Application of FEA in Stamping Auto Underbody Parts

Yuyuan Wang, Marcel Pillon, Ron Ouellette, Chris Pitre, and John Laporte
Canadian Engineering & Tool

Abstract

The complex auto underbody components need a long process of die design and tryout, some times need several to hundred times of costly trial-and-error to get required stamping parts. It is very critical to the die design how to decide and evaluate the die shapes of each forming stage and how to distribute the deformations between preform(s) and form for multi-stage forming. Combination of simulations for each forming stage using Dynaform and shape design using Catia can reduce the time and cost of die tryout, and make the die design optimization possible. The stampability of the part can be evaluated. The optimized die shapes and deformation distribution can be obtained. The main forming failures, such as wrinkles/double metals and cracks can be solved at die design stage. This paper attempts to show some applications of simulation techniques combined with shape design in the die design.

Introduction

The forming of auto underbody components such as rails and cross-members are usually very difficult because of complex part shape combined with HSLA sheet metal, and limited forming dies/operations. The main forming failures are wrinkles/double metals, cracks or necking, and springback. Simulation technology can provides reliable and good agreement numerical results with actual production die tryout for the failures of wrinkles/double metals and cracks. The following are some applications of simulation using Dynaform and shape design using Catia to the rail and cross-member parts.

Evaluating Forming Stages and Processes

By simulating the main forming stages of proposed stamping process can evaluate the stampability of the parts and reassess stamping process, and can avoid failure of process and die. Fig.1 is rail part. It is composed of tailored weld blanks of two different thicknesses. At die design stage, using Dynaform simulated and evaluated the main forming stages of initial proposed process. After many times of changing shape and simulating still could not get satisfied results, developed different forming processes, and got success in the actual die tryouts.

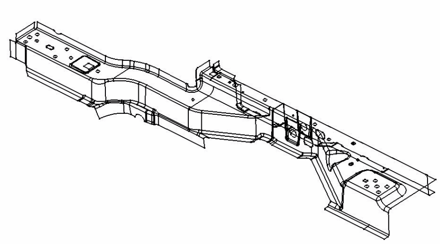
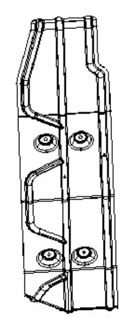


Fig.1



2a

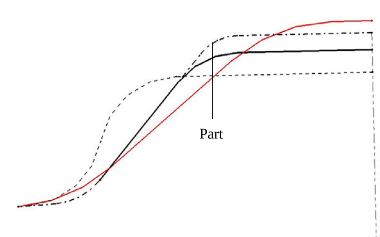
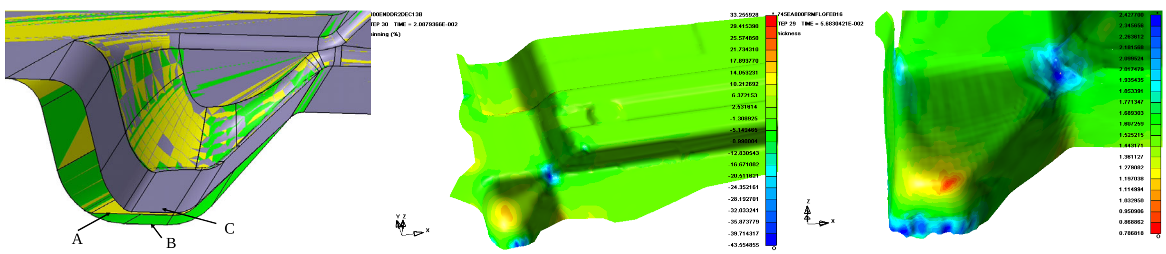


Fig. 2 2b

Optimizing Preform Shapes

How to decide and evaluate the die shapes of each forming stages? How to control and distribute the deformations between preform(s) and form for multi-stage forming? It is very critical to the die design. Combination simulation with shape design provides a solution, and makes die design optimization possible. By comparing and analyzing simulation results from different designed die shapes can obtain the locations and vary tendencies of the failures. According to the results, design new shapes and redo simulations, until obtain satisfied results. This is similar to the real die tryout. This kind of soft tryout can solve main forming failures—wrinkles/double and cracks, obtain defect-free preform shapes, and control deformations between preform(s) and form.

Skid plate (Fig.2a) has four cone bubbles near beads. It is required the thinning of the bubbles less than 20%. Fig. 2b shows the part section and some different preform sections. Even if the section lengths are same as parts, many shapes still cause cracks in form. From simulation results, we could judge which type of shape is better and can finally obtain the ideal preform shape.



