GREAT DESIGNS IN STEEL

EDGE FRACTURE CHARACTERIZATION OF AHSS USING HALF-DOME TEST

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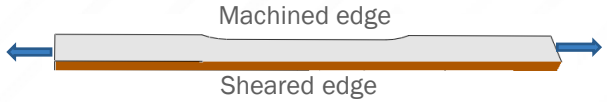
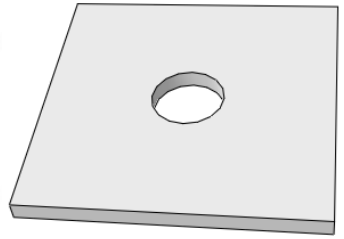
OUTLINE

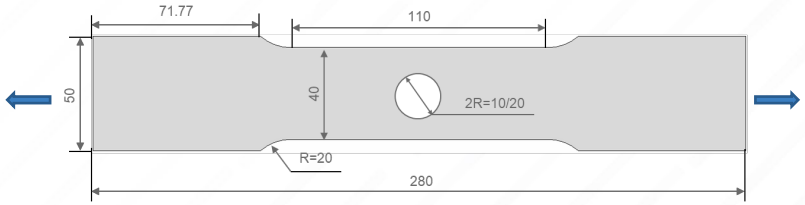
- Background
- Experimental methods
- Result and discussions
- Conclusions

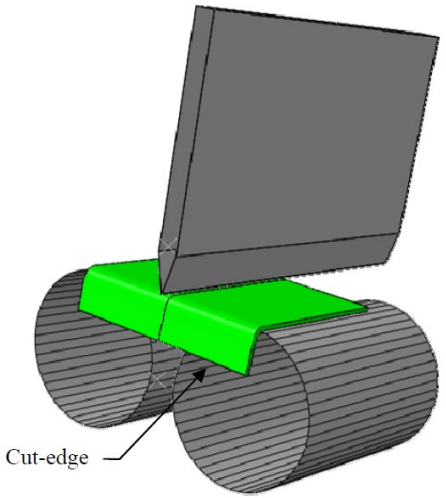
BACKGROUND

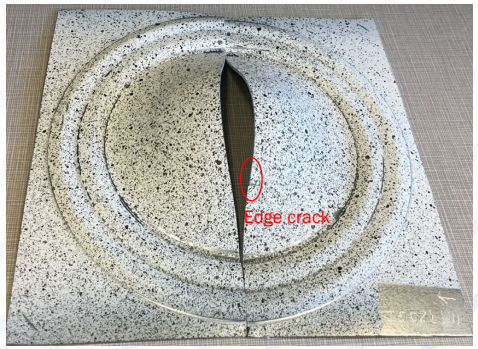
- Edge fracture tests
  - Half-dog bone tensile test
  - Center-hole tensile test
  - Hole expansion/extrusion test
  - Double edge-flanging test
  - Half-dome test
- Objectives: characterize edge fracture of AHSS using dome test and compare the result with hole expansion test.











