FINITE ELEMENT ANALYSIS OF COMPOSITE PARTS

Md. J. Haque, B. A. Gama, S. M. Andersen, and J. W. Gillespie Jr.

University of Delaware ▪ Center for Composite Materials

OBJECTIVES

The objective of the finite element analysis of composite parts is to achieve a solid and sound product that will meet or exceed all the required performance criteria.

COMPOSITE PARTS

- **Hummer Hood**
- **M35A3 hood**
- **M939 truck's Fenders**
- **Bulkhead**
- **Trailer**

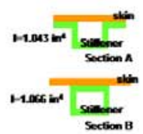
RE-ENGINEERING AND RE-DESIGNING OF M35A3 HOOD

Static Load – The hood shall withstand a 250 lb minimum static load applied over a 10 in maximum by 10 inch maximum area on the center and on the front of the hood with and elastic deflection of not more than 0.5 inch at +250ºF and not more than 0.25 inch at −50ºF. The load shall be applied on the outside surface and the deflection measured at the center within 0.5 inch of the applied area.

Flexural Strength – The hood shall be mounted on a vehicle equivalent fixture. The load to lift the front right corner of the hood 0.375-0.500 inch, with center and right side of the hood secured, shall be 50 lb minimum. The load shall be applied at the center ±0.50 inch of the handle.

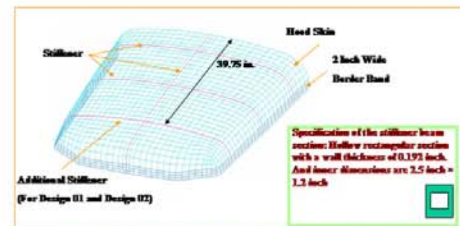
SHELL MODELED STIFFENER VS. BEAM MODELED STIFFENER

From simulation, we found there is no significant difference in the shell and beam element models, so beam elements could be used to model the hood stiffener. The reason behind using beam elements in the model is easy change of stiffener location and cross section.



	Shell Stiff	Beam stiff
Upward Max. Disp. (inch)	0.161	0.153
In Plane X stress (PSI)	Max: 1100.0 Min: -1082.0	1000.0 -875.0
In Plane Y stress (PSI)	Max: 975.0 Min: -975.0	711.0 -800.0
Inter Laminar Shear Stress	25.07	N/A
In-Plane Strain	0.036 %	0.035 %

HOW WE CAN IMPROVE THE EXISTING DESIGN ?



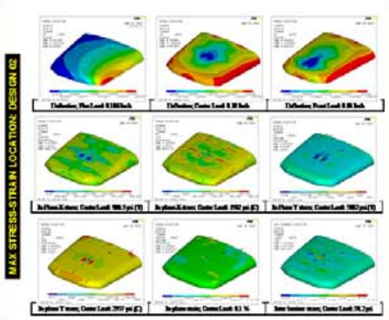
Re-engineered: Hood skin: 8 Layers; Stiffener: 8 Layers; Band: 8 Layers; Total Weight: 62.57 lbs

Design 01: Hood skin: 4 Layers; Stiffener : 8 Layers; Band: 4 Layers; Total Weight: 38.84 lbs

Design 02: Hood skin: 6 Layers; Stiffener : 4 Layers; Band: 6 Layers; Total Weight: 45.55 lbs

Design 03: Hood skin: 4 Layers; Stiffener: 4 Layers; Band: 4 Layers; Total Weight: 33.89 lbs

RESULTS



RESULTS

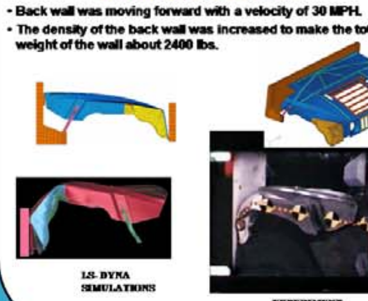
MAX STRESS-STRAIN DATA SHEET: DESIGN 02

	Potential failure parameter		Simulated value	Failure value/Design goal	Factor of safety
DESIGN 02 Hood Skin: 6 L Stiffener: 4 L Border Band: 6 L Material properties are equivalent to 250ºF (Bases on Lab Tested Data)	Deflection, in. (Flex Load)		0.186	0.375 – 0.5	
	Deflection, in. (Center Load)		0.100	0.5	5.0
	Deflection, in. (Front Load)		0.060	0.5	8.3
	In-plane X stress (psi)	Tension	906.5	58000.0*	64.0
		Compression	1582.0	56500.0*	35.7
	In-plane Y stress (psi)	Tension	3062.0	58000.0*	18.9
		Compression	2937.0	56500.0*	19.2
	In-plane strain (%)		0.10	0.50	5.0
	Maximum Inter laminar Shear (hood+band) stress (psi)***		30.2	4500.0**	149.0
	Through the thickness stress		No data available from simulation		
	Impact delamination		Simulation haven't been done		
	Weight		45.55 lbs	N/A	N/A
REMARKS:	In-plane stress and strain, and inter II. shear stresses are the maximum of the load case. *Fiber volume fraction 50%, Source: Composite materials design and applications, ISBN–1-58716-084-6, p. 44 ** CCM test data, *** Free edge interlaminar shear stresses may not be accurate				

TABLE 04: MAXIMUM STRESS-STRAIN DATASHEET FOR DESIGN 02

RESULTS OF 30 MPH CRASH BEHAVIOR HMMWV HOOD

- **Back wall was moving forward with a velocity of 30 MPH.**
- **The density of the back wall was increased to make the total weight of the wall about 2400 lbs.**



Buckling comparison between simulation and experiment.

CONCLUSIONS

- **Successfully simulated the crash behavior of the HMMWV hood.**
- **Re-designed the existing M35A3 hood for light weight and better performance.**
- **Completed the study of the effect of layer numbers and effect of stiffener location on the M35A3 hood performance.**
- **FEA was applied successfully (waiting through testing) to assess the stress-strains in the M35A3 hood model.**

ACKNOWLEDGEMENTS

This work is supported by the Tank-Automotive Research, Design, and Engineering Center through the Composite Materials Technology program.