3a 3b 3c

Fig. 3

Fig. 3a is three different preform shapes in which with same inner shapes but different outer shapes for the end EC of cross-member (Fig.4a). The shape and the results are shown in Table 1 below. Fig. 3b is the thinning distributions of preform shape B (blank sheet thickness is 1.6mm). Fig. 3c is thickness distributions of end flange up using result of shape B as blank. From Table 1 and Fig. 3, the bottom edge area is always with wrinkles, the shorter and narrower outer shape (shape C) not only increases edge wrinkles but also causes inner crack. This provides the guidelines for die design and tryout: must use other measures to remove the wrinkles and make the bottom flat other than use shorter or narrower preform shape.

Table 1

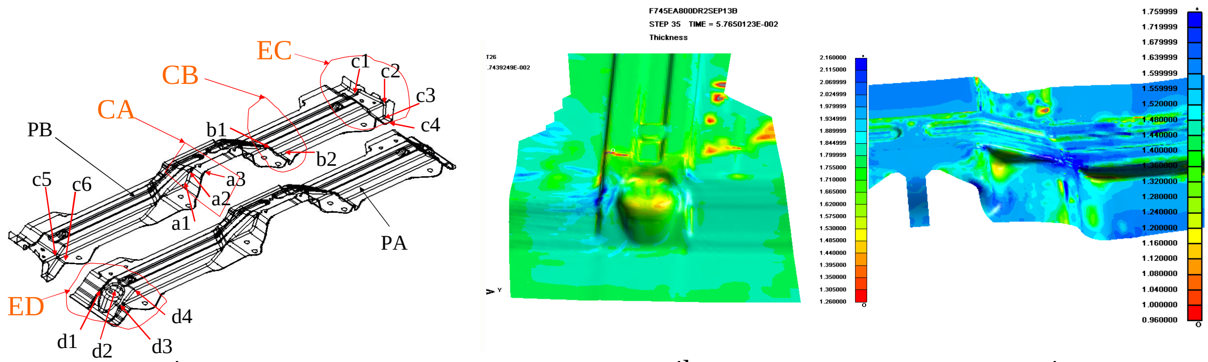
Shape	Outer shape feature	Thinning at inner corner	Thickening at edge
A	Part shape	32.8%, crack	43.7%, wrinkles
B	Deeper & wider	18%	35%, wrinkles
C	Shorter & narrower	32.9%, crack	75.6%, wrinkles

Forming of Cross-Members

Fig.4 is two cross-member central pillars in which with same central areas but with different ends. The two parts are made of HSLA steel of 1.6mm thickness with n value 0.123 and r value 1.06. Two parts have four critical areas: two central areas—CA and CB, and two end areas—EC and ED. The main defects are as below:

CA: a1 cracks and causes wrinkles at a2. a3 will crack if decrease blank width at a3.

CB: b1 is double and b2 is crack.
EC: Corner c1 cracks. c2 is too sensitive to the trim line and easy to crack. Because flange is 90 degree and shape of corner c2, the end is also difficult to trim. Corner c3 cracks. Edge c4 is with wrinkles and causes double in flange-up operations. c5 is with wrinkles. If preform end shape and central at same stage, c5 will be double. c6 will crack if decreases blank width.
ED: d2 and d4 crack, d1 and d3 are with severe wrinkles and easy to double metal.



4a 4b 4c

Fig. 4

Simulation results: some final results are shown in Fig. 4 and Fig.3. Fig. 4c is thickness distributions of central area after 2nd draw (blank thickness=1.6mm). Fig. 4b is thickness distributions of end ED (blank thickness=1.8mm) after 2nd draw. The preform and flange up of end EC are shown in Fig.3b and 3c, respectively. After many times of iterations, obtained the optimized preform shapes, and developed the stamping processes as below:
Part PA: blank—1st draw—2nd draw—trim—restrike—pierce.
Part PB: blank—1st draw (central)—2nd draw (central and preform ends)—trim—form ends —restrike and flange up—pierce and trim ends.

Die tryouts: Part PA did not do anything in tryout and without cracks or wrinkles/double.
Part PB had to tryout the end EC, and situations were in good agreements with simulations. By making blanking wider and adding end trim stage could solve the bottom edge wrinkles/double other than by making short preform shape or narrow blank width.

Summary

Simulation technology has become an important and very useful tool to the stamping die design of complex auto underbody components.

1. Simulation can be used to evaluate stamping processes. Simulation results are in good agreement with the real cases. By means of simulation can save costly trial-and-error of die tryouts, solve main forming defects like wrinkles/double metals and cracks at die design stage.

2. Combination of simulations for multi-stage forming with shape design can obtain optimized preform shapes and control deformation distributions for multi-stage forming.

3. Springback is still a big problem for complex components with HSS material. It includes two aspects. First is how to improve and control simulation to obtain reliable and accurate springback results. The second is, assuming simulation results were accurate, how to effectively change the die shapes to make up the springback and get good quality parts without re-cutting dies.