EXPERIMENTAL METHODS

Test setup

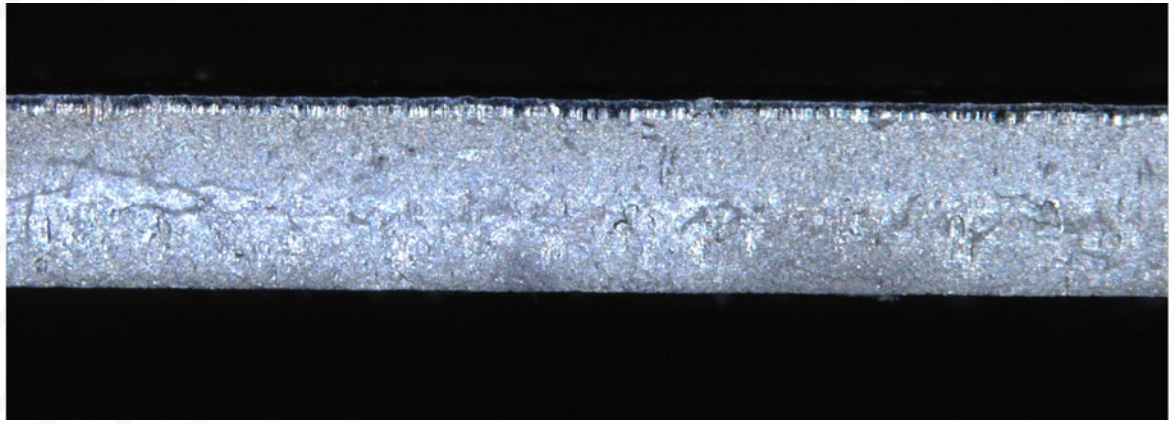
Half dome

In-plane hole expansion

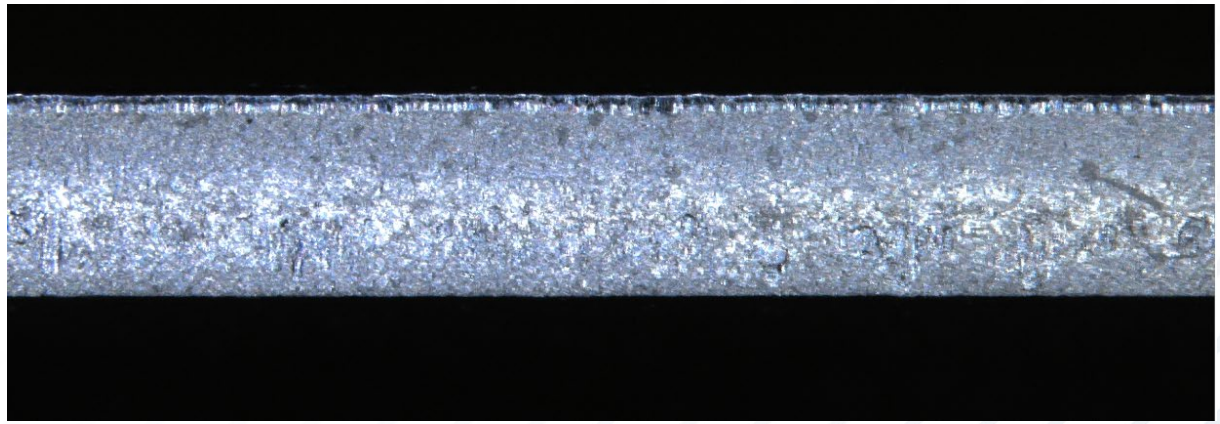
EXPERIMENTAL METHOD

- Materials
  - DP780 uncoated
  - HF980 uncoated
  - HF1180 uncoated
  - Fortiform®980 GI
- Edge preparation for specimens
  - Straight edge blanking
  - Hole punching with hole diameters of 10 mm and 40 mm
  - Shear cutting clearance: 12.5%
- Edge fracture test
  - Half-dome test (Nakazima testing)
  - In-plane hole expansion test (Marciniak testing)

RESULTS – EDGE QUALITY

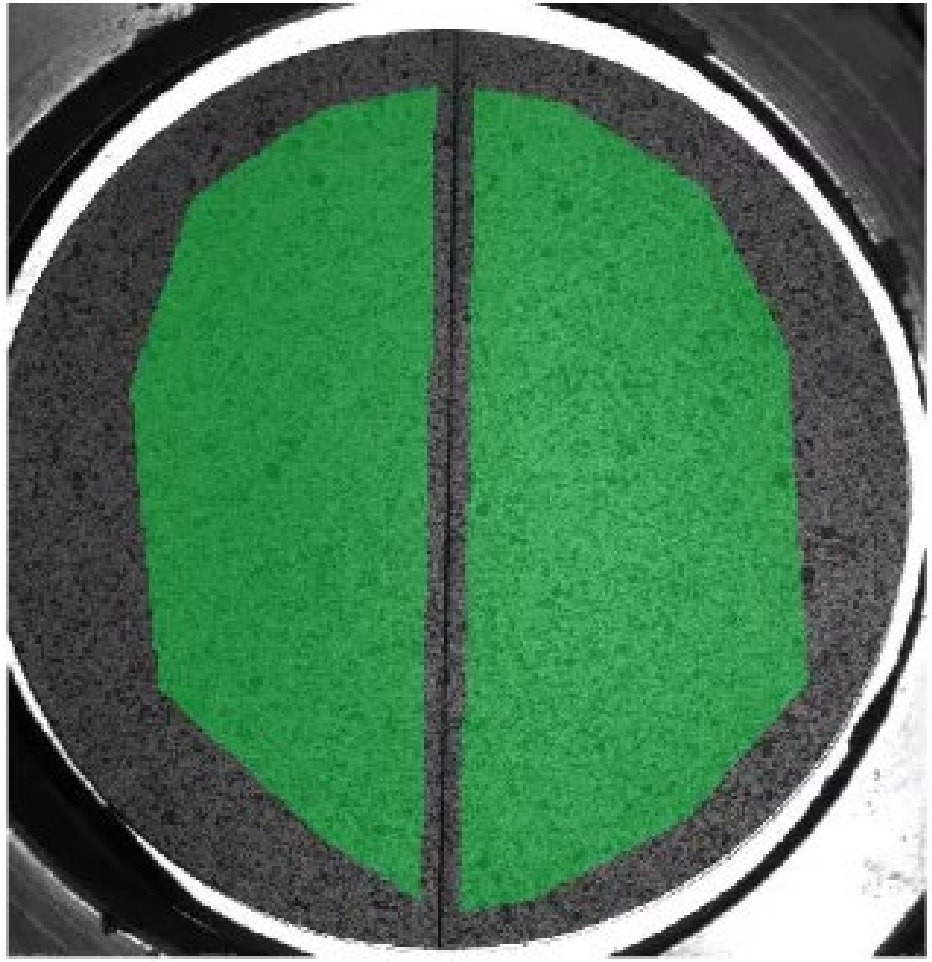


Edge in rolling direction (DP780)

