

A Dedicated Forming Package

LS-FORM for Stamping Simulation with LS-DYNA®

Xinhai Zhu, Yuzhong Xiao, Jin Wu, Junyue Zhang, Yiquan Tang, Yi Xiao and Wei Ding
Livermore Software Technology, an ANSYS Company

Abstract

One dedicated package providing the complete solution is always desired by LS-DYNA forming users. Being developed as a process-based package, LS-FORM achieves a seamless integration of pre-processing, LS-DYNA simulation and post-processing. An innovated tooling setup interface in pre-processing makes it easy to define complicated tool motions. The one-button submission provides the shortcut to the LS-DYNA solver to simulate a multi-stage stamping process. The post-processing module can perform a real-time analysis of the forming process by automatically chaining the multi-stage simulation results into a unified database. The user-friendly GUI, up-to-date graphic rendering and impressive stability will also make LS-FORM attractive to users.

Introduction

LS-DYNA stamping applications contribute to the whole product development cycle from initial product design to final stamped part, as illustrated in Figure 1. Many original and unique ideas are implemented for ensuring reliable stamping simulations, which make LS-DYNA an excellent choice for this manufacturing process. The usage of LS-DYNA stamping simulation has been steadily increasing with a reputation for prediction accuracy. More and more forming users are expecting a user-friendly one-stop GUI package to provide a complete LS-DYNA solution.

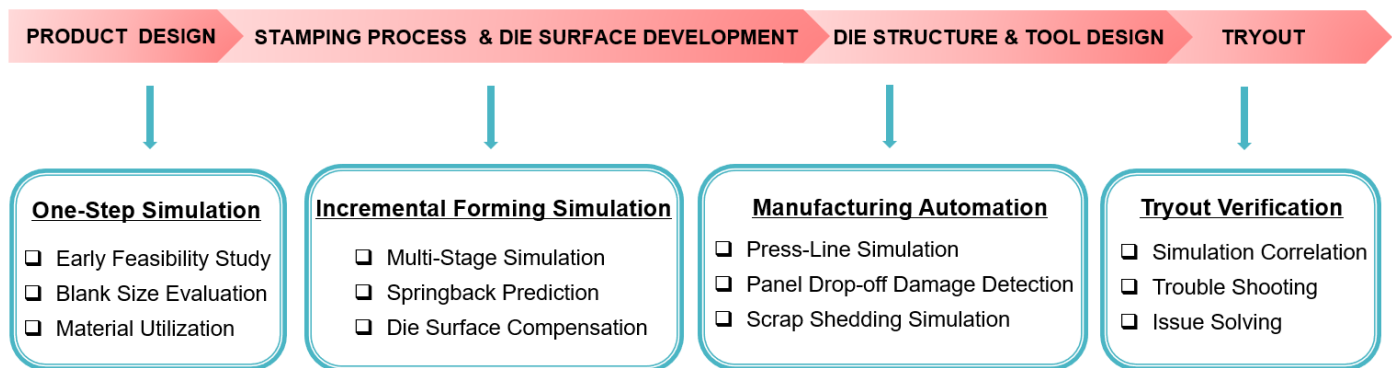


Figure 1. LS-DYNA stamping applications in a product development cycle

A dedicated forming package, LS-FORM, is thus being developed to achieve the following features:

- A process-based package as a workflow to minimize the prerequisites of FEA background
- A flexible interface for different technical levels of user's forming expertise
- A one-stop complete forming solution with minimum manual operations

LS-FORM Beta Version

According to the development plan, LS-FORM package will consist of four major modules:

- PRODUCT FORMABILITY
- PROCESS PLANNING
- DIE SURFACE ENGINEERING
- MULTI-STAGE SIMULATION

Up to date, the key module ‘Multi-Stage Simulation’ has been implemented into LS-FORM beta version which provides a process-based platform integrated with LS-DYNA. LS-FORM beta version achieves a seamless integration of pre-processing, LS-DYNA simulation and post-processing, as illustrated in Figure 2.

