Roof Rail Airbag Folding Technique in LS-PrePost® Using DynFold Option

Vijay Chidamber Deshpande
GM India – Tech Center
Wenyu Lian
General Motors Company, Warren Tech Center
Amit Nair
Livermore Software Technology Corporation

Abstract

A requirement to reduce vehicle development timelines is making engineers strive to limit lead times in analytical simulations. Airbags play a crucial role in the passive safety crash analysis. Hence they need to be designed, developed and folded for CAE applications within a short span of time. Therefore a method/procedure to fold the airbag efficiently is of utmost importance.

In this study the RRAB (Roof Rail AirBag) folding is carried out in ***LS-PrePost®*** *by DynFold option. It is purely a simulation based folding technique, which can be solved in* ***LS-DYNA®****. In this paper we discuss in detail the RRAB folding process and tools/methods to make this effective. The objective here is to fold the RRAB to include modifications in the RRAB, efficiently and realistically using common analysis tools (LS-DYNA & LS-PrePost), without exploring a third party tool , thus reducing the turnaround time.*

Introduction

To meet the regulatory and consumer metrics requirements, multiple design iterations are required using advanced CAE simulation models for the various safety load cases. One of the components that requires frequent changes is the roof rail airbag (RRAB). After any changes to the geometry or pattern in the airbag have been made, the airbag needs to be folded back to its design position. Airbag folding is available in a few pre-processors; however, there are some folding patterns that are difficult to be folded using the pre-processor folding modules. Simulation based airbag folding has been gaining ground in the airbag industry recently to address this and is able to perform more complex folding patterns and even crush folding; however we have also found that for simple folding patterns like in RRAB, simulation folded RRAB and preprocessor folded RRAB models have very similar deployments. In the following sections of this paper we will describe the simulation folding method and process using the folding module available in LS-PrePost: DynaFold (Figure 1). We will then summarize and discuss our findings. The example used in this paper is only for demonstration purpose. It does not reflect any actual product information.

Folding an airbag needs pre-planning and fold step management. Both of these can vary depending on the bag being folded. The following methodology for a RRAB involves the following steps:

1) Tool Development
2) Roll
3) Thin Fold
4) Morphing (position)