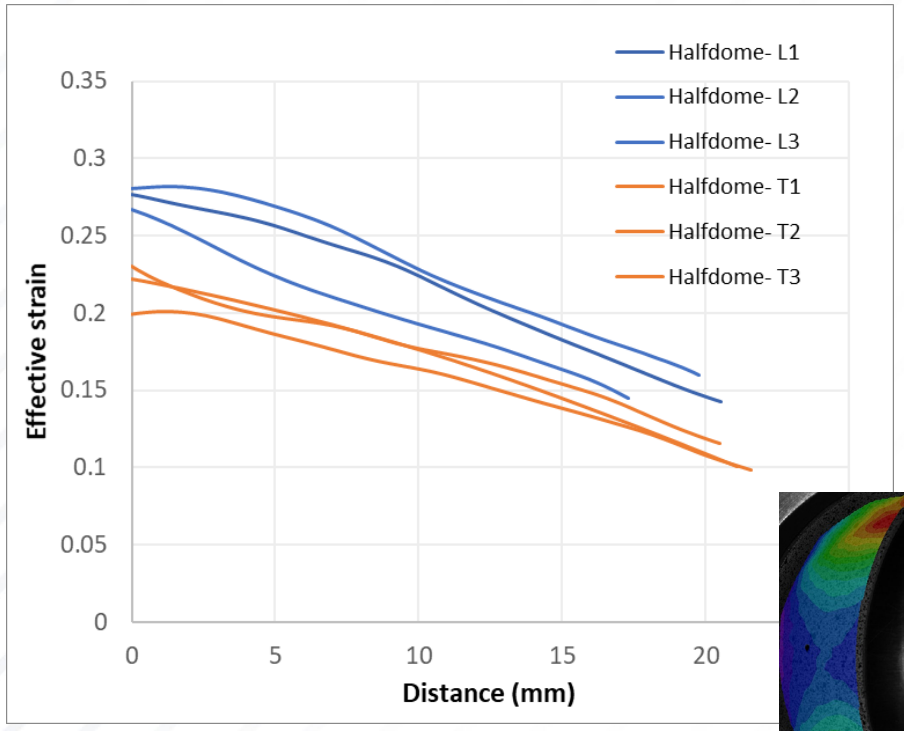


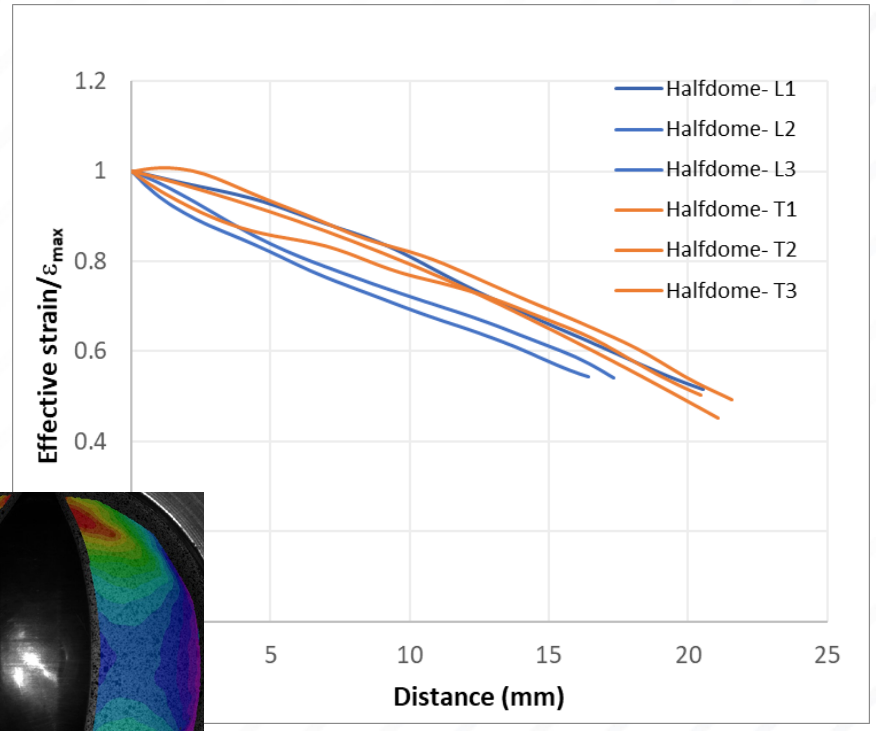
Edge in transverse direction (DP780)

