The numerical failure prediction by the damage model GISSMO in various materials of sheet metal

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1 Abstract

Responding to continuous demands for weight saving and enhancement of collision safety of vehicles, high-strength steel sheets are widely used for car bodies. Also, the applications of aluminum sheets are increasing for seeking more lightweight, recently. In applying sheet metals with thinner thickness and higher strength to car bodies, numerical fracture predictions are strongly required to ensure collision safety, since the reduction of ductility becomes key issure for these materials.
As a failure model, we use a well examined damage model GISSMO which includes incremental formulation for the description of material instability and localization.

In this study, failure curves for GISSMO are identified by experimental data. Numerical failure prediction using GISSMO is conducted for the quasi-static axial crush test of HAT member. Based on experimental and numerical results, validity of the damage model GISSMO for high strength steel and aluminum alloy sheets are discussed.

2 Failure criteria for GISSMO

Fracture strain at several stress states are required to identify the fracture curve. They are obtained from notched tensile tests (uniaxial and plane strain) [1], shear test [2], and erichsen test (biaxial tensile). Then, fracture strains are calculated on the assumption of plane stress condition.

In this study, we evaluated several materials, namely, PHS (TS 1500MPa grade), UHSS (TS 980MPa grade), aluminum alloy 7000 series and 6000 series. In the present paper, we focus on the UHSS. “UHSS A-type” is a metal that has higher uniform elongation. “UHSS B-type” is a metal that has better local ductility.

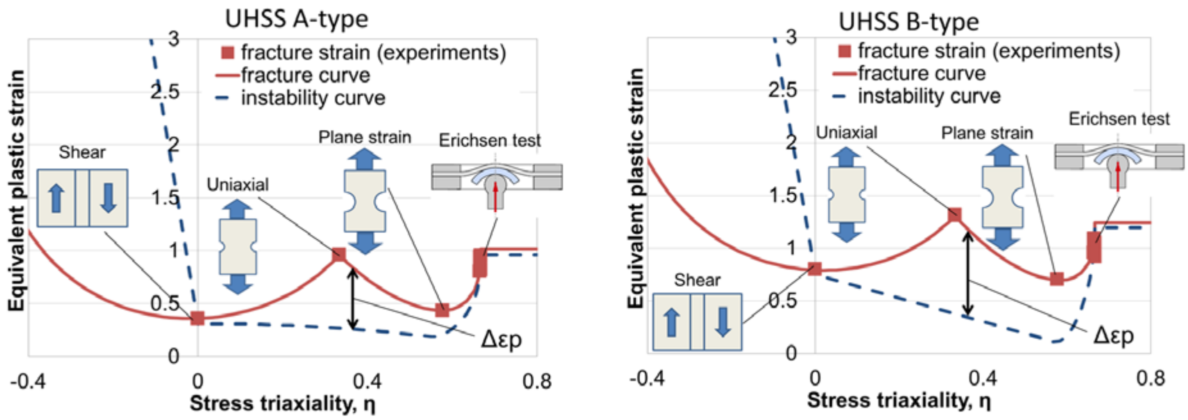


Fig.1: The fitted curve for fracture and instability.

The curve of fracture and instability identified from material tests are shown in Fig.1. In Fig. 1, the difference of equivalent plastic strains between the fracture and instability curves, denoted by Δεp, is thought to correspond to the progress of local ductility. From the figure, Δεp of the UHSS B-Type is greater than that of UHSS A-Type. This shows that the local ductility of the former is higher than that of the latter, and it corresponds with the experimental facts. The correlation between Δεp and the local ductility is also confirmed in other experimental results.