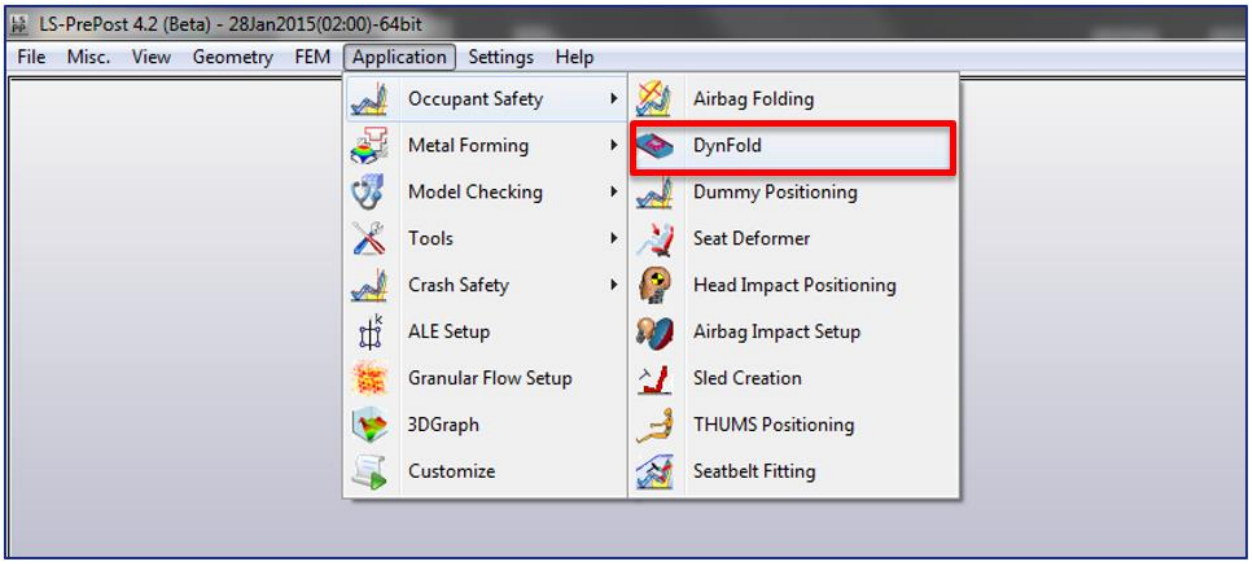

Figure 1 DynFold Interface in LS-PrePost 4.2

Tool development

Tools are required to perform folding. Some of the tools that are available in the DynaFold interface are basic and they do not come with Tool Library. This limitation requires development of in-house tools that are specific to the type of bags that need folding. The tool needs to be developed as per the folding requirement, taking into consideration the diameter and the length of the RRAB as well as the actual folding tool hardware. The tool can be modelled (meshed) in any of the pre-processors. To complete the folding process for our sample RRAB, two tools needed to be developed: one for rolling (Figure 3) and another for thin folding (Figure 4). Rigid materials are assigned to these parts. For the rolling process, *BOUNDARY_PRESCRIBED_MOTION is assigned to the tool with appropriate boundary conditions like rolling direction and number of turns (Figure 2).

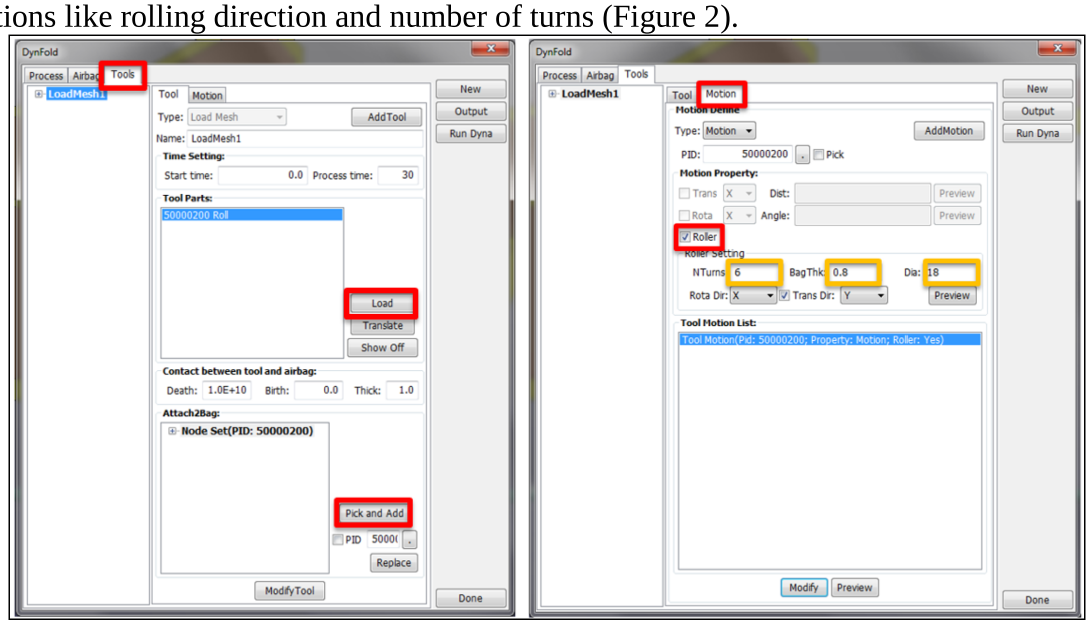

Figure 2 Tool Load and Motion Interface in DynFold

The thin fold process also involves application of *BOUNDARY_PRESCRIBED_MOTION and the angle of bend.

