# INVESTIGATION ON THE CHARACTERISTICS OF SINGLE-PHASE GAS EXPLOSION AND GAS-COAL DUST COUPLING EXPLOSION IN BIFURCATED TUBES

by

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*In order to deeply understand the overpressure propagation characteristics of explosion shock wave of single-phase gas explosion and gas-coal dust coupling explosion in bifurcated tube, this paper makes a comprehensive and in-depth study on the change and distribution law of explosion shock wave overpressure of single-phase gas explosion and gas-coal dust coupling explosion in bifurcated tube by means of experimental research, the results show that: the explosion shock wave overpressure of single-phase gas explosion and gas-coal dust coupling explosion is all affected by the bifurcation angle of the tube, the larger the bifurcation angle of the tube is, and the greater the explosion shock wave overpressure is. In terms of explosion shock wave overpressure distribution, single-phase gas explosion and gas-coal dust coupling explosion show a similar overall development trend, and the maximum explosion shock wave overpressure is obtained in front of the bifurcation point. The mutation coefficients of explosion shock wave overpressure of single-phase gas explosion and gas-coal dust coupling explosion before and after the bifurcation point of the tube are all affected by the bifurcation angle of the tube. In the straight tube section, the mutation coefficient of explosion shock wave overpressure increases gradually with the increase of the bifurcation angle of the tube, while the situation in the inclined tube section is just the opposite. Under the condition of the same bifurcation angle, the shock wave overpressure mutation coefficient of gas-coal dust coupling explosion is smaller than that of single-phase gas explosion.*

Key words*: bifurcated tube, gas explosion, gas-coal dust coupling explosion, shock wave overpressure, mutation coefficient*

## Introduction

The coal industry is an accident-prone industry, which causes a large number of casualties and property losses due to coal accidents every year. Gas explosion and gas-coal dust coupling explosion are two important types of accidents in the coal industry, and the consequences caused by them are particularly serious [1-3]. Therefore, how to formulate effective explosion-proof and explosion-suppression measures to avoid the occurrence of gas explosion and gas-coal dust coupling explosion or to weaken its explosion effect has become the top priority of the safety work of the coal industry.

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A clear understanding of the reaction mechanism, development process and influencing factors of gas explosion and gas-coal dust coupling explosion is a necessary basis for formulating explosion-proof and explosion-suppression measures. The research on the characteristics of gas-coal dust coupling explosion started as early as the 1950's. In 1952, Schultze carried out two large-scale explosion tests with gas volume fraction of 9.5% and accumulation area of 300 m in an abandoned mine in the USA, the peak explosion pressure was measured as 1.01 MPa [4]. Nagy *et al.* [5] first studied the ignition and explosion characteristics of gas-coal dust coupling explosion, the results show that the mixture of coal dust and gas is more easily ignited, and the consequences of explosion are more serious. Cai *et al.* [6] studied the shock wave energy, propagation velocity and attenuation law of gas-coal dust coupling explosion in large-scale roadway. Si and Wang [7] and Si *et al.* [8] conducted a series of experimental studies on gas and coal dust explosion, and found that gas can reduce the minimum ignition energy and lower limit concentration of coal dust explosion, and the power and damage degree of gas and coal dust coupling explosion is much greater than that of simple gas explosion. Wang [9], Zhu and Bai [10], and Bi and Li [11] conducted a series of in-depth studies on the influence of gas and coal dust concentration, coal dust particle size, ignition delay time and other factors on the characteristics of gas and coal dust coupling explosion. Li [12, 13] and Wang and Li [14] have studied the explosion of sedimentary coal dust caused by gas explosion, it is pointed out that the flying and explosion of coal dust belong to gas-solid two-phase flow, and the process is very complicated. Dong *et al.* [15], Zhou *et al*. [16], and Jing *et al.* [17] studied the influence of obstacles on the characteristics of gas-coal dust coupling explosion, and found that obstacles have a certain incentive effect on the explosion. Rockwell *et al.* [18] used a hybrid flame analyzer to conduct a series of studies on the burning velocity of gas, dust and hybrid (gas and dust) premixed flames, and found that the addition of particles usually increases the turbulent burning velocity. Ajrash *et al.* [19] conducted a series of studies on methane coal dust explosion and found that the increase of initial ignition energy can significantly increase the explosion pressure. Addai *et al.* [20] studied the minimum ignition energy of gas-dust mixture and found that the addition of a small amount of flammable gas can significantly reduce the minimum ignition energy of dust explosion. Song *et al.* [21] simulated the process of dust participating in gas explosion and found that the addition of coal dust can stimulate the propagation of explosion flame in the tube. Cuervo *et al.* [22] found that for the two-phase mixed reaction of low concentration gas and high concentration dust, the presence of dust often limits the flame propagation speed. Song *et al.* [23] used 20 L spherical explosion vessel to carry on the experimental study, it was found that with the increase of the concentration of coal dust or methane, the maximum explosion pressure and the maximum pressure rising rate increased at first and then decreased at the initial stage of the reaction. Ban *et al.* [24] conducted a series of experimental studies and found that the initial ignition energy has a significant effect on coal dust explosion.

