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NUMERICAL ASSESSMENT OF THE PROTECTIVE WALL STRENGTH UNDER GAS EXPLOSION CONDITIONS

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Safety is a complex interdisciplinary and cross-sectoral phenomenon. Consequently, ensuring safety in all spheres of public relations is essential for the state of protection of vital interests of the individual, the state and society as a whole [1]. That is why, ecological issues, technical conditions, and means of ensuring safety are especially important on industrial objects where explosive, and toxic substances are stored and used.

The aim of this study is to assess numerically the bending stress in the foot of the protective wall that is under the influence of the explosion wave front overpressure caused by accidental hydrogen-air mixture explosion on hydrogen fueling station (fig. 1).

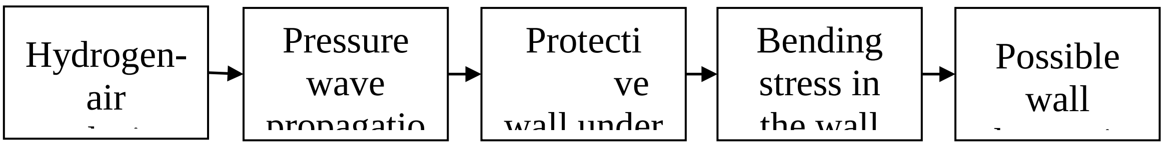

Fig. 1. A development scheme of the wall-explosion wave interaction.

A three-dimensional mathematical model of the instant explosion of hydrogen-air cloud formed after the destruction of the high-pressure storage cylinders is used. The model takes into account the complex terrain and three-dimensional non-stationary nature of the explosion wave propagation process in order to obtain overpressure distribution on the protective wall (fig. 2), which has dimensions l_x = 10,2 m width and l_y = 2,2 m high, is installed between the explosion's epicenter, at 4 m distance, and a working place of the personnel [2].

Overpressure fields are the source data for the calculation of the discrete pressure force and bending momentum distribution on the wall surface (fig. 3).

It is obtained that the overall momentum effort M_{max} to bend the wall at its foot is around 2553 kN·m. It is known from the materials stress theory that the minimum required design moment of resistance of the wall foot section can be found from this formula

$$W = \frac{l_x l_z^2}{6} \geq \frac{M_{\max}}{[\sigma]}, \qquad (1)$$

where [σ] is permissible stresses for the wall material. For the steel wall ([σ] = 160 MPa) the minimum required design moment equals $15959 \cdot 10^6$ m^3.

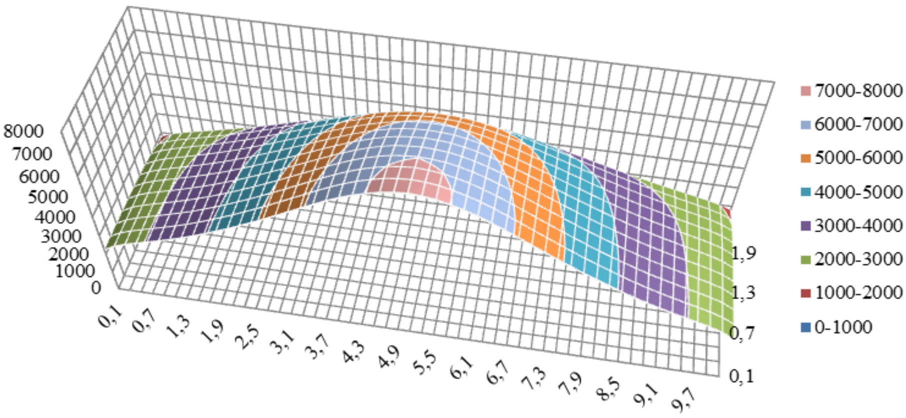

Fig. 2. Overpressure (kPa) distribution on the wall surface.

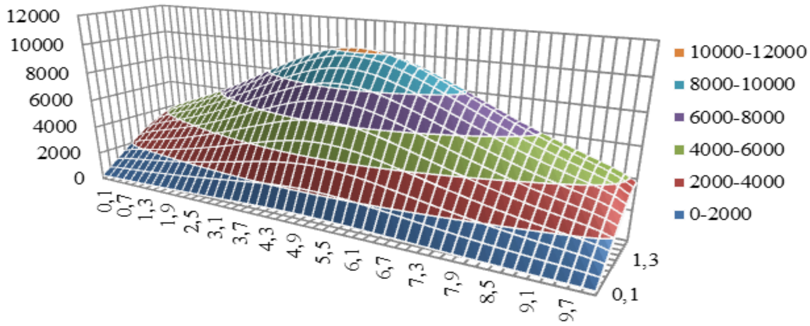

Fig. 3. Bending momentum (kN·m) distribution on the wall surface.

From formula (1) it can be calculated that the depth of the steel wall l_y has to be greater than 0,097 m to satisfy the bending strength condition.

The developed computer methodology resolves a coupled problem of gas dynamics and strength and allows an expert to carry out an automated analysis of the safety situation at the fueling station, where hydrogen is accidentally released and explodes, and to provide recommendations about the dimensions of the safety wall in order to effectively protect personnel from the harmful impact caused by an explosion wave without the destruction of the wall.

REFERENCES

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