Ductile fracture is a topic of great importance in automotive and aerospace industries. Prediction of ductile fracture in engineering structures relies on developing robust material models under complex loading conditions. This dissertation addresses the anisotropic and strain rate effects in constitutive and ductile fracture models of lightweight metals. In the present modeling framework, the anisotropic plasticity behavior is modeled by combination of an initial anisotropic yield function and an isotropic hardening correction by Lode dependence. A new all-strain based anisotropic fracture model is proposed based on the approach of linear transformation on plastic strain rate tensor. The strain rate effects in ductile fracture is considered as an extension of the modified Mohr-Coulomb (MMC) fracture model by coupling strain rate with stress state in terms of Lode angle parameter. The rate-dependent MMC model provides a well-bound solution up to the intermediate strain rate range for metal forming and crashworthiness applications. The present modeling framework is calibrated from coupon tests of aluminum alloy and advanced high strength steel (AHSS) sheets using digital image correlation (DIC) technique and validated through correlations by finite element (FE) simulations. This study also demonstrates the applications of ductile fracture modeling in manufacturing processes. The thermo-mechanical FE simulations of orthogonal cutting processes using the Johnson-Cook constitutive and damage models show that the highly damaged regions in zones of material separation form a thin boundary layer at the tool tip. The numerical simulation results explain the success of analytical model with uncoupled component works of plasticity, friction and separation. The FE modeling results of formability and component-level testing suggest that part behavior and material failure is well predicted using calibrated ductile fracture models under different loading conditions.

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The public is welcome to attend.