Computer Simulation of Sheet Metal Forming

and

Drawbead Effects Using eta/DYNAFORM

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Abbreviations: BHF CAD CAE FEA FLD
Keywords: Computer simulation, Drawbead, FEA, Sheet metal forming

ABSTRACT

The kernel technology of a computer simulation system and the general procedure of dynamic simulation in sheet metal forming are presented. As an example, processing parameters of the experimental die of a car inner door panel were optimized with eta/DYNAFORM software. The appropriate round corner of punch, BHF and the correct layout of the drawbead were obtained.

INTRODUCTION

Sheet metal forming has been widely applied in many industrial fields; the automobile industry, the steel industry, etc. In traditional manufacturing processes, design and manufacturing of Tool & Die, selection of material, definition of dimension & shape of the blank, and stamping process planning, all need several try-outs and modifications to determine. This " Trial and Error "process results in lots of resource consumption, high production cost, and a long development cycle. The foundation of a FEM simulation analysis system of sheet metal forming fulfills the " Trial and Error "processes with the computer. So production costs and the development cycle can be reduced dramatically and production quality and competition can be improved.

LS-DYNA has been widely used for sheet metal forming simulation since 1993. ETA developed a specialized sheet metal forming software package including LS-DYNA, a pre-processor and postprocessor. In this paper, firstly the general procedure of sheet metal forming simulation is introduced. Next, an application example for parameter optimization of a car inner door using eta/Dynaform is given and the results are analyzed.

APPROACH

The general procedure of sheet metal forming computer simulation is as follows:

Modeling of Tool and Blank

For most CAE software, the modeling function is quite simple. But tool shape is usually very complex, so generally, CAD software is used to generate the model geometry; for example, Pro/E, CATIA, UG, etc.

There are two ways to generate model geometry:

a. Direct modeling according to design graph paper;
b. Smoothing Processing using discrete data from a scanner.

After the modeling is done, data is transferred to CAE software.

Pre-processing of FEM Analysis

a. First, read the model geometry from the CAD system through the specific mesh builder, generate tool mesh and blank mesh. For computation precision and time, adaptive mesh is preferred for the blank. For the drawbead, the equivalent drawbead model is used to replace the real drawbead model to save computation time.
b. Define the material model and parameters, contact, boundary conditions, etc.
c. Define tool motion, force, and control parameters.

FEM Analysis using LS-DYNA, etc

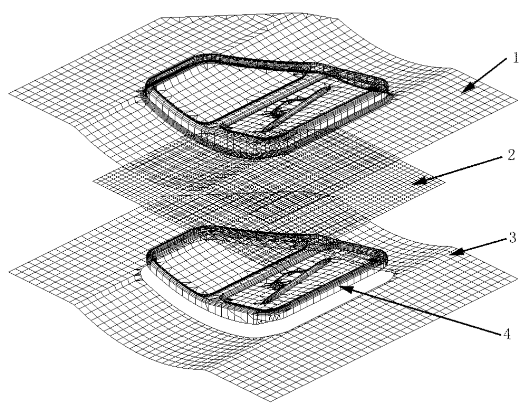
Post-processing of analysis results

Among analysis results, thickness, strain, and FLD (Forming Limit Diagram) are key results to analyze. These results provide reliable support for tool design and process design.

DISCUSSION OF RESULTS

Computer Simulation

According to the general approach in Section 2, using eta/DYNAFORM software, dynamic simulation has been performed to analyze the forming process of a car inner door panel together with Shanghai Volkswagen. The aim is to optimize the process parameters and drawbead layout. The FEM model is shown in Figure 1.



1- DIE 2-BLANK 3-BINDER 4-PUNCH

Figure 1. FEM Model

Table 1. ST14 material property

Direction	$\cdot_{s}$(Mpa)	$\cdot_{b}$(Mpa)	$\cdot_{80}$(%)	n	r
0°	169	315	42	0.229	1.48
45°	174	317	41	0.220	1.40
90°	167	300	40	0.220	1.91
Average	170	311	41	0.22	1.60

The blank material is Steel ST14, the material properties are shown in Table 1. The thickness of the blank is 0.7 mm., the friction coefficient is 0.1, and the travel speed of punch is 5 m/s.