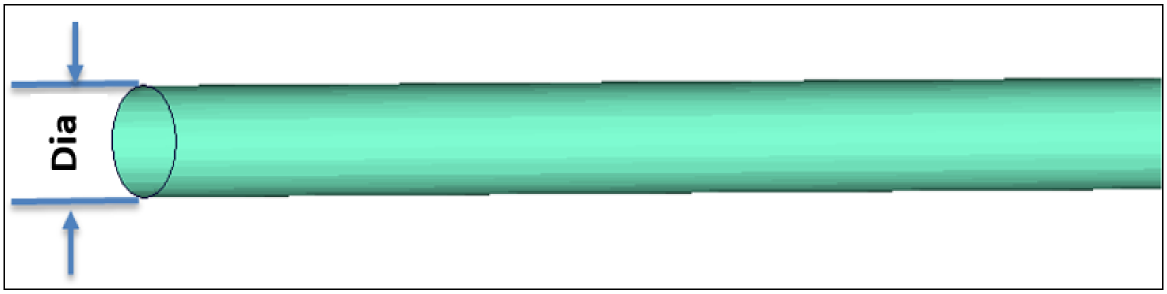

Figure 3 Tool for Rolling

For thin folding, a special tool is developed, which is in tubular form with two plates which run from the center of the tube to its periphery (Figure 4). The tool runs along the length of the RRAB.

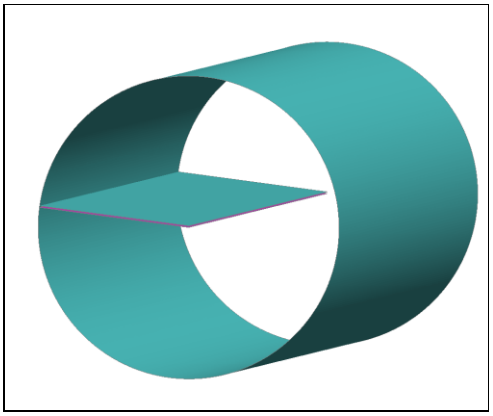

Figure 4 Tool for Thin folding or Bending

Roll

In order to roll the RRAB to a predetermined height, the RRAB and the tool need to be loaded into the LS-PrePost using the DynFold option (Figure 2). *NODE_SET is created, consisting of the nodes of the RRAB which are in contact with the tool (Figure 5), to create *CONSTRAINED_EXTRA_NODE between the tool and the RRAB.

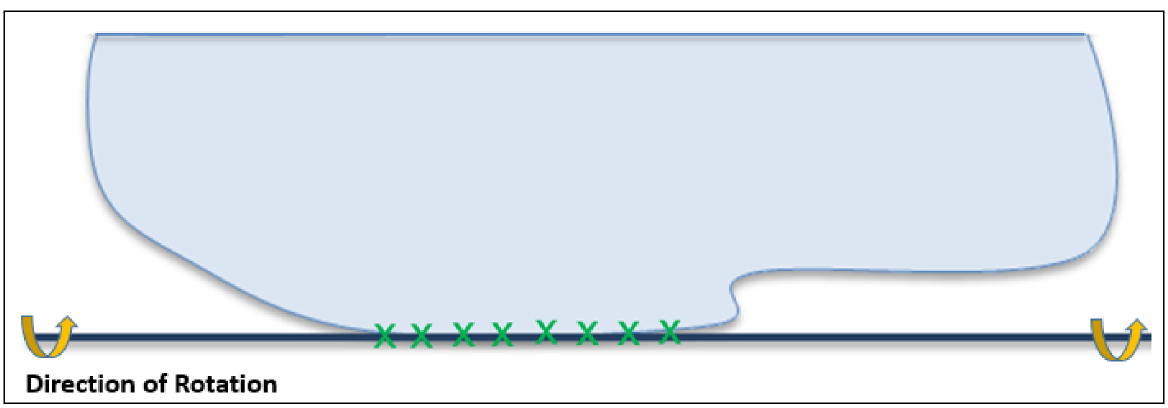

Figure 5 Nodes to be added in the *NODE_SET

*CONTACT_AUTOMATIC_SURFACE_TO_SURFACE is defined between the tool and the RRAB. Next the motion is assigned to the tool by defining number of turns, bag thickness and the diameter of the tool. Assigning motion creates the

*BOUNDARY_PRESCRIBED_MOTION for the tool. Figure 6 below shows the roll of the RRAB.

