GREAT DESIGNS IN STEEL

CFPHS COMPONENT COMPARISON: 3-POINT BEND TESTING RESULTS

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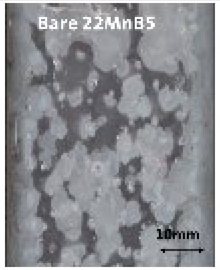
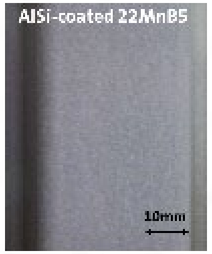
2023

OVERVIEW

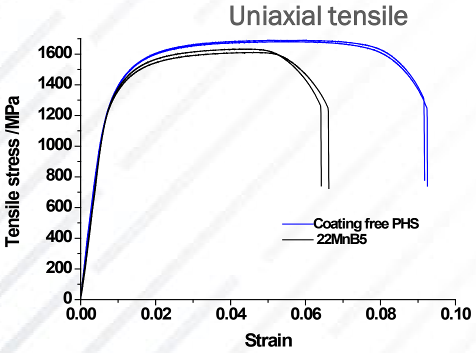
- Overview of CFPHS material properties
- Prior component bending results
- Production of components from Nucor 1.9mm CFPHS
- Door beam Nucor CFPHS vs AlSi 22MnB5 testing parameters
- Results comparison and discussion
- Conclusion

CFPHS- COATING FREE PHS

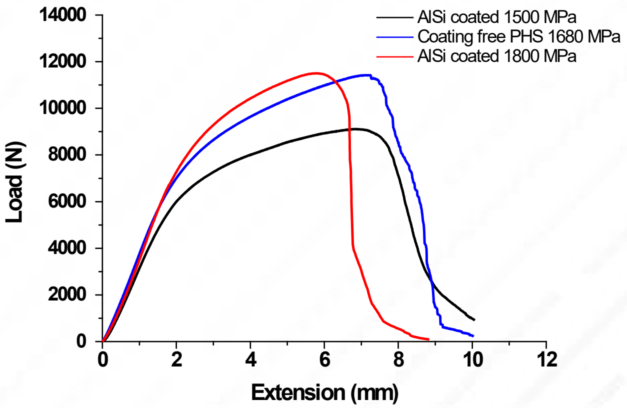
- Coating Free PHS (CFPHS) was designed to eliminate the need for AlSi coating, improve surface condition and improve part performance.
- CFPHS creates a thin stable oxide layer in the furnace that eliminates the need for shot blasting on bare steel.
- CFPHS shows superior performance in mechanical properties in both tensile and 3-point bend tests.

Surface condition after hot forming:	Advantages & Drawbacks
	Low cost but poor oxidation resistance (die cleaning and shot blasting needed)
	Good oxidation resistance but high price and limited supply base (IP monopoly)
	Good oxidation resistance, lower cost, no scale removal necessary

Mechanical Properties: CFPHS vs AlSi 22MnB5 (1500MPa) and AlSi 1800MPa PHS



New PHS: 1680 MPa/9% vs. 22MnB5 (1500MPa/7%)



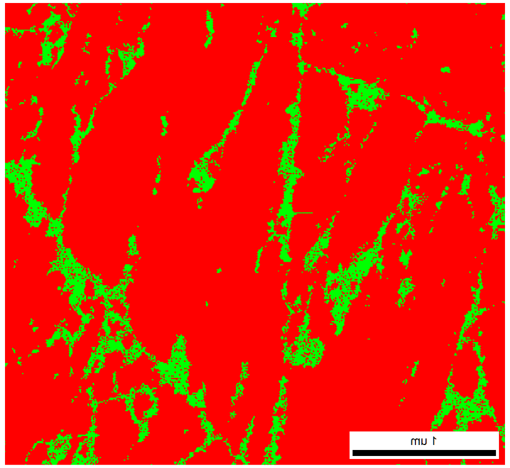
New PHS: similar bending performance vs AlSi coated PHS 1500 MPa; same peak force vs AlSi coated PHS 1800 MPa.

