Conversion between FLD and Stress Triaxial Limit Curve

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INTRODUCTION/MAIN FEATURES

Increasingly, as more Advanced High Strength Steels (AHSS) are being used, stamping engineers need to worry about material failure such as shear fracture during forming, in addition to the traditional necking failure. Two keywords are created in response to the users' requirement to account for the material failure modes from necking to fracture. They are: *DEFINE_CURVE_FLD_FROM_TRIAXIAL_LIMIT, and *DEFINE_CURVE_TRIAXIAL_LIMIT_FROM_FLD.

The FLD conversion from stress triaxial limit curve creates the corresponding necking failure limit curve when only a triaxial limit curve exists. The stress triaxial limit curve conversion from FLD curve generates the corresponding fracture limit curve when only a FLD limit curve is available.

Such conversions can be used in material models such as *MAT_037_NLP_FAILURE, *MAT_ADD_EROSION, or *MAT_260B, or in keywords such as *CONTROL_FORMING_ ONESTEP.

The conversion assumes plane stress and Von-Mises yield criterion. The converted FLD or stress triaxial curve can be found in the ".o" file (a scratch file from batch queue run).

EXAMPLES:

An example of the keyword *DEFINE_CURVE_FLD_FROM_TRIAXIAL_LIMIT is listed below. Note the abscissas represent stress triaxialities, typically ranging from -1/3 to 2/3; the ordinates represent equivalent plastic strains to fracture. The stress triaxial curve is referenced from the paper by *Li, Yaning et al, "Prediction of shear-induced fracture in sheet metal forming," Journals of Material Processing Technology, Volume 210, issue 14, (2010).*

```
*DEFINE_CURVE_FLD_FROM_TRIAXIAL_LIMIT
909
-.3284545, 2.485632
-.3193636, 2.327586
-.3102727, 2.198276
-.3011818, 2.04023
-.2875454, 1.882184
-.2739091, 1.70977
-.2602727, 1.522989
-.2466363, 1.37931
-.2239091, 1.235632
-.2011818, 1.106322
-.1648182, .9626437
-.133, .8477012
-8.754542E-02, .7471265
```

```
-4.663633E-02, .6896552
-1.481815E-02, .6465518
3.36367E-03, .632184
3.972731E-02, .6178162
8.518185E-02, .6034483
.1397273, .6034483
.1897273, .6465518
.2351819, .7183908
.2715455, .7758621
.3033637, .862069
.3306364, .9770116
.3488182, .9195403
.3715455, .8189656
.3988182, .7040231
.4351819, .5890805
.4715455, .5028736
.517, .4310345
.5533637, .4166667
.5760909, .4166667
.617, .4310345
.6397273, .4885058
.6533636, .5603449
.6670001, .8045977
*end
```

Figure 1 illustrates this conversion from stress triaxial curve to FLD curve. Note the red curve is the input triaxial curve and green curve is the output FLD curve from LS-DYNA. The LS-DYNA calculated FLD curve exactly matches that from the paper.

