Hypervelocity impact and shock wave attenuation in porous medium.

M.V. Rashev and T.J. Ahrens, Caltech 252-21, Pasadena, Ca 91125

Introduction

Collisions and following shock compressions of matter are frequent events in the Solar System. Many of natural solids are porous and their behavior under compression can differ of non-porous solids (crater size, material mixing, pressure and temperature attenuations). Here we want to investigate energy partitioning and shock wave attenuation for several porous and non-porous materials. This will show how initial kinetic energy of a projectile is distributed over colliding bodies and how different attenuation in porous material is.

Calculations

For the calculations we use Autodyne software that allows us to model an impact using several solvers like Euler, Lagrange, SPH. Here we model the impact using two of them (Lagrange and Euler) and make their comparison.

We present results of our impact modeling when iron meteorite of 20 km diameter collides with non-porous and porous quartz at velocities of 10km/s. As a result of such an impact most of kinetic energy of the projectile is converted to internal energy of the target. The second large energy deposition is made to kinetic energy of the target. It was also noted that for the case of high porosity, shock wave in the target proceeds the projectile by a very small fraction of time.

Several examples of these simulations are in Figures 1,2

Figure1 shows simulation example when iron impacts porous quartz (400x300 cells, 2D). At this some cells contain two materials at the same time. The iron meteorite still moves toward while the target material blows outwards.

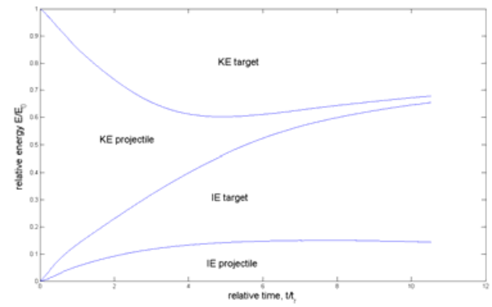

Figure 2 shows an example of energy partitioning between kinetic and internal energies for the projectile-target system.

For the projectile (iron) we used shock wave equation of state and Johnson Cook strength model. Quartz behavior is represented by a shock wave equation of state (EOS) family, where parameters depend on how porous quartz is. These relations are deduced from experimental data on porous quartz [1] [2] [3]. Figure 3 shows shock wave Up-Us relation for Quartz..

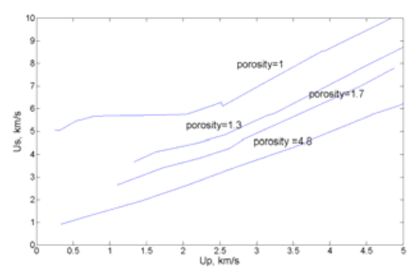

Figure 3. Relation between particle velocity and shock velocity for quartz at different porosities.

Conclusion

The purpose of this work is to study several porous and non-porous materials like quartz, ice, anorthosite, iron; calculate energy partitioning and attenuation laws. First study of iron impacting porous quartz shows that most of projectile kinetic energy is converted to target internal energy. This study also shows that shock wave propagation is comparable the projectile velocity for highly porous material.

References

1. S. P. Marsh (Ed.), LASL Shock Hugoniot Data, (Univ. California Press, Berkeley, 1980)

2. R. F. Trunin, G. V. Simakov, M. A. Podurets, B. N. Moiseev, L. V. Popov, Dynamical compressibility of quartz and quartzite at high pressures, Izv. Akad. Nauk SSSR. Fiz Zemli 1, 13-20 (1971) (Bull. Akad. Nauk SSSR, Physics of the Solid Earth 1, 8-15 (1971))

3. M. van Thiel (Ed.), Compendium of shock wave data, (Livermore: Lawrence Livermore Laboratory Report UCRL-50108, 1977), 373-376