충돌성능을 고려한 프론트 사이드 멤버의 경량설계

2015121868

노 유 한

Outline

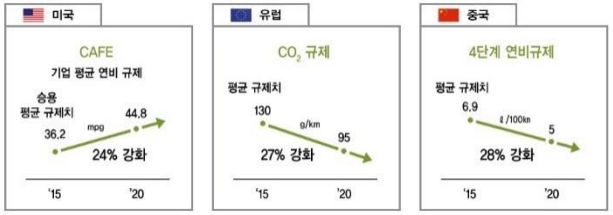
- Motivation
- Crash Analysis
- Design of experiments
- Optimization
- Conclusion

Motivation

➢ Global trend

Energy conversation

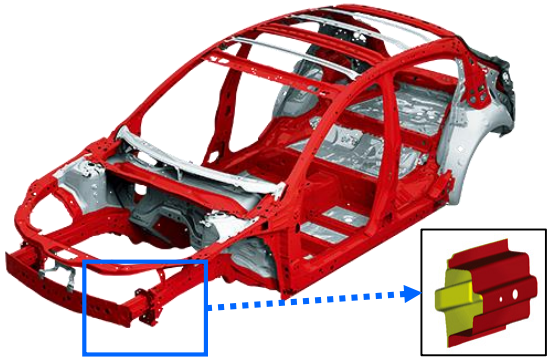
Environment protection



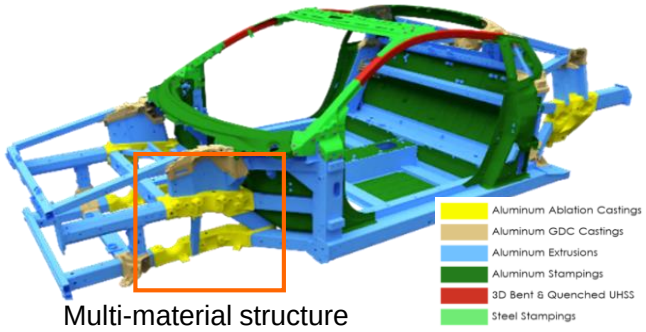
Insurance Institute for Highway Safety
Highway Loss Data Institute

FOR SAFER CARS
EURO NCAP

➢ How to increase fuel efficiency satisfying crashworthiness?