CFPHS- COATING FREE PHS

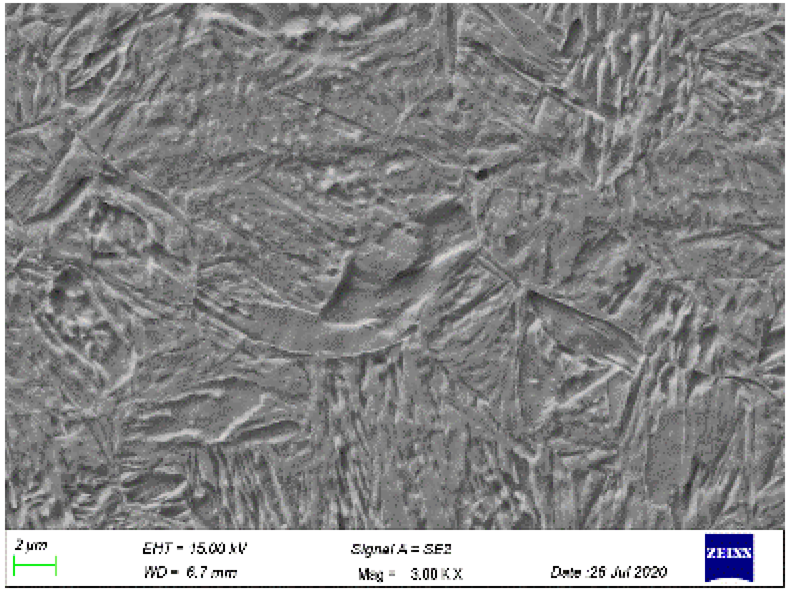
- CFPHS microstructure is the key to the improved mechanical performance over 22MnB5.
- Retained austenite in the microstructure allows for a TRIP effect, increasing the toughness of the material.
- Martensitic microstructure can be obtained via air cooling, allowing for more robust die design.
- CFPHS uses Cr and Si additions to form the stable oxide layer and increase hardenability of the material.

Material	C	Mn	Cr+Si +Mo	Nb+Ti	B	Bal.
22MnB5	0.19~ 0.25	≤1.4	≤1.0	≤0.12	0.0008- 0.005	Fe
Coating free PHS	0.19~ 0.25	≤1.4	≤4.0	≤0.12	None	Fe

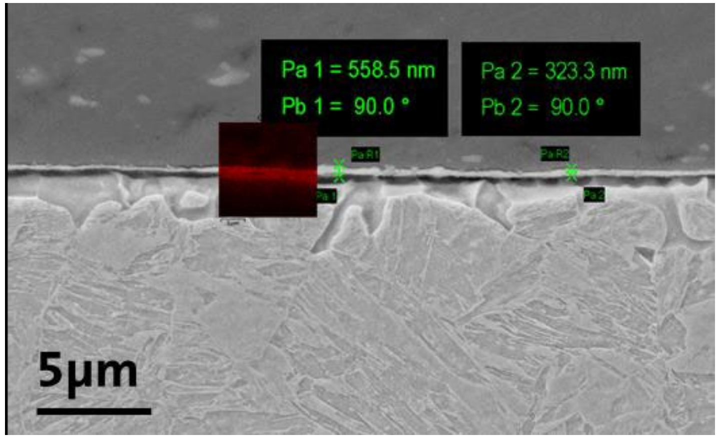
Retained Austenite in Green, Martensite in Red