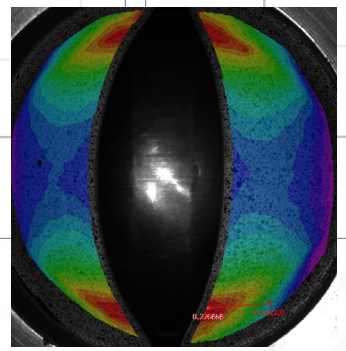
RESULTS – DEFORMATION EVOLUTION



RESULTS – STRAIN DISTRIBUTION



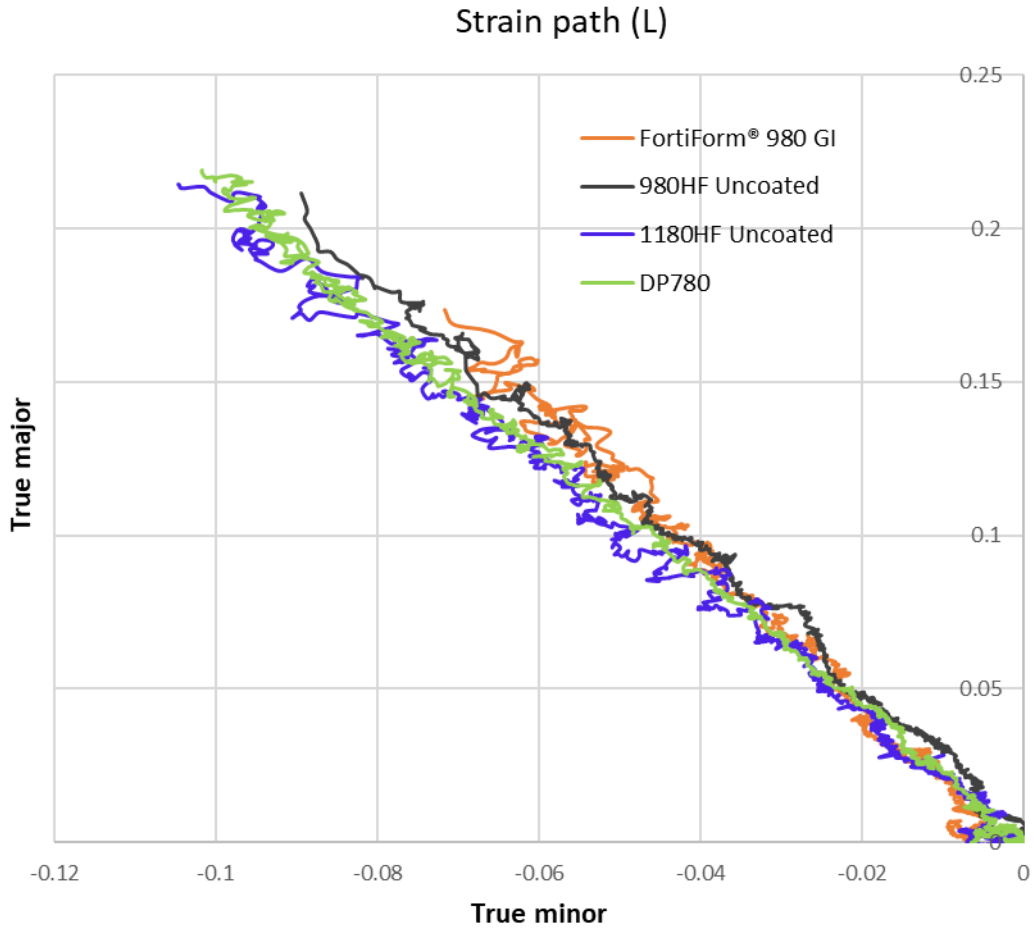


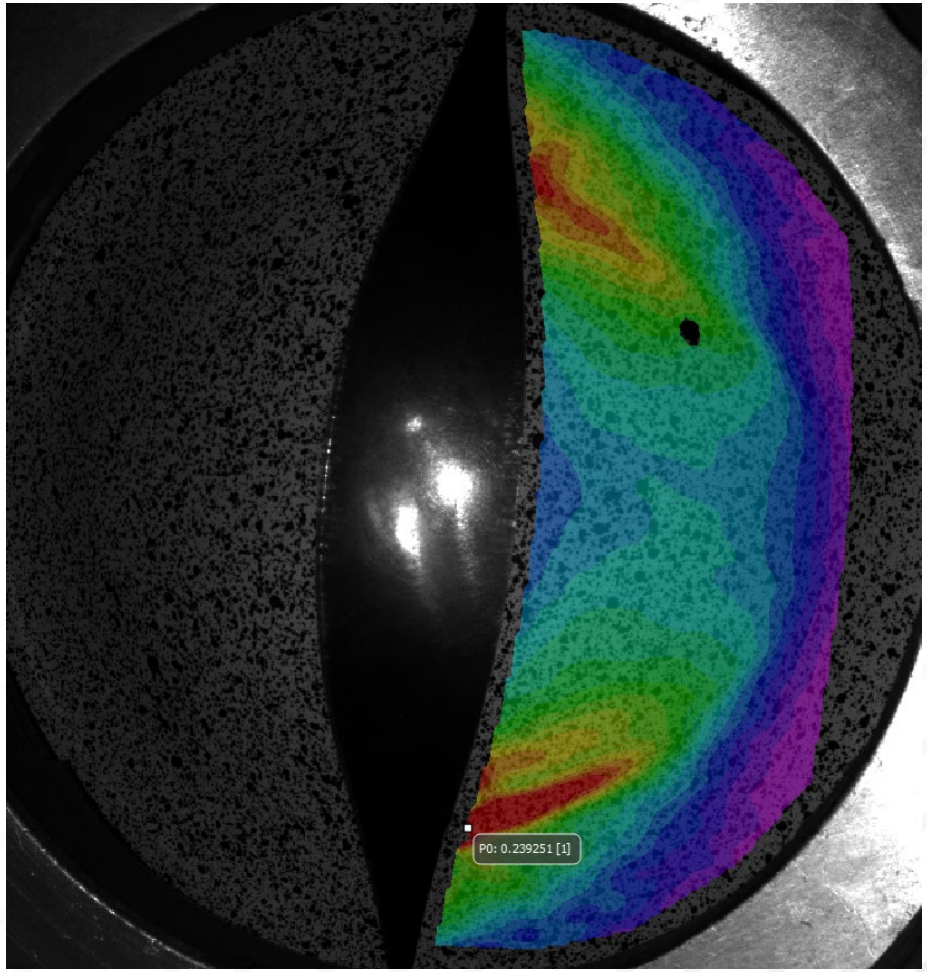


*Note:

- The line for strain distribution is perpendicular to the edge
- The reference point for distance is around 1 mm away from the hole edge

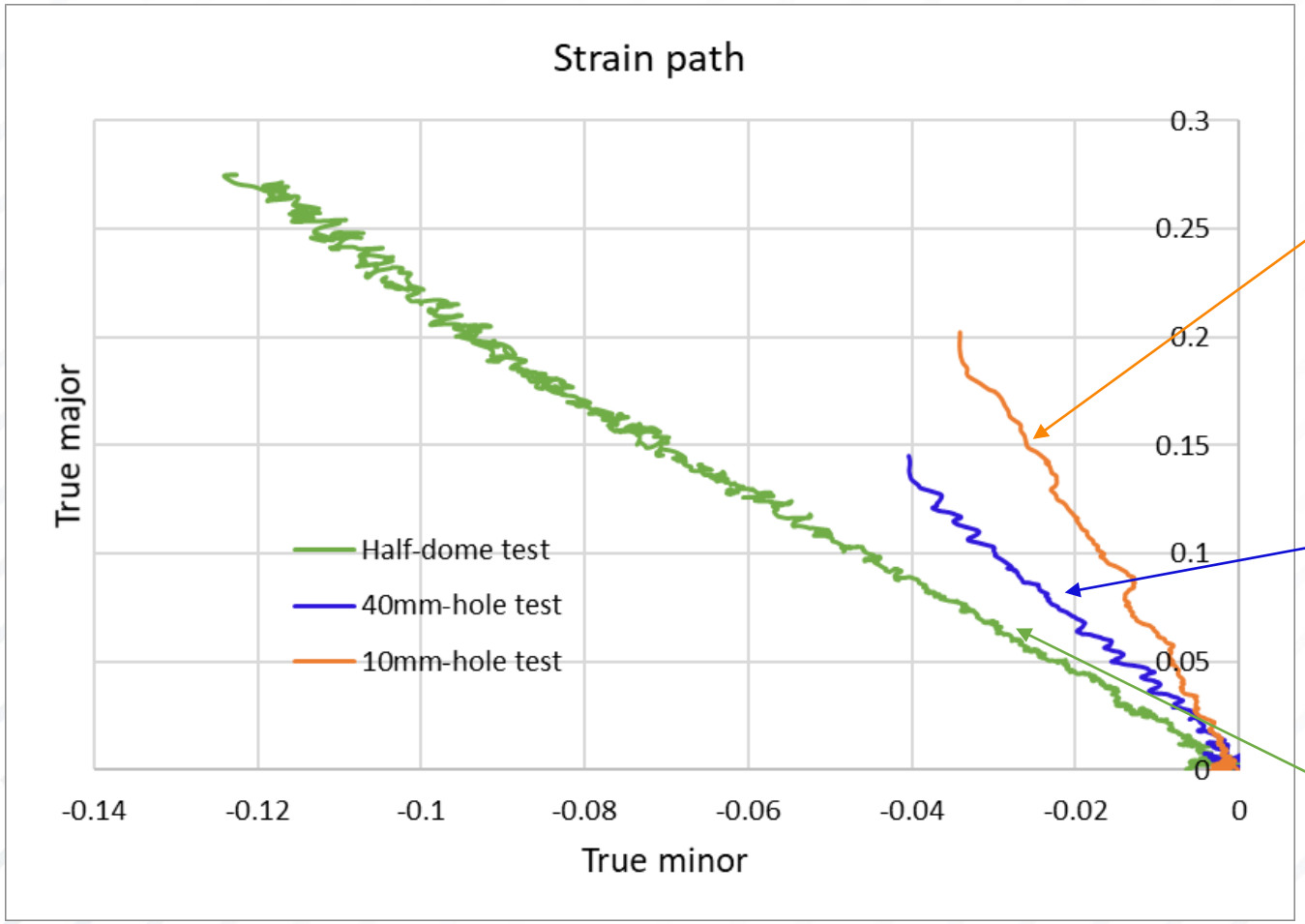
RESULTS – STRAIN PATH

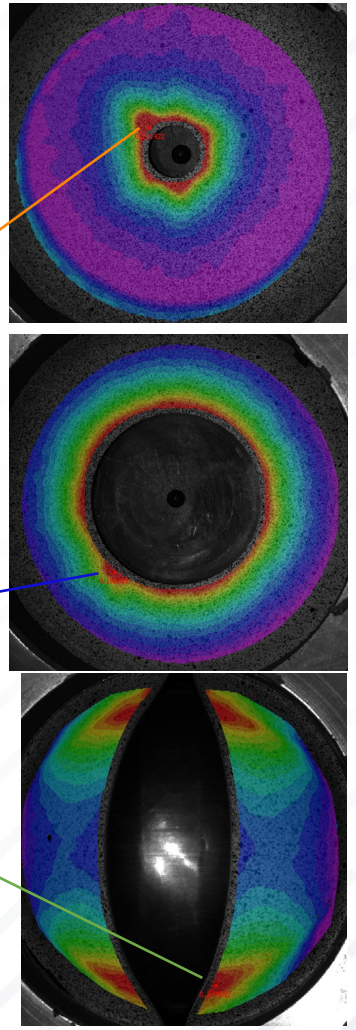




Strain path at the eventual failure location is uniaxial tension

