Introduction of Die System Module in LS-PrePost®

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Abstract

Die system module (DSM) is developed to generate tool geometry in an early stage and to evaluate these result by forming simulation. DSM Graphics User Interface is designed to provide metal forming users a tool to generate die face more effectively. The main focus of module is placed on easy modification and reuse of existing design. This paper illustrates the algorithm and some special feature of DSM.

Motivation

Die system module (DSM) is developed as a simple and userfriedly GUI that allows to generate draw die geometry for an initial feasibility analysis of sheet metal parts in an early stage of the process and to evaluate this geometry by forming simulation with LS-DYNA®.

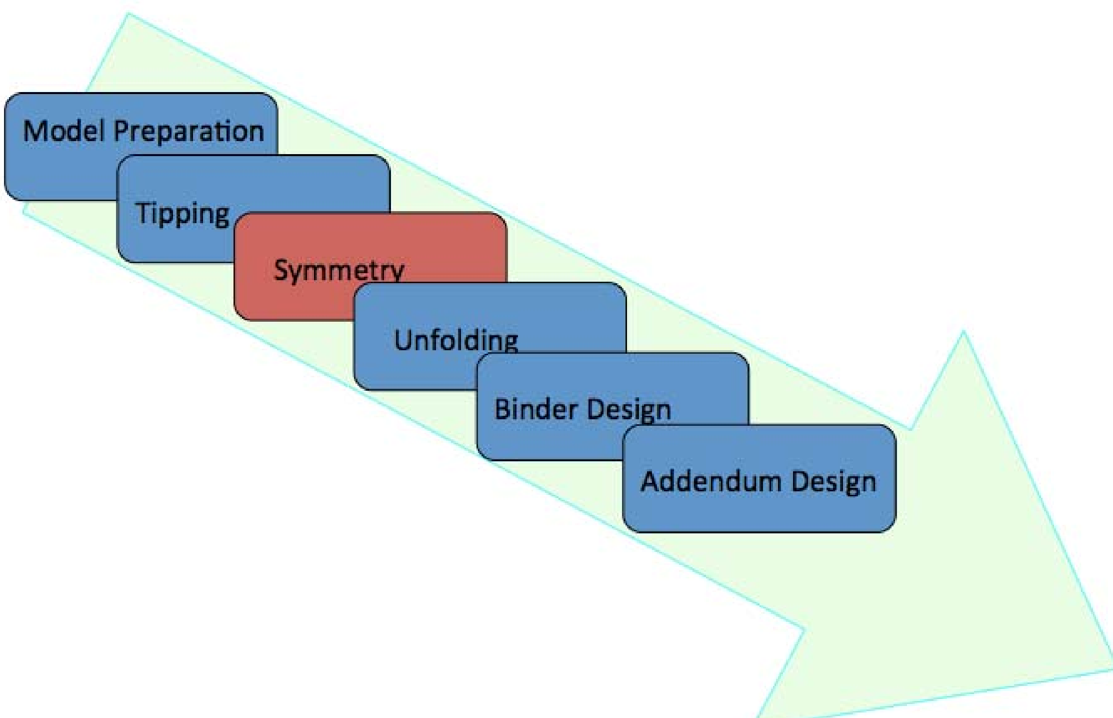

Fig. 1 shows the flowchart of DSM.

The main functions are:

- Model preparation
  - Import geometry (IGES) or mesh of the part
  - Surface meshing

  - Geometry /mesh based fill of holes
- Tipping
  - Define tipping center
  - Manual tipping
  - Auto tipping (average normal, min draw depth, max contact area, min undercut)
  - Contour display of undercuts
  - 2D Section view for model check
- Symmetry (under development)
- Unfolding
  - Definition of flange and layout areas
  - Flange unfolding
  - Boundary repair
- Binder design
  - Flat, conical and free hand drawing binder design
  - Sketch for free hand drawing
  - Binder morphing
- Addendum design
  - Profile definition
  - Build addendum by patch
  - Addendum patch modification in 3D environment
  - P.O. Smooth and editing
  - Auto updating addendum patch when design parameters is changed

This paper shortly describes the main functions of DSM.

