Bifurcation analysis based on a material model with stress-rate dependency and non-associated flow rule for fracture prediction in metal forming

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ABSTRACT

Recent increasing aplication of adnvanced high-strength metals leads to demand for high precision of fracture prediction in metal forming simulation. However, since the construction of objective and reliable fracture prediction method is generaly difficult, essential progress in fundamental theory that supports evolution of fracture prediction framework is required.

In this study, a fracture prediction framework based on the bifurcation theory is presented. The main achievement is a novel material model[1] based on stress-rate dependency related with non-associate flow rule. This model is based on non-associated flow rule with independent arbitrary higher-order yield function and plastic potential function for any anisotropic materials. And this formulation is combined with the stress-rate-dependency plastic constitutive equation, which is known as Ito-Goya model, to construct a generalized plastic constitutive model in which non-normality and non-associativity are reasonably considered. Then, by adopting the three-dimensional bifurcation theory, which is known as the 3D localized bifurcation theory[2], more accurate prediction of the initiation of shear band is realized, leading to general and reliable construction of forming limit diagram. Then, by using virtual material data and some experimental data, numerical simulation is carried out to exhibit fracture limit diagram for demonstrating the generality and reliability of the proposed methodology. In particular, the effect of stress-rate dependency on the bifurcation analysis is investigated, and the order of the yield and plastic potential functions are used to investigate their influence on the forming limit prediction.

REFERENCES

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