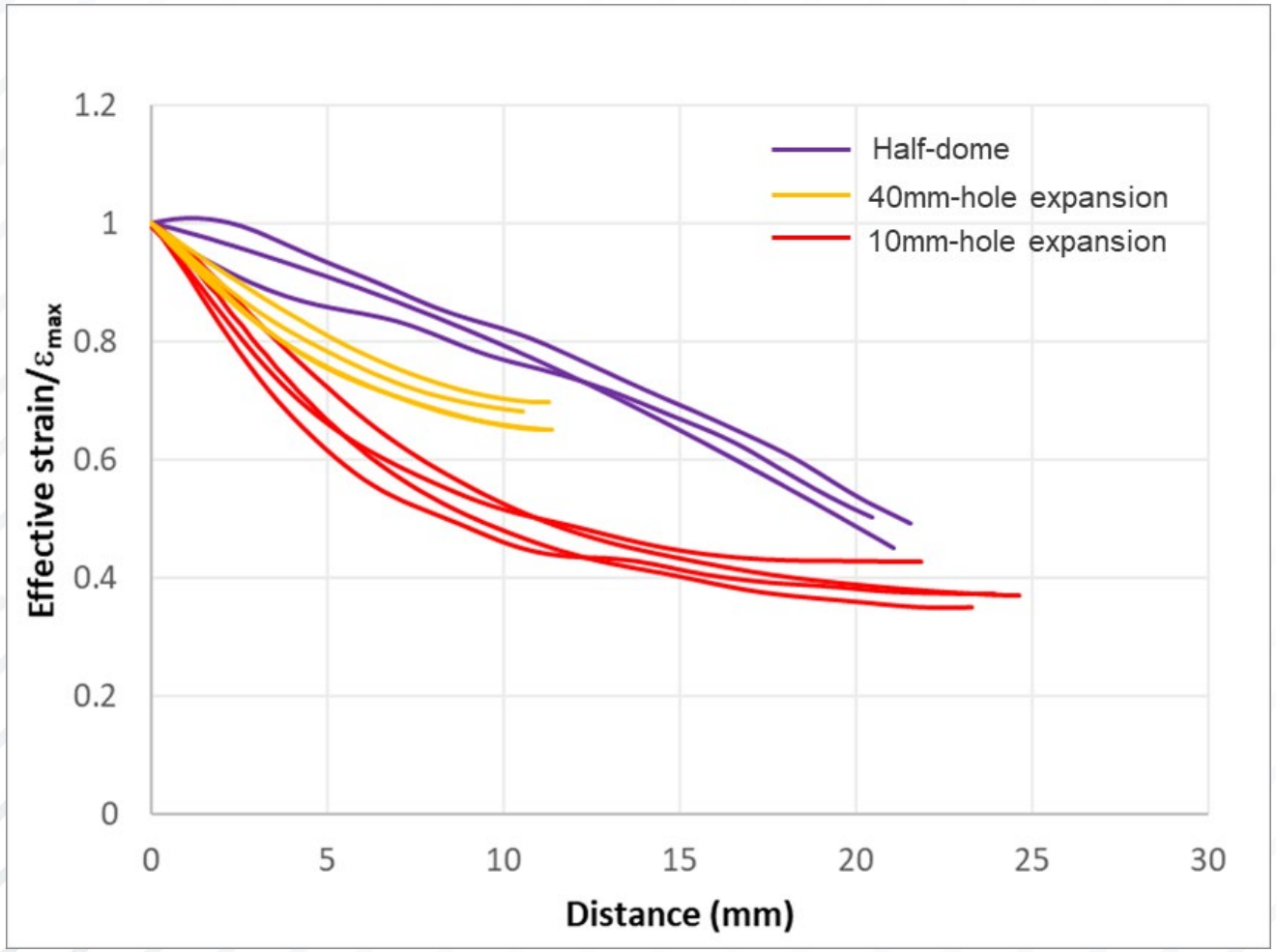
RESULTS – STRAIN PATH COMPARISON

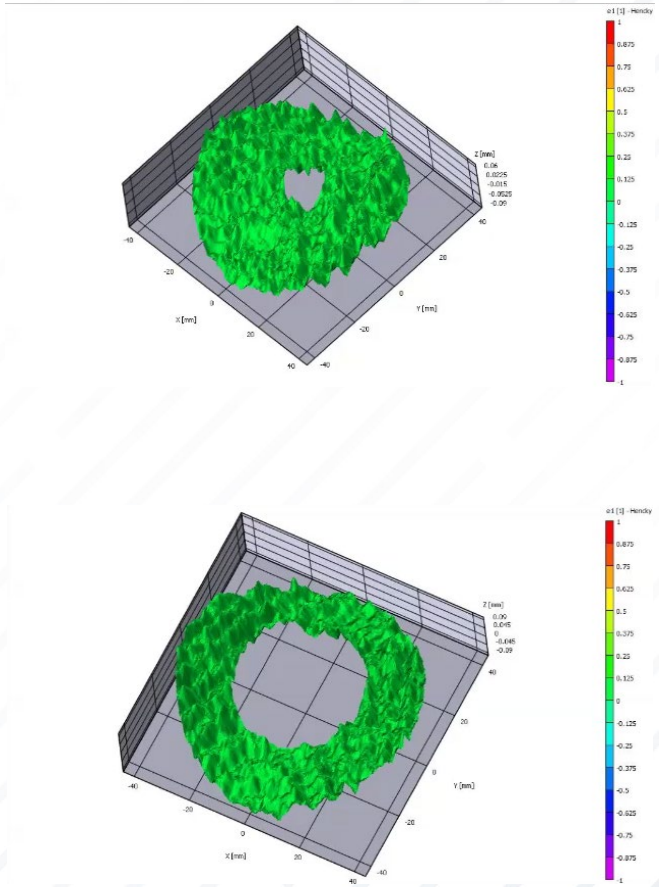




- Linear strain path for both in-plane hole expansion and half-dome tests (DP780)
- Strain path for 10mm & 40mm hole expansion tests between uniaxial tension and plane strain