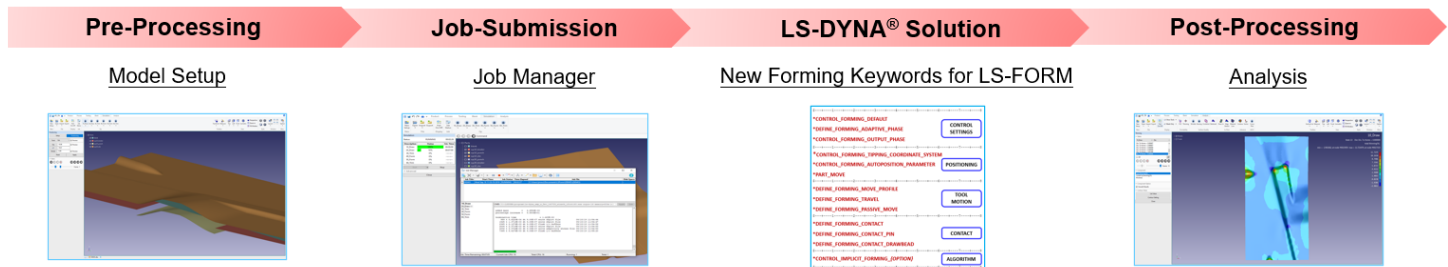


Figure 2. ‘Multi-Stage Simulation’ workflow in LS-FORM beta version

1. Pre-Processing

LS-FORM pre-processing are highlighted as follows for its innovation:

- **Innovated tooling setup**
 - ✓ Flexible to define complicated tool motion
 - ✓ Easy to distinguish and manage the tools
 - ✓ No limitation of total tool number
- **Preset/user-defined process templates**
 - ✓ Shortcut for forming users
 - ✓ Consistency of simulation settings

1.1 OP Definition

A user-friendly interaction is provided to define a production line with multi-stage stamping operations. It is easy to create or edit any OP definition by adding, deleting or switching. See Figure 3.

1.2 Preset/user-defined process templates

A preset or user-defined process template can be imported directly as current setting. It is also allowed for further modification and exported as another new user-defined process template. See Figure 4.

1.3 Innovated Tubular Tooling Setup

As shown in Figure 5, the tooling setup panel integrates all the process information using a tubular format. The first column is the tool list, and the first row defines the tool motion phases. The rest of table cells specify the tool travel patterns in each motion phase. Various tool travel patterns and motion velocity profiles are available to define a complicated tool motion. Flexibility of tooling setup has been achieved in such a special way.

1.4 Convenience with Utilization of Stamping Coordinate System

Forming simulation takes the global coordinate system as default for a stamping coordinate system. However, in most cases, the product tipping angle may be varied between adjacent stamping operations. If a local coordinate system is applied, not only can the model views be switched correspondingly (see Figure 5), but also the model tipping change will be automatically conducted in simulation with no need for users' interaction. Much convenience has been offered by this feature, especially for a multi-stage simulation with various tipping angles.