To sum up, researchers from various countries have done a lot of research work in the field of gas-coal dust coupling explosion and achieved fruitful research results. However, the vast majority of studies are carried out in straight tubes or spherical devices [25-27]. We know that in the actual underground roadway, in addition the common straight tubes, there are many other forms of tubes, such as turning tubes, bifurcated tubes, variable cross-section tubes and so on. These special structures will have a great impact on the development and propagation of explosion shock wave overpressure, which is of great value for the study of explosion shock wave overpressure in these tubes. Therefore, on the basis of previous studies, this paper makes an in-depth study on the propagation and distribution of shock wave overpressure of single-phase gas explosion and gas-coal dust coupling explosion in bifurcated tube, to explore the propagation law of explosion shock wave overpressure of single-phase gas explosion and gas-coal dust coupling explosion in bifurcated tube.

## *Experimental system and scheme*

### ***Experimental system***

The experimental system consists of experimental tube, gas distribution system, ignition system, pressure data acquisition system and synchronous control system. Among them, the experimental tube is a transparent plexiglass tube with different bifurcation angles, the inner section size of the tube is 80 × 80 mm, the wall thickness of the tube is 20 mm, and the compressive strength is 2 MPa, the left end of the experimental tube is completely closed, and there are two outlets at the right end, all of which are sealed with PVC film. The gas distribution system is composed of a gas cylinder, an air compressor and two gas mass-flow controllers, which is used to configure the required concentration of methane and air premixed gas. The ignition system is composed of HEI19 series high heat energy igniter and ignition electrode, the ignition voltage is 6 kV, the ignition point is located on one side of the completely sealed port and the distance from the tube port is 100 mm. The pressure data acquisition system is composed of MD-HF high frequency dynamic pressure sensor and USB-1608FS data acquisition card, which collects the pressure data produced by explosion in real time during the experiment. The synchronous control system is a multi-thread control device designed by OMRON Company of Japan, which is used to control the ignition system and the pressure data acquisition system to start and shut down according to the preset order and interval. The experimental system is shown in fig. 1.

