

Kinetic Energy of the Explosion in a Blast Hole and Its Transfer into the Rock

When a cylindrical, elongated explosive charge is initiated from one end, the explosive compressive wave advances at a speed denoted as the detonation velocity (V_e). The compressive stress at the wave front (P_c) can be calculated using the well-known formula:

$$P_c = \frac{V_e^2 \cdot \rho_e}{2}$$

And the lateral compressive load on the borehole wall is two times smaller, i.e.:

$$P_b = \frac{V_e^2 \cdot \rho_e}{4}$$

Since the pressure impulse lasts for a very short time, only about 10 microseconds, the loss of heat from the explosion product gases as well as their outflow is minimal, so their volumetric density is considered equal to the volumetric density of the explosive (ρ_e).

In fluids, molecules are organized into clusters which may be analogous to particles in rocks, so we shall treat them as particles. At the moment of explosion, a gas "particle" strikes a rock particle in the borehole wall and thereby transfers to it the corresponding kinetic energy, Figure 1.

The gas particle has approximately 3 times smaller volumetric density than the rock particle (ρ_s), therefore the energy transferred from the gas particle to the rock particle will be reduced accordingly. Thus the compressive stress of the rock at the borehole boundary in the radial direction will be:

$$\sigma_r = \frac{V_e^2 \cdot \rho_e}{4 \cdot \rho_s}$$

When the velocity of the compressive wave in the rock has the same value as the detonation velocity, the particles move at the same speed after the impact. When the velocity of the compressive wave in the rock is greater than the detonation velocity, the rock particle moves faster, while the gas particle catches up with it until it transfers the complete energy to it.

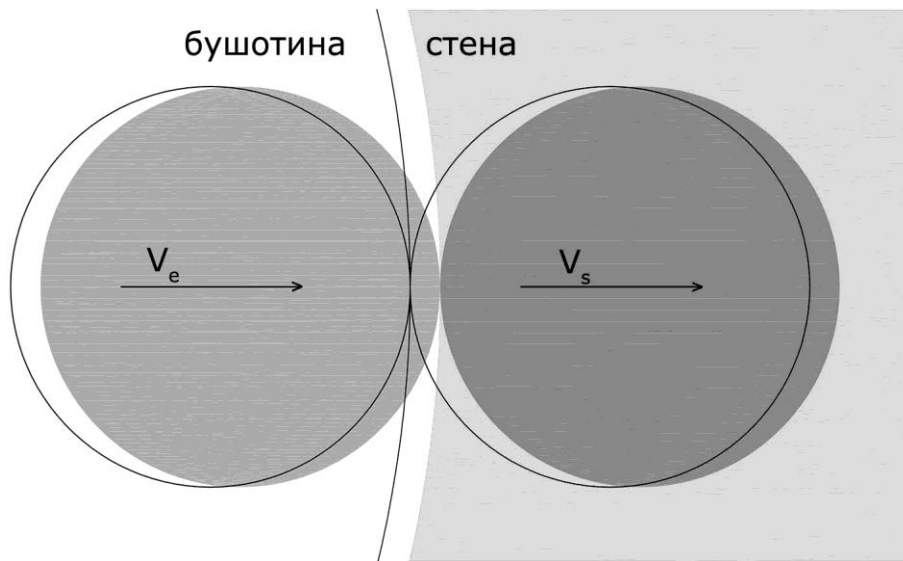


Figure 1. Transfer of energy from a gas particle to a rock particle

When the velocity of the compressive wave in the rock is lower than the detonation velocity, the gas particle will not transfer the complete kinetic energy to the rock particle because it cannot move faster than its maximum velocity, which is a characteristic of the material (in this case the rock material). Therefore, for the calculation of compressive stress in the rock at the borehole boundary in the radial direction, the velocity of the compressive wave in the rock (V_s) will be used.

$$\sigma_r = \frac{V_s^2 \cdot \rho_e}{4 \cdot \rho_s}$$

It is obvious that rocks with a low compressive wave velocity, with a low deformation velocity, that is, a low particle velocity, have low conductivity of kinetic energy. Of course, nothing can be done with the rock itself. The borehole diameter can be increased, and thereby also the contact surface between the explosive and the rock. The volumetric density of the "particles" of the gaseous explosion products could also be increased.