Shape Optimization with LS-DYNA® Suite For MDO (Multidisciplinary Design Optimization)

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1. Abstract

LS-DYNA has been able to optimize several different calculations to meet each criterion with LS-OPT® freely. In previous year, we showed MDO (Multidisciplinary Design Optimization) would be great powerful solution that LS-DYNA suite including LS-OPT and LS-PrePost® would be able to solve crucial problem during development of product. In this study, we are trying shape optimization to solve trade-off which occurs in the process of product development much frequently. In order to optimize design parameter such as shape, bead and so on, the tool changing product shape automatically is needed. On the other hand, LS-PrePost becomes very powerful that morphing function has been integrated. The challenge in this study is to connect LS-PrePost to LS-OPT and do a shape optimization.

2. Background

LS-DYNA is heavily used to analysis transient phenomenon like car crash and makes a great achievement about physical simulation in a wide variety of industry. For the concept of LS-DYNA, “one-model, one-code” as solution it gives you, a wide variety of function has been developed at each section.

Nowadays, LS-DYNA has been developed further and become possible to evaluate even Frequency domain analysis and Acoustic analysis as FRF/SSD/Acoustic_BEM/Acoustic_FEM etc. This paper is, for example, intended for MDO (Multidisciplinary Design Optimization) with LS-DYNA and LS-OPT. The target is automotive which has many complicated parts. It is so hard to meet the demand for couple of standard for the safety/NV/strength.

LS-DYNA can calculate for not only the crash but strength and NV (noise, Vibration) evaluation.

The MDO evaluating some linear analyses simultaneously is the common case, but optimization with combination of both linear and non-linear analysis like car crash would be not so common case.

It would be possible for LS-DYNA and LS-OPT to consider this case. So, the purpose of this paper is challenge to this case, which means the confirmation to benefit and effect to design process. When MDO with collision consideration is regarded useful for car design process and estimation of performance, the usage of this type of MDO would become widely used. To confirm it, firstly we pick simple example up, the cover of phone.

3. Shape optimization

3.1 The model and condition

As mentioned in previous chapter, to consider the shape optimization, we chose cover of phone. The cover of phone is as below figure (fig.1).
The purpose of cover is absorption of shock when the phone is dropped (fig.2). The thicker thickness of cover at the bottom, the better it's to absorb energy of collision when it hits on the ground during dropping. To consider thus phenomenon, we put this simulation into optimization explicitly as same to car crush or dropping test.
On the other hand, the person who uses this cover sometimes needs to take cover off the phone. To take thus demand into consideration, another simulation would be needed. This simulation is strength analysis with contact (fig.3). To take it off smoothly, the thinner thickness would be better. This means trade-off, which usually makes designer annoyed every time they struggle with thinking about the best product.