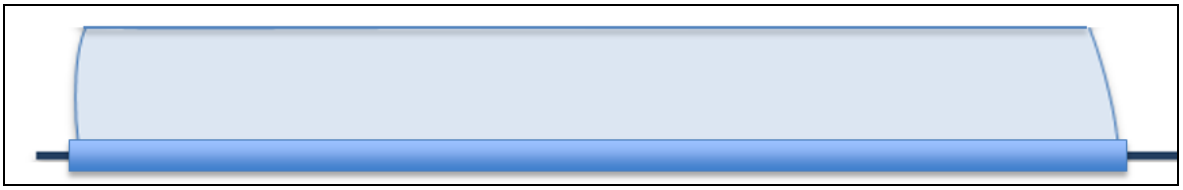

Figure 6 Roll of the RRAB

Thin Fold

After the roll of the RRAB, the next step is to thin fold the RRAB. In thin fold the airbag needs to be folded in a zig-zag pattern one layer above the other as shown in Figure 7. As described in tool development section the tool for the thin fold is loaded in the DynFold.

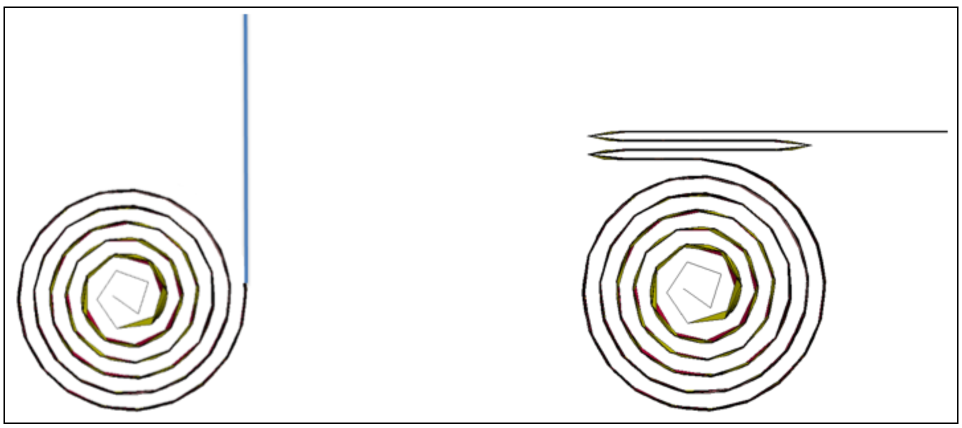

Figure 7 RRAB at the end of the roll process Required thin fold for the RRAB

The placement of the tool with respect to the RRAB is shown below in Figure 8.

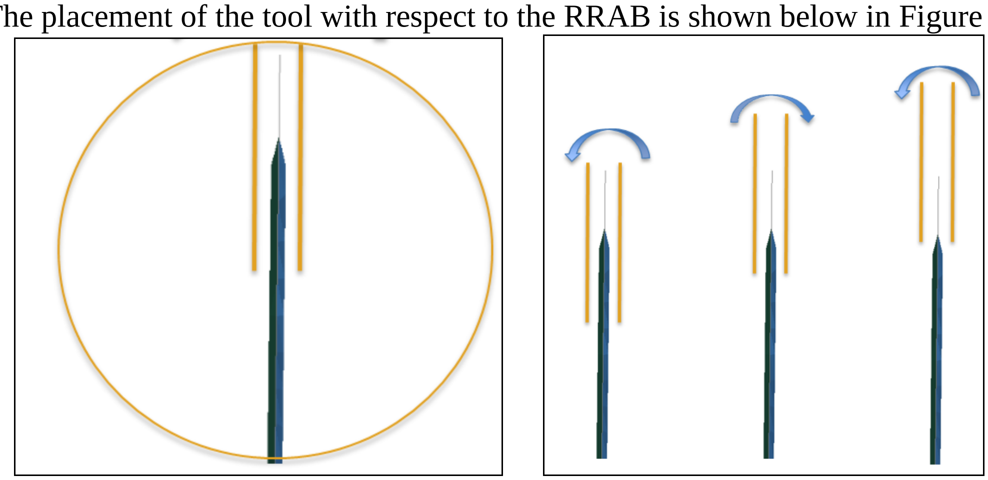

Figure 8 Tool placement with RRAB and Tool Motion

A contact between the RRAB and the plates of the tool needs to be created with appropriate birth and death time. The birth time for the contact should start once the roll process is completed. In order to get the fold, the tool is assigned motion of 90 degrees (as required), this creates the *BOUNDARY_PRESCRIBED_MOTION for the tool rotation. Once the tool is rotated by the given angle, the tool is raised as per the requirement and the process is repeated (Figure 8). The output file is written out, which is submitted to LS-DYNA solver.

