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SEGMENTATION OF EXPLOSION CHARGE AS A WAY TO INCREASE THE AIR EXPLOSION PARAMETERS

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As is known [1], segmentation is the process of dividing the whole into its constituent parts (segments). With regard to the air blast of the explosive charge, under segmentation it is necessary to understand the division of a single charge into identical segments, their separation in space, the initiation of each segment simultaneously or with a shift in time so that, due to the interaction of air shock waves (SW) between individual segments, explosion in certain areas of space and in total for the entire charge as a whole.

In this work, a numerical simulation of an explosion in the air of a monolithic cylindrical charge of TNT weighing 100 kg and an elongation of ~ 10 (the first option) was carried out. The charge was located above a rigid surface that simulates the surface of the earth, perpendicular to it, while the lower end of the charge was at a height of 1 m.

During segmentation, the charge was divided in the transverse direction initially into two equal segments (the second option), and then into three segments (the third option), which moved up along the axis of symmetry of the charge upward by distances equal to the diameter of the charge Ø 200 mm (Figure 1).

A monolithic charge was initiated one-point at a central point on the surface of the lower end, and segmented charges - two-point at the central points of the ends of the lower segment and one-point at the upper end of the other segments simultaneously at the initial time t = 0. This initiation was carried out in order [2].

In the calculations, the effect of the characteristics of segmented explosive charges on the parameters of an air explosion recorded in markers located on a rigid surface was estimated.

The calculation results were processed, and the corresponding graphical dependencies were constructed in a dimensionless form. The scales of dimensioning were chosen as the charge radius = 0.1 m; sound speed in air = 340 m/s; normal atmospheric pressure = $1.013 \cdot 10^5$ Pa. Then for the time scale and specific impulse we will have - = $2.941 \cdot 10^{-4}$ s and = 29.794 Pa · s.

Figure 2 in logarithmic coordinates shows the dependence of the maximum excess pressure on the distance along the surface of the earth, respectively, for monolithic 1 and segmented charges 2 and 3.

Analysis of the curves shows that at distances ~ there is an excess of the maximum overpressure for segmented charges (curves 2 and 3) over the corresponding values for the monolithic charge (curve 1), with the maximum excess being more than 2 times for the segmented charge 2. Apparently and due to the fact that in the version of the three segments the upper segment was at the highest height, its effect on the parameters of the explosion on the ground surface was less than from the upper segment in version 2, located near e to the surface of the earth, which led to some decrease in the values in the third version of the calculation.

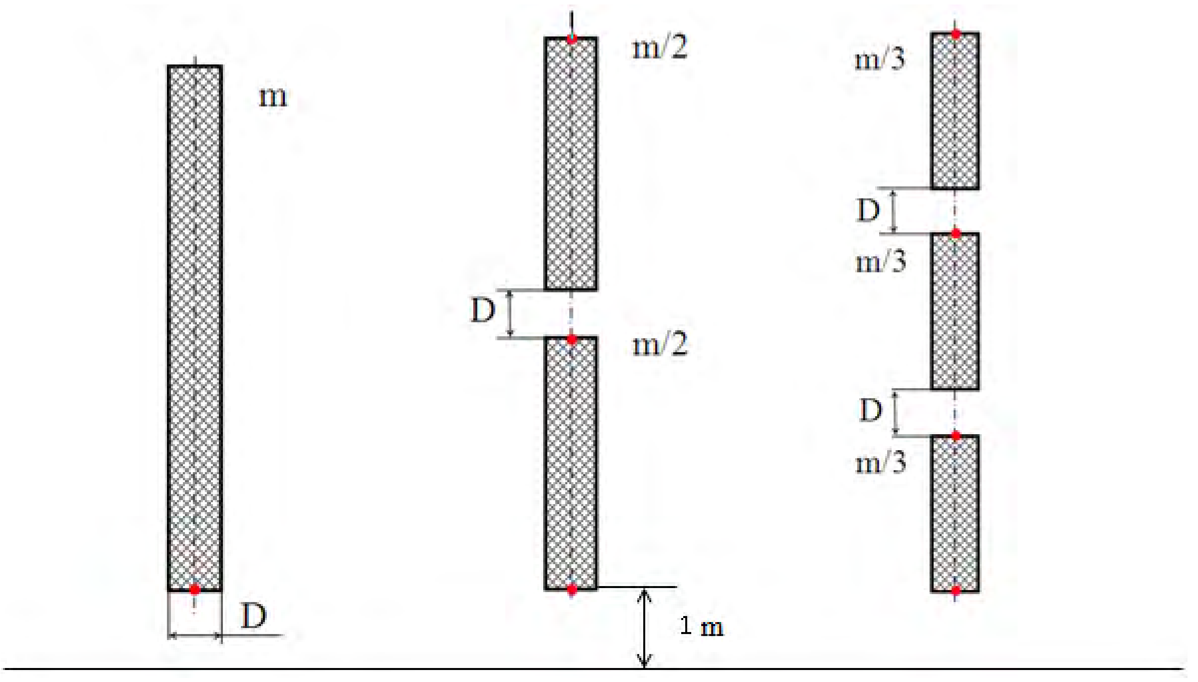

Figure 1. Variants of considered explosive charges with points of their initiation:
a) - monolithic charge with mass m = 100 kg TNT; b) and c) - segmented charges
b) of the corresponding mass (given next to the segments)

Figure 3 shows similar dependences of the duration of the phase of compression of air HCs on the distance along the surface of the earth. It can be seen that in the near explosion region () the duration of the compression phase of air HCs for segmented charges have smaller values compared to the monolithic charge, but at large distances the opposite is observed, and already here the segmented charges form an air blast with a longer compression phase.