< MAZDA : SKYACTIV-BODY>



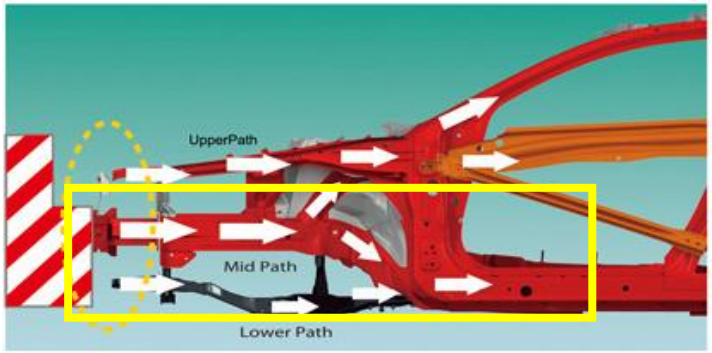
Multi-material structure

< 2017 Acura NSX BIW Structure >

Optimization for Crashworthiness

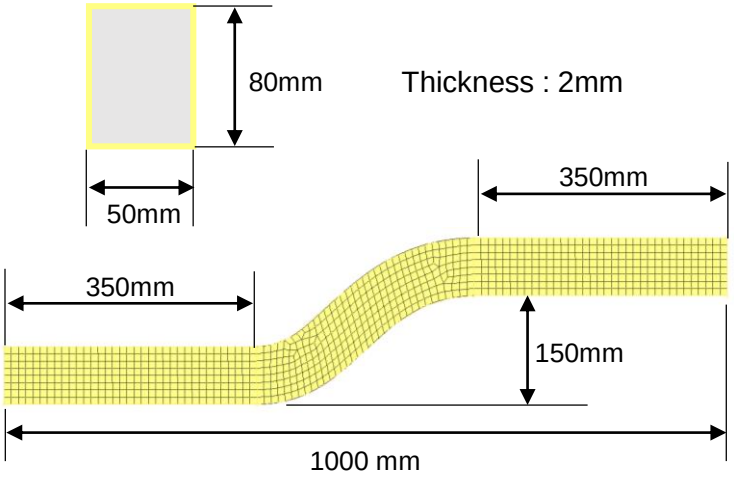
Motivation

➢ Target Component



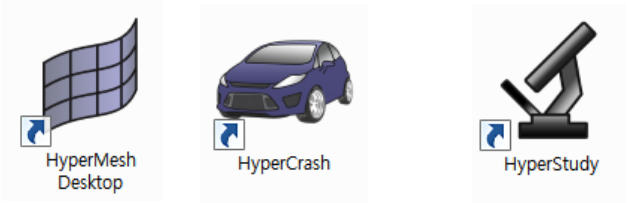
- Front Side Member
  - 50% of the force is generated by the front side rail structure

➢ Base Design



< initial specification >

- Plane
  - Crash analysis
  - Shape & Size optimization for initial design
  - Initiator design (Crash box)

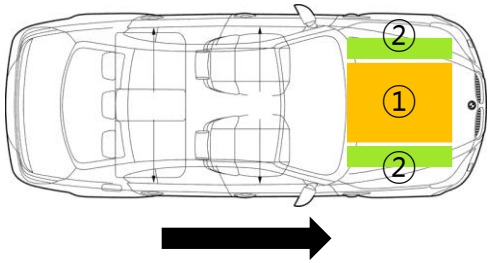


< Analysis > < Optimization >

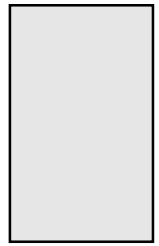
Crash analysis

➢ Analysis model

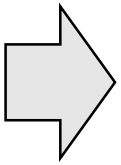
- Assumption

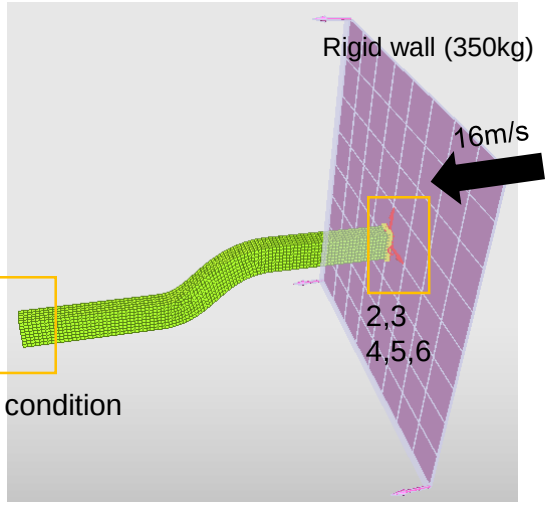


velocity (56km/h→16m/s, NCAP)
empty vehicle weight (1400kg)