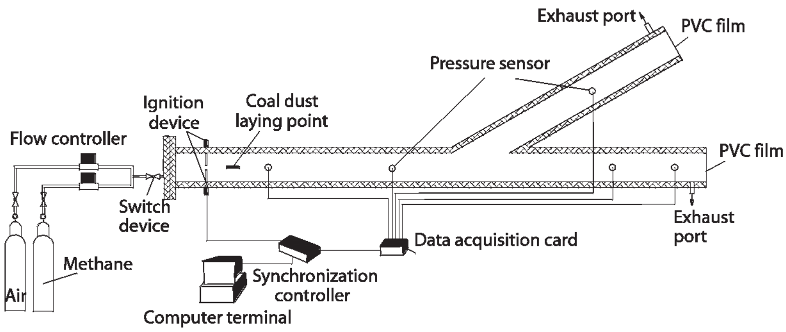


**Figure 1. Experimental system diagram**

In the course of the experiment, first connect the experimental system as shown in fig. 1, and lay a specified amount of coal dust at the coal dust laying point (as shown in fig. 1, the coal dust laying point is located at the 100 mm on the right side of the ignition point, and this step is skipped if it is a single-phase gas explosion). Then the intake of air and methane is controlled by two gas-flow controllers, and a certain concentration of methane-air premixed gas is injected into the experimental tube, and the original air in the experimental tube will be discharged through the vent hole at the end of the tube. During the entire process of inflation, the inner and outer spaces of the experimental tube are always in a connected state, so it can be ensured that the initial pressure inside the experimental tube is constant and equal to the standard atmospheric pressure. In order to ensure the fully discharge of the original gas in the experimental tube, the volume of gas filled into the experimental tube is four times the volume of the experimental tube. After the inflation is completed, close the intake hole and vent hole of the experimental tube and prepare for ignition and explosion. Click the start button of the synchronous controller, and the pressure data acquisition system and ignition system start and shut down according to the preset time sequence and interval. Collate and save the experimental data, and the experiment is completed.

## *Experimental scheme design*

### *Experimental level division*

The main purpose of this experiment is to use the explosion experiment system to test the relevant parameters of shock wave overpressure of single-phase gas explosion and gas-coal dust coupling explosion under different bifurcation angle conditions, to study the propagation and distribution of explosion shock wave overpressure in the bifurcated tube. In this experiment, four groups of bifurcation angles were designed, which were 30°, 45°, 60°, and 90°, respectively, to study the propagation and distribution of explosion shock wave overpressure under different bifurcation angles. Previous studies have shown that gas concentration will also have a certain impact on gas-coal dust coupling explosion, 9.5% is the stoichiometric concentration of gas, higher or lower than this value, the explosion effect will show a significant difference. This paper mainly studies the situation that is lower than the gas stoichiometric concentration, and the gas concentration is 7.5%, which is between the gas stoichiometric concentration and the lower explosion limit concentration, and the explosion power is moderate, it is convenient to analyze and summarize the reaction process and results. The composition, particle size, concentration and other factors of coal dust will also have a certain impact on the gas-coal dust coupling explosion. The industrial analysis results of coal dust used in this experiment are shown in tab. 1, its particle size distribution is shown in fig. 2, the particle size of coal dust is mainly distributed in 4-62.4 μm, and the distribution is relatively uniform. In terms of coal dust concentration, coal dust was laid at the specified position in the tube according to the concentration of 500 g/m$^3$ in the experiment. In addition, the initial temperature will also have a certain impact on the experimental results, so the laboratory ambient temperature is always kept at 25 °C during the experiment. In the course of the experiment, in order to ensure the reliability of the experimental results, each group of experiments were carried out three times or more times. According to the principle of scientific statistics, three groups of effective data were taken as the final data of the experiment at each level.

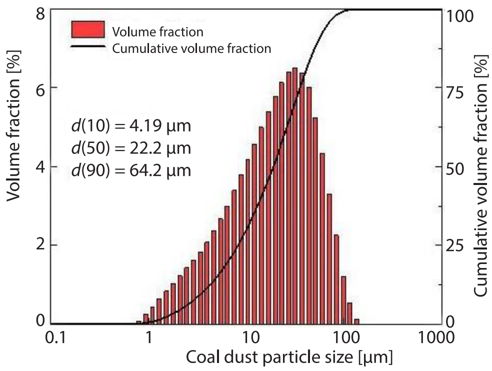


**Figure 2. Particle size distribution of coal dust samples**

**Table 1. Industrial analysis of coal dust samples**

| Coal dust | Ash content | Moisture content | Volatile matter | Fixed carbon |
|---|---|---|---|---|
| Percentage [%] | 1.25 | 13.1 | 27.34 | 58.31 |

### *Lay-out of measuring points*

In order to fully grasp the shock wave overpressure distribution in various parts of the tube during the explosion, we need to set up measuring points in several parts of the experimental tube and install high frequency pressure sensors at the measuring points to monitor the shock wave overpressure at the measuring point. The specific lay-out of the measuring points is shown in fig. 3.