At the end of the Thin Fold the RRAB looks as in figure 10.

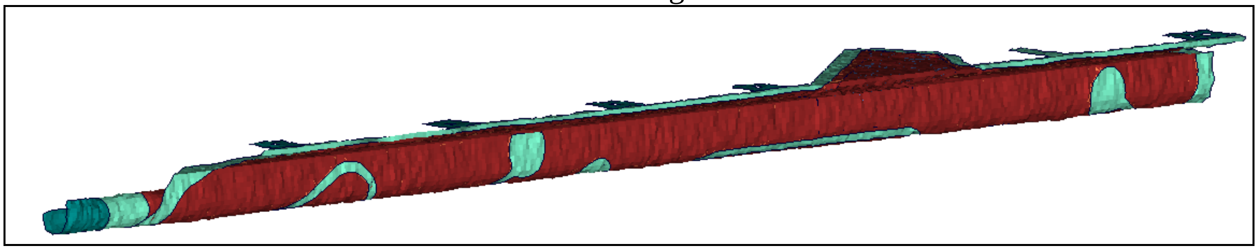

Figure 9 RRAB after Thin Fold

Morphing

After the roll and the thin fold processes are completed using LS-DYNA simulations, the RRAB needs to be positioned in the desired location of the vehicle. To accomplish this, morphing of the RRAB is required. Morph feature of LS-PrePost is used for positioning the RRAB. The Map8L type is selected to map between the 4 source and 4 target lines. The 4 target lines represent the position of RRAB in the vehicle.

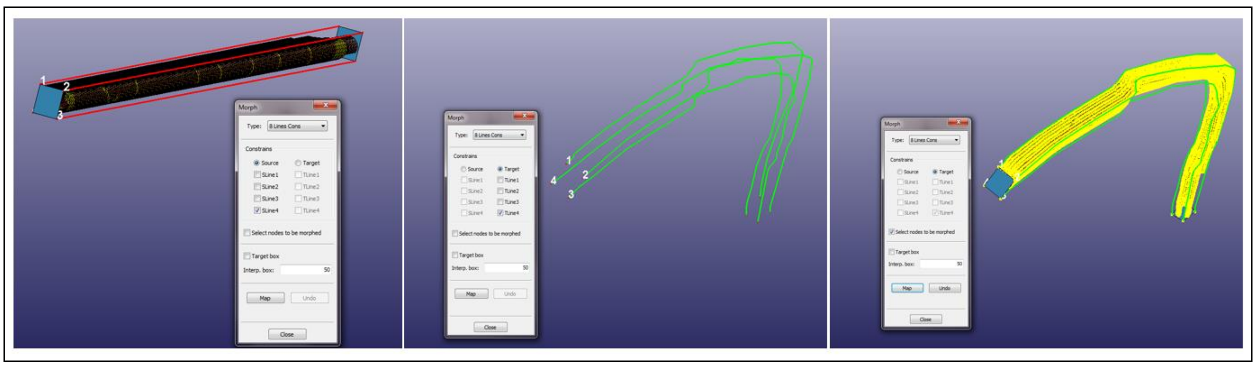

Figure 10 Morphing Process

After morphing the process of RRAB folding is completed as shown in Figure 12.