Model Preparation

IGES Files are read in and holes are automatically filled. The boundaries of the holes are stored and can be retrieved for later definition of cutting process.
An analysis of cutting angles of the cut lines is under development.

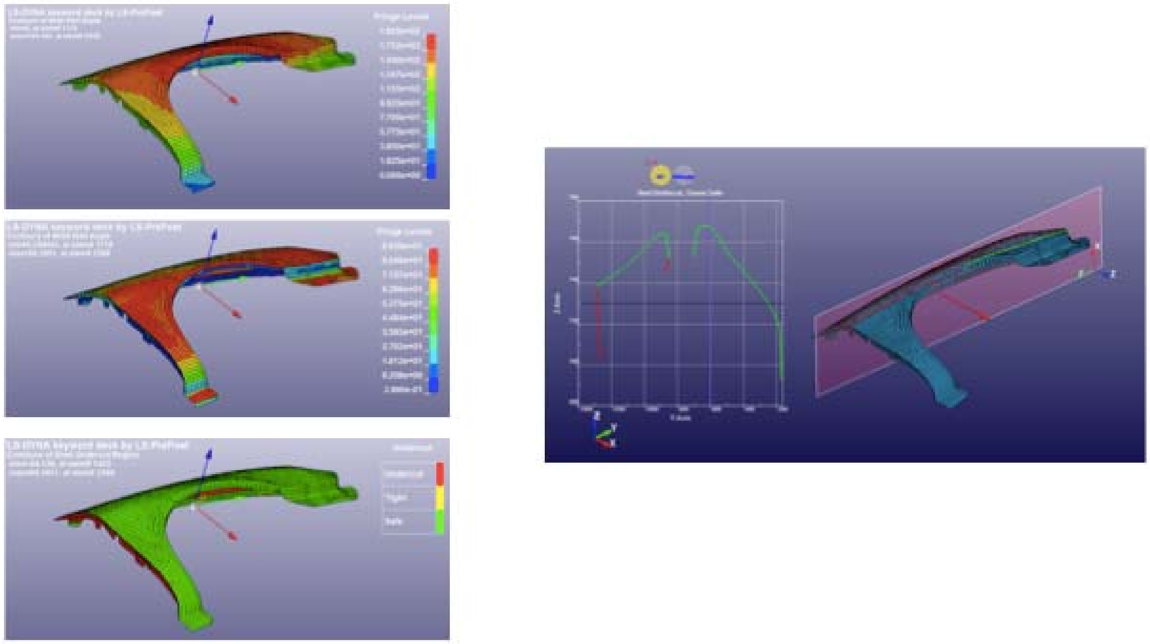

Fig 2: Contour plots (1: draw depth, 2: wall angle, 3: undercuts) and section view for analyzing tipping direction

Tipping

Tipping center can be defined and the best tipping for drawing operation can be specified, either manually or automatically according to one of the following criteria:
1. Average normal – Use the average normal vector of the specified geometry
2. Minimize undercuts – Find the tipping with the minimum undercut
3. Minimize drawdepth – Find the tipping which minimizes the draw depth of the part

For each tipping direction, draw depth and wall angle can be displayed, undercut surfaces are highlighted and a section analysis of the part can be performed (Fig. 2).

Unfolding/Boundary repair

The unfolding/boundary repair page allows to identify flanges and layout areas which are laid out in drawing operation. The definition of the flange/layout area can be done with different methods:

- Start and end of the area can be identified and the flange will be separated.
- A closed loop can be defined and either inner or outer area will be separated.
- Definition of area using underlying surfaces.

For each flange the layout condition can be defined: tangential, horizontal, vertical or lay out on addendum (Fig 3).
Furthermore, this page allows to smooth the boundary so that an addendum can be created. Automatic or manual repair is possible.