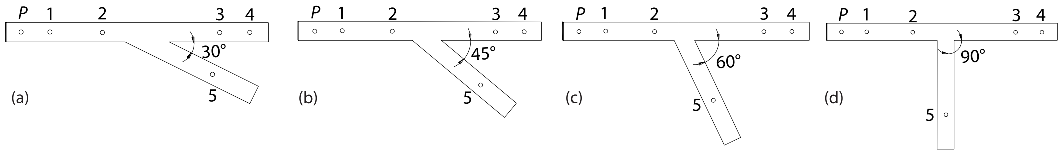


**Figure 3. Schematic diagram of measuring point lay-out; (a) 30°, (b) 45°, (c) 60°, and (d) 90°**

Figure 3 shows the schematic diagram of the lay-out of measuring points in the tube with different bifurcation angles, in which figs. 3(a)-3(d) correspond to bifurcation angles of 30°, 45°, 60°, and 90°, respectively. In fig. 3, the length of the horizontal tube section of the experimental tube is 1700 mm, the length of the bifurcated tube section is 800 mm, the point P is the ignition point, 100 mm from the left port, the measurement Point 1 is located 200 mm to the right of the ignition point, and the measurement Point 2 is located 200 mm in front of the bifurcation point, the distance between measuring Point 1 and measuring Point 2 is 400 mm, measuring Point 3 and measuring Point 5 are located 500 mm behind the bifurcation point, and measuring Point 4 is located 200 mm to the right of measuring Point 3.

## Experimental results and analysis

### *Distribution law of explosion shock wave overpressure*

In order to make an in-depth and specific study on the propagation law of explosion shock wave in the bifurcated tube, the bifurcated tube is divided into two research objects according to the tube structure: the horizontal straight tube section is one research object, and the horizontal straight tube section in front of the bifurcation point and the inclined tube section behind the bifurcation point are combined into another research object. In order to make it easy to distinguish and explain, the aforementioned two research objects are called straight tube section and inclined tube section, respectively (not explained later). Through the experiment, a large number of shock wave overpressure data of single-phase gas explosion and gas-coal dust coupling explosion are obtained, and the distribution curve of explosion shock wave overpressure in the experimental tube is drawn, as shown in figs. 4-7.

Figure 4 shows the shock wave overpressure distribution curve of single-phase gas explosion in the straight tube section. Based on the analysis of the overall development trend of shock wave overpressure, it is found that the internal explosion shock wave overpressure distribution of 30°, 45°, 60°, and 90° bifurcated tubes shows a similar law, it shows a development trend of rising at first, then decreasing and then rising slightly. The shock wave overpressure reaches the maximum at No. 2 measuring point (that is, 200 mm before the bifurcation point), the shock wave overpressure of 30°, 45°, 60°, and 90° bifurcated tubes is $61.59 \cdot 10^2$ Pa, $86.53 \cdot 10^2$ Pa, $95.07 \cdot 10^2$ Pa, and $134.43 \cdot 10^2$ Pa, respectively, the minimum value is obtained at

