Design of fire extinguishing tank system with multiple induction modes and fixed point injection dry powder

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Abstract. This project has improved the position of the spray head of the traditional hanging fire extinguisher, and has designed a set of practical and innovative fire extinguishing system. A series of design of electronic control valves, directional angle adjustable mechanism and temperature sensitive glass ball automatic trigger device are integrated in the position of the traditional sprinkler nozzle. The new design of the shape makes the spray performance of the nozzle further improved. The traditional single directional dry powder sprinkler is redesigned and redesigned only by suspension, which has the multi angle and omni-directional coverage of the fire extinguishing range of the key fire-proof area. Using the coordination of temperature sensing cable, smoke detector and temperature sensitive glass ball, the system realizes accurate monitoring of far and near ignition points, and effectively improves the response ability of fire extinguishing system.

1. Introduction

With the rapid development of China's industrial and commercial logistics industry. Modern warehouses often store large quantities of high-value goods, once a fire, huge losses. In order to minimize the loss caused by fire, the design and application of advanced fire extinguishing system has become an important part of the overall design of the warehouse [1].

A lot of experts and scholars at home and abroad have different opinions on the research of fire extinguishing system. Zhu Xuebao et al. made a new design for the fire sprinkler, using the design of automatic rotating multi-hole sprinkler, realized the omni-directional direction of water spray, and according to the size of the hole, suitable for different fire situation [2]. In document [3], a distributed fixed point fire extinguishing system based on CAN bus is put forward. A more intelligent and effective fire extinguishing system is designed by combining the early detection and location technology based on image, the CAN bus communication technology and the clean and efficient foam extinguishing technology. An intelligent sensor has been developed abroad, which integrates a silicon wafer with a photoelectric conversion part equivalent to the human eye, a signal transmission part equivalent to the human visual nerve, and a part equivalent to the human brain memory and calculus [4]. The emergence of this sensor further improved the alarm system.

The existing traditional suspended fire extinguisher only sprays fire extinguishing materials to the high temperature and open fire signals near the installation position. Fire occurs far away from the tank body in the protection area, and the damage degree is great when the tank body can sense. When the fire is big, the fire extinguishing effect will also be affected because of the tank capacity and pressure and so on, so the fire extinguishing effect can not be prevented from unburned. Therefore, this paper designed a new set of fire extinguishing tank system to solve this problem.

2. Overview of multi induction fire extinguishing system

The design system is composed of the following parts as shown in Fig. 1(a) Directional Conversion Tube, Self-Triggering Device, Temperature Sensing System and Main Body of Fire Extinguishing Tank. The fire extinguishing system of the fire extinguishing tank can not only sense the high temperature and open fire signals near the tank, but also sense the high temperature and fire signals far away from the tank by adding the temperature sensing cable Fig. 1(b) in the protection range of the original device. Through the signal converter, the temperature sensing signal is converted to electrical signal and transmitted to the fire alarm controller. The "emergency start" switch on the fire alarm controller responds; when smoke is generated in the protection area, the smoke detector responds to the outgoing electrical signal, which is transmitted to the fire alarm controller. Fire alarm controller on the "emergency start" switch response and release dry powder.

