Newly Developed Capabilities of DYNAFORM Version 5.0

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ABSTRACT

Over the past two decades, the finite element analysis (FEA) has emerged as one of the most important engineering tools in the many industries, due to its flexibility and accuracy in prediction. Nowadays, it is widely used in sheet metal forming industry to predict the forming feasibility of wide variety of complex components, ranging from aerospace and automotive components to household products.

As the demand of FEA accelerates, the need for a robust and streamlined process based pre-processor has become crucial, especially in the tool and die manufacturing industry. As a continuous effort, the DYNAFORM Version 5.0 has been developed to meet the needs. This paper will discuss the capabilities of two newly developed key features embedded in the DYNAFORM Version 5.0. These "state of the art" features are Quick Setup (QS) and Die Face Engineering (DFE) module. The QS module aims to reduce the setup time for stamping simulation, while the DFE module allows stamping engineers to create, re-design and re-engineer the tooling from part geometry.

INTRODUCTION

DYNAFORM was originally developed from a traditional finite element pre-/post-processor approximately eight years ago. With numerous automated features and incorporating the power of explicit non-linear FEA code LS-DYNA [1,2], the innovative DYNAFORM has proven to be an efficient FEA tool for stamping simulation. It has been widely used by sheet metal forming industry for solving complex forming problems such as wrinkling, skidmark, tearing, excessive thinning and springback.

For the past few years, DYNAFORM has continuously gained its popularity in the tool and die industry. As the same time, there is increasing demand from the tool and die industry DYNAFORM users. One of the major demands is a robust and process based simulation technology. It has become the development direction of the DYNAFORM Version 5.0. In order to meet such demand, a Quick Setup (QS) scheme is organized using process guidance approach. It offers user a simulation environment based on the stamping processes.

In formability analysis, a set of tooling design usually consists of a suite of part, binder and addendum design surfaces, is required. This suite of design data usually are not available during the early stage of the product design phase which hidden the full realization of the formability study's value that DYNAFORM can contribute to this stamping process. Hence, the Die Face Engineering (DFE) module is developed, as part of DYNAFORM Version 5.0, to enable the user to derive a suite of binder and addendum surfaces as a baseline tooling design for subsequent formability study. With the powerful and versatile toolbox, the DFE serves as a bridge to enable early assessment of the part and tooling design.

Personal computer (PC) version of the DYNAFORM was first developed to suit the tool and die industry users who is predominately using Microsoft Operating System (OS) based PC.   With additional modules and capabilities to be added to the revolutionize DYNAFORM, the development team has decided to unify the graphic user interface (GUI) and database for both PC and Unix/Linux platforms in order to avoid double development effort. As result of this unification, DYNAFORM/PC is retired with a replacement of Unix based DYNAFORM and its capability quantum leap from release version 2 level to release 5 level.

QUICK SETUP INTERFACE

The QS interface is designed and embedded in DYNAFORM Version 5.0 as a streamlined user-friendly and fully automated menu. The menu contains three major stages used for stamping simulation: I. *Gravity Loading*, II. *Draw Die* and III. *Springback*. It is organized using process guidance approach to offer user a simulation environment based on the stamping processes. The QS minimizes the time spent in repairing meshes for tooling by offsetting the die/punch tooling numerically, rather than physically. In addition, each QS stage is designed using color coded GUI with simplified input and automated model setup.

Prior to the application of QS menu, the blank and tooling surfaces needed to be meshed either by using the advanced topology automeshing features embedded in DYNAFORM Version 5.0 or manually.   The meshed parts will be input in to the following Quick Setup stages:

I. Gravity Loading

As show in Figure 1, the *Gravity Loading* is completed with process guidance approach aiming to help stamping FEA users to prepare simulation model. It allows the user to easily set the type of drawing process, die gap, material properties, blank thickness, blank initial velocity, boundary condition, guide, and type of solving options. In addition, the *Help* icon provides useful information for gravity loading simulation.

There are four different type of drawing processes available in *Gravity Loading*: crash form, inverted draw, toggle draw and four-piece tooling drawing process. The objects (blank, binder, and lower tool) are to be specified once the draw type is selected. For example, if the inverted draw is selected, the blank, binder and lower tool have to be specified. All specified object will turn green, indicating the process is done. Red indicates a process to be taken.