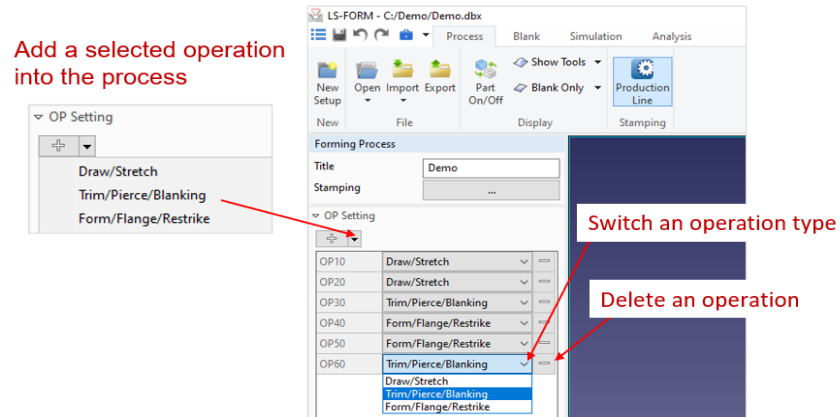


Figure 3. Definition of a production line with multi-stage stamping operations

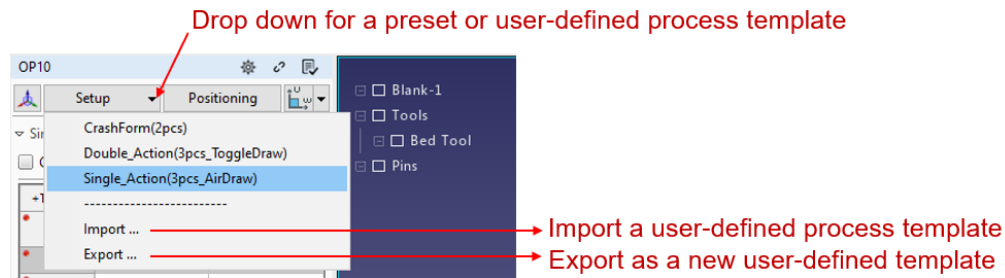


Figure 4. Preset/user-defined process templates

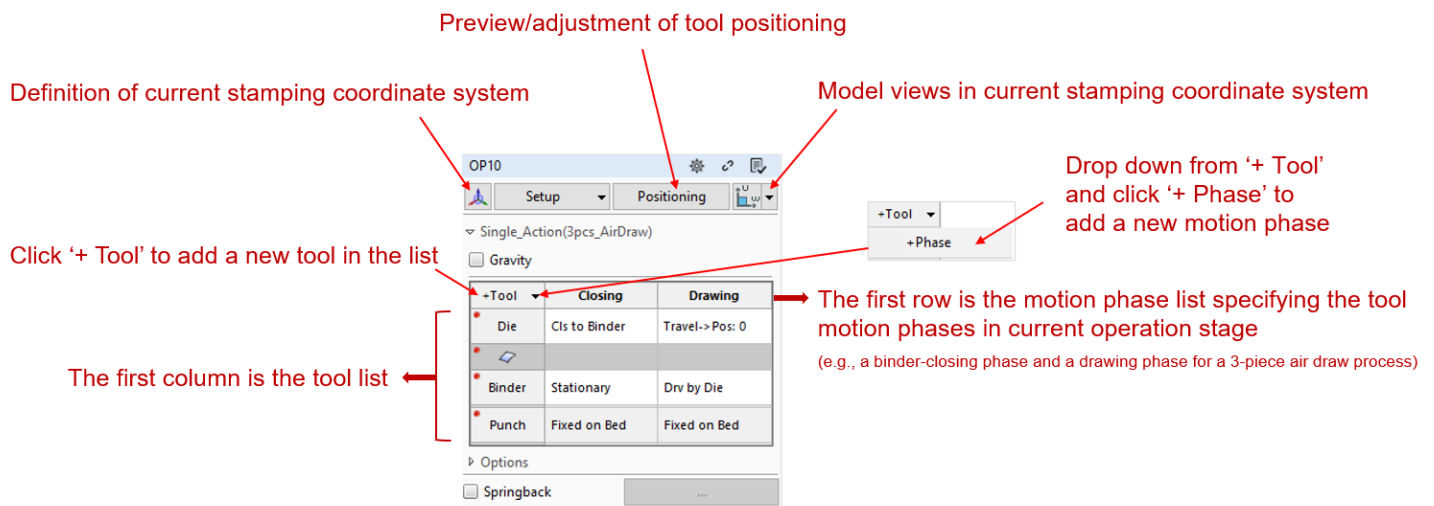


Figure 5. Innovated tubular tooling setup

2. Job-Submission

A customized job manager [1] is embedded with pre-processing seamlessly, with all multi-stage setup information chained together. As shown in Figure 6, one-click on 'Start' button submits all sequential simulation jobs. The stop/restart/queue of the job can be easily conducted with real-time monitoring of job status.