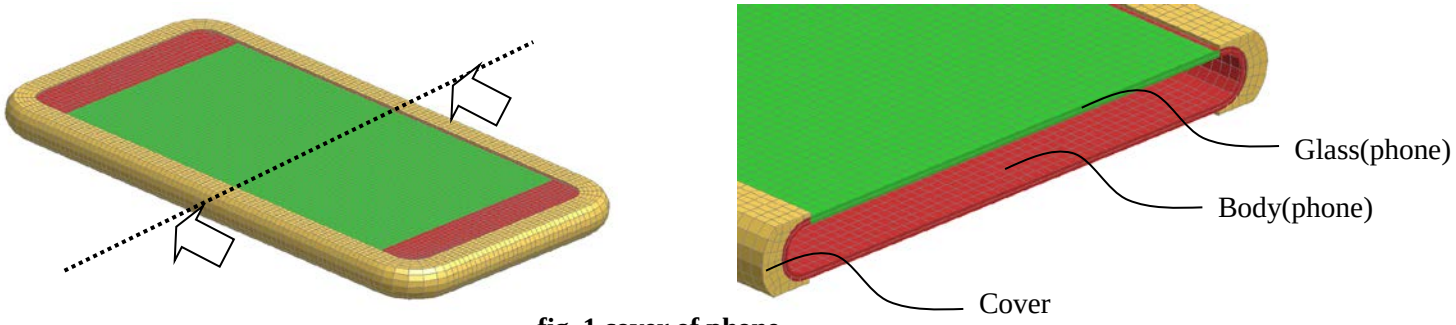


fig. 1 cover of phone

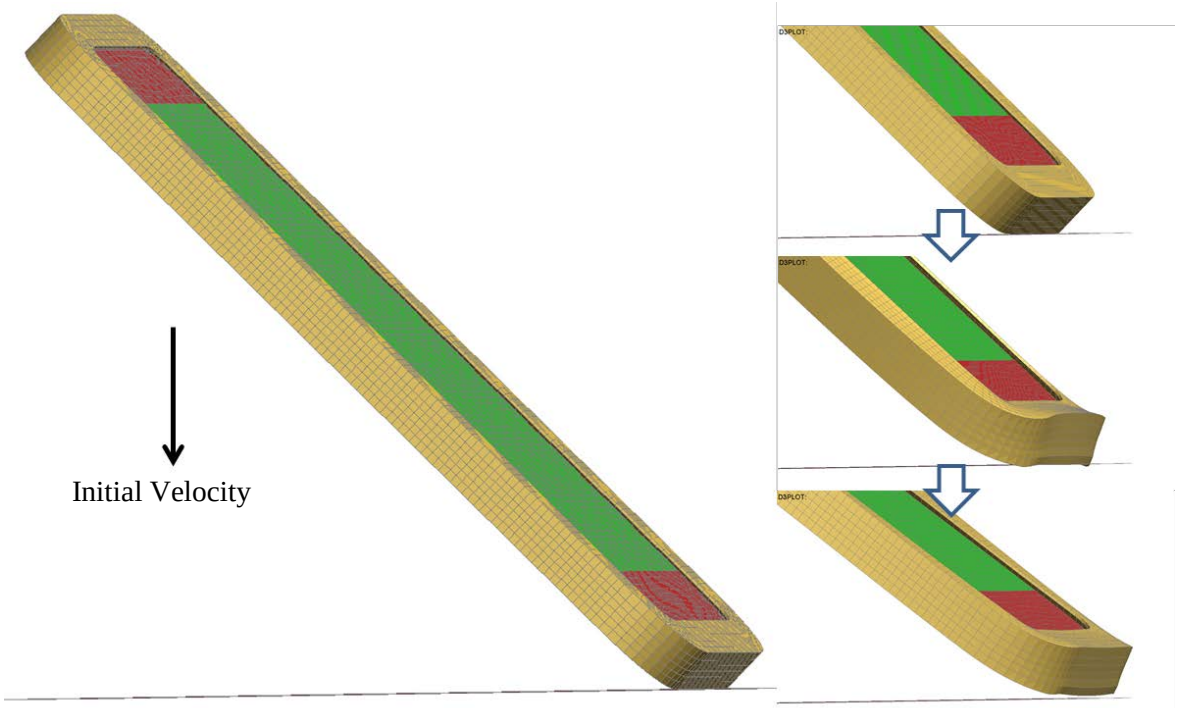


fig. 2 dropping test

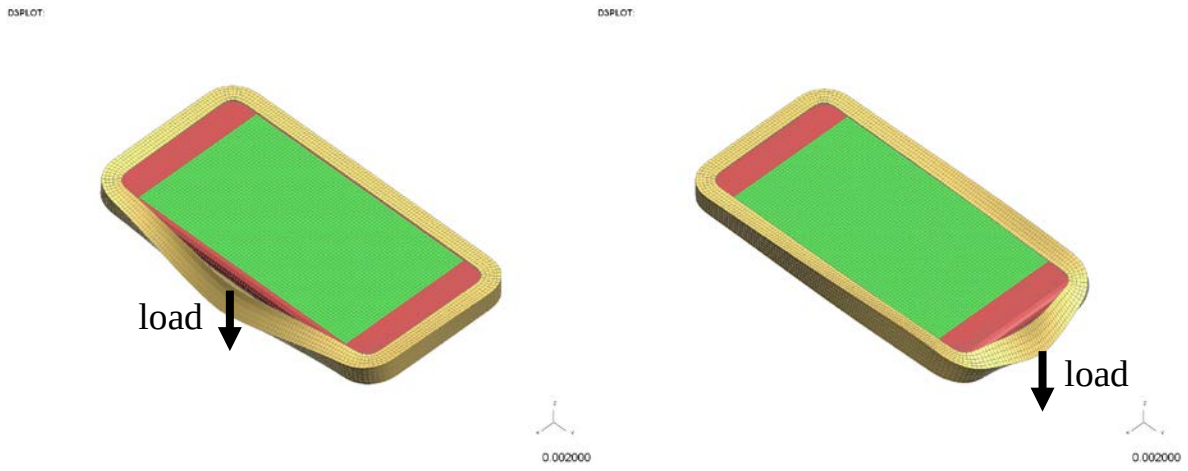


fig. 3 strength analysis with contact

3.2 LS-OPT setting

At the beginning, the analyst needs to set optimization calculating both strength and impact simulation. Before that, each initial calculation should be confirmed whether these inputs include no error and nothing unstable. After that, the optimization setting will be needed. The setting of LS-OPT is the following (fig. 4). These 3 simulations are located parallel and objective function is set to minimize weight.