The material properties and blank thickness can be defined after the selection of object. The definition of necessary boundary conditions can be set from the GUI. In order to ease the selection of material properties, DYNAFORM Version 5.0 provides a default material library which consists of commonly used material categories and types. The user can either select and/or modify the materials provided in the default material library. In addition, the specific material properties can also be imported into the software.
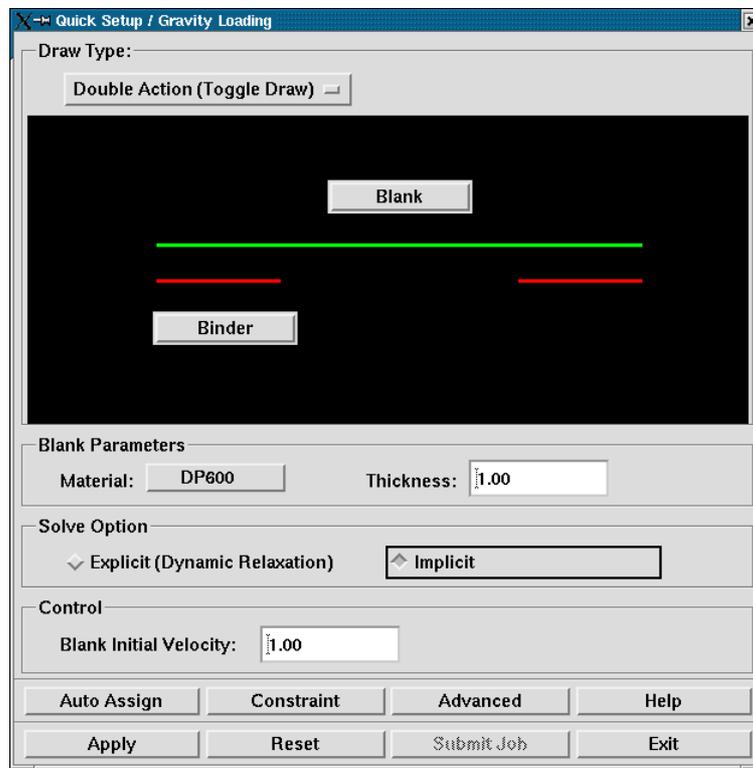
Figure 1: The GUI of Gravity Loading.

II. Draw Die

As part of the QS menu, *Draw Die* provides the user a user-friendly environment for preparation of stamping simulation, such as crash form, inverted draw, toggle draw and 4-piece stretch draw. One of the major advantages of *Draw Die* interface is that the tooling is numerically offset from the original tool, hence saving time in repairing poor meshes. In addition, the automated features enable the user to quickly setup the input deck for running stamping simulation. The color coded GUI is shown in Figure 2.

The *Draw Die* interface is also equipped with four major stamping operations as discussed in *Gravity Loading*. The analytical tooling offset is determined by the selection of upper or lower tooling. The LS-DYNA contact drawbead interface can be quickly created and/or modified from the *Draw Die* GUI. Boundary conditions such as tooling travel speed, binder force and constraints can be easily setup from the interface. Die gap and tooling clearance can also be modified. The *Help* icon provides guidelines and general information for preparing stamping simulation.
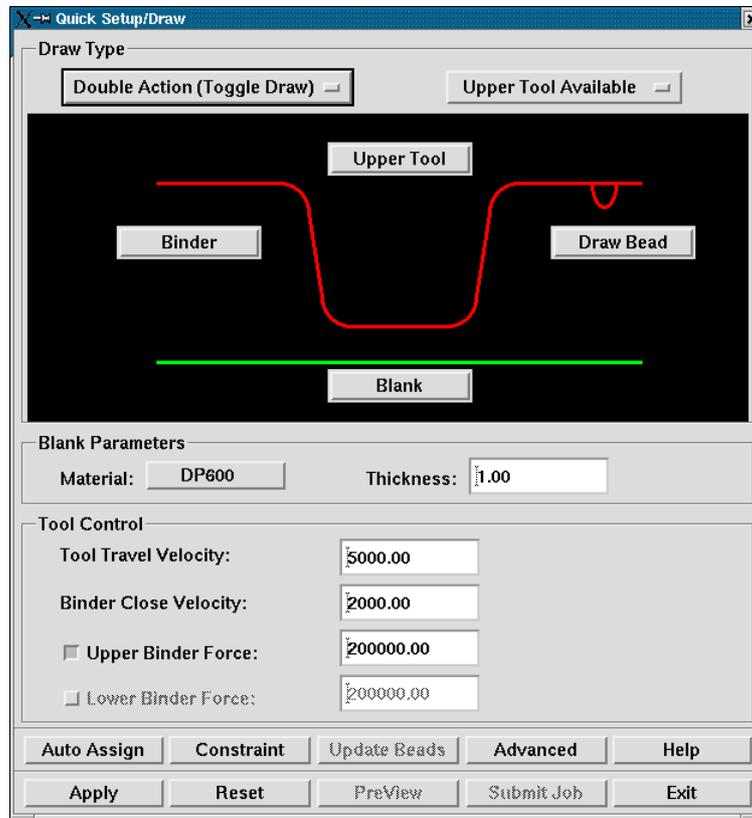
Figure 2: The GUI of Draw Die.