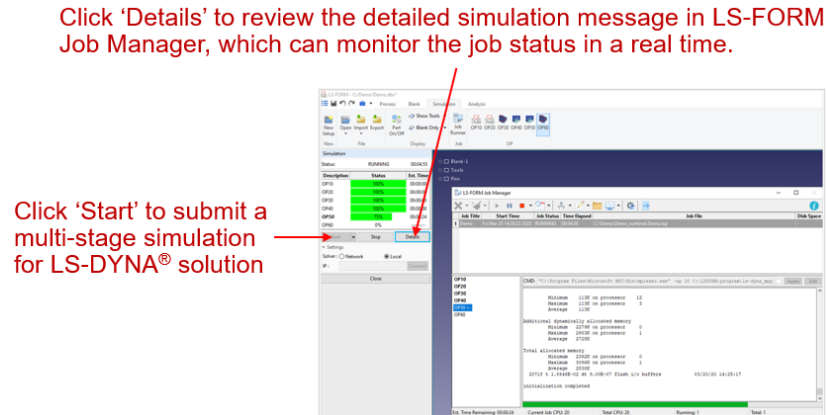


Figure 6. LS-FORM Job Manager

3. LS-DYNA Solution

New metal forming keywords have been implemented in LS-DYNA and optimized to be easy for users:

- Unification of all control setting cards
- Simplified definition of tooling motion
- No need for time-related motion curves
- Straightforward contact definition
- Fast implicit solution for gravity loading

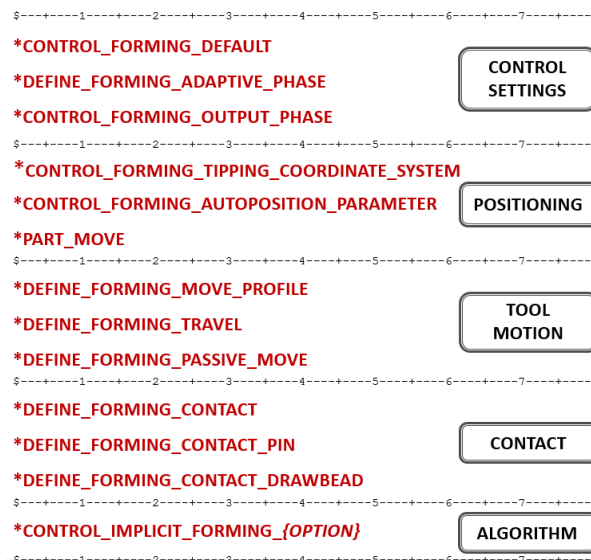
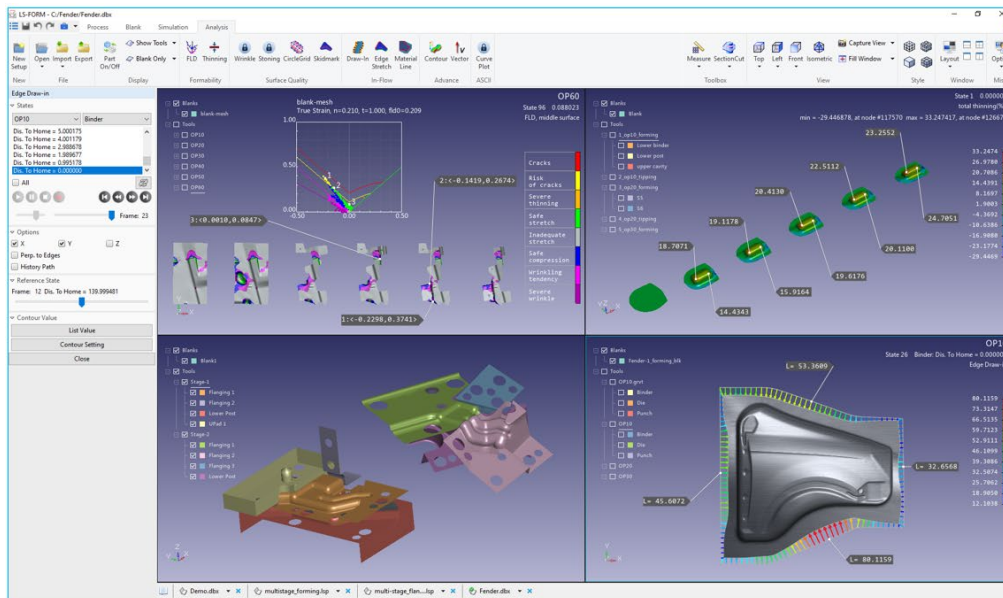


Figure 7. LS-DYNA® keywords commonly used in LS-FORM

LS-FORM utilizes new forming keywords (see Figure 7) to represent actual forming processes and achieves a simplified data interface with the LS-DYNA solver.

