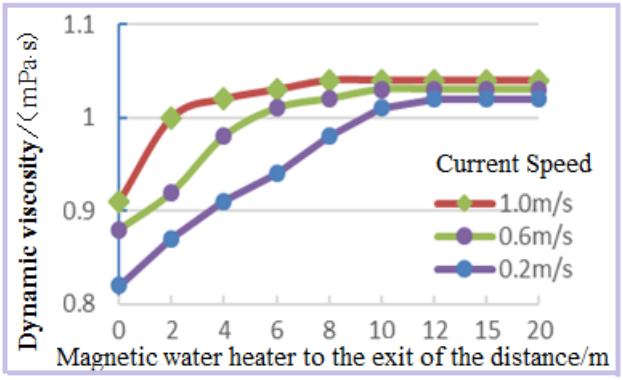

Fig. 6 Relationship between the dynamic viscosity and the position of the magnetic water device

3.3. Effect of magnetized water on the wettability of dust.

From Fig. 7, it can be seen that wet dust removal is mainly through the drop of dust on the dust collection and sedimentation effect of dust, the better wetting effect of water be on dust, the faster the dust capture the dust, the dust settling time is shorter, and the effect is better. In this experiment, the wetting time of the dust was tested by using the fixed wetting time, and the wetting property of the dust in the capillary was compared with that of the non-magnetized water.

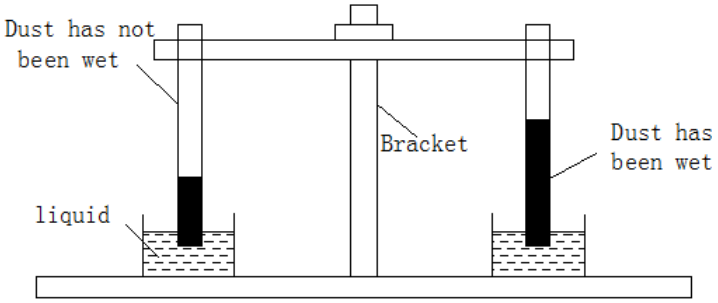

Fig. 7 Experimental apparatus for water wetting rock powder

From Fig. 8, we can see from the diagram that the wettability of the magnetized water is higher than that of non-magnetized water, and Under the treatment of 170 mT magnetic induction intensity, the wetting property of magnetized water is the best. And the amount of dust and moisture in the surface tension of the size approximate inverse proportional relationship.

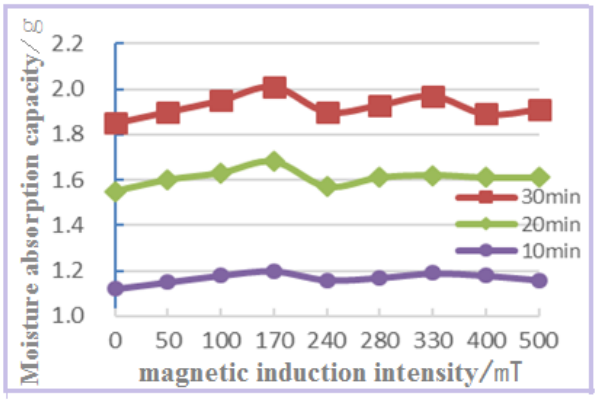

Fig. 8 Relationship between moisture absorption and magnetic induction intensity

3.4. Effect of dust removal under different spray pressure.

The effect of dust on non-magnetized water and magnetized water was tested by using the broken coal dust of the Huainan Mining Group as the experimental dust. Experimental apparatus is shown in Fig. 9.