III. Springback

The *Springback* interface is designed to help the user to quickly setup the input deck for springback simulation in LS-DYNA. As shown in Figure 3, the Springback GUI contains a trim function which allows the user to easily trim the drawn parts.

A mesh coarsen function is embedded in the interface to facilitate springback convergence. The springback simulation can be carried out in LS-DYNA using single step or multi-step implicit method. The control parameters can be modified for better springback convergence. However, the default parameters are usually sufficient. There is also a *Help* icon that provides useful guidelines for springback simulation.
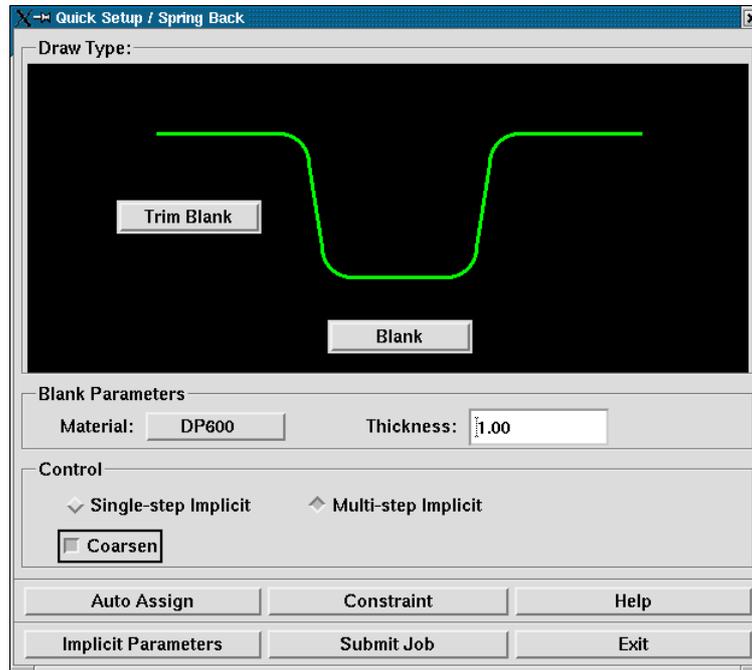
Figure 3: The GUI of *Springback*.

DIE FACE ENGINEERING MODULE

The DFE is a toolbox for incremental stamping FEA users to engineer the draw die, including binder and addendum from the part geometry. The DFE module created to enable the user to quickly derive a suite of binder and addendum surfaces as a baseline tooling design for further formability feasibility study. As a result, it reduces iteration time for tooling design and development cycle. At the end, the module helps to reduce the associated cost.

The architecture of DFE in DYNAFORM Version 5.0 provides one-code-one environment pre-processor for stamping simulation. It allows the user to easily design and re-engineer the die tooling using the numerous automated functions available in the software. The DFE contains both semi- and fully-automated features such as element fillet, reverse trimming, outer smooth, binder generator, addendum generator, morphing, tipping, surface mapping, draw bar, sausage and so on. In this paper, some of these features are discussed in details.

Element Fillet
The element fillet function allows the user to quickly fillet the sharp corners on the part geometry to a user defined radius for forming feasibility study.

Outer Smooth
Outer smooth is a function that enables smooth transitions from one facet to another facet on a die face prior to addendum and binder design. Several outer smooth features that are currently available in DFE include outer expand, outer morphing, concave radius and roller.

Reverse Trimming

Several reverse trimming functions are available in DFE to aim the filling of incomplete part geometry prior to die design and forming analysis. These functions include inner and outer fill. The reverse trimming provides both mesh and surface of filled areas. An illustration showing the reverse trimming functions is shown in Figure 4.
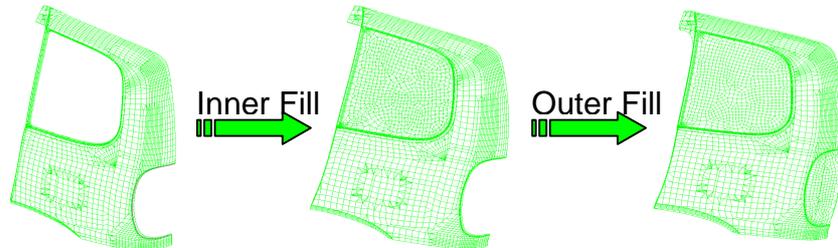
Figure 4: An illustration showing the application of reverse trimming.

Binder Generator

As shown in Figure 5a, there are three types of binder design currently available in the DFE for construction of curved and flat binder design. The binders are generated based on the part geometry. In addition, the generated binders can be edited and morphed based on user input to meet design criteria. An example of binder design process is shown in Figure 6.