4. Post-Processing

LS-FORM post-processing performs a real-time analysis of the forming process by automatically chaining the multi-stage simulation results into a unified database. The user-friendly GUI, up-to-date graphic rendering and impressive stability are attractive to users as shown in Figure 8. Major functions are demonstrated by Figures 9-18.



- ☐ User-friendly GUI design
- ☐ Simplified access to functions
- ☐ Integrated post-processing of multi-stage jobs
- ☐ Easy multiple-window management
- ☐ Up-to-date graphic rendering
- ☐ High software stability

Figure 8. LS-FORM post-processing GUI and highlights

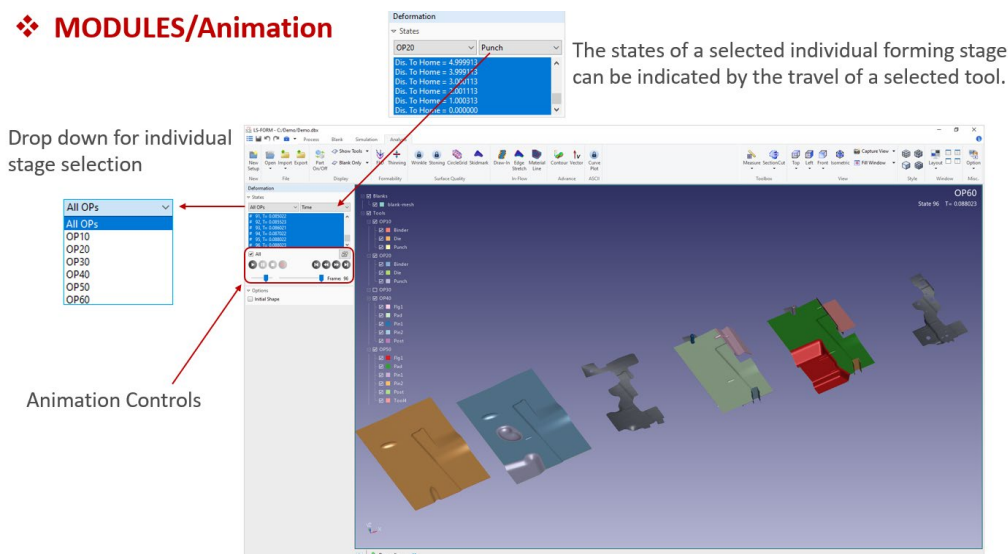


Figure 9. Animation

❖ MODULES/Model Display

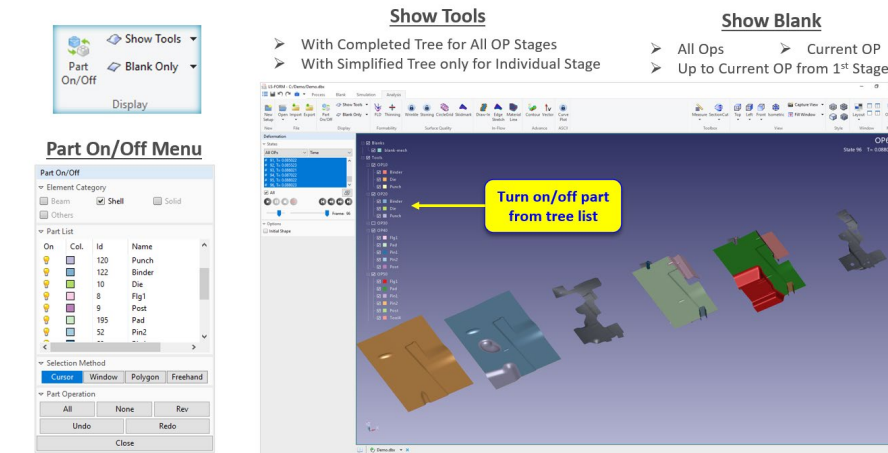


Figure 10. Model Display

