Acoustic Analysis for Impact Sound with LS-DYNA

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1 Introduction

Nowadays, LS-DYNA has been developed further and become possible to evaluate Frequency domain analysis and Acoustic analysis as FRF/SSD/AcousticBEM/FEM etc.

This study is intended for the evaluation to impact sound when a crash occurs between one object and another. To compare the result with experiment and check the both sound by ear is executed in this paper with LS-Prepost. The conventional other softwares dealing with acoustic analysis executes with frequency domain or also do frequency analysis with the assumption that steady state lasts in appropriate period. It defines the source of sound on the surface of object vibrating and set it as input to BEM/FEM.As it is well known that LS-DYNA can do a transient analysis, it can calculate the source of sound itself. The object vibrates due to collision and the sound is emitted to the air. This is the mechanism for sound. LS-DYNA is further able to calculate acoustic analysis taking over previous collision simulation. The comparison between LS-DYNA analysis and experiment is the theme of this paper. In acoustic simulation this time, the BEM(boundary element method) is used.

In the future, In order that LS-DYNA has evaluated physically many kinds of simulation in one model and it will be alternative to actual experiment.

The consideration at this time is a first step to confirm the validity and helpfulness of this solution.

Dr.Yun and Dr.Zhe have made an extensive contribution to this comparison. I'd like to express heartfelt thanks to them.

2 The Overview of Experiment

To inspect the availability of acoustic analysis in LS-DYNA such as impact sound reproduction, the experiment was executed. Acoustic experiment was executed in semi-anechoic room. The diameter of disk is 300mm and thickness is 2mm. The ball's diameter is 10mm. The image of this setting is described in Fig.1. The material is steel for both ball and disk. About boundary condition, the center of disk is fixed to flame. There is a hole in center and screw can go through hole and fix it.

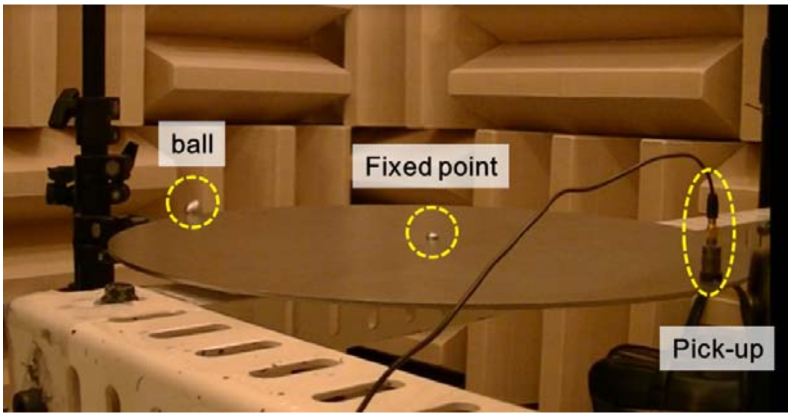

Fig.1: disk and ball

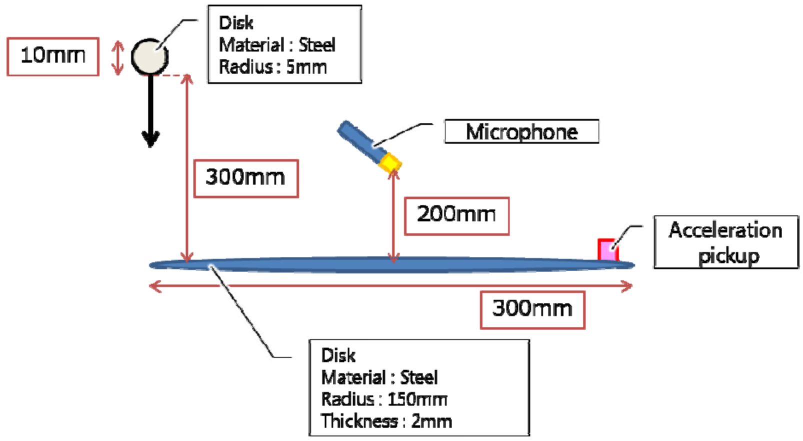

Fig.2: the image of drop test

The microphone above disk picks up sound and measure sound pressure along both time domain and frequency domain. The height of microphone from disk is 200mm.

While experiment is executed, it should be careful to contact both disk and ball twice at once drop after bounce. If the ball bounces and contacts disk at second time, it would lead inaccurate data from measure of sound In order to prevent from it, the disk is inclined slightly at a little angle.