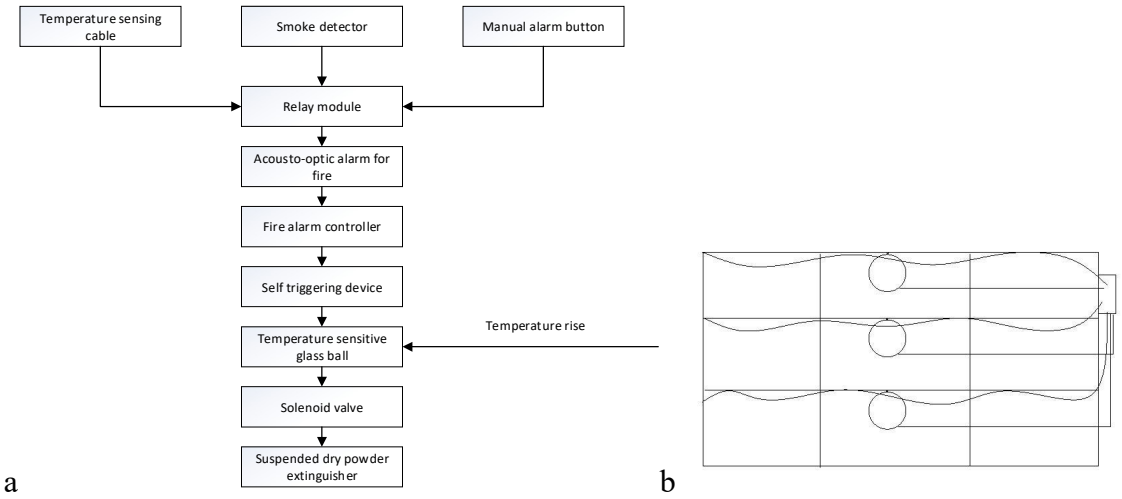

Figure 1. (a)Working flow chart of the extinguisher (b) Layout of fire extinguishing tanks and temperature sensitive cables

3. Design of multi-induction fire extinguishing system

The main body of the multi induction fire extinguishing system is a self triggering dry powder fire extinguisher. Fig. 2 is a main body for improving the fixed point ejector. The fixed-point spraying dry powder fire extinguishing tank is composed of a fire extinguishing tank body, an electromagnetic valve, a direction regulating pipe, a self-triggering device and an improved sprinkler head.

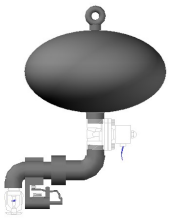

Figure 2. Multi induction fixed-point injection dry powder fire extinguisher

3.1. Design of self triggering device

The self-triggering device is designed with a colliding needle to break the temperature sensitive glass ball[5]. The mechanism device is shown in Figure 3(a), uses the electromagnetic force provided by the electromagnet to overcome the spring's elastic work, Store energy by spring to shatter the temperature sensitive glass ball with a firing pin.

The automatic trigger consists of three parts: the starting mechanism, the ejection mechanism and the fixing mechanism.

The starting mechanism is mainly composed of electromagnet, moving iron core and rocker mechanism. The whole device is started by starting mechanism.

The ejection mechanism is mainly composed of a pin-impact box, a launching spring, a pin-impact with a stop structure (replaced by a pin-impact) and a stop spring. The whole mechanism sends the pin to a designated position, the pin pops up to break a thermosensitive glass ball, and the pin springs back and fixes under the stop of the stop structure to prevent the impact on the ejection.

As shown in the following formula, in the non-triggered state, The firing pin is affected by the L type sucker rod buckle, the top disc of the impact pin compresses the launching spring upward, the deformation displacement of the launching spring is Δx_s , and then the launching spring compresses and stores energy. The energy stored in the compression state of the spring is U_s :

$$U_s = \frac{1}{2} k \Delta x_s^2 \tag{1}$$

k is the elastic coefficient of the transmitting spring. When the L-shaped clasp is attracted by the electromagnet, it releases the pin and the launching spring action, which converts the stored elastic potential energy into the kinetic energy of the pin and hits the temperature-sensitive glass ball. When the spring touches the temperature-sensitive glass, the remaining kinetic energy Et is needed to push away the broken glass ball. Therefore, the energy Ez used to shatter the temperature sensitive glass ball is the difference between the above two values:

$$E_z = U_s - E_t - U_f \tag{2}$$

Uf is part of the kinetic energy consumed by the impact pin of the reset spring. After smashing the temperature-sensitive glass ball, The repositioning electromagnet, which is mounted after the launching spring, responds to the springback of the repositioning spring to reset the pin to its initial state. At this time, the launching spring is in the compression and storage state, and the clip of the L-shaped suction rod restores the impact pin. The suction value of the reset electromagnet is determined by F_{fd}:

$$F_{fd} = -k\Delta x_s \tag{3}$$

The automatic trigger can break the temperature sensitive glass ball conveniently and quickly. The automatic triggering device mainly uses the electromagnetic starting principle and starts with the electromagnet. When the starting signal arrives, the electromagnet attracts the iron core to release the pin, releases the spring and produces the impact force, thus pushing the pin to start the whole device. When the impact pin is sent out a certain distance, the stop spring will resist the impact pin, so that the impact pin rebound to a specific position, while moving iron core and the impact pin stop structure combined to make the impact pin fixed, To complete the impact process.

3.2. Design of direction switching device

The directional conversion device includes a directional switch tube, gasket and a sealing threaded nozzle. Directional switch tube as shown in Figure 3(b), With a mechanical design similar to ratchet,

the fixed unidirectional sealing tube is replaced by an omni-directional adjustable directional transfer tube. it controls the adjusting angle through the teeth of two pipes. The gasket is used to rebuild the sealing property when connecting, so as to realize the all directional fixed-point injection of the dry powder of the fire extinguisher.