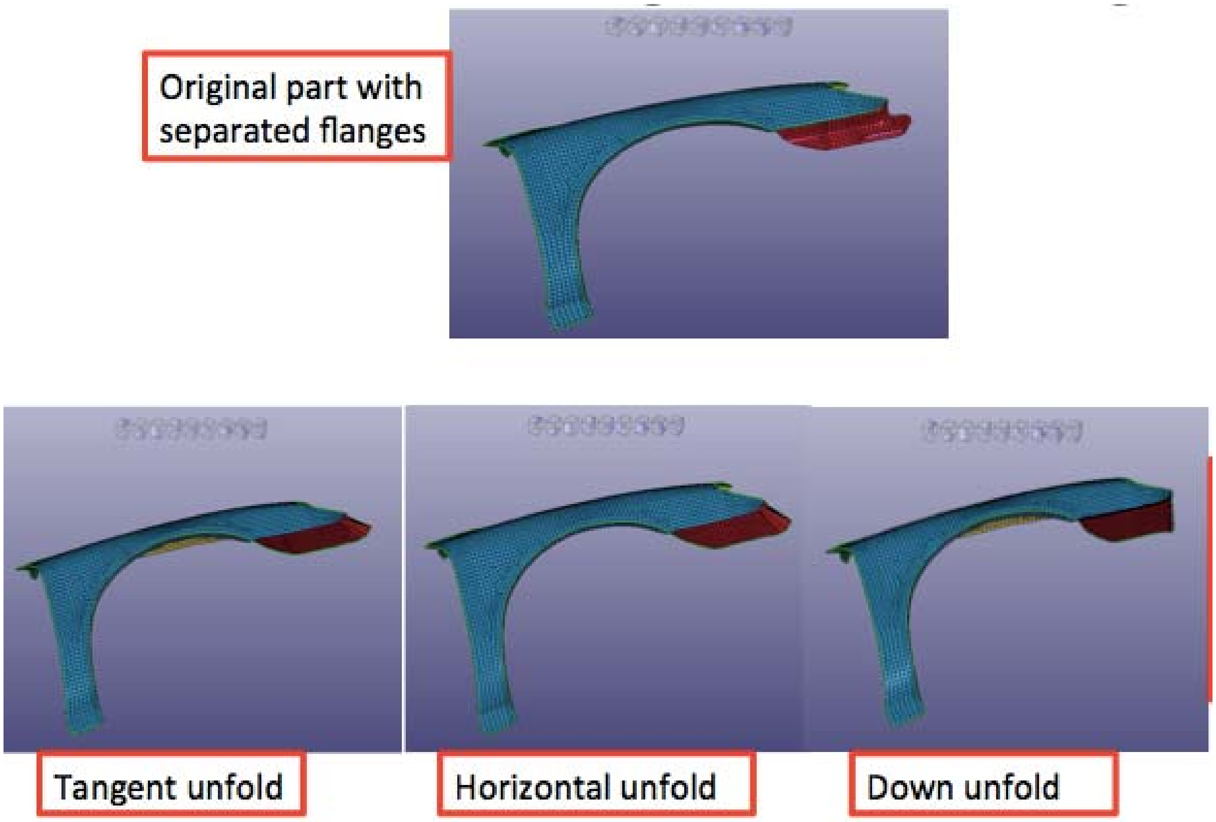

Fig 3: Different unfolding methods (lay out on addendum also possible after addendum is generated)

Binder

One of the most difficult things to do is the correct definition of a binder surface. On one hand the binder should follow the part as much as possible so that the initial punch contact is uniform and on the other hand the binder surface should be simple and developable so that no wrinkles appear when the binder is closed.

The DSM binder page allows to do both. A binder surface is normally generated with two profiles that can be generated from the shape of the part. It can be defined if upper or lower contour of the part is taken into account. After generating the contour line, this line is simplified into only a few straight segments that can be filleted with a radius so that the remaining profile consists of lines and arcs. The generated binder surface can be modified in different ways:

1. modifying one of the 4 profiles of the surface
2. adding additional profiles in u or v direction
3. modifying the control points of the b-spline surface to locally adapt binder surface and draw depth

Fig 4 shows an overview of functionality to create a binder surface.

