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# Experimental Study of Zinc Borate Coupling Cavity Structure to Suppress Explosive Flame

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## Abstract

**By setting up a large circular tube gas explosion test system, and using a flame sensor to study the wave attenuation effect of a 500 * 500 * 200mm cavity combined with zinc borate powder, a conclusion is drawn by comparing the flame pressure behind the cavity and With the increase of the amount of zinc borate powder, the flame attenuation is greater. When it reaches 100g, the flame can be basically eliminated, and the zinc borate powder can effectively reduce the degree of explosion hazard.**

## Keywords

**Gas, suppress explosion, powder.**

## 1. Introduction

Coal resources are one of the important energy sources to support our national economy. However, the frequent occurrence of gas explosions seriously threatens the production safety of coal mines. At the same time, most of the major explosions in coal are caused by gas explosions, which bring great losses to the development of the national economy and the safety of people's lives and property every year. Therefore, relevant academicians at home and abroad have carried out a large number of gas explosion suppression experiments.

Zinc borate powder fire extinguishing agent is a halogen-free flame retardant. The propagation of gas explosions in actual coal mines is very complicated. Although many scholars at home and abroad have done a lot of work in the aspects of gas explosion propagation, gas explosion suppression and gas explosion numerical simulation in different pipe networks, there are still some problems Further research is needed, such as insufficient research on structural wave elimination, and experiments on the suppression of gas explosion by zinc borate powder.

The anti-explosion research was conducted by combining the wave-eliminating cavity and zinc borate powder, and the flame reduction law before and after the cavity was analyzed. The amount of zinc borate powder was used as a variable. After repeated experiments in multiple groups, the chance of the experiment was eliminated to ensure the contingency of the experimental results.

## 2. Experimental device

In order to study the wave attenuation characteristics of zinc borate powder combined with cavity structure under the action of gas explosion shock wave, a large-scale gas explosion test system with a tube diameter of 200mm and a thickness of 10mm was designed and built in this paper. Through different test schemes, a series of gas explosion tests were carried out. Figure 1 is a schematic diagram of the overall structure of the experimental system, including the initiation tube, stabilizer tube, cavity, propagation tube, vacuum pump, circulation pump, compressor, flame sensor, ignition system, high speed Data collector, work host, vacuum pump / circulation pump controller, etc.

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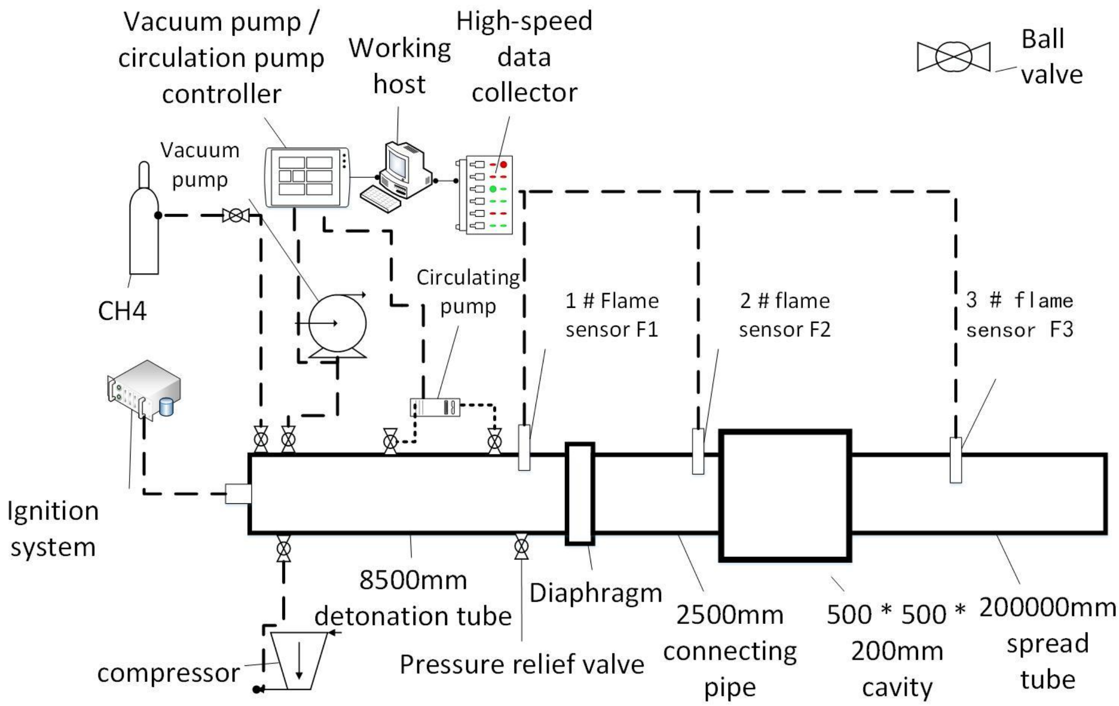