❖ MODULES/Formability

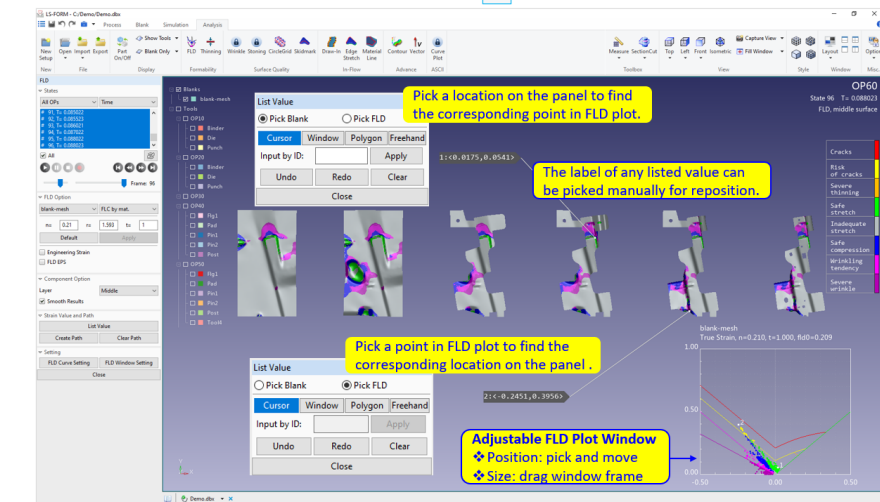


Figure 11. FLD Analysis

❖ MODULES/Formability

❑ Thinning



Three contour options

- total thinning (%)
- current thinning (%)
- thickness

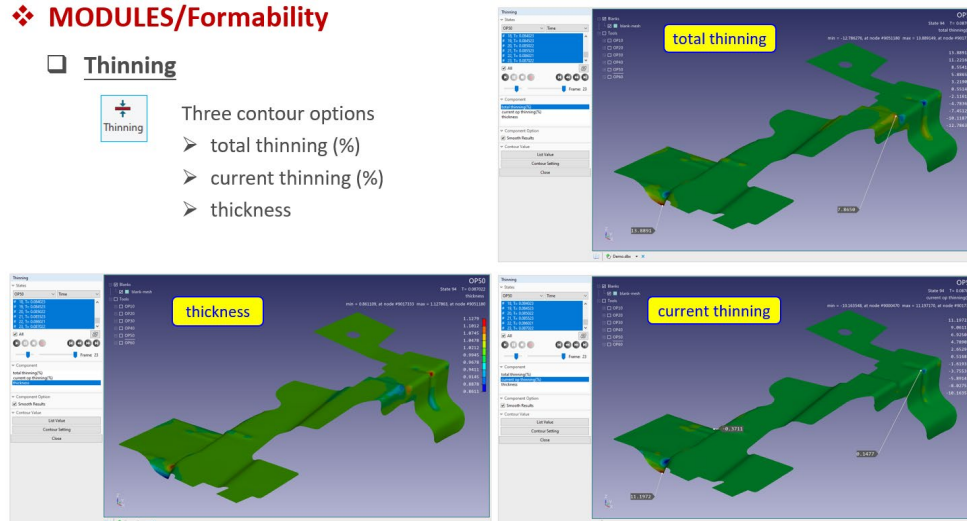


Figure 12. Thinning

❖ MODULES/Surface Quality

☐ CircleGrid


Circle Grid Mode

Options	
Diameter	20.0
Default	Apply
<input checked="" type="checkbox"/> Show Blank <input checked="" type="checkbox"/> Show Circle <input checked="" type="checkbox"/> True Strain <input type="checkbox"/> Plot Contour	

Strain Vector Mode

Options	
Diameter	20.0
Default	Apply
<input checked="" type="checkbox"/> Show Blank <input type="checkbox"/> Show Circle <input checked="" type="checkbox"/> True Strain <input checked="" type="checkbox"/> Plot Contour	