3 The Result (experiment)

The graph in Fig.3 below is three outputs from accelerometer during drop test. They can be seen that sudden and large acceleration has happened and gradually attenuate. When this experiment is measured by accelerometer at some times, it is confirmed that result involves a variation. This is the reason why the same experiments are done 3 times and confirmed a variation during each experiment data. Eventually, an experiment data has been adopted from 3 results by comparing them as it is relatively averaged among some results from same experiment and targeted to be fit to simulation (Fig.4).

The graph in Fig.5 below is the frequency-domain result of sound measurement with microphone. X-axis shows frequency range. Y-axis shows amplitude of sound which has the unit of “decibell”. The noise during test is included in this plot in circled area in Fig 5, which indicates the difficulty of measurement of sound to eliminate noise as possible. The representative result selected from 3 same experiments is as Fig.6. We consider the representative result as targeted data to fit simulation data in next chapter. This result comes from same experiment as shown in Fig.4 (time domain).

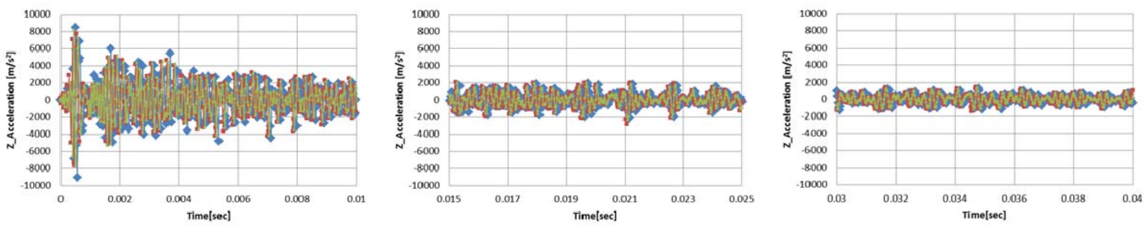

Fig.3: 3 results from accelerometer (0-1000Hz(left), 1500-2500Hz(center), 3000-4000Hz(right))

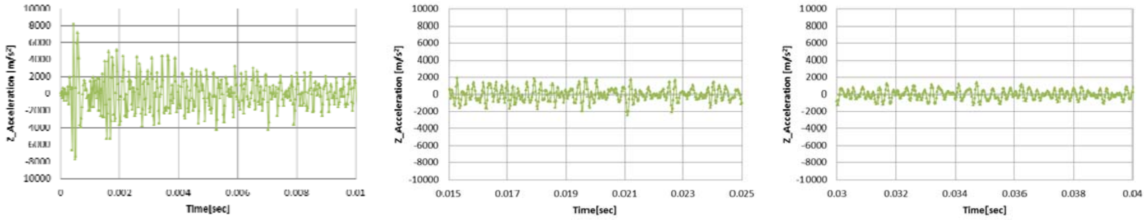

Fig.4: The adopted result of experiment
0-1000Hz(left), 1500-2500Hz(center), 3000-4000Hz(right))

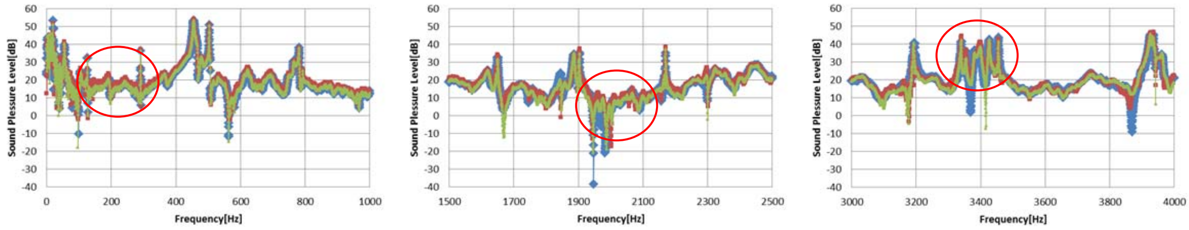

Fig.5: the result of experiment (sound pressure along frequency)
0-1000Hz(left), 1500-2500Hz(center), 3000-4000Hz(right)