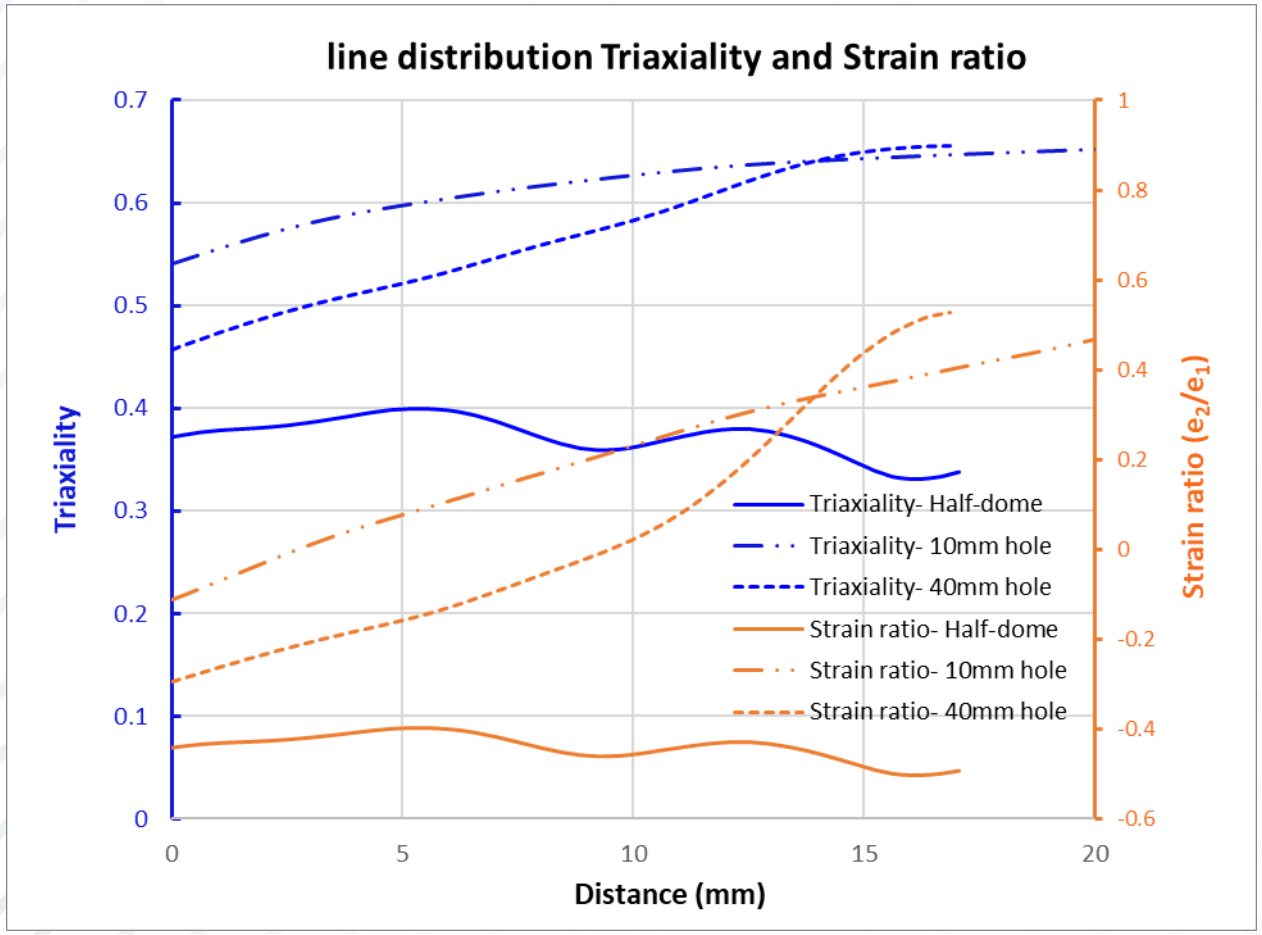
RESULTS – STRAIN GRADIENT COMPARISON

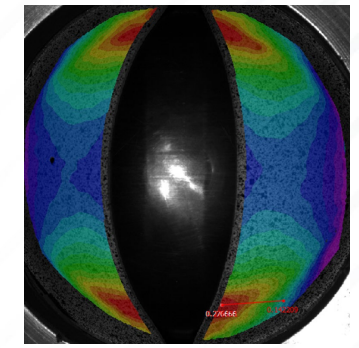


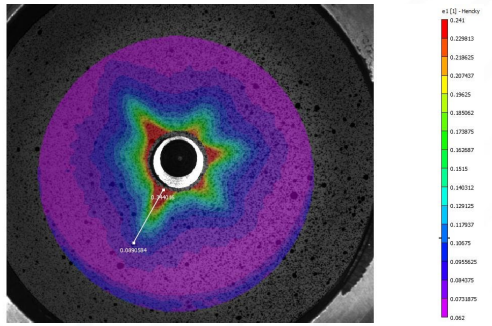


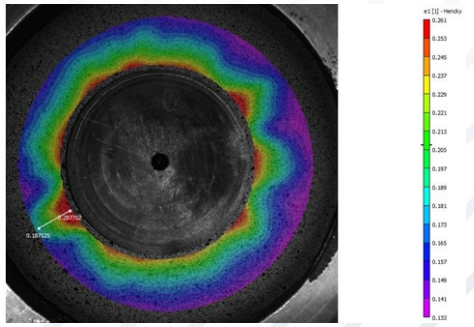
Larger strain gradient for the hole expansion specimens

RESULTS – STRESS STATE COMPARISON









- Compared to hole expansion test, half-dome test provides more stable uniaxial tensile stress state in the edge vicinity area

RESULTS – HALF-DOME FRACTURE STRAINS

1180HF Uncoated

Direction	Test rep.	Fracture strain			
		True minor	True major	Effective	Average
L	Test 1	-0.115	0.227	0.227	0.217
	Test 2	-0.108	0.217	0.217	
	Test 3	-0.104	0.207	0.207	
T	Test 1	-0.102	0.222	0.222	0.205
	Test 2	-0.112	0.216	0.216	
	Test 3	-0.102	0.220	0.220	
	Test 4	-0.087	0.185	0.185	
	Test 5	-0.084	0.185	0.185	
D	Test 1	-0.092	0.219	0.219	0.211
	Test 2	-0.103	0.215	0.215	
	Test 3	-0.098	0.205	0.205	
	Test 4	-0.089	0.202	0.203	

980HF Uncoated

Direction	Test rep.	Fracture strain			
		True minor	True major	Effective	Average
L	Test 1	-0.086	0.220	0.221	0.213
	Test 2	-0.084	0.191	0.191	
	Test 3	-0.090	0.222	0.223	
	Test 4	-0.077	0.213	0.215	
T	Test 1	-0.078	0.203	0.205	0.202
	Test 2	-0.079	0.213	0.215	
	Test 3	-0.069	0.197	0.199	
	Test 4	-0.076	0.189	0.190	
D	Test 1	-0.086	0.209	0.210	0.211
	Test 2	-0.081	0.189	0.190	
	Test 3	-0.080	0.204	0.205	
	Test 4	-0.091	0.204	0.205	
	Test 5	-0.089	0.242	0.245	

RESULTS – HALF-DOME FRACTURE STRAINS

Fortiform® 980 GI

Direction	Test rep.	Fracture strain			
