Theoretical Analysis and Computational Modeling of Dynamic Mechanical Response of Magnesium

Qizhen Li
Washington State University

As the lightest structural metal, magnesium is an emerging material candidate for various structural components in automobiles, aircrafts, etc. These components often experience high strain rate dynamic loadings during their actual services. It is attractive to investigate dynamic mechanical behavior of magnesium through theoretical analysis and computational modeling since they can reduce the high cost associated with experimental testing. We built both theoretical and computational model based on Johnson-Cook law and dynamic experimental data of Mg single crystal and pure Mg. Both theoretical and finite element simulations for the strain rates used in the experiments predicted the mechanical responses of the material that agree well with the experimental data. The stress-strain curves of Mg single crystal show that (a) the fracture strain slightly increases with the strain rate; and (b) the maximum strength and strain hardening rate increase significantly when the testing changes from quasistatic to dynamic, although they do not vary much when the strain rate for dynamic testing varies in the range of 430–1200/s. For pure Mg, the dynamic stress-strain curves show somewhat linear strain hardening at the early stage of plastic deformation, increasing strain hardening at the intermediate plastic deformation region, and decreasing strain hardening at the region before fracture.