Pressure-Shear Plate Impact Experiments

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Pressure-Shear plate impact experiment is a very important experimental method to test the strength of materials at high strain rates (10^4-$10^7 s^{-1}$). This experiment involves the impact of two skewed plates. The projectile and target plate are parallel, but inclined relative to the axis of the gun so that the particle velocity in the target have components both normal and parallel to the plate of impact. The generated normal and shear waves are well characterized one-dimensional plane waves.

This experimental technique has been used to investigate the dynamic behaviors of a wide range of materials, including the shearing resistance of aluminum at temperatures approaching melt. The objective of these experiments was to look for a possible change in the rate-controlling mechanism of dislocation motion from thermally activated motion of dislocations past obstacles to phonon drag as the temperatures becomes high enough that thermal activation becomes relatively unimportant. The experimental results show an upturn in shearing resistance with increasing temperature at high temperatures, suggestive of a change in rate-controlling mechanism. However, the upturn is too steep to be described by a usual phonon drag model with a drag coefficient that is proportional to temperature. Simulated results show that the modeling of strain rate hardening based on a phonon drag model leads to too strong an increase in flow stress with increasing strain rate in the drag-dominated regime.

Experimental and Computational Investigation of the Response of an Elastomer at Pressures up to 18 GPa and Strain Rates of 10^5 -10^6 s^{-1}

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Normal-incidence and pressure-shear plate impact experiments have been conducted to study the mechanical response of an elastomer, polyurea P1000, at high strain rates — $10^5 - 10^6 s^{-1}$ — and high pressures — up to 18 GPa. Configurations with samples sandwiched between two hard plates have been used to conduct constant-pressure, pressure-change, and low-pressure experiments to investigate the pressure dependence of the shearing resistance. A symmetric pressure-shear plate impact configuration has been used to measure directly the thickness-averaged nominal strain rates of the sample — as well as the tractions on both of its interfaces with linear elastic plates. Release wave experiments have been used to capture the behavior at compressive stresses below 0.5 GPa, and still lower until tensile failure occurs. From these experiments, the quasi-isentrope of polyurea is obtained as well as its high-strain-rate shearing resistance at pressures up to 18 GPa. The experimental results show that the shearing resistance of polyurea depends strongly on pressure.

Based on these experimental results, the constitutive model introduced here consists of an instantaneous elastic response followed by relaxation with a distribution of effective relaxation times. To describe the pressure dependence of shearing resistance, the strain energy for the instantaneous elastic response is assumed to have a multiplicative decomposition of contributions associated with devitoric and volumetric changes. This model has been implemented into Abaqus to simulate the response of polyurea P1000 under the impact conditions of the various experiments. Results of these simulations are compared with the experimental results to gain understanding of the viability of the proposed model

压剪炮实验技术及应用

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压剪炮实验技术已经被广泛应用于研究材料在动加载下(10^4-$10^7 s^{-1}$)的强度响应。它将平板碰撞实验中正碰的飞片和靶板沿飞片飞行的方向倾斜。碰撞后，靶板即获得了沿正向又获得沿切向的粒子速度。这样在靶板中产生的压力波和剪切波都是标准的一维应变平面波。

这项实验技术已经被应用于很多材料的动态响应的研究中，其中包括研究铝在接近熔点时的剪切强度。这个课题的主要目的就是通过实验来发现位错运动的机理从热激活机制到声子拖曳机制的转化。实验结果发现当温度升高到一定值后，铝的剪切强度反而随温度的升高而升高。这一实验现象是符合热激活机制到声子拖曳机制的转化的。但是，如果假设粘滞拖曳系数与温度成正比，则实验中所检测到的材料强度的升高幅度要高于声子拖曳模型的预测值。数值拟合结果也显示声子拖曳模型所预测的应变率强化效应高于实验结果。

聚脲在高压、高应变率下的实验和数值模拟研究

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本课题利用平板正碰和压剪炮实验对一种弹性体（聚脲 P1000）在高压（18GPa）和高应变率（$10^5-10^6 s^{-1}$）下的动态响应进行了实验研究和数值拟合。利用三明治式（样品加在两片硬板中）的靶板结构对聚脲剪切强度的压力敏感性进行了常压，变压和低压的压剪炮实验研究。利用对称压剪炮实验直接测量了样品厚度平均的应变率和样品两表面的压力和剪切力。利用层裂实验对样品在压力低于 0.5GPa，直至拉伸应力范围内的响应进行了测量。根据这些实验结果，我们得到了聚脲在高压和高应变率下的剪切强度和其在准等熵情况下的压缩应力应变曲线。实验结果显示聚脲的剪切强度具有很强的压力敏感性。

基于这些实验结果，我们利用准线性的粘弹性本构模型来描述聚脲的动态响应。在该模型中为了描述剪切强度的压力敏感性，描述瞬时弹性的应变能是由偏应变的贡献和体应变贡献的乘积而得。这一模型被编入 ABAQUS 中对各种实验进行了数值拟合，并与实验结果进行了比较。