Stamping effect application for crash CAE procedure with QUIKSTAMP

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ABSTRACT

For having well-correlated crash CAE model, considering the thinning and the work hardening effect on CAE model is important to close to the physical BIW. QUIKSTAMP was used for considering the stamping effect in an early stage with short time instead of the conventional (incremental) approach. With considering the stamping effect, it is needed to predict the panel tearing behavior and the spot weld failure during impact.

INTRODUCTION

Many studies for considering the stamping effect like the work hardening and the thickness thinning behavior of BIW had been performed. Johnheon Yoon et al did the study regarding the stamping effect on the lateral crash model, they concluded that The result of the crash analysis demonstrates that the crash mode, the load- carrying capacity and energy absorption can be affected by the forming effect. It is noted that the design of an autobody should be carried out considering the forming effect for accurate assessment of crashworthiness. V. Grolleau et al did the study regarding the effect of thickness change and strian hardening of crash model; they stated that plastically at different thick strain levels ranging from −37% to −6% [2]. In this study, two different calculation approaches for the stamping operation were adopted as considering the work hardening and the thinning behavior: One is the incremental approach and the other is the inverse approach. Generally the incremental approach have been used for the stamping calculation , with this approach, many calculations are needed for each several stamping operation especially for intermediate shape operation and CAD data and tooling information are needed for this calculation. In inverse approach, just one-step calculation for the stamping operation is needed and CAE mesh model could be used for the calculation. Moreover, with the inverse approach, the calculation time could be reduced and the stamping calculation result could be applied on crash calculation from 1st CAE model build compared to the incremental approach.

STAMPING CALCULATION PROCEDURE

Stamping calculation method

The difference between the incremental and the inverse approach could be explained as below figure1 and figure2.
Figure1 shows the schematic drawing of the incremental approach. Several calculations are needed for each stamping operations and the stamping die design parameters and CAD data are necessary during calculation.

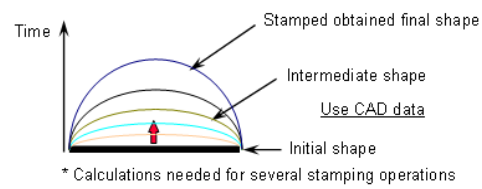

Figure1. Incremental approach

Figure2 shows the schematic drawing of the inverse approach. Different to the incremental approach, just one step calculation is needed for the stamping operation, and CAE mesh model is enough to make a calculation, this means that the stamping calculation results could be considered from 1st crash CAE model build without tooling information through the vehicle development process.

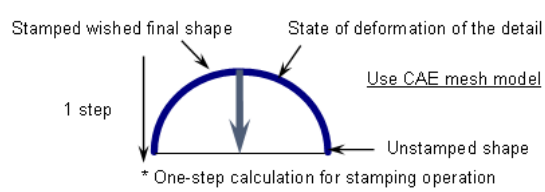

Figure2. Inverse approach

Figure3 shows the overall procedure considering the stamping calculation. The first step is to do the stamping calculation depended on the calculation types, and then the strain as a work hardening and the thickness profile as a thinning would be

exported and mapped to the crash CAE model as a M01 file format. After mapping the stamping calculation result, the crash calculation result could be obtained as considering the work hardening and thinning effect.

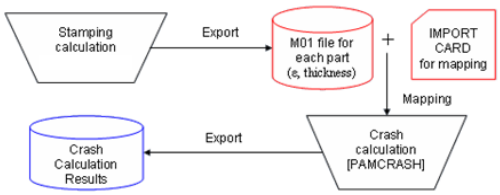

Figure3. Calculation procedure

Incremental vs. Inverse

Though the advantage of the inverse approach like the calculation time and the early application in the vehicle development process, the comparison study between the incremental and the inverse approach is necessary before adopting the inverse approach for the stamping effect.
For the comparison study, the study model is the mid-sized sedan vehicle with checking rear crash performance, Figure 4.

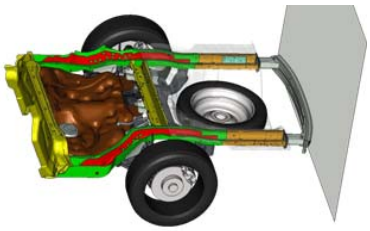

Figure4. Mid-sized sedan vehicle, rear crash performance

Rear side member of this vehicle was selected for the stamping calculation. AUTOFORM software was used for the incremental approach, and QUIKSTAMP software was used for the inverse approach.