Microstructure Post Air Cooling

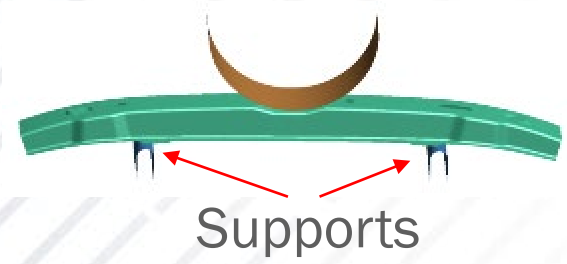


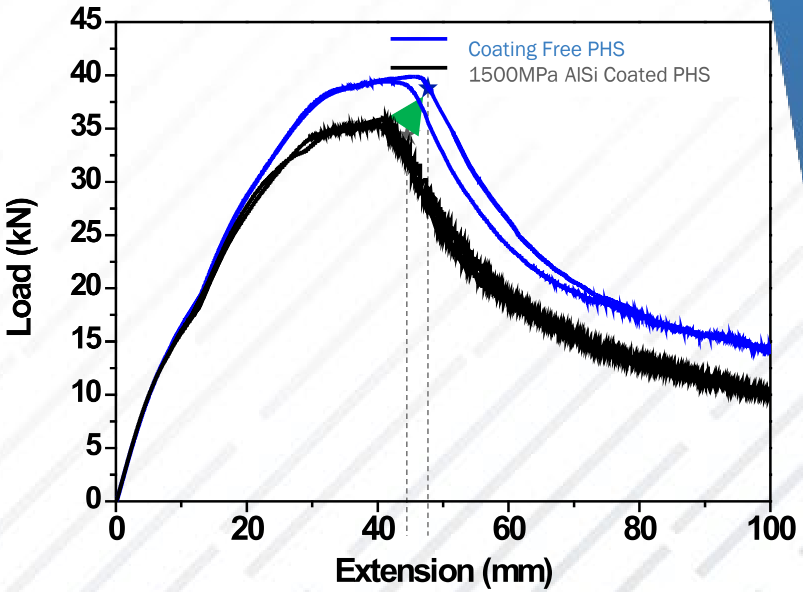
Coating Free PHS, oxide layer in red



PRIOR WORK: BUMPER BEAM 3-POINT BENDING

- CFPHS material vs AlSi 22MnB5 bumper beams.
- Loading rate: 15 mm/min.
- Distance between supports: 550 mm
- Both materials baked at 170 ºC/20 min.
- New CFPHS has ~20% higher energy absorption than AlSi 22MnB5. Calculated via integration of force vs. displacement curve up to the peak force.



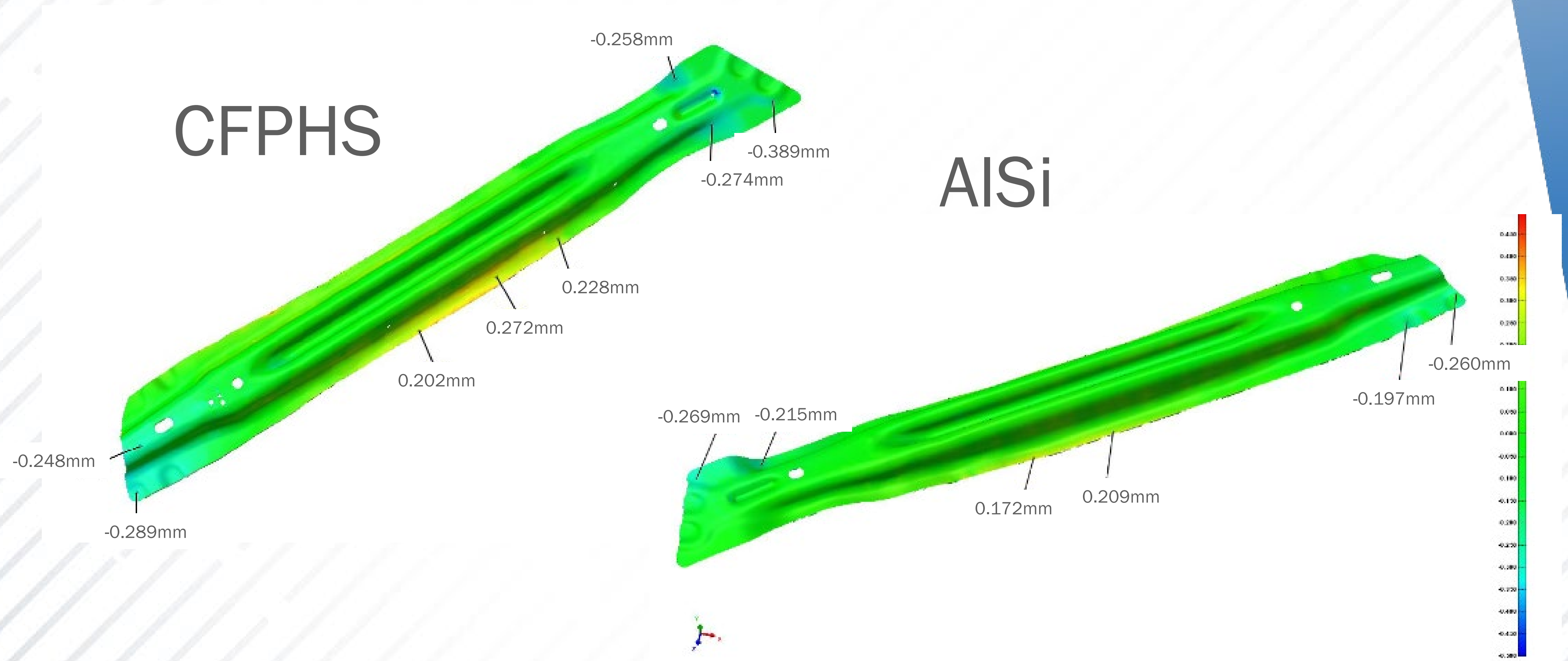


MANUFACTURE OF DOOR BEAMS

- Service program die was chosen for manufacturing door beams as the program is in service parts stage.
- Gestamp in Mason, MI produced door beams for this study on a roller hearth furnace line.
- Material used:
  - 1.9mm Nucor coating free PHS,
  - 1.9mm AlSi 22MnB5
- Performed on oldest line in plant
- Furnace with N2 gas atmosphere