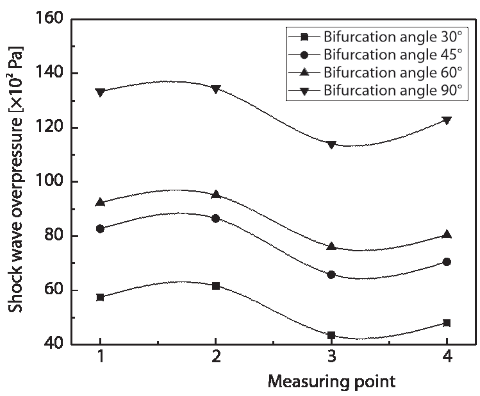


**Figure 4. Single-phase gas explosion shock wave overpressure distribution curve in straight tube section**

point No. 3 measuring point, the shock wave overpressure of 30°, 45°, 60°, and 90° bifurcated tubes is $48.41 \cdot 10^2$ Pa, $65.81 \cdot 10^2$ Pa, $76.06 \cdot 10^2$ Pa, and $114.02 \cdot 10^2$ Pa, respectively. It can be seen that the overall value of the shock wave overpressure in the straight tube section increases as the bifurcation angle increases, as the bifurcation angle increases from 30-90°, the maximum shock wave overpressure in the tube increases by 118.27%.

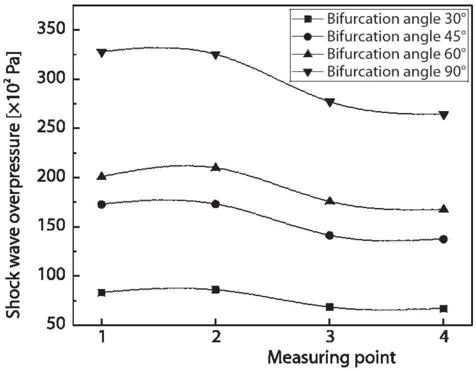


**Figure 5. Gas-coal dust coupling explosion shock wave overpressure distribution curve in straight tube section**

Figure 5 shows the explosion shock wave overpressure distribution curve of gas-coal dust coupling explosion in the straight tube section. It can be found that in the overall distribution of shock wave overpressure, the gas-coal dust coupling explosion is slightly different from the single-phase gas explosion, the shock wave overpressure increases slightly or develops gently in front of the bifurcation point, and after passing through the tube bifurcation point, the shock wave overpressure value decreases rapidly. After reaching the No. 3 measuring point, the shock wave's downward trend slowed down, and finally fell to the minimum value at the No. 4 measuring point. For the 30°, 45°, 60°, and 90° bifurcated tubes, the maximum value is taken at the No. 2 measuring point, which is $85.98 \cdot 10^2$ Pa, $173.05 \cdot 10^2$ Pa, $209.75 \cdot 10^2$ Pa, and $325.18 \cdot 10^2$ Pa, respectively, the minimum value is taken at the No. 4 measuring point, which is $66.87 \cdot 10^2$ Pa, $137.28 \cdot 10^2$ Pa, $167.43 \cdot 10^2$ Pa, and $264.22 \cdot 10^2$ Pa, respectively. It can be seen that the overall shock wave overpressure in the tube increases with the increase of the bifurcation angle. As the bifurcation angle increases from 30-90°, the maximum shock wave overpressure in the tube increases by 278.20%, which is significantly higher than that of single-phase gas explosion. In addition, the overall shock wave overpressure of gas-coal dust coupling explosion is also significantly higher than that of single-phase gas explosion.

Figure 6 shows the shock wave overpressure distribution curve in the inclined tube section of single-phase gas explosion. Based on the analysis of the overall development trend of shock wave overpressure, the internal explosion shock wave overpressure distribution of 30°, 45°, 60°, and 90° bifurcated tubes show a similar law, which increases slightly or develops steadily before the bifurcation point, after the bifurcation point, the explosion shock wave overpressure decreases rapidly. The maximum value of shock wave overpressure is the same as that of the straight tube section, and the maximum value is obtained at No. 2 measuring point. The minimum shock wave overpressure is obtained at the No. 5 measuring point, where the shock wave overpressure of 30°, 45°, 60°, and 90° bifurcated tubes is $28.49 \cdot 10^2$ Pa, $38.37 \cdot 10^2$ Pa, $40.43 \cdot 10^2$ Pa, and $55.82 \cdot 10^2$ Pa, respectively. It can be seen that the overall value of shock wave overpressure in the inclined tube increases with the increase