		True minor	True major	Effective	Average
L	Test 1	-0.075	0.181	0.182	0.170
	Test 2	-0.067	0.173	0.174	
	Test 3	-0.068	0.184	0.186	
	Test 4	-0.054	0.152	0.154	
	Test 5	-0.061	0.154	0.155	
T	Test 1	-0.059	0.140	0.141	0.149
	Test 2	-0.057	0.145	0.146	
	Test 3	-0.062	0.144	0.145	
	Test 4	-0.053	0.162	0.165	
	Test 5	-0.057	0.145	0.146	
D	Test 1	-0.073	0.157	0.157	0.163
	Test 2	-0.072	0.156	0.156	
	Test 3	-0.071	0.156	0.156	
	Test 4	-0.075	0.182	0.183	

DP780

Direction	Test rep.	Fracture strain			
		True minor	True major	Effective	Average
L	Test 1	-0.1211	0.2755	0.2762	0.2622
	Test 2	-0.1127	0.266	0.2670	
	Test 3	-0.1062	0.2355	0.2359	
	Test 4	-0.1317	0.2698	0.2698	
T	Test 1	-0.1073	0.2053	0.2054	0.2177
	Test 2	-0.097	0.2145	0.2148	
	Test 3	-0.111	0.2321	0.2322	
	Test 4	-0.0953	0.2179	0.2185	

Half dome test able to distinguish fracture limits depending on rolling direction

CONCLUSIONS

- The strain gradient perpendicular to straight edge of half-dome test specimen is lower than specimens of in-plane hole expansion test.
- Half-dome test is able to characterize edge stretching in different direction.
- The strain paths at vicinity of edge fracture initiation of both tests are linear.
- The stress state along the direction perpendicular to the edge for half-dome test is much closer to uniaxial tension than that for in-plane hole expansion test.
- Half-dome test has potential for better edge fracture characterization for AHSS.

FOR MORE INFORMATION

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