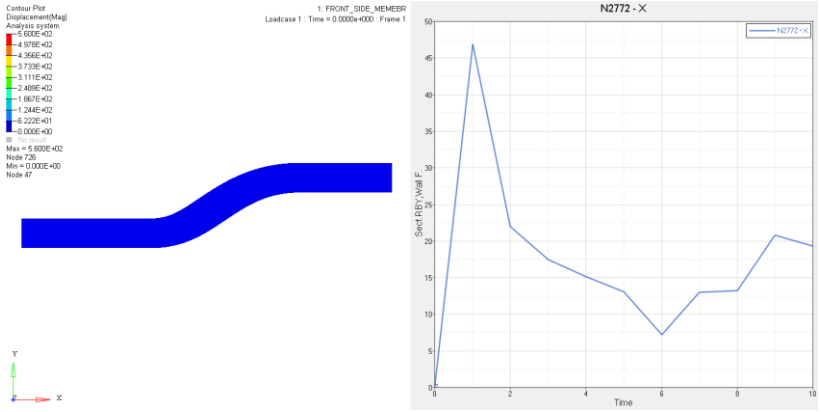
Rigid mass

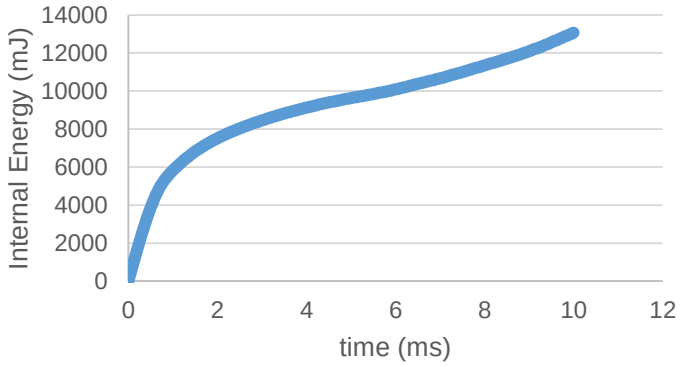




① Engine compartments can not absorb energy.
② Only one-half load is supported by front side member.
③ The load is divided equally into each member

- Result(0~10ms)

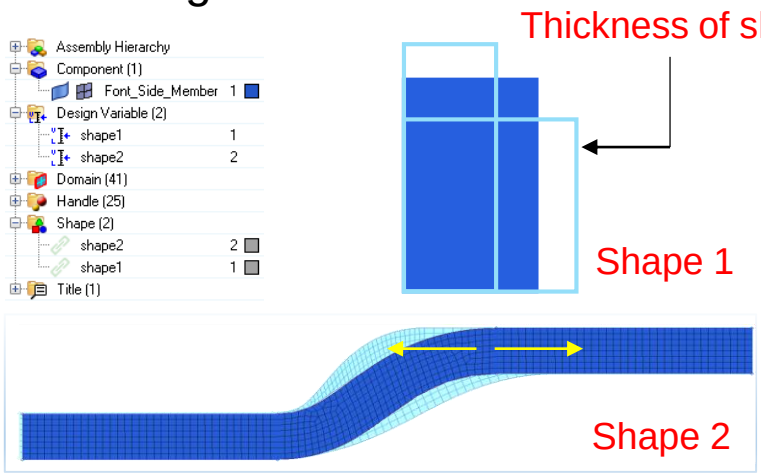




Design of Experiments (HyperStudy)