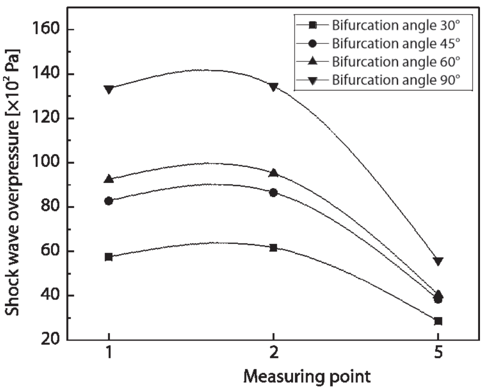


**Figure 6. Single-phase gas explosion shock wave overpressure distribution curve in inclined tube section**

of the bifurcation angle, with the increase of the bifurcation angle from 30-90°, the minimum explosion shock wave overpressure in the tube increases by 95.93%.

Figure 7 shows the shock wave overpressure distribution curve in the inclined tube section of gas-coal dust coupling explosion. It can be found that in the overall distribution of shock wave overpressure, the gas-coal dust coupling explosion is basically similar to the single-phase gas explosion, and the shock wave overpressure increases slightly or develops gently in front of the bifurcation point, and decreases rapidly after passing through the bifurcation point of the tube, up to the exit of the test tube. The maximum value of shock wave overpressure is the same as that of the straight tube section, the maximum value is obtained at No. 2 measuring point. The minimum shock wave overpressure is obtained at the No. 5 measuring point, where the shock wave overpressure of 30°, 45°, 60°, and 90° bifurcated tubes is $39.11 \cdot 10^2$ Pa, $69.80 \cdot 10^2$ Pa, $76.46 \cdot 10^2$ Pa, and $111.41 \cdot 10^2$ Pa, respectively. It can be seen that the overall explosion shock wave overpressure in the tube increases with the increase of the bifurcation angle, and as the bifurcation angle increases from 30-90°, the minimum explosion shock wave overpressure in the tube increases by 184.86%, which is significantly higher than that of single-phase gas explosion. In addition, the overall explosion shock wave overpressure of gas-coal dust coupling explosion is also significantly higher than that of single-phase gas explosion.

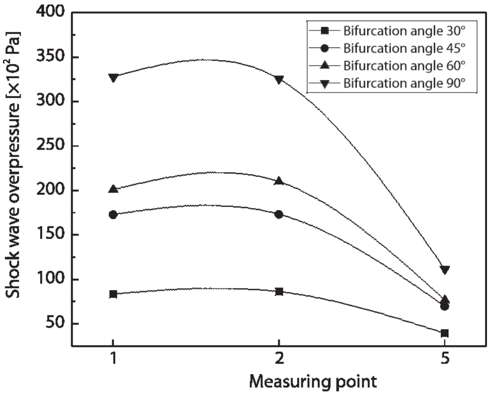

**Figure 7. Gas-coal dust coupling explosion shock wave overpressure distribution curve in inclined tube section**

### *Variation law of explosion shock wave overpressure mutation coefficient*

In order to further study the influence of tube bifurcation on explosion shock wave overpressure, this paper focuses on the change of shock wave overpressure before and after the bifurcation point of tube. In order to study scientifically, the mutation coefficient of explosion shock wave overpressure before and after bifurcation point is selected as the analysis index, and the calculation methods of explosion shock wave overpressure mutation coefficient $\lambda_1$ and $\lambda_2$ are shown:

$$\text{Shock wave overpressure mutation coefficient, } \lambda_1 = \\ = \frac{\text{No.3 measurement point shock wave overpressure}}{\text{No.2 measurement point shock wave overpressure}} \tag{1}$$

$$\text{Shock wave overpressure mutation coefficient, } \lambda_2 = \\ = \frac{\text{No.5 measurement point shock wave overpressure}}{\text{No.2 measurement point shock wave overpressure}} \tag{2}$$

According to the shock wave overpressure data at measuring Points 2, 3, and 5, the explosion shock wave overpressure mutation coefficients $\lambda_1$ and $\lambda_2$ are obtained, respectively. According to the obtained data, the variation curves of shock wave overpressure mutation coefficients of single-phase gas explosion and gas-coal dust coupling explosion with the tube bifurcation angle are drawn, as shown in figs. 8-11.