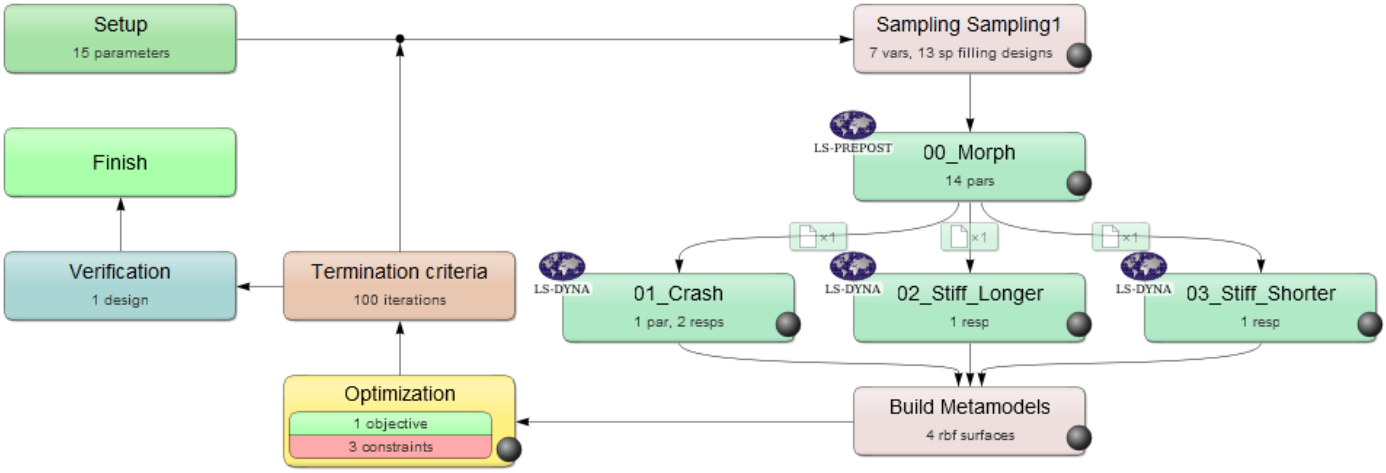
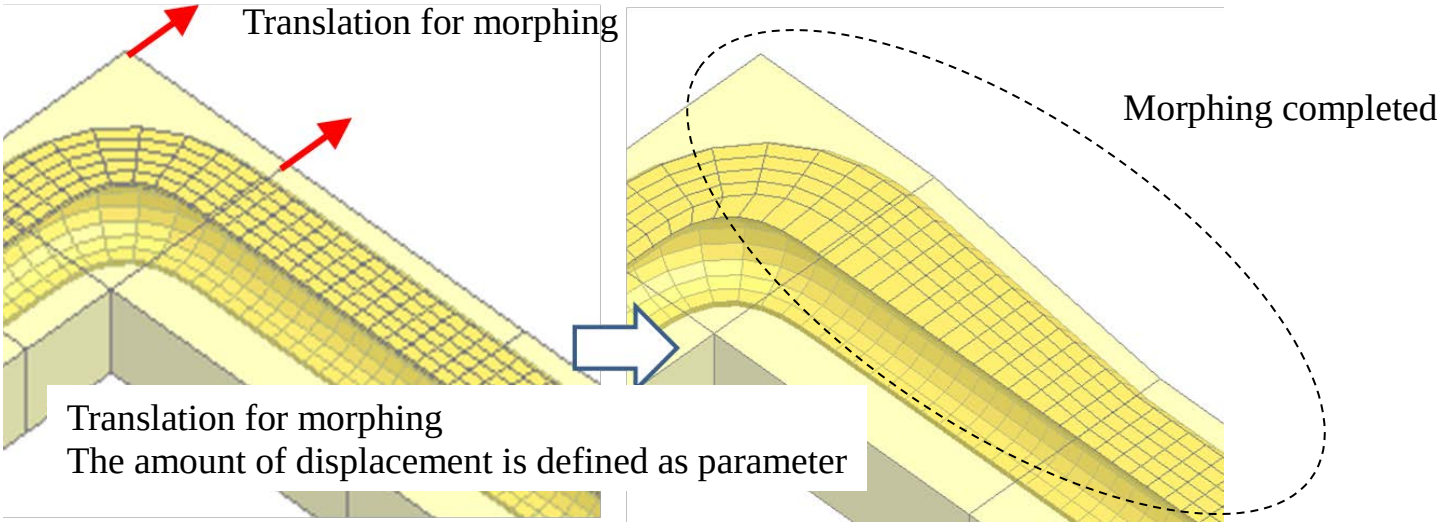


