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NUMERICAL ANALYSIS OF HARMFUL ENVIRONMENTAL IMPACT OF ACCIDENTAL EXPLOSION AT A HYDROGEN FILLING STATION

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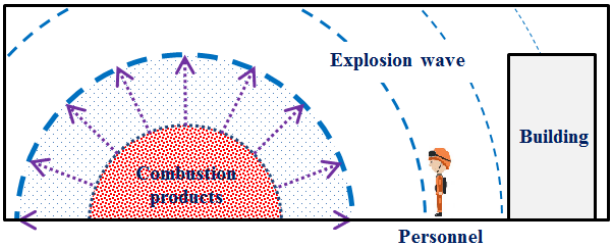
Abstract – Hydrogen is a very important and valuable source of energy for modern vehicles. However, it is extremely explosive. An accidental failure of compressed hydrogen storage equipment at a filling station can lead to the release of hydrogen into the atmosphere, the formation of a hydrogen-air mixture, and its explosion, and the blast wave can lead to destruction and human casualties. The purpose of this study is to evaluate numerically the harmful consequences of a hydrogen-air mixture accidental explosion at a vehicle hydrogen filling station in order to suggest measures to protect the environment from blast wave overpressure. The physical process of the explosion, which takes place after the hydrogen gas release into the air due to the accidental destruction of a number of high-pressure storage cylinders, is considered. The blast pressure wave moves in all directions from the epicenter of the accident, gradually losing its intensity and having a negative shock impact on the service personnel of the filling station and the structures of the surrounding buildings. The scale of the accident depends on the number of destroyed cylinders, which determines the size of the hydrogen-air cloud and the power of the explosion. The degree of negative consequences for the environment depends on the maximum overpressure in the blast wave front. Numerical obtaining of spatial pressure distributions in the area of the accident based on a hydrogen explosion mathematical modelling makes it possible to separate zones that are dangerous to human health and building structures strength. The direct problem of gas dynamics of combustion products of a hemispherical cloud of a stoichiometric hydrogen-air mixture in the surface layer of the atmosphere is considered. The mathematical model of an instantaneous hydrogen explosion takes into account the threedimensional and non-stationary nature of the propagation of the explosion wave, the compressibility of the gas flow, the complex terrain, the shape and initial concentration of the cloud of hydrogen combustion products, and their thermodynamic parameters. The model makes it possible to obtain threedimensional fields of maximum overpressure, which are the basis for deterministic assessment of the consequences of an accident for human health and the integrity of structures in the area of the explosion. The presented computer technology allows security experts to identify potentially dangerous zones by means of mathematical modelling, and recommend effective protective measures to mitigate or even eliminate the negative consequences of the blast wave environmental impact.

Keywords – Gas mixture explosion; pressure wave; maximum overpressure; human health impact degree; structure destruction grade



The scheme of the blast wave propagation in the area of the accident.