(a)   (b)
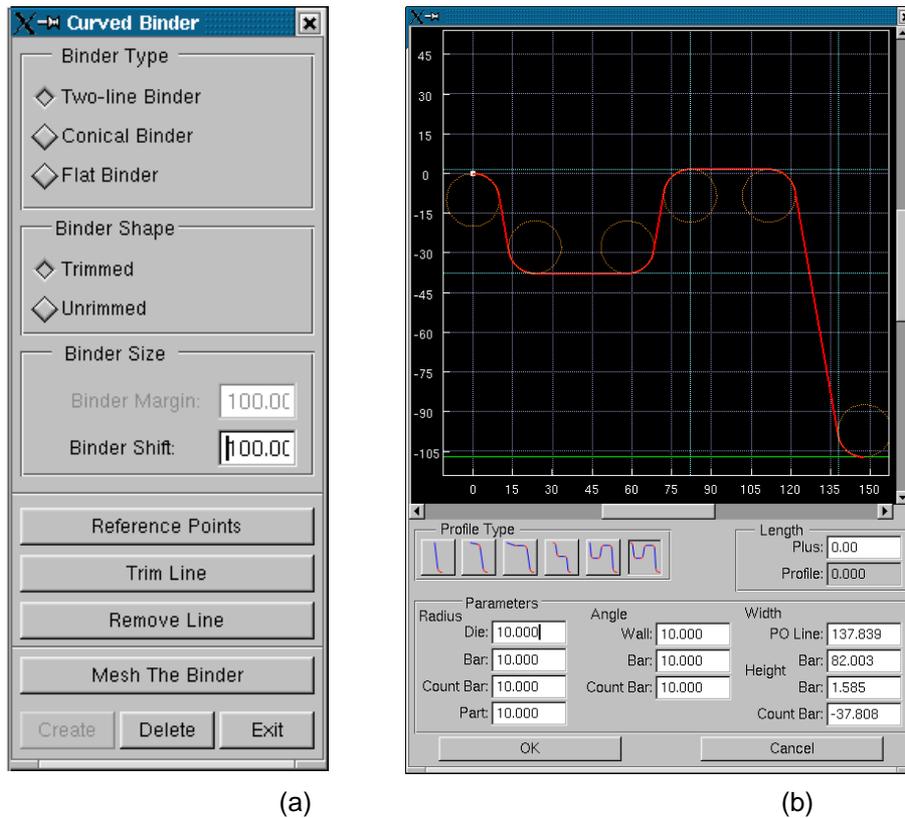
Figure 5: The GUI for (a) Binder Generator (b) Addendum Generator.
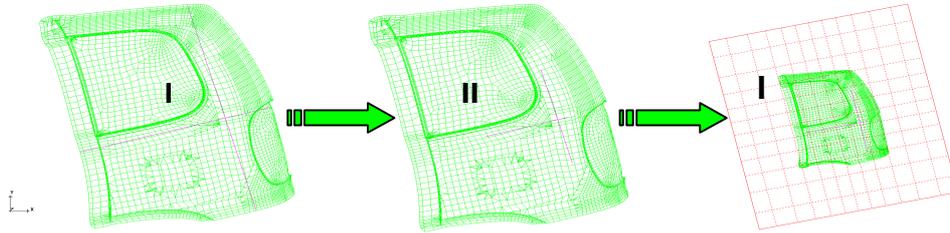
Figure 6: An illustration showing the process of binder generation: I. Define Reference Points for Cross Hairs; II. Trim off Cross Hairs to adjust Binder Curvature; III. Binder is generated.

Addendum Generator
This sophisticated function can automatically generates a series of profiles based on the size, depth, and material of the part. On the other hand, manual profile generator (as shown in Figure 5b) completed with wide variety of profile design is also available for different addendum design. The profiles are then surfaced and meshed to create a complete addendum for forming. Profiles can be edited using an interactive graphic profile editing interface or by punch opening (PO) line morphing.

Morphing
Line, surface and mesh morphing are all offered in the DFE module for stamping engineers to easily manipulate PO lines, reverse trimming functions, addendum and binder design.

Tipping
The tipping function places the part into die position from the design position. In DFE, tipping process can be carried out manually and/or automatically. After tipping process, the undercut can be identified by plotting the tipping contour. In addition, the draw depth is estimated, per the reference of the "Point of the First contact".

CONCLUSION

The newly developed DYNAFORM Version 5.0 is equipped with two "state of the art" modules: QS and DFE. The QS module aims in enabling quick and easy way to setup stamping simulation such as gravity loading, drawing and springback analysis. The DFE module provides numerous automated features for draw die design and development. In addition to the robust and streamlined modules, the GUI of the revolutionize DYNAFORM is also unified for both PC and Unix/Linux platforms.

The architecture of these modules is briefly discussed in this paper. With its streamlined and user-friendly QS and DFE modules, DYNAFORM Version 5.0 has helped shortening the simulation tryouts and draw die design cycle, therefore reducing its associated cost.

REFERENCE

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