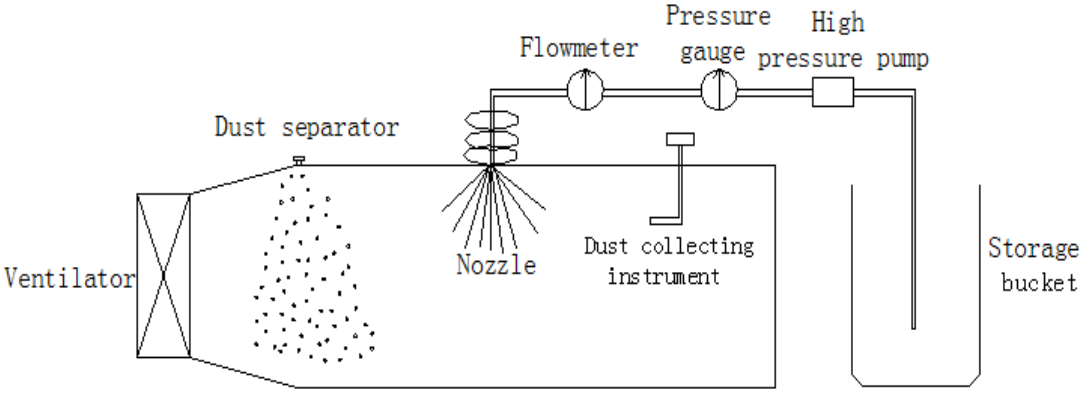

Fig. 9 Experimental apparatus for dust suppression

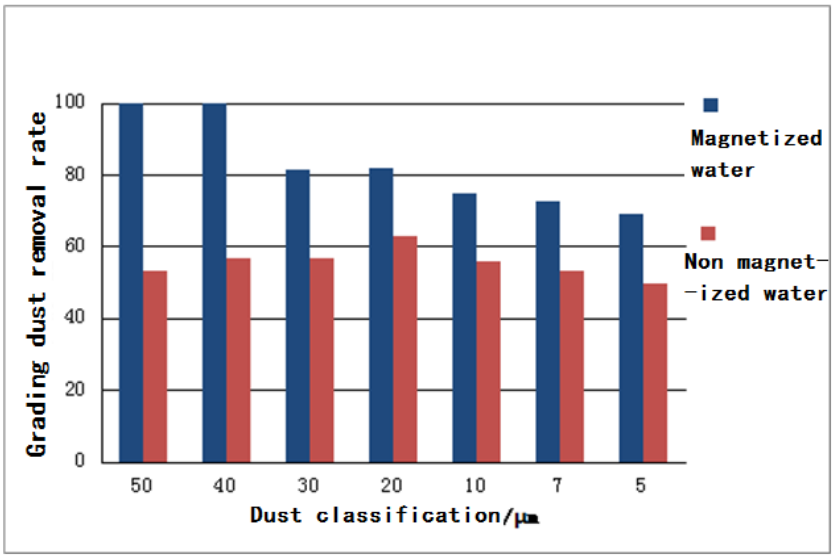

Fig. 10 Comparison chart of the effects of magnetized water and non-magnetized water on the reduction of the dust under the 1.0MPa spray pressure

In the similar model of tunneling, the experiment of spray dust fall is carried out, We control in the tunnel wind speed for 0.25m/s, measuring dust sampling flow for 0.92 m ³/h, pressure test is selected as 1.0 and 2.0 MPa, sampling time for 1min, temperature test set for 25℃, at this point, the nozzle is selected for the spiral spray nozzle. Test results of surface tension, viscosity and wettability of magnetized water are analyzed, from Fig.10 we have optimized the following experimental conditions: the magnetic induction intensity of 0, 170, 240, 330, 500mT, Magnetic water device vertical distance from the outlet is 0,The experimental results of the magnetized water spray dust removal are shown in table 2 and table 3.

From the Table 2 and Table 3, we can know that the use of magnetized water spray, whether it is the total dust falling rate, or the classification of dust removal rate, there is a significant increase compared with the non-magnetized water spray. Especially for the particle size of 10 m below the respiratory dust, the dust removal rate can be increased to about 30%.

Table 2 Comparison of the effect of the magnetized water and the non-magnetized water

Item	Classification rate of dust fall / %						
	50μm	40μm	30μm	20μm	10μm	7μm	5μm
Magnetized water	100	100	81.5	81.7	74.8	72.3	69.1
Non-magnetized water	53.1	56.5	56.7	62.6	55.6	53.3	49.4
Contrast value	46.9	43.5	24.8	19.1	19.2	19.0	19.7

Table 3 Comparison of the effect of the magnetized water and the non-magnetized water on the 2.0MPa spray pressure

Item	Classification rate of dust fall / %						
	50μm	40μm	30μm	20μm	10μm	7μm	5μm
Magnetized water	84.5	87	87.3	84.7	82.7	78.8	76.7
Non-magnetized water	59.0	58.8	58.8	50.6	52.8	48.3	42.8
Contrast value	15.5	28.2	28.5	34.1	29.9	30.5	33.9

4. Conclusion

(1) Magnetized water falling dust equipment is simple, easy to install, explosion-proof, performance reliability.

(2) Does not change the original production order, low cost, one-time investment, long-term effectiveness.

(3) The dust removal rate is higher than that of water and wetting agent; it also can effectively control the surface tension of the water, and capture the effect of breathing dust and other issues.

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