# A Simple, Efficient and Robust Way to do Binder Wrap Simulation with LS-DYNA® Implicit Solver

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## Abstract

*With the newly improved LS-DYNA implicit solver, the possibility to use it for binder wrap simulations of Stamping Process becomes reality. The importance of binder wrap simulation can never be overly emphasized since it will not only approve or disapprove the concepts of binder shape design, hence the whole addendum development of stamping process, but also impact the final results of stamping process simulations.*

## 1. Status of Binder Wrap Simulation in ASME of Chrysler LLC

In the past, binder wrap simulations in ASME are divided into three separate steps: 1) run a suction cup simulation with LS-DYNA dynamic explicit solver to get pre-draped blank shape; 2) run Gravity loading with LS-DYNA explicit solver; 3) run binder wrap simulation either with one of our in-house code, C-Form, which is a static implicit solver or with LS-DYNA explicit solver. This is a very tedious procedure indeed. With the help of newly added feature of implicit solver in LS-DYNA – gravity loading plus binder wrap simulation all together, we can combine all three steps into a single binder wrap simulation and get as accurate results as before.

Binder wrap simulations are very important, which will not only qualify the concept of binder designs, thereafter addenda development for draw dies, but also impact the final results of stamping simulations. They will have a direct contribution on the CPU time (elapsed time) spending in the stamping simulations as well. Since in the real world, the whole stamping process is a dynamic process from binder closing to the home position, therefore a more realistic way to simulate this whole process is to run it with dynamic solver (direct run). A problem for this approach is: direct run simulations with LS-DYNA explicit solver will often take very long time due to the fact that dynamic effects of numerical simulation should be minimized during the binder closing process, therefore very slow speed is to be imposed. For the most of cases, binder closing travel from flat blank position to wrapped shape is much larger than binder travel after binder close. Therefore, simulations of the whole process with Dynamic explicit will take much more time than the ones starting from blanks in binder wrap position (based on our studies, about 2 to 3 times slower). For this reason, in ASME we use in-direct approach for draw die simulations for majority of the panels: run a binder wrap simulation before draw die stamping process simulations.

## 2. Validation of Implicit Gravity + Binder Wrap with LS-DYNA

In order to validate binder wrap simulation with LS-DYNA implicit solver, we choose some typical panels to test.

The first example is a typical fender outer. This example is to emphasis the importance of pre-draped blank in binder wrap simulation. Figure 1a shows the initial setup of binder wrap with a flat blank. As a consequence it results binder wrap buckles, shown in Figure 1b.

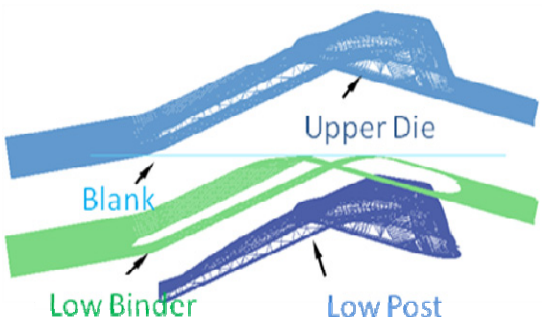


Figure 1a. Initial Setup for Binder Wrap with a Flat blank

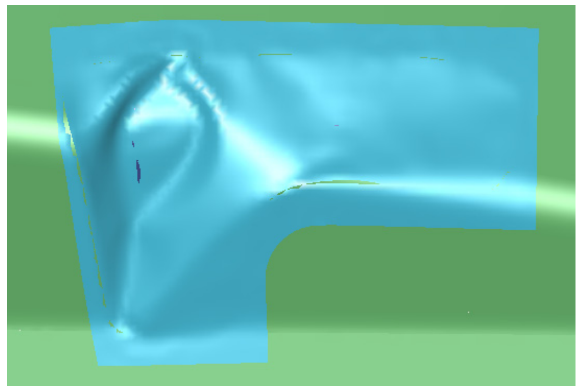

Figure 1b. Binder Wrap with Figure 1a Setup

If a pre-draped blank is used instead, a clean binder wrap is obtained (See Figures 2a and 2b).