➢ Design of Experiments

- Design variable

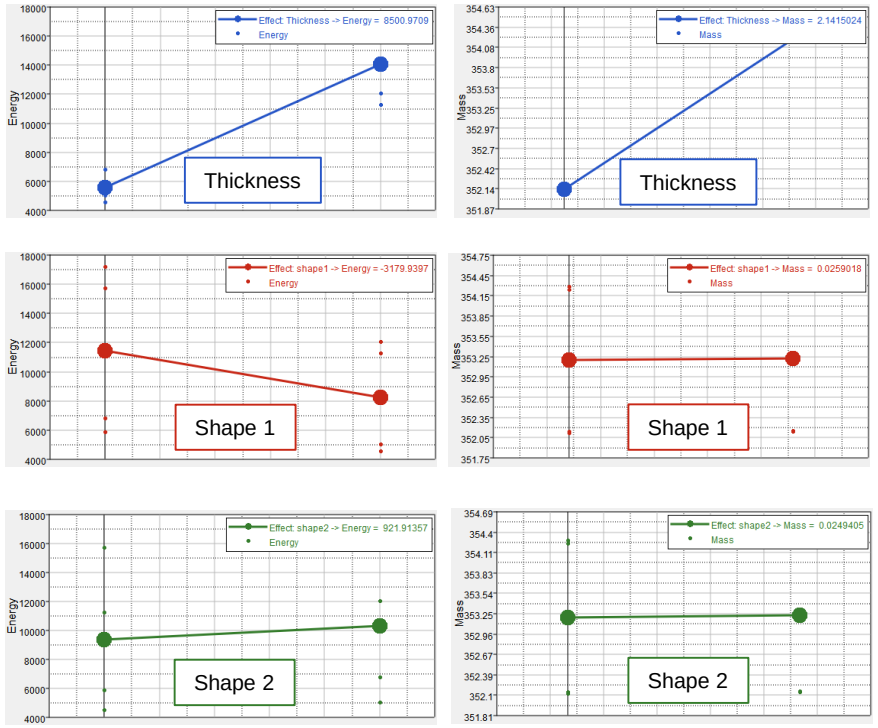


< Hypermorph >

Label	Varname	Lower Bound	Initial	Upper Bound
Thickness	m_1_varname_1	1.0000000 ...	2.0000000 ...	2.0000000 ...
shape2	m_1_shape2	-1.0000000 ...	0.0000000 ...	1.0000000 ...
shape1	m_1_shape1	-1.0000000 ...	0.0000000 ...	1.0000000 ...

- Response
  - Internal Energy
  - Mass

Internal Energy | Mass



< Linear Effects Plot >

Optimization (HyperStudy)

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➢ Formulation

find $\mathbf{x}$

to maximize $f_{\text{mass}}(\mathbf{x})$

subject to $E_{\text{internal}}(\mathbf{x}) \geq E_0$

$$x_k^{lower} < x_k < x_k^{upper}, \quad k = 1, \cdots, 3$$

< Objectives >

Label	Varname	Type	Apply On
Objective 1	obj_1	Minimize	Mass (r_2)

< Constraints >

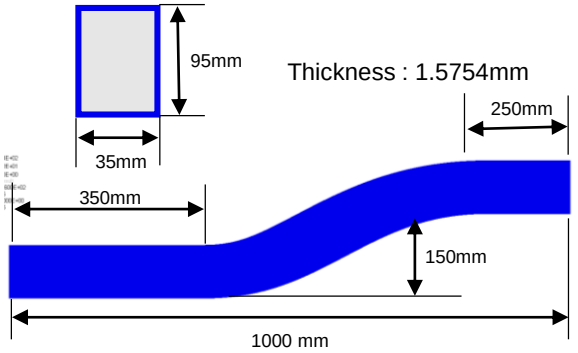
Label	Varname	Type	Apply On	Bound Type	Bound Value
Constraint 1	c_1	Deterministic	Energy (r_···	>=	13061.000

➢ Result (Global Response Surface Mothed)

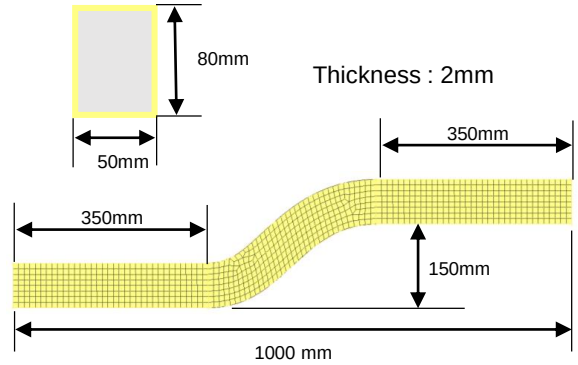
< Initial design >

	Thickness	shape1	shape2	Energy	Mass	Objective 1	Constraint 1
1	2.0000000	0.0000000	0.0000000	13061.332	354.28012	354.28012	13061.332
2	1.7607514	-0.9999992	0.9999979	14915.441	353.77362	353.77362	14915.441
3	1.5753683	-1.0000000	0.9999995	13008.088	353.37631	353.37631	13008.088
4	1.5753683	-1.0000000	0.9999995	13008.088	353.37631	353.37631	13008.088
⋮							
21	1.5753683	-1.0000000	0.9999995	13008.088	353.37631	353.37631	13008.088
22	1.5753683	-1.0000000	0.9999995	13008.088	353.37631	353.37631	13008.088
23	1.5753683	-1.0000000	0.9999995	13008.088	353.37631	353.37631	13008.088
24	1.5753683	-1.0000000	0.9999995	13008.088	353.37631	353.37631	13008.088

	Thickness	shape1	shape2	Mass	Internal Energy
Initial	2.0000	0.0000	0.0000	4.2801	13061.33
Optimum	1.5754	-1.0000	1.0000	3.3763	13008.09
reduced	21.23%	-	-	21.12%	0.41