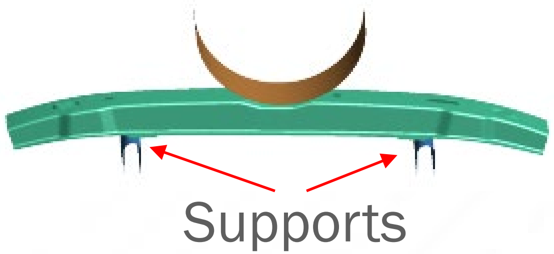
DOOR BEAM DIMENSIONS

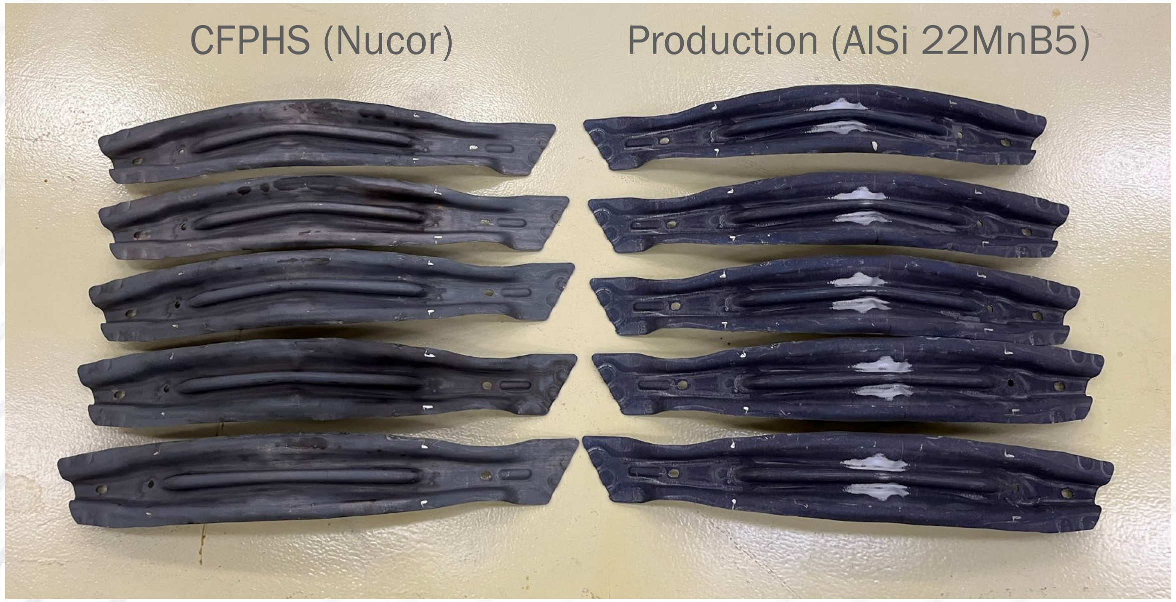
- Similar dimension tolerance between CFPHS and AlSi Door Beams



3 POINT BENDING OF DOOR BEAMS

- 3-point bending was performed at GM's China Science Lab on the Instron machine with no fixturing at the ends.
- 5 samples of each door beam were tested.
- Punch radius: 152.4 mm
- Support radius: 25.4 mm
- Supporter distance: 350 mm
- Displacement rate: 15 mm/min.