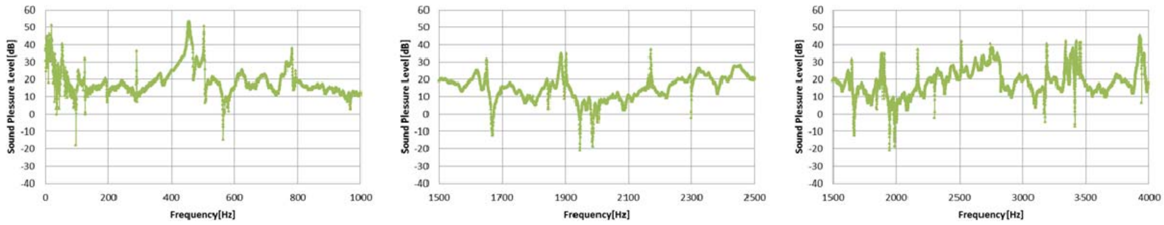

Fig.6: The adopted result of experiment (frequency domain)
0-1000Hz(left), 1500-2500Hz(center), 3000-4000Hz(right)

4 Simulation

4.1 The Overview of Drop Test Simulation with LS-DYNA

We start to simulate drop test analysis. It is collision simulation which is one of most popular simulation in LS-DYNA. After taking over information (acceleration) from result of former analysis, the flow of acoustic analysis with collision is shown as Fig.7. It calculates acoustic analysis of which we are going to inspect availability. The BEM is selected in this study because it doesn't need the mesh for any space except the objective like disk and ball.

The input of LS-DYNA is set several conditions as same to experiment. The initial mesh size is 1mm.

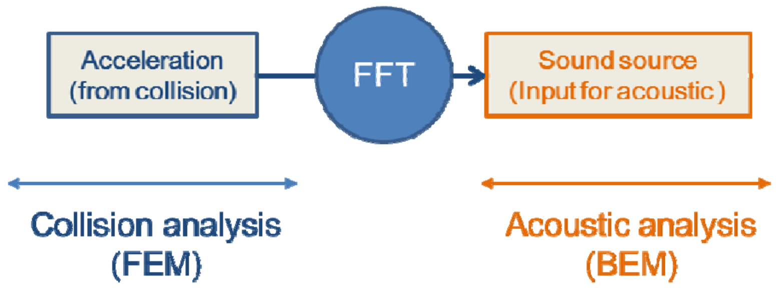

Fig.7: The Flow of Acoustic Analysis with Collision

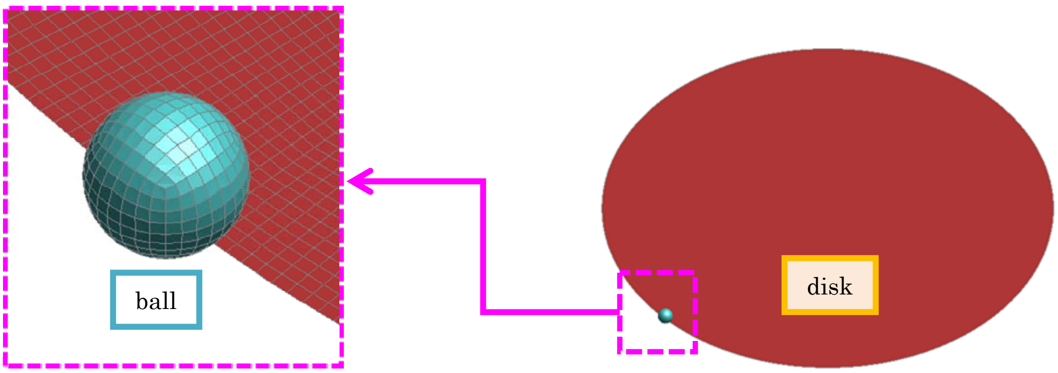

Fig.8: input model

4.2 Damping setting effect

The result of transient simulation with/without damping is as Fig.9 and 10. In comparison to experiment and LS-DYNA, the damping in experiment is stronger than simulation. When we simulate physical phenomenon, it would be important to add damping in order to be consistent with experiment. But it is difficult to define how large damping we should set in simulation. The damping is set by using *DAMPING_GLOBAL and damping ratio is 50%.The effect to damping is as Fig.10. This setting is not within normal range to add damping. It will be our future work to consider it in the near future. The time to calculate physical phenomenon is 1 sec.