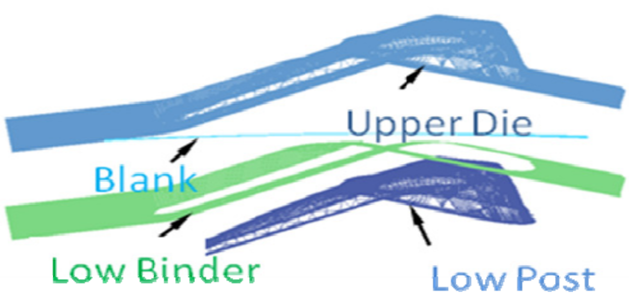


Figure 2a. Initial Setup for Binder Wrap with a Pre-draped Blank

Figure 2b. Binder Wrap with Figure 2a Setup

The following two examples are to demonstrate the contribution of total CPU time with binder wrap simulation before the draw-die FEA simulations for LS-DYNA explicit solver.

Example two is a typical Deck Lid Inner panel. Due to a almost 90 degress bend of the panel, for a direct run, the binder travel before binder close is very large in comparison with the binder travel in draw-die after binder close (See Figure 3 for reference).

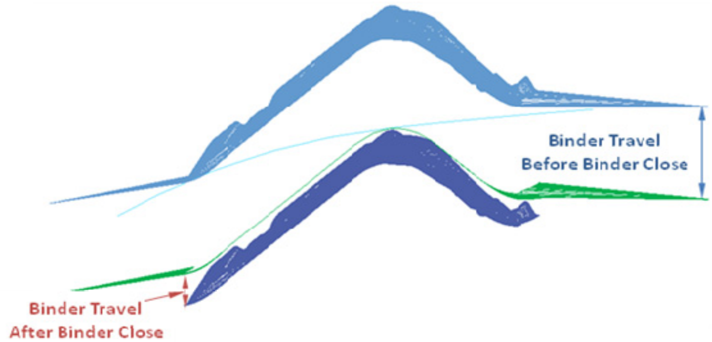


Figure 3 – Comparison of Binder Travel Before/After Binder Close for a Direct Run

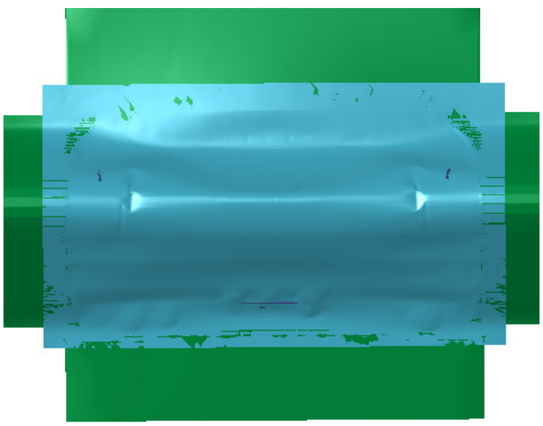

Figure 4a. Binder Wrapped Blank with LS-DYNA Explicit Solver for a Direct Run

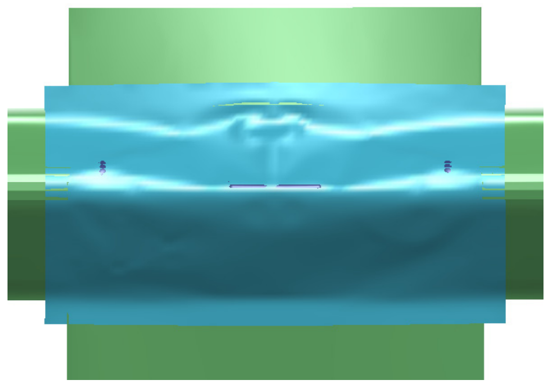

Figure 4b. Binder Wrapped Blank with LS-DYNA Implicit Solver

It is clear that if simulations of draw die process are setup without binder wrap simulation (direct run), as shown in the figure 3, then the total CPU time (elapsed time) will be much longer than the simulations using binder wrapped blanks instead. For this specific example, a total CPU time (elapsed time) of 20 hours and 15 minutes is used for direct run simulations in comparison with a total CPU time (elapsed time) of 5 hours for simulations with binder wrapped blanks used instead (the CPU time used for implicit binder wrap is about one hour). A total saving of 14 hours is gained for the cases with binder wrapped blanks used in the simulations.

