INFLUENCE OF EXPLOSION CHAMBER SHAPE ON TIMING PARAMETERS OF DISPERSER

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Abstract

A standardized device with a volume of 1 m³ or 20 L is used to determine explosion parameters. An explosion chamber where explosion takes place is of a spherical or cylindrical shape that suits the shape of a cubic container. In the case of a cylindrical vessel, the diameter and depth of the vessel are 1: 1. In this case, it is a spherical vessel with a volume of 365 liters. Time parameters of the disperser in the spherical vessel are compared with those of a truncated spherical vessel with a volume of 291 liters. Comparison of the measurement results showed that the optimal delay time of the explosion chamber with a volume of 291 liters is 290 ms, while the delay time of the explosion chamber with a volume of 365 liters is 350 ms.

Keywords

Explosion chamber, dispersed dust, disperser, timing parameters

INTRODUCTION

Dust is a by-product of different processes that include dry and powdery material conveying, solids crushing and screening, sanding, trimming of excess material, tank and bin feeding and storing of granular materials, and a number of other processes. Combustible dust explosions result in the loss of life, multiple injuries and substantial property and business damage [1].

Explosive dust can be produced mainly [2, 3, 4, 5, 6] in:

- chemical industry
- food and agricultural industries
- mining industry
- engineering industry
- wood processing industry
- textile industry
- automotive industry, etc.

MATERIALS AND METHODS

An explosion chamber KV 150M2 was used to determine the timing parameters of the disperser. The chamber consists of a spherical iron shell with an inner diameter of 900 mm. Inside the chamber is an iron plate for damping shock waves. The plate divides the space inside the chamber (Figure 1). Explosion occurs in the upper part of the chamber with a volume of 291 l. Since the lower part of the space in the chamber is separated by an iron plate, the explosion takes place in a container shaped as a truncated sphere with a diameter of 900 mm and a height of 625 mm.

Figure 1 Explosion chamber KV 150M2 (1 – chamber cover, 2 - disperser, 3 - shock wave absorbing plate, 4 - stand, 5 - igniter, 6 - manometer, 7 - reservoir of pressurised air, 8 - fast-opening valve, 9 - bushing)

For comparison, timing parameters were also determined in the modified KV 150M2 chamber, where the iron plate to absorb the shock waves damping was removed (Fig. 2). In such a case, explosion of dispersed dust takes place in a spherical vessel with a diameter of 900 mm and a volume of 365 liters.

Figure 2 Redesigned explosion chamber KV 150M2 (1 – chamber cover, 2 - disperser, 3 - dispersing plate, 4 - stand, 5 - igniter, 6 - manometer, 7 - reservoir of pressurised air, 8 - fast-opening valve)

A nitrocellulose igniter was used to ignite the dispersed dust inside the chamber. Ignition of nitrocellulose was provided by a resistance wire (in a chamber with a volume of 291 L) with the igniter activation time of 30 ms [7] or a pyrotechnic fuse head with an igniter activation time of 29 ms.

The same dust dispersing system was used for dispersion of dust in the explosion chamber. The dispersing system consists of a supply pipe (for compressed air) and a dispersing element - a dispersion plate. Compressed air is supplied to the chamber from a reservoir of pressurised air with a volume of 7.5 L and a pressure of 10 bar.

The time delay value is independent of the sample and its granulometry, and therefore the granulometric composition of the samples is not reported. A starch sample with a concentration of 150 g.m^{-3} was used to determine the delay of ignitor activation in the 291 L chamber (Table 1), and a lycopodium with a concentration of 250 g.m^{-3} was used in the 365 L chamber (Table 2). The measurement was performed according to the STN EN 14004 Standard [8].

RESULTS AND DISCUSION

The measured values of explosion pressure $P_{\max}$ and rate of pressure rise are listed in Table 1 for the 291L chamber and Table 2 for the 365 L chamber.

Table 1 Explosion characteristics of starch sample with concentration of 150 g.m^{-3} in 291 L chamber		
Delay time [ms]	Maximum overpressure $P_{\max}$ [bar]	Maximum rate of pressure rise $dP/dt_{\max}$ [bar.s⁻¹]
270	3.71	21.6
280	3.52	19.6
290	3.91	22.0
300	3.67	16.2
310	2.88	9.6
340	3.71	19.2

Table 2 Explosion characteristics of lycopodium sample with concentration of 250 g.m^{-3} in 291 L chamber

Delay time [ms]	Maximum overpressure P_{max} [bar]	Maximum rate of pressure rise dP/dt_{max} [bar.s ⁻¹]
330	6.71	103.1
340	6.84	112.6
350	6.91	135.7
360	6.85	123.0
370	6.70	109.7
380	6.77	125.5
390	6.58	100.4

Figure 3 Explosion pressure P and rate of explosion pressure rise dP/dt of starch sample with concentration of 150 g.m^{-3} in 291L chamber and igniter activation delay 290 ms

Figure 4 Explosion pressure P and rate of explosion pressure rise dP/dt of lycopodium sample with concentration of 150 g.m^{-3} in 291L chamber and igniter activation delay 350 ms

The measured values show that the highest value of explosion pressure and rate of pressure rise in the 291 L chamber was reached at the igniter activation delay value of 290 ms, as shown in Figure 3. In the 365 L chamber, the highest values of explosion parameters were reached at the igniter activation delay value of 350 ms, as illustrated in Figure 4.

The time delay of igniter activation after dispersing the sample is an important factor in measuring the explosion characteristics. The delay is affected by the shape and size of the vessel in which the explosion occurs. As the volume of the vessel increases, the optimal delay time increases, too. A comparison of the delay time from the characteristic dimension of the vessel (equivalent diameter) with the standardized values (60 ms in 20L sphere and 600 ms in 1 m^3 chamber) is shown in Figure 5. Figure 5 also indicates that the value of the igniter activation delay is directly proportional to the equivalent chamber diameter.

Figure 5 Igniter activation delay time versus the equivalent radius of the chamber

CONCLUSION

The time delay for activating the igniter depends on the size the volume of the chamber where the explosion of the dispersed dust takes place. For explosion chambers with a volume of 20L and 1 m³, the delay value is specified in EN 14034 Standard. Based on the measurements, it can be concluded that the value of the igniter delay is 290 ms for the 291 L chamber, and 350 ms for the 365 L chamber. The value of the delay is directly proportional to the characteristic dimension of the chamber, which is the inner diameter.

Further measurements will be focused on monitoring the time parameters of various types of igniters which can be used to study of explosion parameters of dispersed dusts.

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