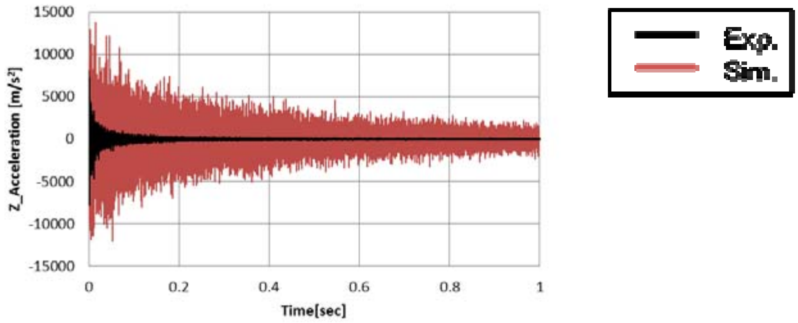

Fig.9: The acceleration result of drop test simulation without damping setting)

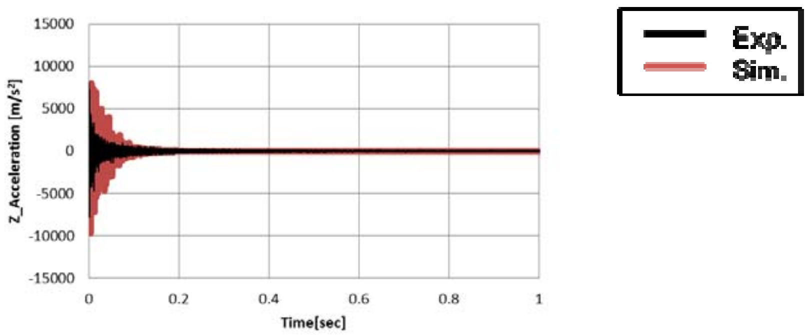

Fig.10: The acceleration result of drop test simulation with damping setting

4.3 Acoustic Analysis with LS-DYNA

Secondly, acoustic analysis, LS-DYNA can take over previous simulation result (acceleration). It selects and sets the source of sound as boundary condition. In this case, sound source is assumed the surface of disk.The result is shown in Fig.11.When acoustic analysis , to take over time-domain result from collision analysis , A window function would be needed. In this case, exponential window which Zhe and Yun from LSTC has inplemented is used .

The noise an experimental data has rarely happens in simulation result. That means it is hard to measure sound precisely in expeirment. We're going to improve these challenges in the near future by closer looking into both experiment and simulation with LS-DYNA.

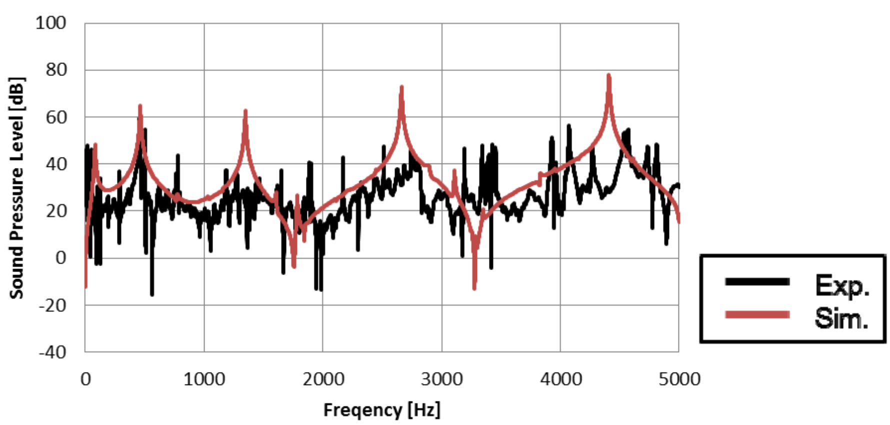

Fig.11: Acoustic analysis result compared with experiment data

4.4 Sound check with LS-Prepost

LS-Prepost is very useful to check acoustic pressure by hearing actual sound with your ears. It can output sound WAV.file and confirm it. This simulation will be expected to determine the shape or material of product in the process of design. And there would be possibility of integrating sound simulation manufacturing instrument like guitar or cymbal which is similar to this case.

5 Summary

Acoustic analysis with LS-DYNA has possibility of wide usage by designer who want to inspect sound quality of product. Especially, the sound of collision like automotive door or instrument would be good example for thus simulation. In the future, we are going to inspect and find the tip of reproduction to sound generation. When you're interested in thus challenge or going to inspect anything like this study, please email to me. Email : ishii.ryo@jsol.co.jp

6 Literature

・Boundary Element Analysis of Muffler Transmission Loss with LS-DYNA
Z. Cui, Y. Huang (LSTC) 2014
・BEM Methods For acoustic and vibroacoustic problems in LSDYNA
Souli Mhamed, Yuang Yun, Zhe Cui, Zeguar Tayeb (LSTC)