**Figure 1.** Experimental system diagram

Considering the realistic reproduction of the state and scene of gas explosions in coal mines, and a more realistic expression of the propagation law of gas explosions in the pipe network, a round pipe was selected to build the pipe network system. It is necessary to choose a pipeline that can withstand the impact of gas explosion and high temperature and high pressure. The research results of scholars at home and abroad, the 8500mm initiating tube, 2500mm stabilizing tube, 200000mm propagation tube, and 500 * 500 * 200mm cavity used in this experiment are made of steel, and a certain number of orifices are arranged in the pipeline. Gas distribution in the pipe network; on the other hand for sensor assembly; in order to ensure air tightness between the pipes, flanges, rubber gaskets and asbestos gaskets are used to connect and seal the pipes, and the orifices are round. A sealing ring is used for sealing. A PVC diaphragm is sandwiched between the detonation tube and the stabilization tube to isolate the detonation tube from the stabilization tube. The 1 # flame sensor is installed on the side of the 50mm detonation tube in front of the PVC film, and the 2 # flame sensor is installed 30mm in front of the cavity, 3 # flame sensor is installed 50mm behind the cavity. In order to support the stability and the stability of the pipeline on the bracket, the pipeline is fixed on the channel steel bracket by a clamp. The experimental device is shown in Figure 2.


Figure 2. Experimental device physical map

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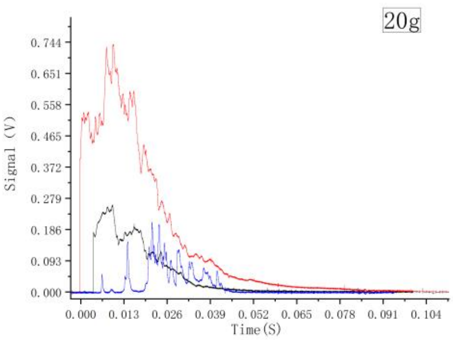
# 3. Experimental process and result analysis

## 3.1 Experiment procedure

The gas cylinder uses high-purity methane gas with a purity of 99.9% or more. Before the test, the pipes are sealed and connected, and the air compressor is used to send positive pressure to the initiating pipe to check whether the sealing performance of each connection is intact. The powder is spread in the cavity, and 20g, 40g, 60g, 80g, and 100g of zinc borate powder are weighed respectively for multiple groups of experiments; then the vacuum tube is used to evacuate the detonation tube, and the Dalton partial pressure method is used for gas distribution. After experimentally studying the required volume fraction of methane gas, the circulation gas and air mixed gas in the detonating tube were circulated for 10 minutes using a circulation pump to uniformly mix the methane and air in the detonating tube. The detonation was performed by the ignition system. The explosion shock wave and flame destroyed the PVC film and entered Stabilization tube, each flame sensor transmits the collected data to a high-speed data collector, which is processed by special software DAP7.30 in the working host.

## 3.2 Relationship between different powders and flame size



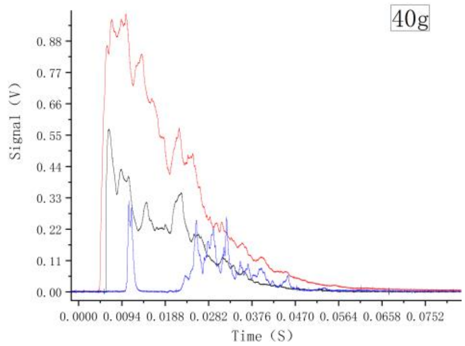
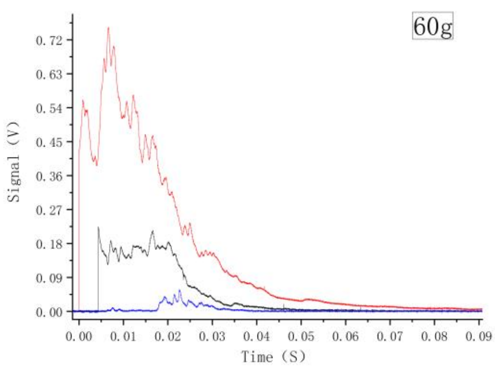