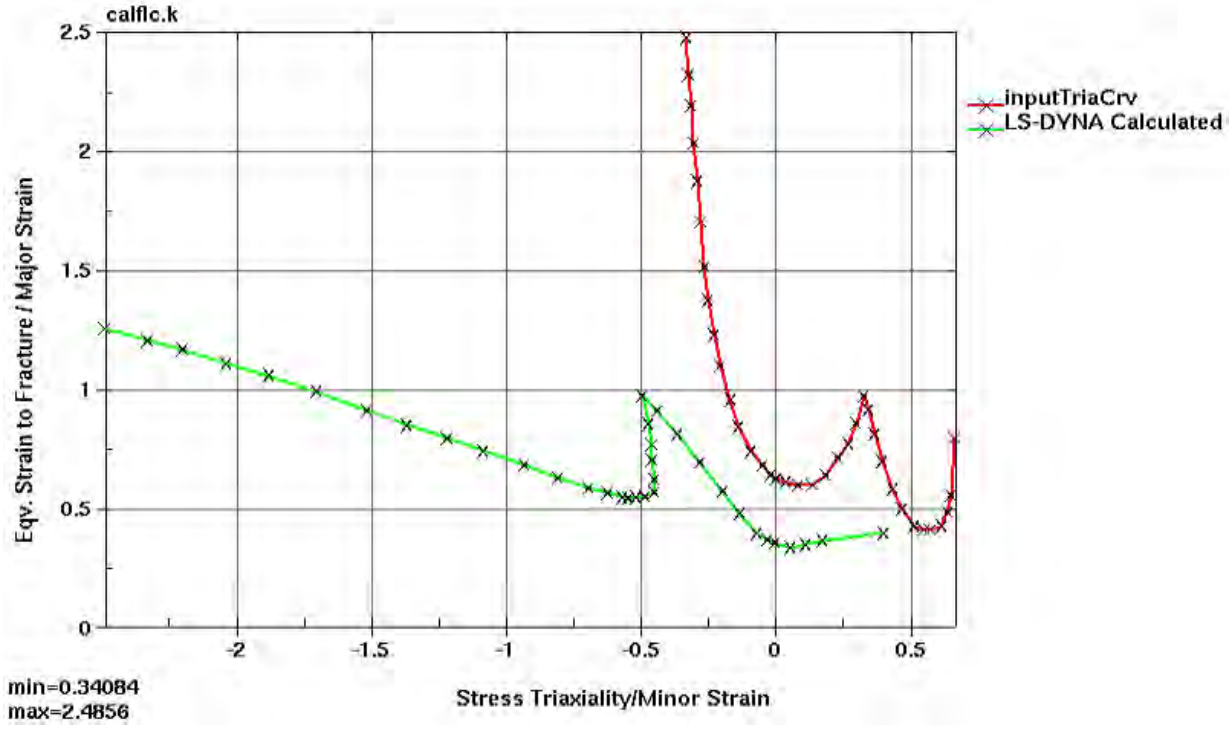

Figure 1 Conversion from Stress Triaxial Curve to FLD Curve

Another example of the keyword *DEFINE_ CURVE_TRIAXIAL_LIMIT_FROM_FLD is listed below. Note the abscissas represent minor true strains of a FLD curve; the ordinates represent major true strains of a FLD curve.

```
*DEFINE_CURVE_TRIAXIAL_LIMITFROM_FLD
909
-2.485543, 1.260929
-2.326915, 1.211872
-2.196562, 1.173440
-2.037161, 1.115458
-1.876514, 1.064689
-1.701195, 0.9987057
-1.511570, 0.9169926
-1.364909, 0.8546170
-1.215432, 0.8004163
-1.080362, 0.7465187
-0.9267878, 0.6888055
-0.8039308, 0.6348159
-0.6904781, 0.5923799
-0.6199200, 0.5716710
-0.5669760, 0.5526081
-0.5458882, 0.5490728
-0.5156967, 0.5524927
-0.4797515, 0.5568793
-0.4477362, 0.5742416
-0.4447934, 0.6287722
-0.4554417, 0.7088588
-0.4556653, 0.7716601
-0.4686948, 0.8609383
-0.4924086, 0.9770012
-0.4380930, 0.9192049
-0.3606666, 0.8170972
-0.2779830, 0.6991526
-0.1942268, 0.5787448
-0.1300228, 0.4857036
-6.8558961E-02, 0.4028141
-2.8324760E-02, 0.3741716
-1.5549607E-03, 0.3616189
5.8079619E-02, 0.3408428
0.1153265, 0.3534369
0.1781329, 0.3710328
0.4022586, 0.4023391
*end
```

Figure 2 shows the conversion from the FLD curve to stress triaxial limit curve. Note the red curve is the input FLD curve and green curve is the output stress triaxial limit curve from LS-DYNA. Again, the LS-DYNA calculated stress triaxial limit curve exactly matches that from the paper.

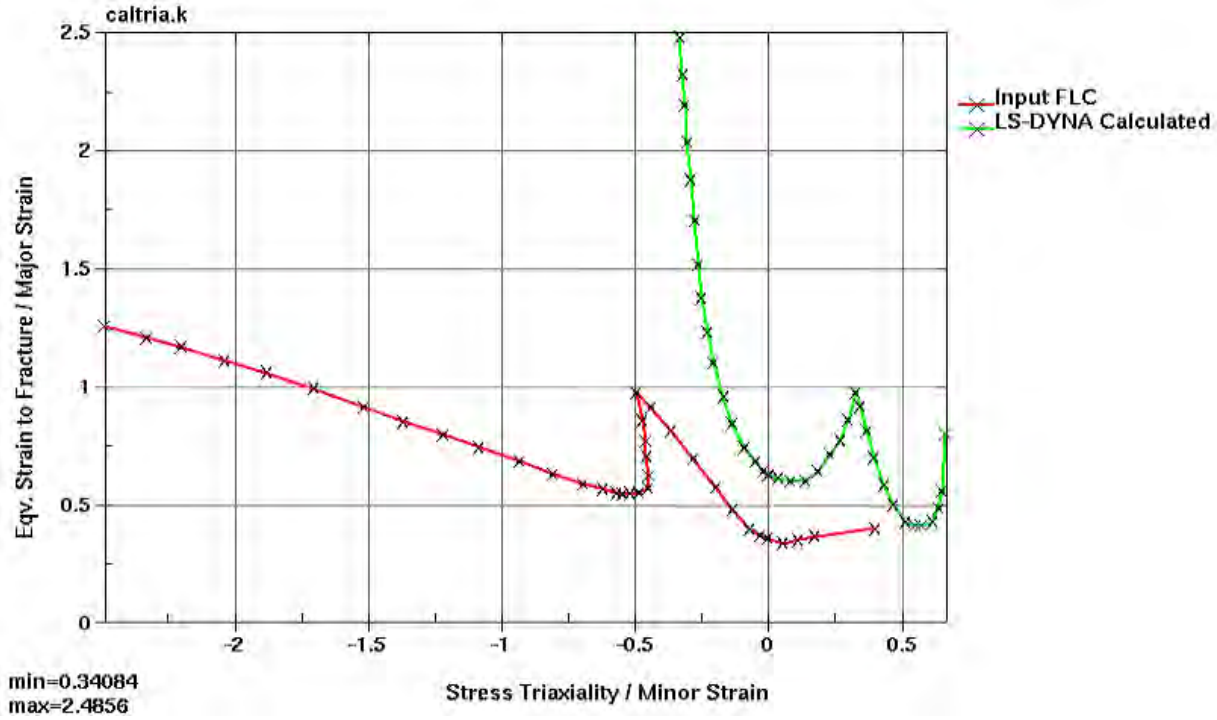

Figure 2 Conversion from FLD Curve to Stress Triaxial Limit Curve

REFERENCE:

1) LS-DYNA User's Manual (draft).
2) Li, Yaning et al, "Prediction of shear-induced fracture in sheet metal forming," *Journals of Material Processing Technology*, Volume 210, issue 14, (2010).