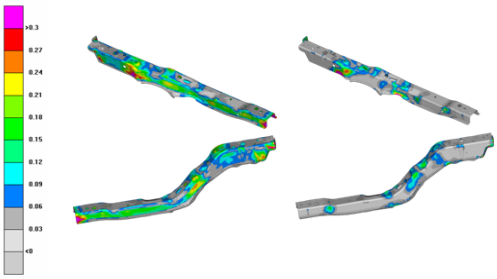

Figure5. Strain distribution

Figure5 shows the strain distribution on rear side member as a result of each stamping calculation approach: Left one for the incremental and right one for the inverse approach. The strain distribution on rear side member shows different between two approaches; however, the concentrated area followed well between two results. Figure6 shows the thickness profile, and the tendency was similar to the strain distribution.

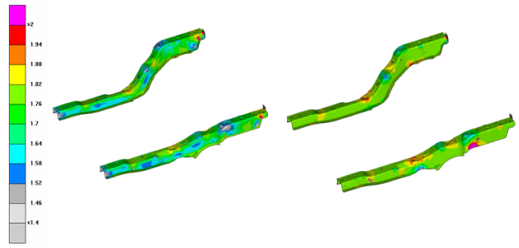

Figure6. Thickness profile

These strain distribution and thickness profile was mapped to the crash model, and the rear crash calculation performed. The section force of rear side member was compared to see the possibility for adopting the inverse approach instead of the incremental approach as considering the stamping effect on crash calculation.

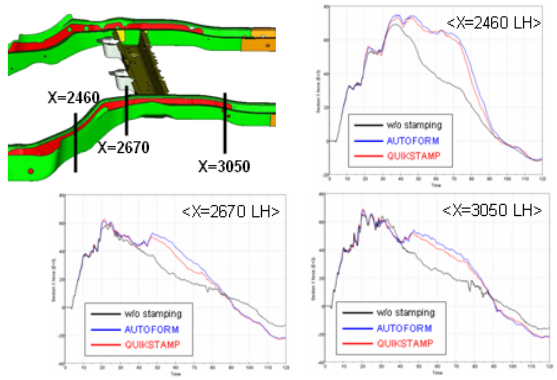

Figure7. Comparison of section forces on rear side member

Figure7 shows the section force results on rear side member in case of rear crash type, on each section definition, the stamping effect considered case was different to the others; however, the inverse case (red curve) followed well to the incremental case (blue curve), that means the inverse approach could be adopted for considering the stamping effect on crash calculation.

CRASH CALCULATION

Model definition

In this study, 65 KPH frontal crash calculation with 40% offset deformable barrier was performed for small family car, and 55KPH lateral crash calculation was performed for small MPV.

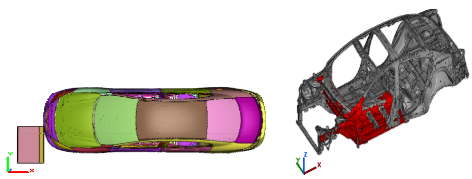

Figure8. 40% offset frontal crash model definition

Figure8 shows the model definition that was used for the frontal crash calculation, red colored parts located front left hand area of BIW was selected for the stamping calculation. These parts were selected in order of the part internal energy during crash calculation as below figure9.

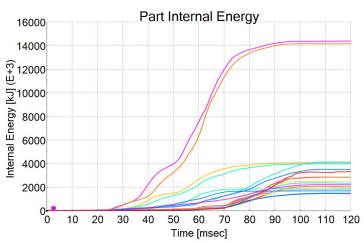

Figure9. Part internal energy of BIW during frontal crash calculation

Figure10 shows the model definition which was used for the lateral crash calculation. All BIW parts located in front left area were considered for the stamping calculation

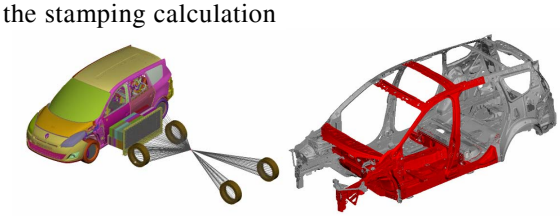

Figure10. Lateral crash model definition

Results: w/o stamping vs. w/ stamping

With 65 KPH frontal crash calculation, globally similar tendencies were found between two results, however, in some areas, the difference could be found. One of them is the A pillar area. In case of w/o stamping model, there's no bending behavior, but w/ stamping model, the bending behavior can be observed. This difference showed in Figure11. In the physical test, the bending behavior also could be found in Figure12.

