Development of an Anisotropic Material Model for the Simulation of Extruded Aluminum under Transient Dynamic Loads

Anthony Smith[1], Paul DuBois[2], Thomas Borrvall[3]

[1]Honda R&D Americas
[2]LSTC Consultant
[3]Dynamore Nordic

The movement towards lightweight materials in the construction of automotive bodies is leading to an increase in parts made from extruded aluminum and other materials with a large degree of anisotropic behavior. The need to model these anisotropic properties and predict the behavior of these materials is increasing rapidly. A review of the anisotropic material models available in LS-Dyna including Material types 36, 133, 135, and 243 led to the decision that Material type 36 with option "Hardening Rule 7" (HR7) was the most appropriate choice for application towards analysis of extruded aluminum parts under both static and dynamic loads. Material type 36 (`*MAT_3-Parameter_Barlat`) has a history of use in forming applications and shows promise as a valuable tool for modeling anisotropic behavior in high strain, high velocity simulation applications as well.

An investigation into this application of the material model revealed fundamental limitations in the stability of the model, particularly in cases of high anisotropy (with R-values diverging greatly from 1.0). The authors updated the material model which should improve both accuracy and stability. The most important of these updates was the inclusion of four more input parameters to the `*MAT_3-Parameter_Barlat` HR7 formulation. These parameters enable the user to input hardening curves detailing the material stress-strain response in the shear and biaxial loading conditions. They also enable the user to input constant or hardening curves defining a novel shear and biaxial "R-Value" response over a chosen strain range for the material. These additions serve to improve the stability of the model over a greater range of input parameters, and allow for implementation of the model towards materials with higher levels of anisotropic behavior.

Investigations based upon single element and coupon level simulation contibuted to the validation of the robustness of the updated material model. Further work with coupon and component level models will support the effort to understand its predictive capabilities for simulation of transient dynamic loading conditions. The final goal of the project is to predict the anisotropic strength, stiffness and fracture of extruded aluminum during impact loading. The main focus of this presentation is to explain and illustrate the changes to the `*MAT_3-Parameter_Barlat` HR7 formulation to improve the accuracy and robustness of the model.

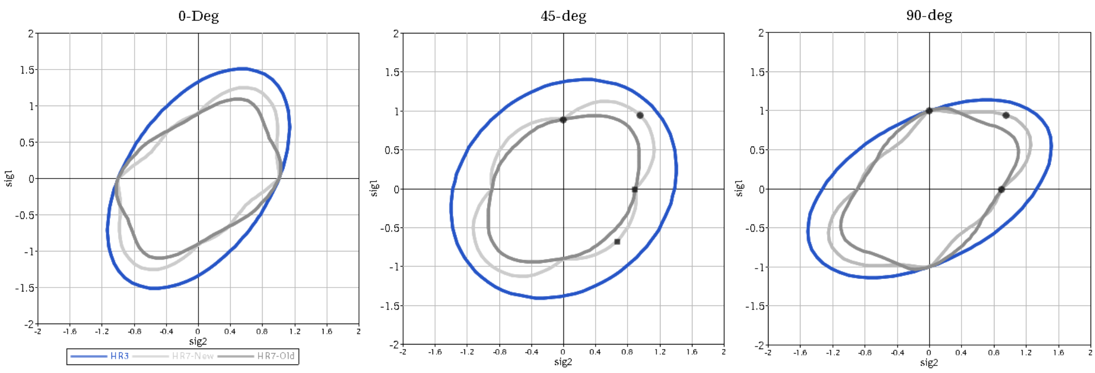

*Fig.1: Comparison of Yield Surface Generated by Various Implementations of *MAT_3-Parameter_Barlat at Three Material Orientations.*