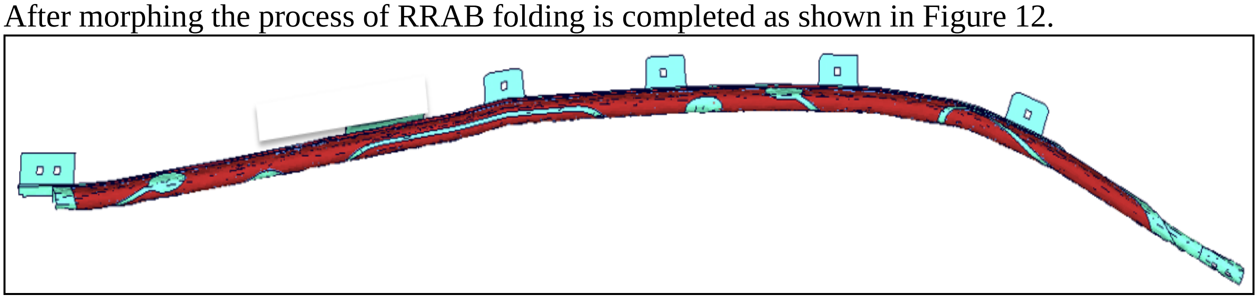

Figure 11 The end result : Folded RRAB

Lessons learned

In this example, we had two special treatments in the process:

1. <u>Smoothening the Edges:</u>

If the edges of the RRAB are uneven, it results in sharp spikes at the edges resulting in penetration during the roll (Figure 13). Hence smoothening the edges is necessary.

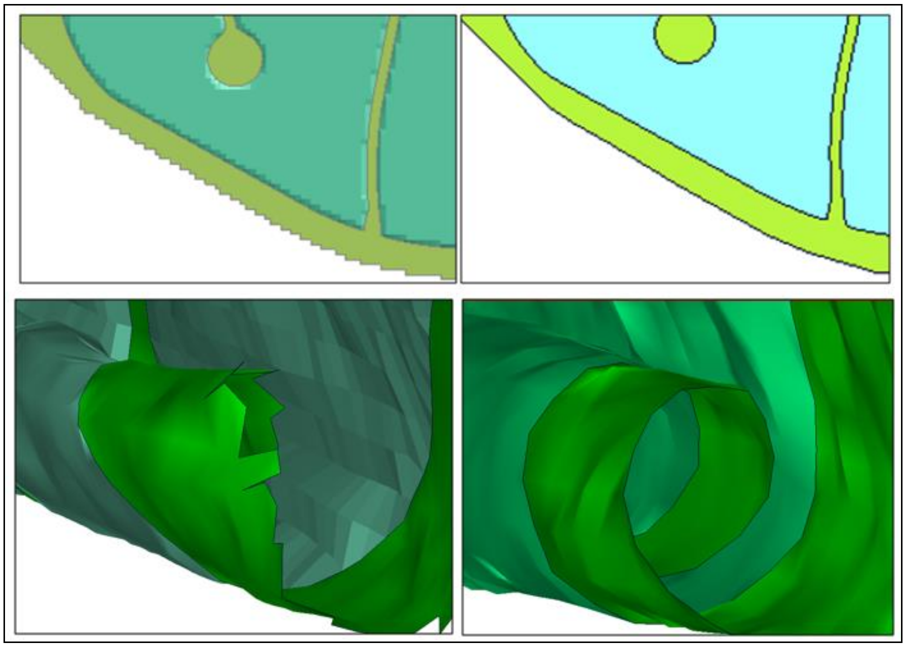

Figure 12 Roll with and without edge smoothening

2. <u>Adding extra parts (fabric) to smooth folded model</u>

To avoid random oscillation issues around airbag edge, we added one piece of fabric that filled the gaps between the bag edge and the rolling tool bar. With the additional pieces, the entire length of the RRAB is in contact with the tool during the roll process. This results in the proper rolling of the RRAB. The added piece will be removed after folding. As evident from Figure 14 below, a surface needs to be created so that the RRAB along its entire length is in contact with the tool.