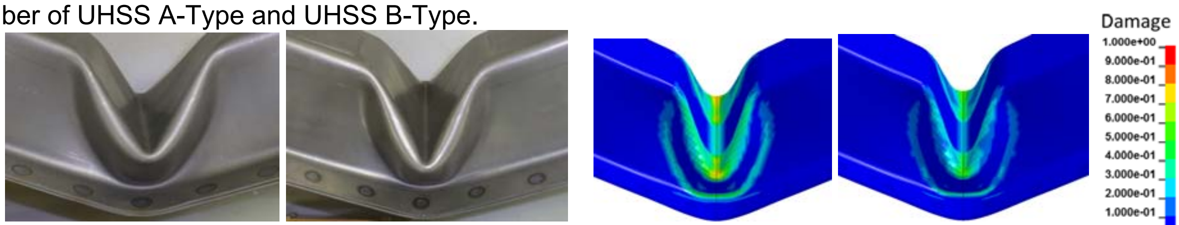
3 Numerical failure prediction (Shell model)

Numerical failure prediction using GISSMO with the above failure criteria is performed for the quasi-static 3-point bending test and axial crush test of HAT member.

The GISSMO damage model is implemented in card 3 and card 4 of the LS-DYNA keyword **`*MAT_ADD_EROSION`** and activated by the first flag IDAM=1. In this study, the widely-used **`*MAT_PIECEWISE_LINEAR_PLASTICITY`** (**`*MAT_024`**) is chosen for the material model.

3.1 Quasi-static HAT 3-point bending test

Fig.2 shows the numerical and experimental result for quasi-static 3-point bending test of HAT member of UHSS A-Type and UHSS B-Type.



UHSS A-Type UHSS B-Type
Experiment

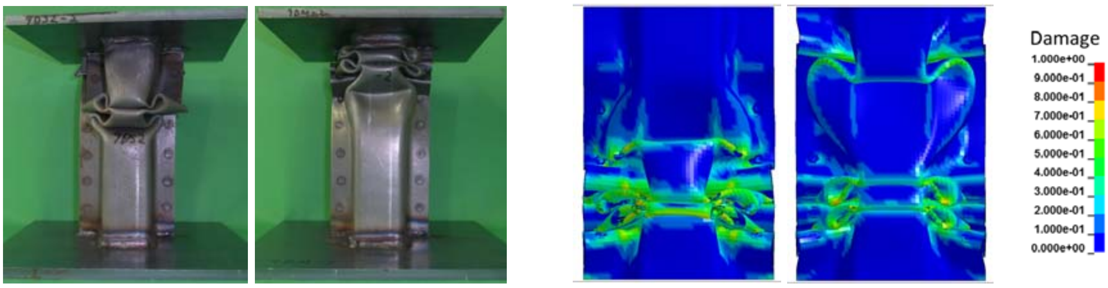
UHSS A-Type UHSS B-Type
Simulation

Fig.2: Comparison of numerical and experimental results for 3-point bending test of HAT member

As shown in Fig. 2, there is no crack in numerical and experimental results. It is confirmed that numerical prediction can reproduce that crack doesn't occur.

3.2 Quasi-static HAT axial crush test

Fig.3 shows the numerical and experimental result for quasi-static axial crush test of HAT member of UHSS A-Type and UHSS B-Type.



UHSS A-Type UHSS B-Type
Experiment

UHSS A-Type UHSS B-Type
Simulation

Fig.3: Comparison of numerical and experimental results for axial crush test of HAT member

As shown in Fig. 3, crack locations obtained by the simulation are agree well with the experiment and it is confirmed that the failure prediction can be performed accurately using GISSMO.

4 Conclusions

The fracture and instability curves are identified from fracture strains from material tests. Numerical predictions using GISSMO are performed using those curves. Then, it is confirmed that numerical predictions almost agree with experiments.

5 Literature

[1] Till, E. T.; Hackl, B.; Schauer, H.: "Crash simulation of roll formed parts by damage modelling taking into account preforming effects", AIP CONFERENCE PROCEEDINGS, 2011, pp.267-274

[2] An, Y.G.; Vegter, H.; Heijne, J.: "Development of simple shear test for the measurement of work hardening", Journal of Materials Processing Technology 209, 2009, pp.4248-4254