fig. 4 LS-OPT flow

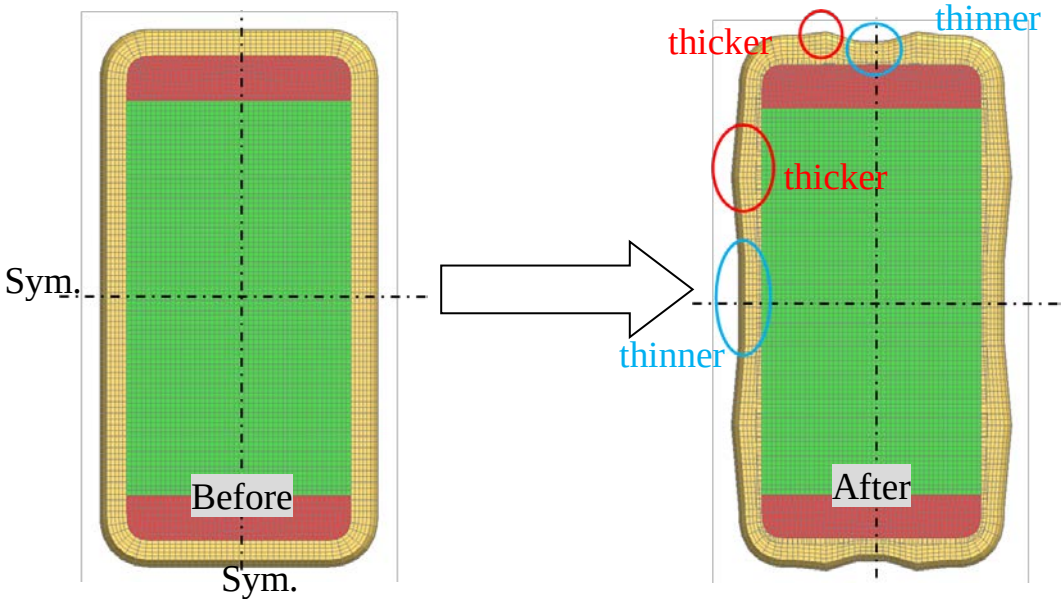
3.3 LS-PrePost setting

As described, LS-PrePost can morph the shape as like ANSA, Hypermesh and other softwares. It is so powerful tool that it makes users able to do a shape optimization. When shape optimization is executed, parameter should be set. This example sets parameters as displacement of thickness direction of phone cover. When the thickness is increasing during optimization, the weight gets high and shock absorption will be improved. But, it would be difficult to take it off the phone. This is trade-off which the designer usually comes across when they think about new product or improve it.



3.4 Result

The best shape getting from optimization is as below figure. The bottom place gets thicker in order to absorb shock when phone with cover is dropping. One the other hand, the side part of cover gets thinner in order to be removed off the phone. And result shows it might be better for two salient at the bottom to take over shock from the ground as possible as efficiently. In case of side part of cover, it would be easier to peel the cover from phone.



4. Discussion

4.1 Current flow

To do such things with LS-DYNA suite, there are some hurdles when setting up input for optimization.
Firstly, it's complicated operation. There are few examples of LS-Opt using LSPP. When users want to calculate similar optimization, they would struggle with building the system of whole flow of optimization.
Secondly, users have to make many commands into flow in cluster. When we would like to do a shape optimization, they should calculate in cluster in case of large model. LS-DYNA suite are designed for local machine. But the optimization would be better to calculate in cluster instead of local machine. These additional works they have to do are more complicated than we imagine. It would be impossible for customers to complete the whole inputs and setting of shape optimization without LSTC's or vender's help.
Thirdly, LS-PrePost doesn't have appropriate morphing function focusing on shape optimization. That means it is very difficult to link many parameters to displacement in morphing direction. And users have to prepare command file of LS-PrePost and edit it for enabling to repeat morphing operation during optimization. Users have to open and figure out what the meaning of each command without API.

4.2 Suggestion

A new pre-post would be very powerful tool for shape optimization. But we still think about rough idea so far. In the near future, we hope we will think about new GUI and want to ask feedback or opinion from users and venders.
Simultaneously we'd like to look for demand for shape optimization with LS-DYNA suite. We would like to help customers execute whole process successfully and spread the possibility of LS-DYNA for many kinds of industry.

5. Conclusion

We have made a newly successful solution with LS-DYNA suite. In this case, shape optimization has been fulfilled and it shows some other possibilities of such solution without any link to other software from other company instead of LSTC. But the procedure for making the setting for thus solution would be so hard for users. In next step, we would like to consider how the user can make input files for shape optimization easily.

References

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LS-OPT Support Site: Geometric optimization using LS-PrePost as a preprocessor.
http://www.lsoptsupport.com/howtos/integrating-pre-processor/ls-prepost