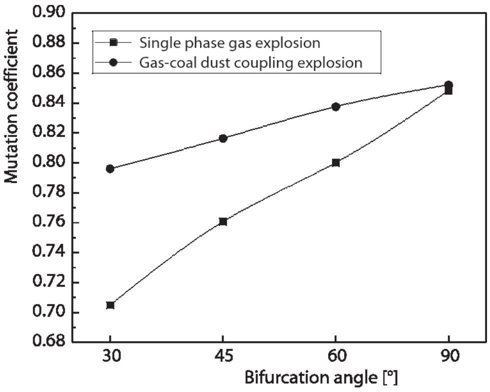


**Figure 8. Variation curve of explosion shock wave overpressure mutation coefficient with tube bifurcation angle in straight tube section**

Figure 8 shows the variation curve of the explosion shock wave overpressure mutation coefficient of the straight tube section of the bifurcated tube with the bifurcation angle. Firstly, the change of the single-phase gas explosion shock wave overpressure mutation coefficient with the tube bifurcation angle is analyzed. As can be seen from the curve in fig. 8, the explosion shock wave overpressure mutation coefficient is affected by the bifurcation angle, and gradually increases with the increase of the bifurcation angle. The maximum and minimum values are obtained at the bifurcation angles of 90° and 30°, respectively, which are 0.8481 and 0.7049, respectively, the mutation coefficient of 90° is 20.31% higher than that of 30°. Next, the shock wave overpressure mutation coefficient of gas-coal dust coupling explosion is analyzed. It can be seen that the same development trend as the single-phase gas explosion, the explosion shock wave overpressure mutation coefficient increases with the increase of the tube bifurcation angle, the maximum and minimum values are obtained at the bifurcation angles of 90° and 30°, respectively, which are 0.8519 and 0.796, respectively, the mutation coefficient of 90° is 7.02% higher than that of 30°. The overall value of shock wave overpressure mutation coefficient of gas-coal dust coupling explosion is higher than that of single-phase gas explosion, indicating that under the condition of the same bifurcation angle, the decrease of shock wave overpressure after bifurcation point of gas-coal dust coupling explosion is smaller than that of single-phase gas explosion.

Figure 9 shows the variation curve of the shock wave overpressure mutation coefficient of the inclined tube section with the bifurcation angle. Firstly, the change of the single-phase gas explosion shock wave overpressure mutation coefficient with the tube bifurcation angle is analyzed. As can be seen from the curve in fig. 9, the overpressure mutation coefficient is affected by the bifurcation angle, and gradually decreases with the increase of the bifurcation angle. The maximum and minimum values are obtained at the bifurcation angle of 30° and 90°, respectively, which are 0.4625 and 0.4152, respectively, the mutation coefficient of 90° is 10.23% lower than that of 30°. Then, the overpressure mutation coefficient of gas-coal dust coupling explosion is analyzed, which also shows the overall trend that the overpressure decreases with the increase of bifurcation angle. The overpressure mutation coefficient reaches the maximum value of 0.4549 when the bifurcation angle is 30° and the minimum value of 0.3426 when the bifurcation angle is 90°, the overpressure mutation coefficient of 90° is 24.69% lower than that of 30°. The overall value of overpressure mutation coefficient of gas-coal dust coupling explosion is smaller than