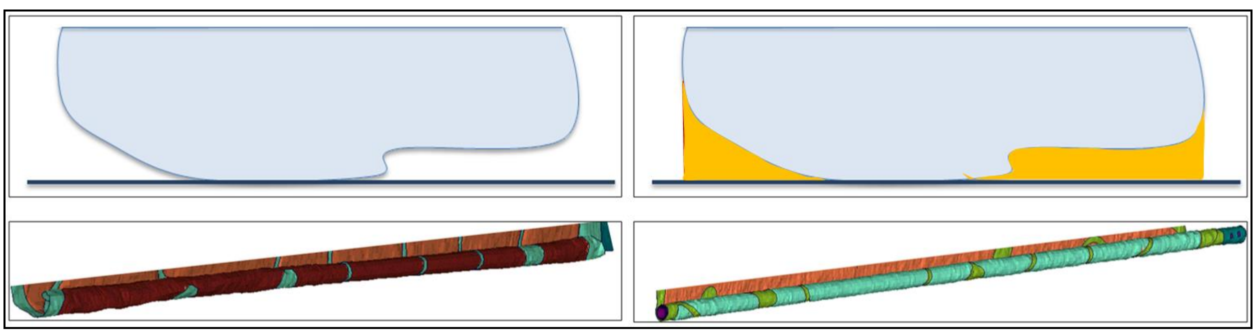

Figure 13 Tool to RRAB contact

Results Comparison

A comparison study for deployment, volume and pressure was carried out on the airbags folded with the Pre-Processor based and the Simulation (DynFold) based processes. From the deployment point of view the performance of airbags were almost identical as evident from the Figure 15.