Figure 3. Represent the front flame sensor. Figure 4. Represent the front flame sensor



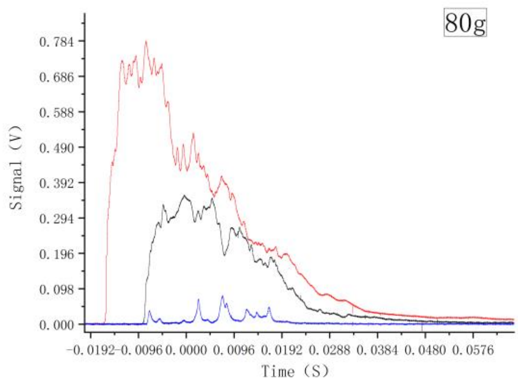




Figure 5. Represent the front flame sensor. Figure 6. Represent the front flame sensor

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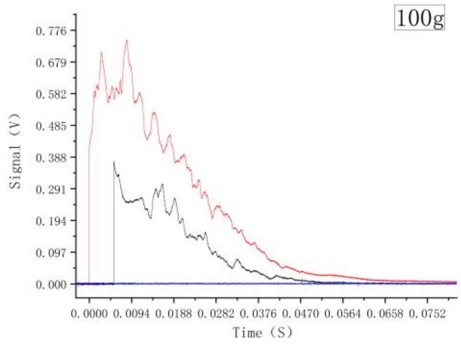


Figure 7. Represent the front flame sensor

Figures 3, 4, 5, 6, and 7 represent the front flame sensor F1 of the PVC film when the 20g, 40g, 60g, 80g, and 100g zinc borate powder is installed in the cavity. The flame peak information of the rear flame sensor F3. The red, black, and blue lines in the figure represent the flame front information of F1, F2, and F3. The integrated area of each curve in the figure represents the flame size. It can be concluded that:

(1) When 20g of zinc borate powder is installed in the cavity, as shown in Figure 3, the area integrated by F1 is 0.0115589, the area integrated by F2 is 0.004253, and the area integrated by F3 is 0.001578. In general, the flame passing through the stabilization tube is After passing the cavity with 20g zinc borate powder, the attenuation is about 62.88%.

(2) When 40g of zinc borate powder is installed in the cavity, as shown in Figure 4, the area integrated by F1 is 0.0118076, the area integrated by F2 is 0.007375, and the area integrated by F3 is 0.002628. In general, the flame passing through the stabilization tube is After passing through the cavity filled with 40g zinc borate powder, it weakened about 64.36%.

(3) When 60g of zinc borate powder is installed in the cavity, as shown in Fig. 5, the area integrated by F1 is 0.0114165, the area integrated by F2 is 0.003745, and the area integrated by F3 is 0.000543. In general, the flame passed through the stabilizer tube After passing the cavity with 60g zinc borate powder, the attenuation is about 85.49%.

(4) When 80g of zinc borate powder is installed in the cavity, as shown in Figure 6, the area integrated by F1 is 0.0118594, the area integrated by F2 is 0.008064, and the area integrated by F3 is 0.001578. In general, the flame passing through the stabilizer tube After passing the cavity with 80g zinc borate powder, the attenuation was about 91.44%.

(5) When 100g of zinc borate powder is installed in the cavity, as shown in Fig. 7, the area integrated by F1 is 0.0116106, the area integrated by F2 is 0.005715, and the area integrated by F3 is 0.000005. In general, the flame passing through the stabilizer After passing the cavity with 100g zinc borate powder, the attenuation is about 99.91%.

It can be seen that with the increase of the amount of zinc borate powder, the effect of the powder combined with the cavity to eliminate the flame is better. After several experiments, 100g of zinc borate powder can effectively eliminate the flame. The main reasons for the analysis are as follows. First, zinc borate powder is decomposed into melamine and cyanuric acid by heat, and the endothermic reaction takes away a lot of heat. The second is that the melamine sublimation generated by decomposition is also an endothermic reaction, taking away a lot of heat. The third is that the shock wave lifts the zinc borate powder. The surface of the powder particles can adsorb the free radicals H ; OH ; O · during the methane explosion chain reaction process, which reduces the collision probability of free radicals during the methane explosion chain transmission process.

## 4. In conclusion

100g zinc borate powder combined with 500 * 500 * 200mm cavity can effectively eliminate the explosion flame. After multiple sets of repeated experiments, the fire suppression rate can reach

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99.9%; 100g zinc borate powder combined with 500 * 500 * 200mm cavity is to suppress the explosion flame. Optimum powder volume.

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