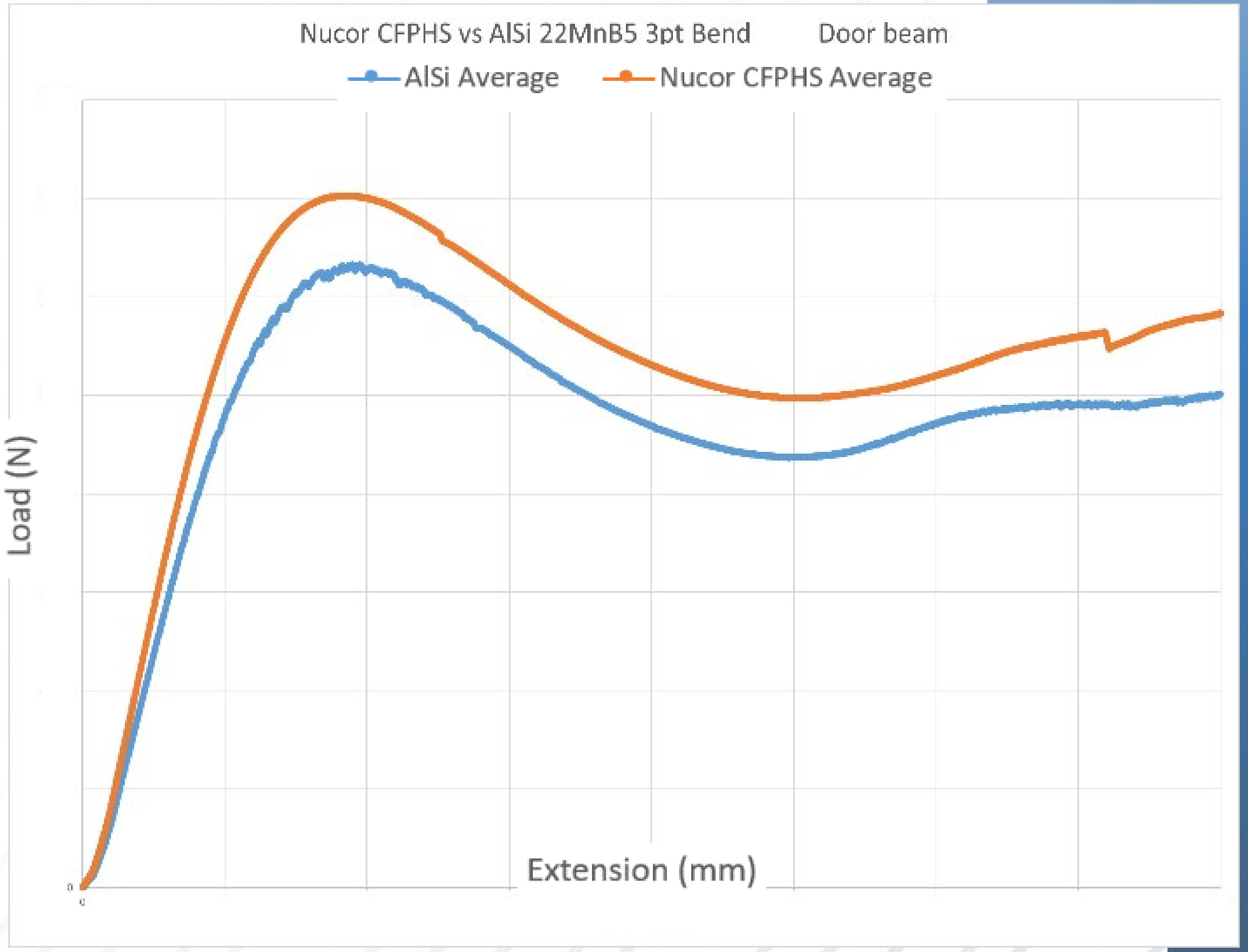
RESULTS: SERVICE DOOR BEAM ALSI VS CFPHS

Results were averaged across 5 tests for each material, averaged results are shown in chart.

	Max load (kN)	Disp. (mm)
Production	31.7 ± 0.6	19.2 ± 0.4
Nucor	35.1 ± 0.9	18.5 ± 0.4

kJ Absorption 0-60mm	Increase (%)
Production	-
CFPHS	13.1%

kJ Absorption 0-max mm at max load	Increase (%)
Production	-
CFPHS	8.9%



CONCLUSION

- Initial results from bumper beam trial showed ~20% improvement in energy absorption of CFPHS material vs bare 22MnB5.
- Results of service door beam trials between CFPHS and AlSi 22MnB5 show an increase of ~13% energy absorption to 60mm and ~9% energy absorption to end.
- Both material suppliers and applications results showed increased energy absorption.
- CFPHS shows good potential for material mass reduction in both applications as the same performance can be obtained with lighter gauge.
- FUTURE WORK:
  - Material card validation using door beam test results
  - Hot blow form tube trials
  - TWB AlSi to CFPHS
  - Feasibility study for A Pillar drop in application

THANK YOU FOR YOUR ATTENTION!

FOR MORE INFORMATION

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Special thanks to Nucor and the Gestamp Mason team for their assistance. The project would not have been possible without their services.