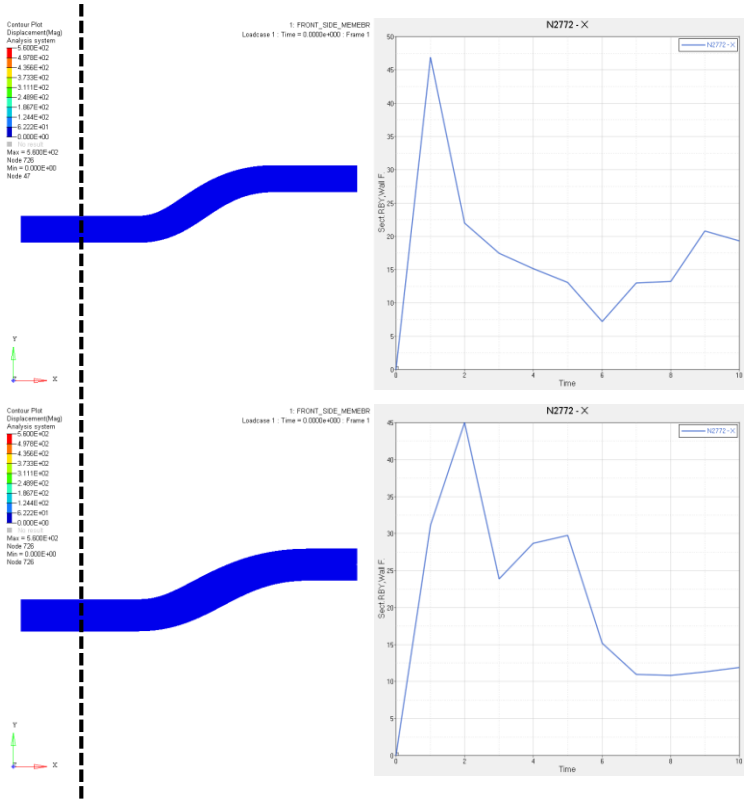
< Optimum design>



< Initial design >

Optimization

➢ Result (Comparison)



	Thicknes s	shape1	shape2	Mass	Internal Energy
Initial	2.0000	0.0000	0.0000	4.2801	13061.33
Optimum	1.5754	-1.0000	1.0000	3.3763	13008.09
reduced	21.23%	-	-	21.12%	0.41

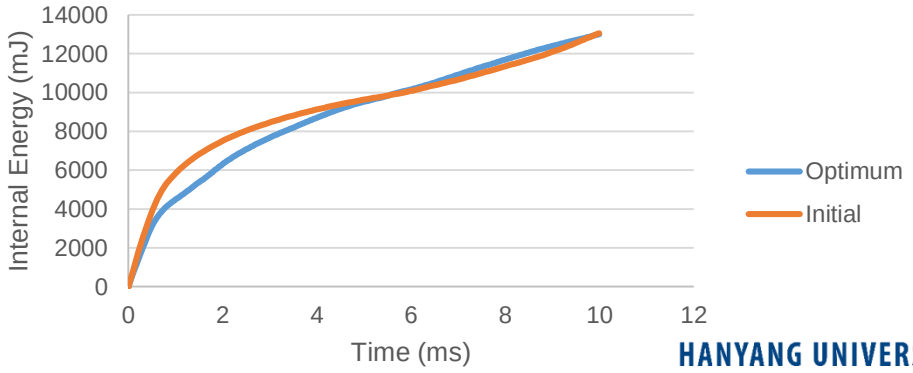
The optimum design is better than the initial design?

Yes? or No?

High internal energy !!

Is it good performance for crashworthiness?

Yes? or No?



Conclusion

Good point

- Optimization about crash analysis that is highly nonlinear
- Shape optimization using HyperWorks, not NFX (HyperMesh, HyperCrash, HyperStudy)

Bad point

- Insufficient analysis (More constraints, Crash box, Reinforcement)
- Insufficient understanding for theory
- Unaccustomedness about program

Thank you for your attention

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