The resulting draw depth will be displayed on the part and is used to fine tune the binder surface according to the requirements of the part. Binder surface can be shifted in z-direction to globally adjust draw depth.

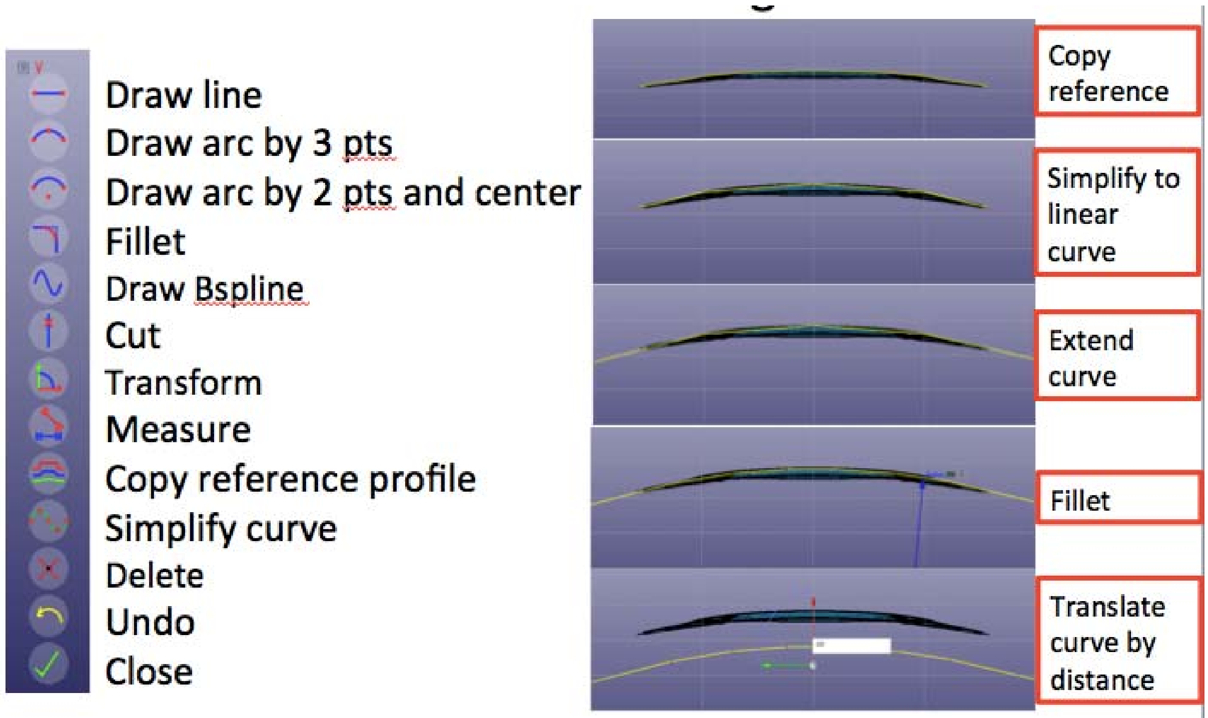

Fig. 4: Functionality to create a binder surface

Addendum

The addendum will be created from different individual patches whereas each patch consists of two profiles. At first these profiles are created perpendicular to part boundary. If it is not possible to create one profile perpendicular to the boundary, e.g. at convex edges of the part, the system automatically creates two profiles at this point, one profile perpendicular to one side and the other profile perpendicular to the other side (Fig. 5). This procedure allows to create a reasonable addendum with profiles even for sharp edges of the part.

Another key feature of the profile is the die radius. Each profile is specified with a die radius but the addendum is initially generated without die radius. Die radius is created as a fillet between binder and addendum as a last step of the addendum definition. This procedure guarantees that the die radius corresponds to the specification at each point of the addendum.

