MDO Collision/NV/Stiffness Optimization with LS-OPT

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1 Introduction

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

Nowadays, LS-DYNA has been developed further and become possible to evaluate Frequency domain analysis and Acoustic analysis as FRF/SSD/Acoustic_BEM/_FEM etc. This paper is intended for MDO (Multidisciplinary Design Optimization) with LS-DYNA and LS-OPT. The object 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 car design process.
When MDO with collision consideration is regarded useful for car design process and estimation of performance, the usage of this type MDO would become widely used.

2 the Model as Objective to Optimize

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3 Each Simulation for MDO to evaluate the performance

In MDO this time, some kind of evaluation of automotive are prepared. The aim at this MDO is to meet all of these performances as same to initial situation as possible and as automatically. The consisting parts in input for calculation are the parts of chassis in this model.

3.1 The NV Evaluation Analysis

First of it, we start the evaluation about vibration. The things we seek for with LS-DYNA in this simulation is eigenvalue of chassis, especially a specific mode we want to evaluate. The eigenvalue exists in specific frequency. In this trial, it is assumed that comfortability while automotive driving get better by making targeted mode much higher as possible along frequency.

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3.2 The Stiffness Evaluation Analysis

Secondly, we confirm stiffness with strength analysis. In case to evaluate the torsion in front of automotive, especially considering driving performance, in simulation the static upper load is applied to one side of strut tower and down load to another. By thus simulation, we can get displacement in vertical direction. In optimization, the demand is to minimize this value from simulation, which means the lower displacement, the stiffer front area is. It would be beneficial to make a curve turn easily for example.

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3.3 The Collision Evaluation Analysis

The third consideration in optimization, it is about collision analysis. It is well known this simulation is so popular to LS-DYNA users. We adopt FRB (Frontal Rigid Barrier) as the type of collision test in this paper. Rigidwall is set in front of car. Two index for FRB performance are prepared and associated with a part of objective function. One is the space of interior in cabin, and another is maximal acceleration during FRB test. The space of interior in cabin can be evaluated by looking into deformation in chassis at the range from front part to rear part.
Maximal acceleration while FRB can be regarded as the amplitude of impulse load to human in cabin. This index indicates energy absorption efficiency.

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4 MDO (Multidisciplinary Design Optimization) Overview

When starting to simulate optimization with LS-OPT, it is important to define the formula of objective function.There are three terms we have to consider in optimization as described in chapter 2 above. The formula is described as following.

$$MINIMIZE\left[(-1)\times\frac{optimized\ result(1)}{initial\ result(1)}+\frac{optimized\ result(2)}{initial\ result(2)}+\frac{optimized\ result(3)}{initial\ result(3)}\right]$$

(1):NV (2):stiffness (3):collision

The design variable set are thickness of several parts consisted in chassis.

About constraint condition, LS-OPT optimizes these situations trying to minimize whole weight of chassis.The flow of LS-OPT is as below (Fig.1). Each evaluation flow is located in parallel.

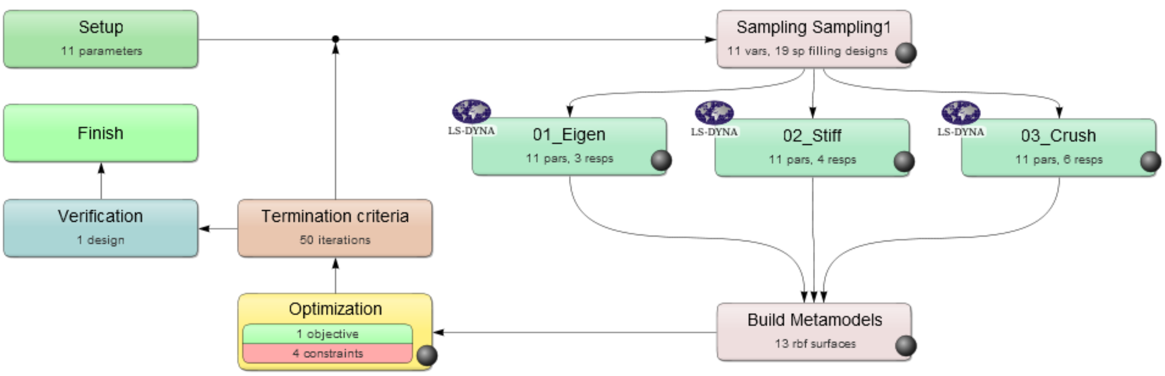

Fig.1: LS-OPT Optimization Flow

5 MDO Results

Taking a look into mass reduction every iterations to optimize, the constraint condition is kept within initial whole mass in chassis and mass decreasing can be confirmed.
The result indicates MDO with LS-DYNA and LS-OPT is very powerful tool to design the balance on weight of each part consisted of chassis. This simulation leads designers to get better distribution of part weight and stiffness against several indications about automotive performance.

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6 Summary

It would be tough for automotive designers to adjust and control the best pattern of part's weight and stiffness which meets some different evaluation such NV, stiffness and collision. This challenge to MDO with LS-DYNA and LS-OPT would be helpful when you want to figure out how better performance can be integrated in current development or part mass reduction can be fulfilled without getting poor performance. In the near future, we are going to improve and learn better way of MDO.

7 Literature

・Design optimization with Modal Assurance Criteria (MAC)
Sumie Kinouchi, Ryo Ishii, Masahiro Okamura (JSOL Corporation)