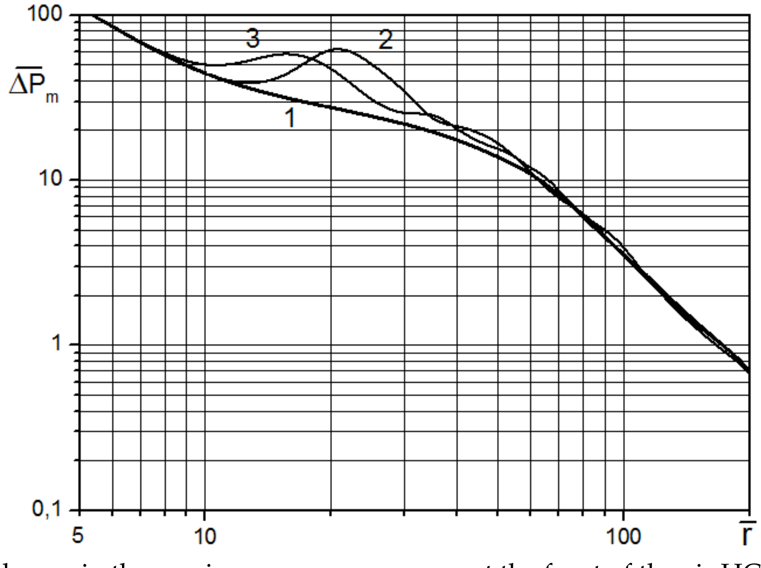

Figure 2. The change in the maximum excess pressure at the front of the air HC with increasing distance from the explosion along the earth's surface:
1 - monolithic charge; 2 and 3 - segmented charges

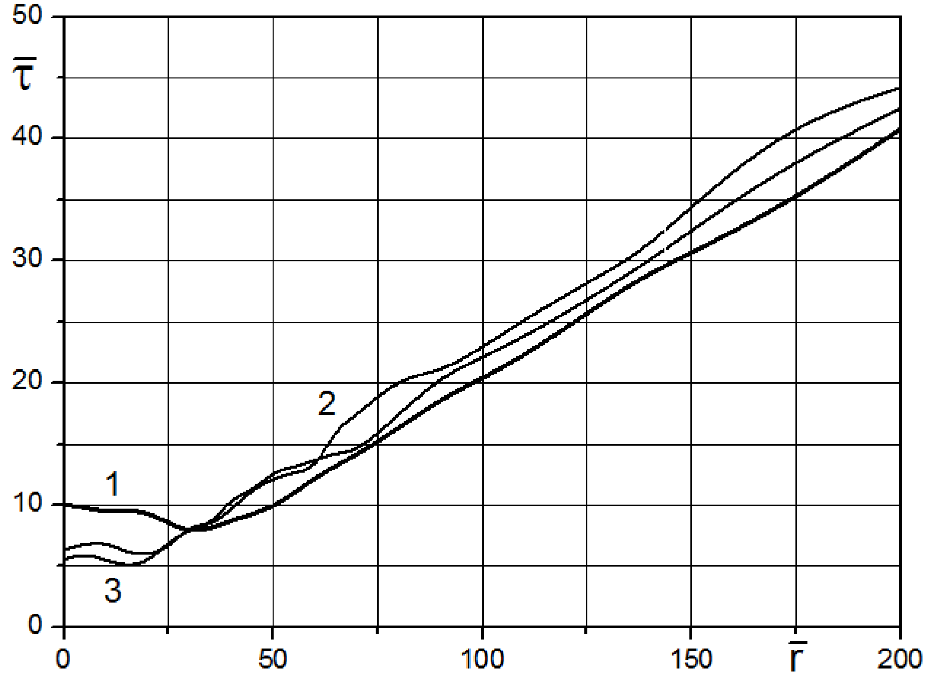

Figure 3. The change in the duration of the phase of compression of the air HC with increasing distance from the place of the explosion along the surface of the earth: 1 - monolithic charge; 2 and 3 - segmented charges