In order to improve the sealing performance of the joint, the sealing thread nozzle is made of hard rubber and connected by threads for secondary sealing. At the same time, it can play an angle fixing role of the direction changer.

3.3. Design of new sprinkler head

When the traditional sprinkler sprays dry powder vertically, there is a situation that the dry powder is too concentrated in the lower part of the sprinkler. After adding a baffle at the sprinkler, a large number of experiments are needed to determine the shape and size standard of the baffle. From the point of view of design, AUTOCAD is used to map the improved sprinkler. As can be seen in Fig. 3(c), a baffle with a certain inclination angle is arranged below the improved nozzle, and a ten-lobe right-angle baffle is adopted, which enlarges the effect of premixed turbulence between dry powder and air, that is, enlarges the spraying range of dry powder.

a b c

Figure 3. (a) Self triggering device (b) Directional switch tube (c)New nozzle design

4. Multi induction system design

The system adopts multi-induction design method, and improves the starting mechanism of suspended dry powder fire extinguishing tank, so that it has a greater improvement in fire sensitivity and fire extinguishing performance.

4.1. Fire signal induction method for fire extinguisher

The induction of fire signal of fire extinguishing tank is divided into automatic induction and manual triggering. The automatic induction is temperature induction to the heat source in response to fire protection area by temperature sensing cable and temperature sensing glass ball, while manual emergency switch is needed to trigger the fire signal manually, so as to realize the purpose of emergency start-up of supervisors.

When the temperature sensor cables feel the temperature changes, through the signal converter, the temperature signal will be converted into electrical signals and then transmitted to the fire alarm controller, fire alarm controller on the "emergency start" display lamp alarm prompt; When there is smoke in the protection area, the smoke detector responds to the electrical signal, the electrical signal is transmitted to the fire alarm controller, and the "emergency start" display lamp on the fire alarm controller gives an alarm prompt; When the temperature sensing glass ball reaches the upper limit of temperature by sensing the change of the surrounding temperature, the fire extinguishing system receives the signal to trigger automatically.

4.2. Fire extinguishing starting method of suspended dry powder fire extinguisher

(1) Mechanical action device:

When the "emergency start" display lamp on the fire alarm controller alarms, the electrical signal is transmitted to the self-triggering device manually, and the self-triggering device starts. After the firing pin smashed the sensing glass ball, the conductor ring fell off. Send instructions to the fire alarm controller for 30 seconds, then the electromagnetic driver is started by 24V power supply, and the working diaphragm on the container valve is broken by puncturing needle, and the electromagnetic valve is started, so that the suspended dry powder extinguishing tank can be sprayed with dry powder to achieve rapid fire extinguishing.

(2) Automatic triggering device

When the temperature rises to the pre-set trigger temperature limit T_{lim}, the temperature-sensitive glass ball of the suspended dry powder fire extinguishing tank breaks automatically, the conductor ring falls off, and the solenoid valve starts, so that the suspended dry powder fire extinguishing tank sprays dry powder to achieve rapid fire extinguishing.

(3) Manual trigger device

When the fire alarm is detected or the "emergency start" light is displayed, the manual alarm button is turned on artificially and the electric signal is transmitted to the fire alarm controller. Fire alarm controller on the "emergency start" switch response, temperature glass ball through the self-triggering device smashed, wire ring off, solenoid valve to start so that suspended dry powder fire extinguisher spraying dry powder to achieve rapid fire extinguishing.

5. Conclusion

Aiming at the distributed fire extinguishing in warehouse, this paper presents a new design, which improves the function of the original suspended fire extinguishing tank.

The system adds multiple sensing modes to the fire area, which makes the device more sensitive to the fire situation in every corner of the warehouse. A multi-angle adjustable sprinkler is designed for the fire extinguishing tank, and the spraying effect of the traditional sprinkler is improved. The shelf of the warehouse is improved at any height and arbitrary. Positional stacking and fire extinguishing effect in open area can solve the problems of rapid sensing and distributed fire extinguishing. The dry powder of the fire extinguishing tank can be effectively utilized to save resources and achieve the goal of energy saving and emission reduction. Therefore, this paper has a certain reference value for the selection of fire extinguishing methods in storehouses.

Acknowledgments

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