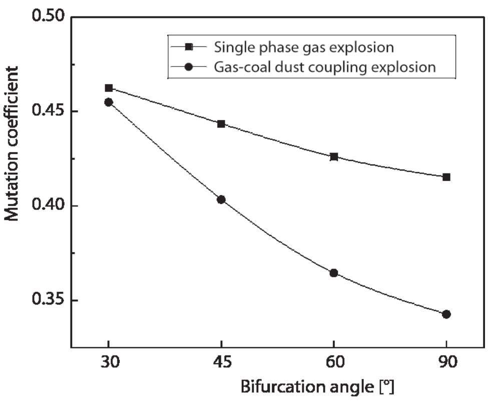


**Figure 9. Variation curve of explosion shock wave overpressure mutation coefficient with tube bifurcation angle in inclined tube section**

that of single-phase gas explosion, indicating that under the condition of the same bifurcation angle, the decrease of shock wave overpressure after bifurcation point of gas-coal dust coupling explosion is larger than that of single-phase gas explosion.

In terms of the specific values of the explosion shock wave overpressure mutation coefficient, under the condition of different bifurcation angles, the shock wave overpressure mutation coefficients of single-phase gas explosion and gas-coal dust coupling explosion in the straight tube section are all larger than those in the inclined tube section, it shows that under the influence of tube bifurcation, the variation range of explosion shock wave overpressure before and after the bifurcation point in the inclined tube section is always greater than that of the straight tube section. The explosion shock wave overpressure in the inclined tube section is more significantly affected by the bifurcation of the tube.

## Conclusion

In this paper, the propagation and distribution of explosion shock wave overpressure of single-phase gas explosion and gas-coal dust coupling explosion under different bifurcation angles are studied, and the following conclusions are obtained as folows.

- The explosion shock wave overpressure of single-phase gas explosion and gas-coal dust coupling explosion are all affected by the bifurcation angle, the larger the bifurcation angle is, the greater the overpressure is. With the increase of bifurcation angle from 30° to 90°, the maximum overpressure of single-phase gas explosion and gas-coal dust coupling explosion increased by 118.27% and 278.20%, respectively. Under the condition of the same bifurcation angle, the overpressure of gas-coal dust coupling explosion is larger than that of single-phase gas explosion.
- In terms of explosion shock wave overpressure distribution, single-phase gas explosion and gas-coal dust coupling explosion show a similar overall development trend: the overpressure value in the tube section before the bifurcation point is at a large level, and the values of each position are basically the same, after passing through the bifurcation point, the overpressure in the straight tube section decreased slightly, and the lowest overpressure value was obtained. After that, the overpressure increased slightly in front of the tube outlet, the overpressure at the tube outlet was lower than that in the tube section before the bifurcation point. In the inclined tube section, after the bifurcation point, the overpressure decreases rapidly and the lowest overpressure value is obtained. The minimum overpressure in the inclined tube section is lower than that in the straight tube section.
- The mutation coefficient of explosion shock wave overpressure is affected by the bifurcation angle. In the straight tube section, the overpressure mutation coefficient increases gradually with the increase of bifurcation angle, and as the bifurcation angle increases from 30° to 90°, the overpressure mutation coefficient of single-phase gas explosion and gas-coal dust coupling explosion increases by 20.31% and 7.02%, respectively. In the inclined tube section, the overpressure mutation coefficient decreases with the increase of bifurcation angle, and as the bifurcation angle increases from 30° to 90°, the overpressure mutation coefficient of single-phase gas explosion and gas-coal dust coupling explosion decreases by 10.23% and 24.69%, respectively. The overall value of overpressure mutation coefficient of gas-coal dust coupling explosion is smaller than that of single-phase gas explosion, indicating that the influence of bifurcation angle on shock wave overpressure of gas-coal dust coupling explosion is more significant than that of single-phase gas explosion.
- Under the condition of different bifurcation angles, the variation range of explosion shock wave overpressure before and after the bifurcation point in the inclined tube sec-

tion is always greater than that of the straight tube section, the explosion shock wave overpressure in the inclined tube section is more significantly affected by the bifurcation of the tube.

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