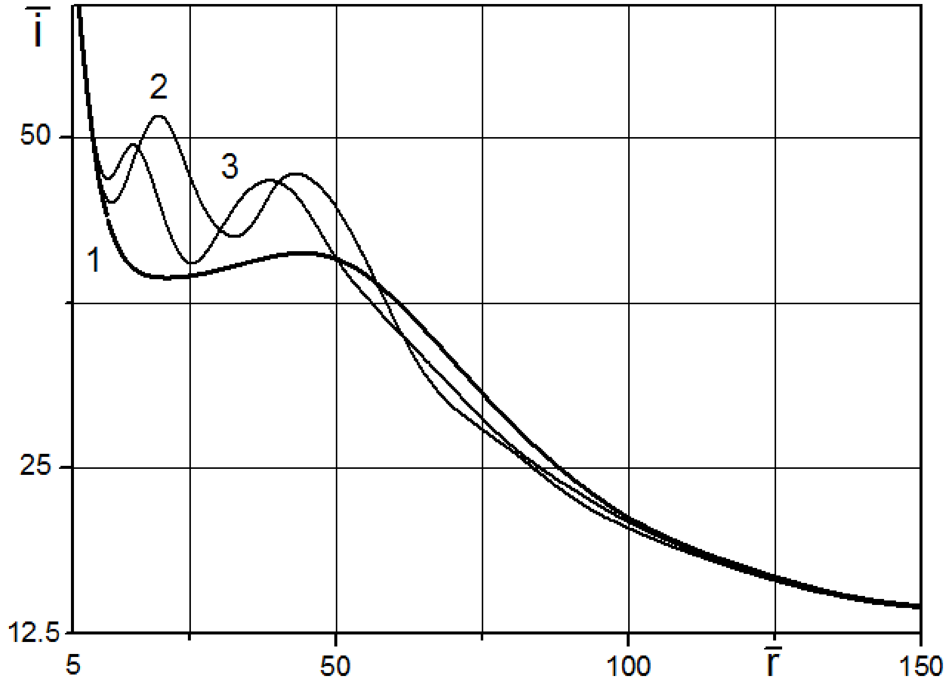

Figure 4. The change in the specific impulse of the air HC with increasing distance from the explosion site along the surface of the earth: 1 - a monolithic charge; 2 and 3 - segmented charges

Finally, figure 4 shows the results of calculations for the specific impulse of the air HC propagating along the surface of the earth from the explosion site. Here, similarly to Figure 2, one can also observe a noticeable excess of the specific impulse in the region for segmented charges over monolithic, and this excess is ~ 30% and ~ 35% for options 3 and 2, respectively.

Findings

1. Segmentation of explosive charge, i.e. dividing it into equal parts and separating them in the air space along the axis of the initial charge over distances of the order of the charge diameter is indeed a way to increase the parameters of an air explosion determined on the surface of the earth, compared to the explosion of a single explosive charge of total mass.
2. An increase in the explosion parameters of a segmented explosive charge is determined by the physics of the interaction of airborne hydrocarbons in the intercharged gaps, namely, the formation here at the initial times of dispersal of individual high-speed jets of explosion products moving in the radial direction parallel to the earth's surface and generating intensive hydrocarbons in front of them.
3. An increase in the explosion parameters of a segmented explosive charge does not manifest itself instantaneously, but after some time, after the air shock waves from the upstream charge segments reach the ground surface and interact with each other and the hard surface, which for this formulation of the problem occurred approximately in the middle region of distances from the center of an explosion ~ (1 ... 6) m. At large distances, the parameters of the explosion of all charges approach each other, since the total energy of the explosion remains constant in all calculation options.

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ИСПОЛЬЗОВАНИЕ АДАПТИВНО-ВСТРАИВАЕМОЙ ДРОБНОЙ СЧЁТНОЙ СЕТКИ ПРИ ЧИСЛЕННОМ МОДЕЛИРОВАНИИ ВЗАИМОДЕЙСТВИЯ ВОЗДУШНОЙ УДАРНОЙ ВОЛНЫ С ИЗЛОМОМ ГРАНИЦЫ ТЕЧЕНИЯ

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В 2018г. в параллельной версии трёхмерной методики ЭГАК [1] были реализованы алгоритмы адаптивно-встраиваемых дробных сеток, аналогичные использовавшимся ранее в последовательной двумерной версии методики ЭГАК [2]. Использование автоматического дробления счётной сетки в нужной области (адаптивно-встраиваемой счётной сетки) потенциально позволяет снизить время счёта при сохранении точности. Более подробная сетка создается путём многоуровневого дробления исходной четырёхугольной (в двумерном случае) или шестигранной (в трёхмерном случае) сетки, называемой основной. Дробление ячеек выполняются согласно следующим принципам:

1. Способ дробления ячеек одинаковый на всех уровнях, новые (дочерние) ячейки получаются отрезками, проведёнными через середины сторон (в двумерном случае) или рёбер (в трёхмерном случае) первоначальных (материнских) более крупных ячеек. Таким образом, при дроблении каждая материнская ячейка делится на четыре (в двумерном случае) или восемь (в трёхмерном случае) дочерние ячейки, другие методы дробления не допускаются.

2. Число уровней должно быть не больше 5 (то есть линейный размер минимальной ячейки может быть меньше основной в 32 раза).

3. Соседние ячейки могут отличаться не более чем на один уровень.