The use of a safety construction for explosion relief venting

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Abstract. The emergency venting of gaseous deflagration is widely used to prevent severe consequences of a confined explosion. Processes of vented deflagrations have been studied extensively and experimental data has been analysed. It is determined that venting starts after a safety construction is destroyed and the area of expiration of gases is opened. In the protecting structures of buildings of explosive production it is necessary to establish protective designs. In the work, triplex panels are considered as protective designs. Process of opening and driving of the panel with release of the area for a depressurization is studied during explosion development. In the work, questions of influence of pressure of opening and speed of explosive combustion at pressure peak size are investigated. The criterion for determination of efficiency of opening of panels is injected.

1 Introduction

Explosion relief venting is commonly used form of explosion protection, employed in a wide range of industries, to protect vessels and production units from overpressures generated by dust or gas explosions. Considerable research has been undertaken on the control of internal explosion pressure by relief venting and this has resulted in the production of a number of guidance documents for the use and sizing of explosion relief vents. The possibility of excess pressure relief when internal explosion - a mandatory requirement for hazardous facilities [7, 8]. Acceptable results are obtained by weakening part of the necessary walling. Their destruction during the explosion open area for the flow out of gases, which leads to lower burst pressure. Best results are obtained with quasi-static nature of the explosion when the wave processes are neglected.

Full success is achieved, if the open area does not allow the rise of the burst pressure to allowable values ΔP_d , which is determined by the carrying capacity of protected structures. This success is possible, if the area of openings, covers easy detachable more than the required minimum, and easily jettison able constructions are opened fast enough to provide the required area expires during the development of the explosion. It is necessary that the time development of the explosion was more than time for the opening of area. Internal quasi-static explosion devoted many works [1, 2]. Most of the required area is determined by the expiration. Question - how do you ensure this area remains on the sidelines with the exception of destructible structures: glass and membrane [4, 5].

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2 Material and methods

In industrial hazardous locations more convenient to use light panels that have weak connections. The explosion destroyed the first, and the panels fly off under the action of pressure and release they overlap the square. In this paper the process of opening the light panels and the change in pressure directly after the destruction of relationships, retaining panel. The analysis is performed using the equations describing the pressure changes with increasing square of the expiration of the [4] and the equations of motion of the panel.

This assumes that:

1. The movement of the panel is described by the equation:

$$M \frac{d^2x}{dt^2} = \Delta P ab$$

2. Expire cold gases.

3. The average pressure acting on the panel $\Delta P = \frac{\Delta P_1 + \Delta P_v}{2}$, where ΔP_1 – corresponds to the first maximum pressure immediately after opening, ΔP_v – pressure opening. From experiments and numerical solutions performed in [6] shows that ΔP_1 depends on ΔP_v and the speed of combustion and may no exceed ΔP_d .

4. Dealt with the pressure at which the velocity is described by the expression $\sqrt{\frac{2\Delta P}{\rho_0}}$ that overrides the carrying capacity of many buildings. However, this limitation does not matter.

Note the experimental fact that the maximum ΔP_1 occurs at the opening of sandwich

panels with incomplete opening of the opening, i.e. $x < \frac{ab}{2(a+b)}$, «a» and «b» – sides.

Using assumptions 1-4 and condition of maximum pressure $\frac{dP}{dt} = 0$ is the value of this maximum

$$\frac{\Delta P_1 - \Delta P_v}{\Delta P_v} = \frac{2A^{1/2} - 1}{(A^{1/2} - 1)^2} \quad (1)$$

$$A = \frac{v_1(a+b)ab\Delta P_v^{3/2}N}{2^{3/2}\pi M\rho_0^{1/2}U_g(\sigma-1)\sigma^2}; U_g - \text{the rate of combustion at the time of opening of}$$

easily jettison able constructions, v_1 – rate coefficient, N - is the number of opened panels, M – mass of the panel, σ - the rate of expansion during combustion, ρ_0 - is the initial density of the gaseous medium.

The number of panels is determined from the condition that the area is completely uncovered openings provided for reducing the pressure of the explosion to ΔP_d , at the time of the maximum speed of energy release, i.e. at the moment when there $(U_g A_f)$ is maximum (where A_f - is the area of burning).

Thus, $(N \cdot a \cdot b)$ has the necessary space required fully opened openings. This area is defined by the expression [4,6]:

$$S_{treb} = \left(\frac{2\rho_0}{\nu_2\Delta P_d}\right)^{1/2} \frac{\sigma^2(\sigma-1)U_gK_fV_0^{2/3}}{(1+\sigma^{1/2})} \tag{2}$$

Substituting this expression into the previous one and requiring that would $\Delta P_1 < \Delta P_d$ after simple transformations, we obtain the condition:

$$\Delta P_d \left[1 - \left(\frac{\Delta P_v}{\Delta P_d}\right)^{1/2}\right]^2 > \frac{2\pi MU_g^2(1+\sigma^{1/2})}{(a+b)K_fV_0^{2/3}} \tag{3}$$

Here K_f is the shape factor of the premises, determined from:

$$(F)_{max} = K_fV_0^{2/3} \tag{4}$$

F – surface area of the flame when deflagration internal explosion.

3 Results

Using data on the known parameters of an internal explosion and properties of easily jettison able constructions, you can pick up ΔP_V to ΔP_1 does not exceed ΔP_d . Table 1 presents data

on ΔP_d for different values of $\frac{\Delta P_v}{\Delta P_d}$.

Table 1. data on ΔP_d for different values of $\frac{\Delta P_v}{\Delta P_d}$.

$\frac{\Delta P_v}{\Delta P_d}$	0,5	0,6	0,7	0,8	0,9
$\Delta P_d, kPa$	1,17	1,5	2,25	4,4	5,6

The calculations were performed for data: $V_0 = 1000\text{ m3}$, $K_f = 3$, $\sigma = 7$, $U_g = 2,4\text{ m/sec}$,
 $\frac{M}{(a+b)} = 25kg / m$.

In the Fig. 1 and the Fig. 2 are shown dynamics of change of pressure indoors at different values pressure of opening and burning rate.

The table shows that the magnitude of the pressure opening has a significant influence on the resulting blast load. In [6] experimentally studied the autopsy sandwich panels for some cases of attachment. The opening pressure depends on the thickness of the sheet, the thickness of the structure in which twists of "tapping" and the number of attachment points.

It is clear that the opening pressure $0,5*\Delta P_d$ in this case is unrealistic. Characteristic values obtained in [6] is 3-4 kPa. Likewise, the recommendations to reduce ΔP_V .

4 Conclusion

Follows from results of work and results of works [9,10] that by means of panels it is possible to reduce efficiently pressure of internal explosion and to protect not only load-bearing

frames, but also the protecting designs from a brick and concrete and also panels of the smaller size.

Fig. 1. Dependence $\Delta P(t)$ on time for pressure ΔP_v : 1 - $\Delta P_v=1,5$ kPa, 2 - $\Delta P_v=2,5$ kPa, 3- $\Delta P_v=3,5$ kPa, 4 - $\Delta P_v=4,5$ kPa, $U_g=0,8$ m/c.

Fig. 2. Dependence $\Delta P(t)$ on time for pressure U_g : 1 - $U_g=0,5$ m/c, 2 - $U_g=0,8$ m/c., 3- $U_g=1,2$ m/c., 4 - $U_g=1,6$ m/c., 5 - $U_g=2,0$ m/c.

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