There are 5 different types of profiles, from a simple connection between part and binder up to a very elaborated profile with bar and counter bar. A sixth profile which is user defined is under development.

After generating the profiles, patches are created between two profiles (Fig. 6). Normally these profiles are the same type of profile so that the generated patches have a good surface quality. Profiles of different types will be connected by a function called bridge patches where the connection of the profiles can be user defined by splines.

After the definition of patches, the PO line can be modified, either with a global modification or with a local modification. The profiles and patches are updated after each modification of the PO line.

If the flanges are laid out on the addendum, the theoretical development of the flanges on the addendum can be shown as a line which gives an indication for the size and the shape of the addendum to allow the trimming of the boundary (fig. 7).
The current version just displays the developed flange on the addendum but the analysis of cut and shear angle of each point of the line is under development.

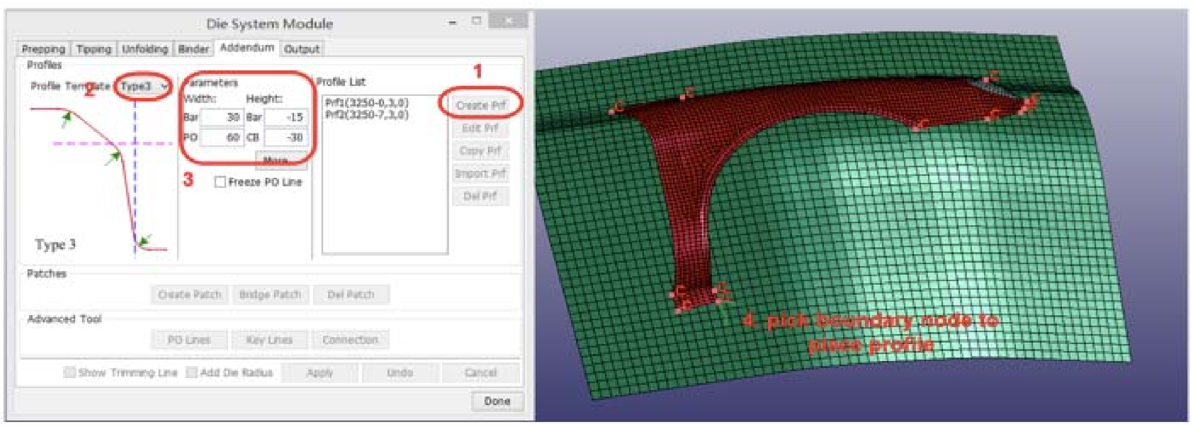

Fig 5: Addendum page with profile type 3 and part with “convex” edges

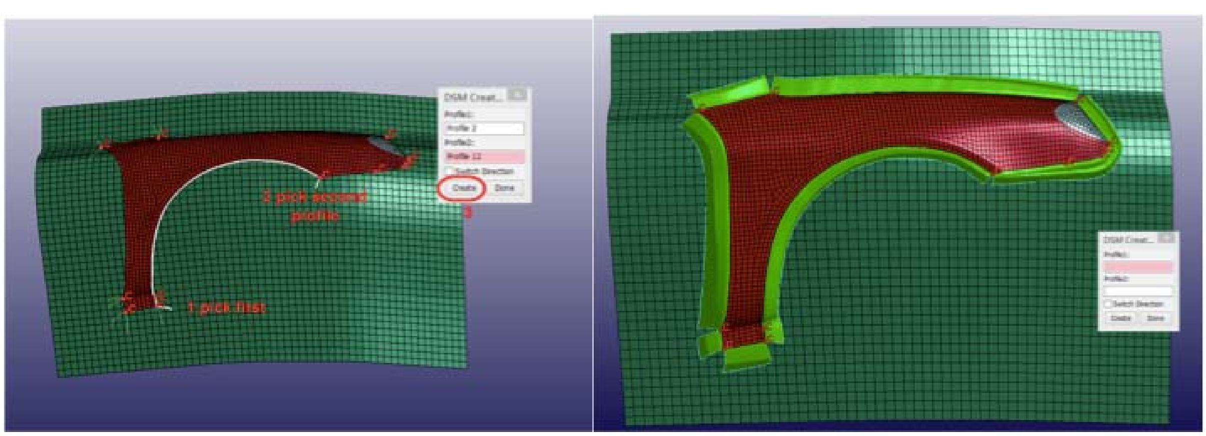

Fig. 6: Initial patches created with two profiles. Gap between patches will be closed by “Bridge gap” functionality (see fig. 7)

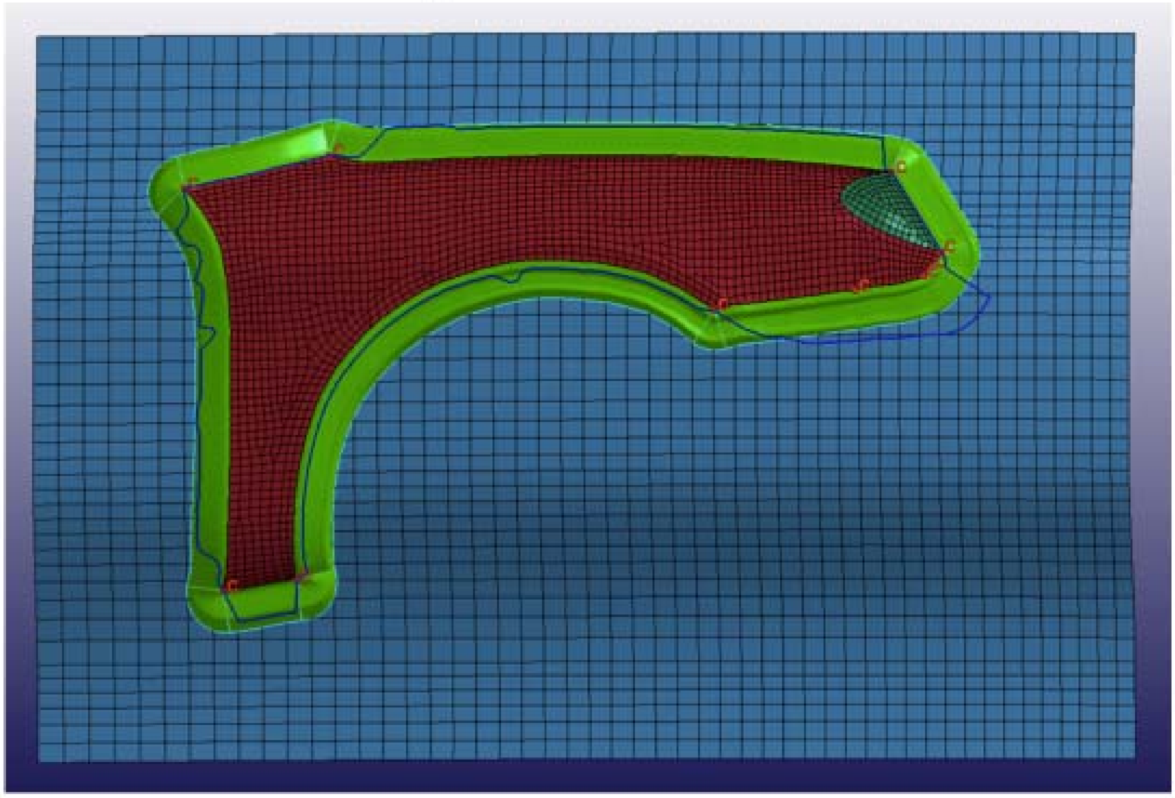

Fig. 7: Addendum with developed flanges shown as blue line

Summary:
DSM is an efficient tool to create a first draw geometry for sheet metal parts and to start an initial feasibility analysis with LS-DYNA. The main functionality is implemented and the version is available for testing in summer 2014.