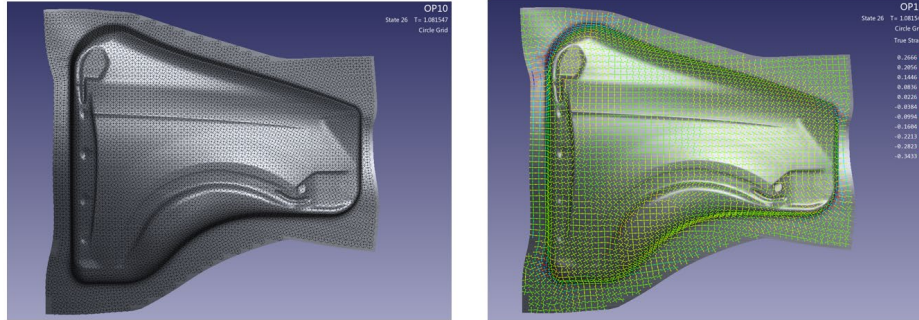


Figure 13. Circle Grid

❖ MODULES/Surface Quality

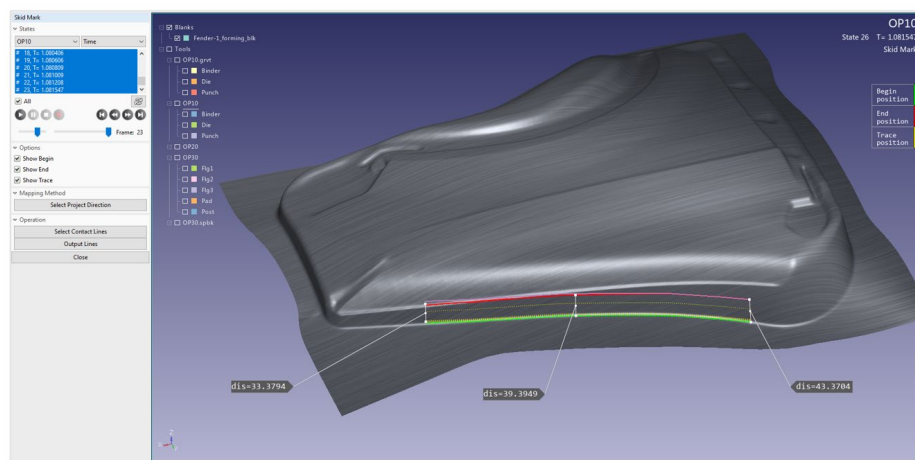
☐ Skidmark


Figure 14. Skidmark

❖ MODULES/In-Flow

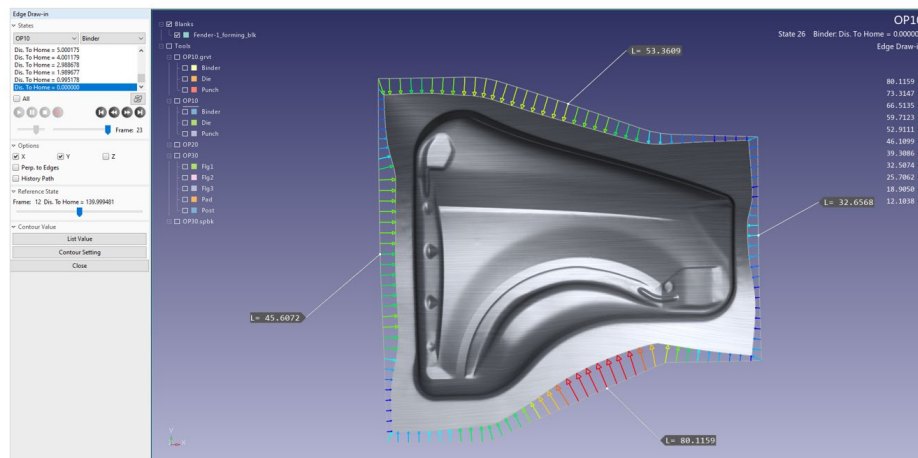
☐ Draw-In


Figure 15. Draw-In

MODULES/In-Flow

Edge Stretch

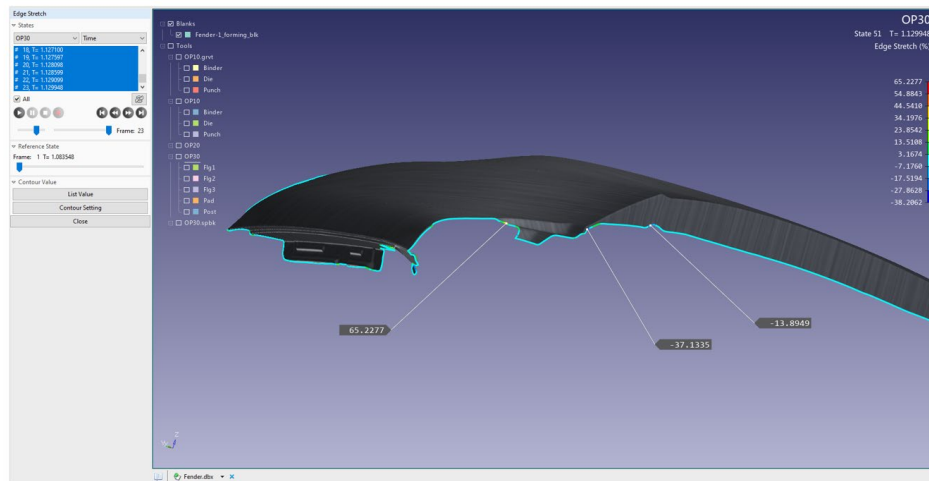


Figure 16. Edge Stretch

MODULES/In-Flow

Material Line

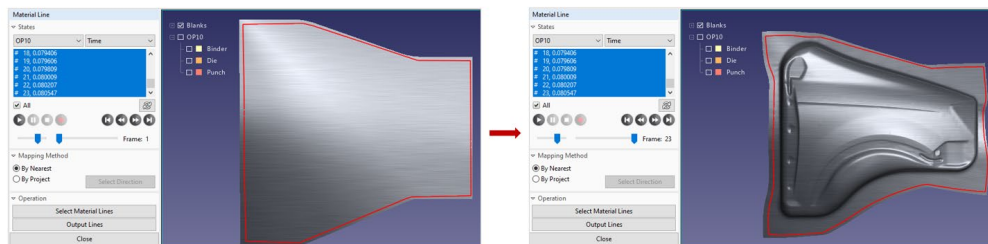
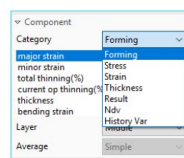


Figure 17. Material Line

MODULES/Advance

Contour

Contour of LS-DYNA®
Component Results



Vector

Contour of LS-DYNA®
Component Vectors

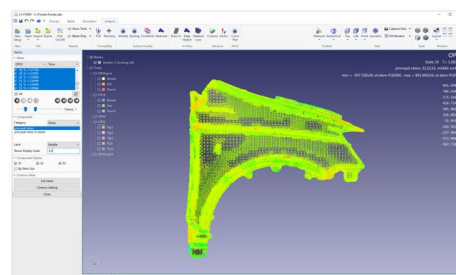
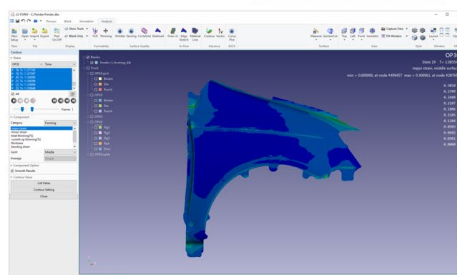
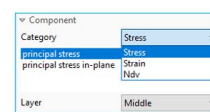


Figure 18. Contour/Vector of LS-DYNA Component Results

Summary

The dedicated forming package, LS-FORM, is a process-based platform integrated with LS-DYNA. The key module ‘Multi-Stage Simulation’ in LS-FORM beta version is presented. Further implementation of more features is in progress. The seamless integration of innovated pre-processing, accurate LS-DYNA simulation and user-friendly post-processing leads to a successful GUI package for LS-FORM. LS-FORM has a great potential to take full advantage of LS-DYNA accuracy and its latest technologies which are desired by other forming processes as well besides stamping. LS-FORM process-based platform demonstrates the latent capacity for many forming applications such as hot forming, tube bending, hydro-forming, hemming assembly, and so on. More and more contributions are being expected in this prosperous forming package.

References

[1] A Customized Job Manager for Metal Forming Simulations with LS-DYNA, Yuzhong Xiao, Xinhai Zhu, Li Zhang and Houfu Fan, LSTC, 15th International LS-DYNA Users Conference.