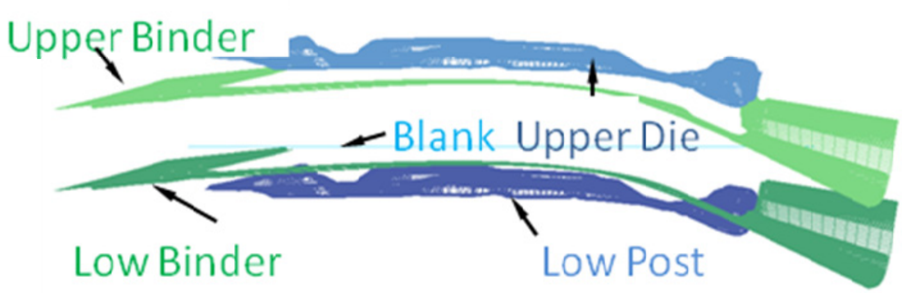


Figure 5 – Initial Direct Run Setup for 4-Pc Stretch Draw with LS-DYNA Explicit Solver

The last example is a hood inner panel with 4-piece stretch draw process. Due to complex binder shape, it is very hard to use our in-house code C-Form to do a binder wrap before draw die simulation. So the simulations were setup to use a flat blank and use LS-DYNA explicit to wrap the blank and draw it to home (see Figure 5 for details). Figures 6a shows the binder wrapped blank of a direct run with LS-DYNA explicit solver verse the wrapped blank shape in Figure 6b with LS-DYNA implicit solver. An obvious dynamic effect is observed in Figure 6a.

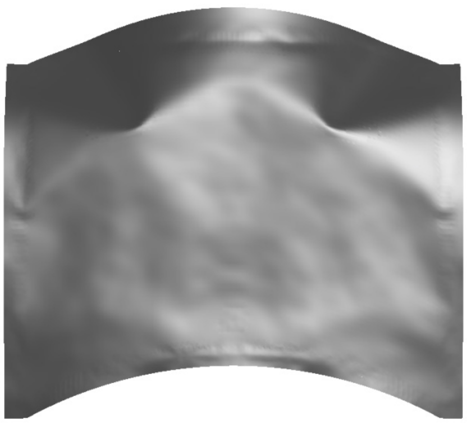

Figure 6a. Binder Wrapped Blank with LS-DYNA Explicit Solver for a Direct Run

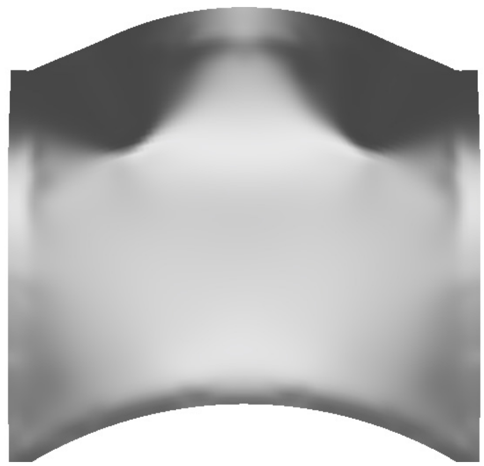

Figure 6b. Binder Wrapped Blank with LS-DYNA Implicit Solver

For this example, the total CPU time (elapsed time) used in case of direct run is about 30 hours in comparison with a total CPU time (elapsed time) of 7 hours for the case with binder wrap done before draw die (the CPU time required for implicit binder wrap is about one hour). Here again a total of 22 hours of CPU time (elapsed time) is saved if a binder wrapped blank is used in the draw die simulation with LS-DYNA explicit solver.

## 3. Conclusion

This paper is to demonstrate the capacity of newly added feature of implicit gravity loading plus binder wrap option in LS-DYNA or above, which can not only significant save CPU time (elapsed time) for draw die simulation with LS-DYNA explicit solver but also simplify the process of setup and run binder wrap simulation and make the tasks of simulation much simple and easy for the simulation engineers without sacrifice simulation accuracy.

## References

Livermore Software Technology Corporation, "LS-DYNA Keyword User's Manual", Version 971, 2007.