Figure11. Global deformation on BIW

Figure12. Deformation view on BIW in the physical test

The level of section forces for stamping effect considered model was little higher than base.

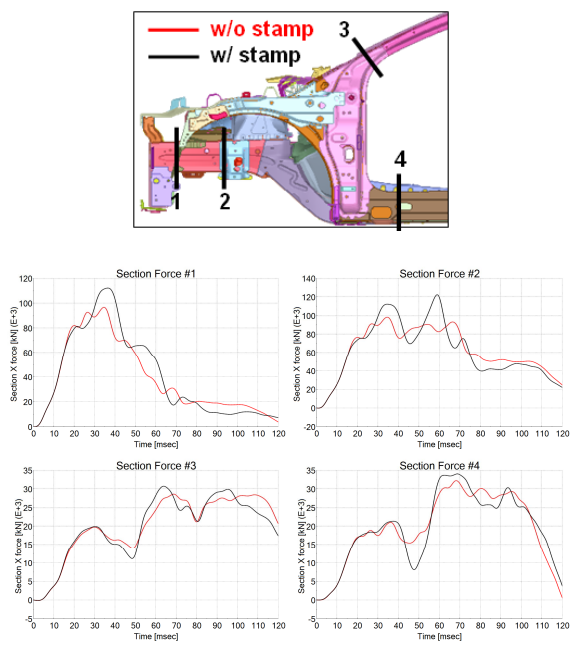

Figure13. Section forces on BIW in case of the frontal crash calculation

With 55 KPH lateral crash calculation, the front door velocity and B pillar intrusion was evaluated for checking the stamping effect. As showing in Figure14, the level of door velocity in the stamping effect considered model were lower than the model without the stamping effect.

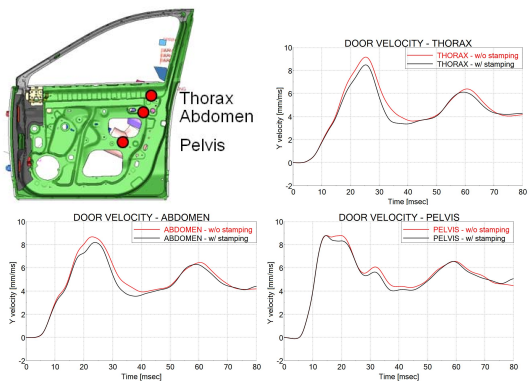

Figure14. Front door velocity

Compared to the model without the stamping effect, the pillar intrusion of the stamping model has been improved, it could be explained that the work hardening affected on BIW deformation. It would have a good effect on dummy injury criteria. See in Figure15.

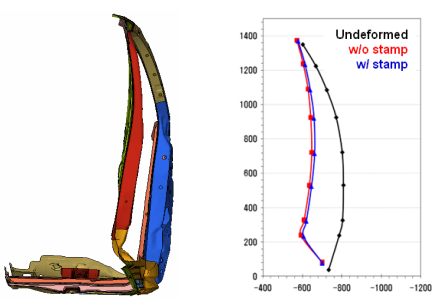

Figure15. B pillar intrusion

CONCLUSIONS

The stamping effect like the work hardening and the thinning effect are needed to be applied in crash calculation for building accurate crash CAE model in BIW point of view.
The crash calculation results with using inverse method was well matched to the results with using the incremental method even though the stamping results itself showed little difference of the initial strain distribution and thickness profile.
Work hardening effect on BIW affected on the crash results and showed stiffer behavior than the model that the stamping effect was not considered.
Comparing the physical test results, the deformation behavior on A pillar of the stamping effect considered model was well matched to the physical deformation.
The inverse method like QUIKSTAMP would be more efficient to build the crash CAE model considering the calculation time and the process focused on the project milestone than the incremental method.

REFERENCES

[1] Johnheon Yoon, Hoon Huh, Seho Kim, Hongkee Kim, Seungho Park 2006. “Side Impact Analysis of the ULSAB-AVC model with considering the forming effect.” Proc. KSTP, Fall Conference, No. 4, April: 37-40
[2] V. Grolleau, B. Galpin, A. Penin, G. Rio 2008 “Modelling the effect of forming history in impact simulations: evaluation of the effect of thickness change and strain hardening based on experiments.”, International Journal of Crashworthiness Vol. 13 No. 4 363p ~ 373p