EXPERIMENTAL SIMULATION OF METEORITE IMPACT

M. M. Rusakov

Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, Vol. 7, No. 4, pp. 167–169, 1966

ABSTRACT: The author presents the results of experiments on the impact of a compact mass with a density of about 1 g/cm^3 against polystyrene and steel targets at a velocity of 24 km/sec. Contrary to expectation, the impact left deep and narrow holes in the target, i. e., did not create the effect of a point surface explosion.

In recent years there have been many studies of the impact of solid objects against targets at cosmic speeds. However, for speeds above 10 km/sec they are theoretical in character and give widely differing results [1-5]. In these studies it is assumed either that the impacting body "explodes" at the surface of the target [1], spreads out, sending a shock wave through the target [4], or penetrates the target and explodes inside it [3].

At high impact velocities the picture of a point surface explosion is evidently correct; however it is not clear at what velocities this picture tends to become asymptotic [1].

A projectile consisting of a compact mass of tungsten particles with a density of about 1 g/cm^3, moving at a velocity of 24 km/sec, was fired at polystyrene and steel targets. The projectile, 5 mm in diameter and about 10 mm long, was fired at the target through an air-filled plastic tube about 100 mm long and with walls 1.5 mm thick.

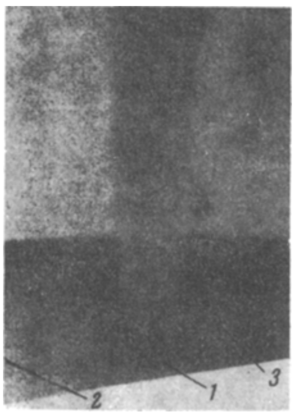


Fig. 1. X-ray photograph of projectile moving through polystyrene target: 1) 1) projectile; 2) target; 3) shock wave.

In the case of polystyrene targets the penetration process was registered at several instants of time by means of a pulsed x-ray machine. It was noted that the projectile penetrates the target without appreciable lateral expansion, i. e., without an explosion. An x-ray photograph of a projectile moving through a target is shown in Fig. 1. In the first period of motion the shock wave in the target "sits" on the tip of the projectile. It luminesces and the motion of the shock front was registered with a SFR-2M high-speed photorecorder. The result of the experiment is shown in Fig. 2, which also includes three points obtained by pulsed x-ray photography.

The initial rate of penetration of the projectile into the polystyrene was 11.5 km/sec or about half the impact velocity, which corresponds to a projectile and target with the same dynamic rigidity.

The results of impact against steel targets under different impact conditions are shown in Figs. 3 and 4.

From the experiments described it is clear that the motion of the projectile in a polystyrene target is similar to that of a solid in a gas.

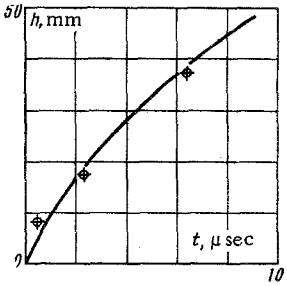


Fig. 2. Graph of penetration of projectile into polystyrene target.

The x-ray photograph shows that it does not expand sideways, while the shock wave in the target "sits" on its tip. Neither explosion nor lateral spreading of the projectile is observed. Moreover, the target even prevents the expansion characteristic of a dispersed body in free flight. In fact, impact against steel through a layer of plastic leaves a hole much deeper than impact through the same layer of air (Fig. 3).

The shape of the craters in steel targets (Figs. 3 and 4) shows that in this case, too, the projectile does not "explode." In the event of an "explosion" upon impact in a "closed" space, the crater would have been almost spherical and would have been formed in both parts of the target, which was not the case. Thus, at the velocities achieved the penetration picture is still not at all similar to a point surface explosion, i. e., this asymptotic condition is apparently still quite remote. The reason for this is not completely clear—insufficiently high velocities, effect of the strength of the target, or some other factor.

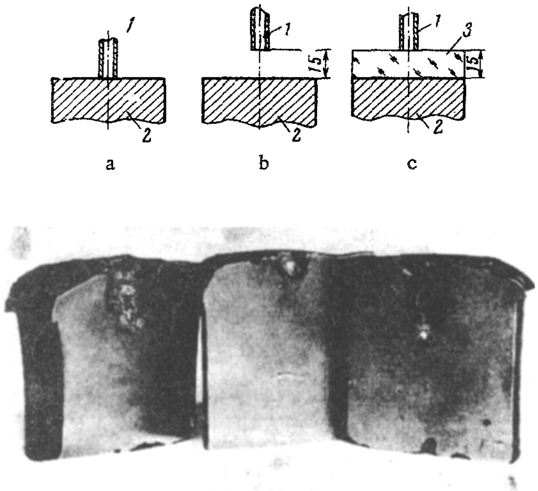
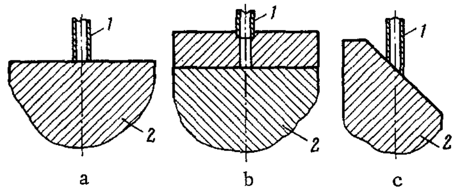


Fig. 3. Craters formed in steel target by the impact of a projectile: a) direct impact; b) impact through air; c) impact through plastic; 1) tube through which projectile moves; 2) target; 3) plastic.



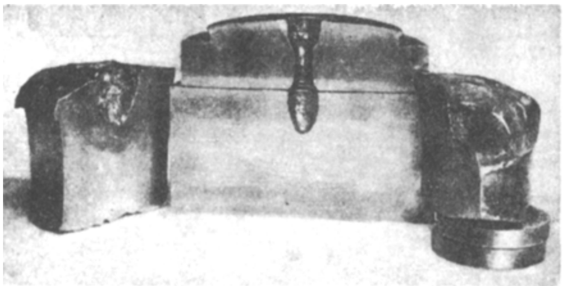


Fig. 4. Craters formed in steel targets by the impact of a projectile: a) direct impact; b) impact in "closed" space; 3) impact at an angle of 45°; 1) tube; 2) target.

REFERENCES

1. Ya. B. Zel'dovich and Yu. P. Raizer, Physics of Shock Waves and High-Temperature Hydrodynamic Effects [in Russian], Fizmatgiz, 1963.

2. M. A. Lavrent'ev, "The problem of penetration at cosmic velocities," Iskusstvennye sputniki Zemli, no. 3, 1959.

3. K. P. Stanyukovich, "Elements of the theory of impact of solids at high (cosmic) velocities," Iskusstvennye sputniki Zemli, no. 4, 1960.

4. A. Ya. Sagomonyan, "Interaction of bodies at very high speeds," DAN SSSR, 156, no. 5, 1964.

5. F. A. Whipple, "An evaluation of the possibility of meteorite penetration of spacecraft," Voprosy raketnoi tekhniki [Russian translation], no. 4, 1965.

9 December 1965 Moscow