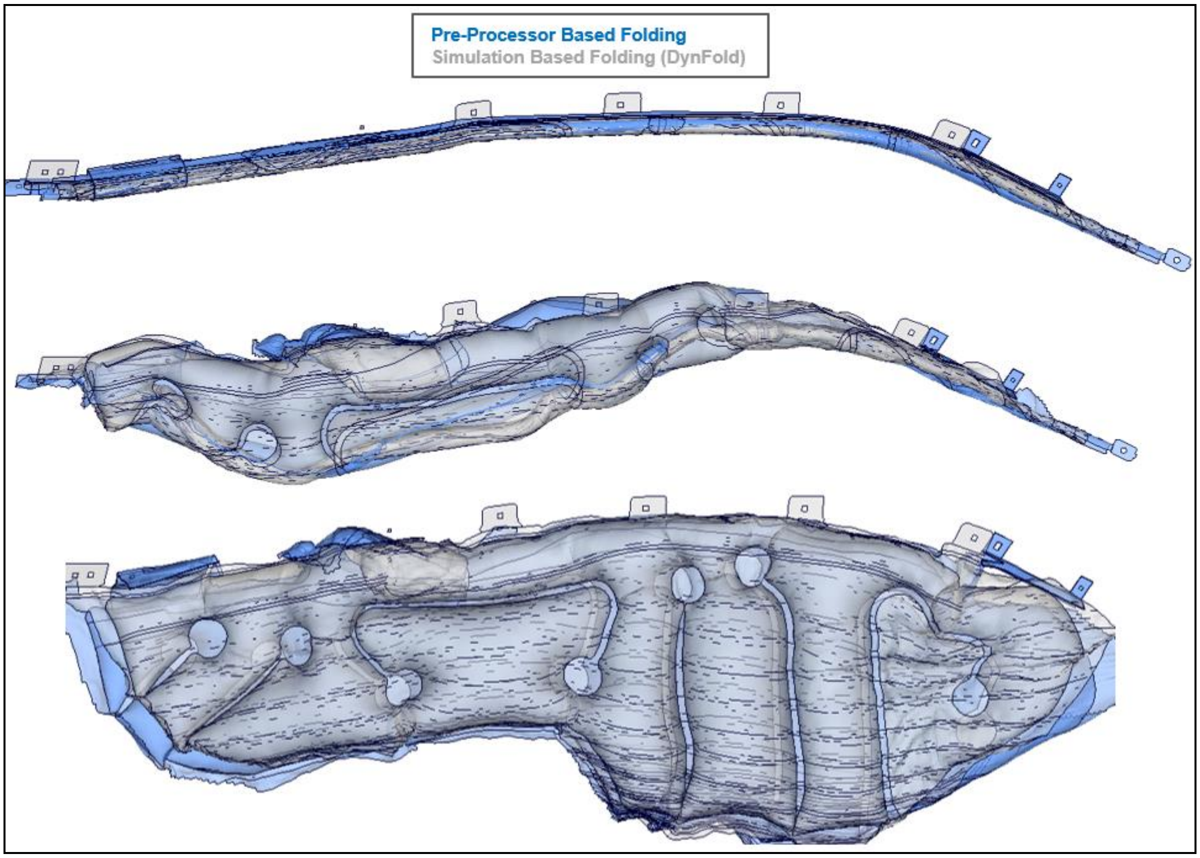

Figure 14 RRAB deployment

The comparison of volume and pressure between the airbags resulted in overlapping curves, shown in Figure 15. Slight variation in pressure was observed at initial stage of airbag deployment.

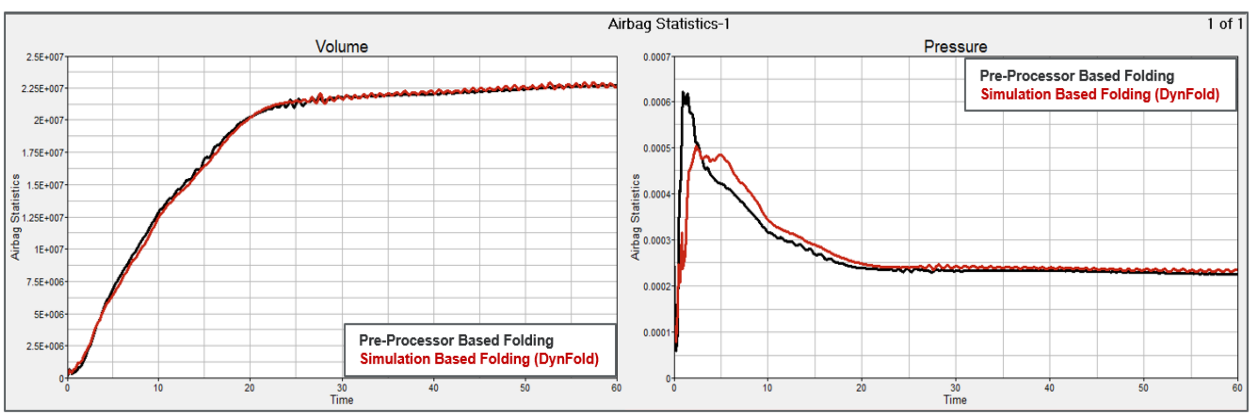

Figure 15 Volume and Pressure Plots

The time estimate to complete the two processes are as mentioned below:

- Pre-Processor Based Folding ~ 1day
- Simulation Based Folding (DynFold) ~ 3 days
- The pre-processor based folding was quick and produced the same outcome as of the simulation based folding using DynFold.

Summary

Once the initial folding process is established, it is easier to modify the RRAB as per the requirement and to follow the folding process for the iterations. The DynFold option of the LS-PrePost offers helpful automation process in folding airbags and creates the LS-DYNA input deck. We only explored the bag folding capability using the example RRAB with relatively simple folding patterns. This capability shall be more suitable for more complicated folding.

Below are some of the suggestions for the tools (DynFold in LS-PrePost) and findings experienced during the entire folding process:

- Introduction of tool library in the LS-PrePost, so that the user can input the tool specifications and the tools are generated.
- For RRAB deployments, no significant differences were found between preprocessor folded bag and simulation folded bag in kinematics, bag pressure and volume.
- Again for RRAB, preprocessor folding process is much more efficient than simulation folding process, for which in our example it only takes about 30% processing time and no simulations are required. Timing limitations should determine use of simulation based folding or Pre-processor based folding methods.
- GUI for defining motion and quick visualization of the tool movement is good.
- After the morphing process, shrinking and surface reduction of RRAB is observed; this is not due to the folding but due to positioning.
- Improve 8-line morphing tools for RRAB positioning to reduce bag surface reductions.
- Integrate bag positioning process into Dynfold (after the bag has been folded). It can be accomplished either through BC control move or using 8-line morphing tools.

References

1. LS-DYNA R712 Manual.
2. DYNFOLD Tutorial: Application DYNFOLD