The software used is eta/Dynaform V3.0 and LS-DYNA 950. The hardware platform is SGI Octane 250 workstation, 128M memory. The computation time is about 6 hours (using adaptive mesh).

Results Analysis

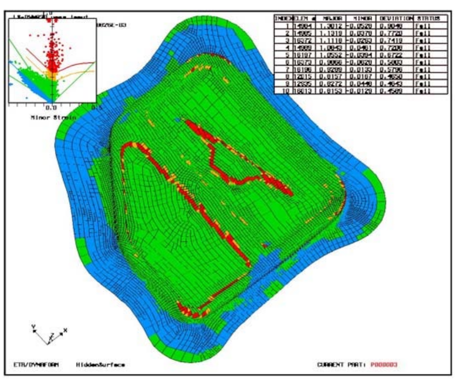


Figure 2. FLD of Initial Design

Figure 3. Real Forming Result

Figure 2 is the FLD of Initial Design. From Figure 2, we can see that a crack has occurred in the outer-frame round corner. After drawing of the real panel, in the real workpiece, a crack has occurred in the same position (Figure 3). There are 2 reasons for this defect:

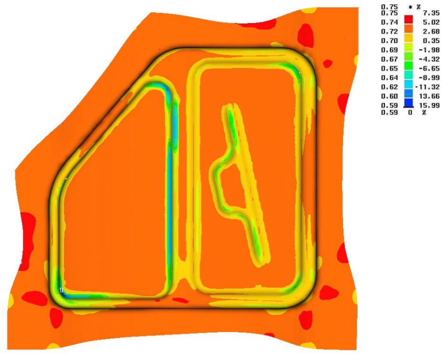


Figure 4. Thickness contour after optimization

one is a larger binder force, another is a smaller round corner radius (R2) in punch. So process optimization has been performed to avoid the crack. Lessen the binder force and change the radius to R3. Simulation results showed that forming results have been improved and no defect appeared.

Figure 4 shows the contour thickness after process parameter optimization. From Figure 4, we found that metal flow is uneven, especially in out-frame. To change this condition, it is no use to only optimize process parameter. Add drawbead in suitable position in Die & Binder is needed.

In eta/Dynaform, a very convenient and useful way to simulate the drawbead is provided; that is, Equivalent Drawbead. As you know, in general, the drawbead is very complicated and hard to define with FEM method. It needs more elements and more computation time and model preparation time. This is especially useful in large-scale automobile die, because drawbead adjustment is very common. As shown in Figure 5, the drawbead is set after several tryouts and the material flow has greatly improved. Thickness contour is shown in Figure 6.

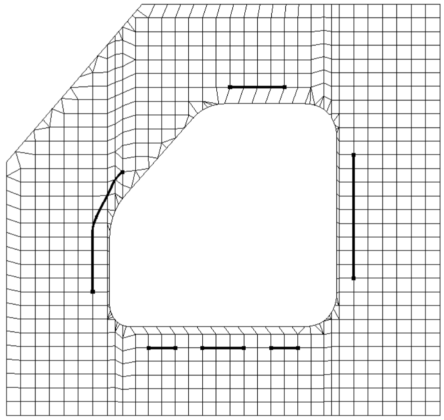


Figure 5. Equivalent Drawbead on Binder

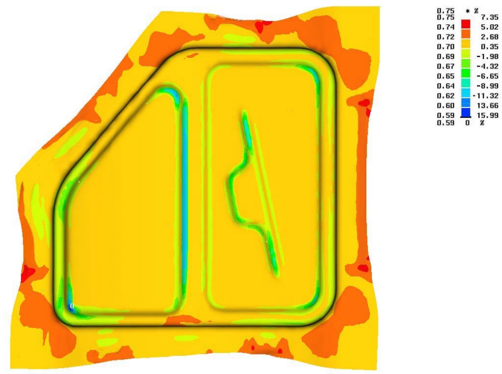


Figure 6. Thickness Contour after Using Drawbead

CONCLUSIONS

Computer simulation can help engineering technicians understand sheet metal forming procedure in the tool design stage, improve design initiative, and reduce unnecessary errors. Computer simulation can be used to obtain appropriate drawbead layout, optimize other processing parameters, reduce costs and shorten design cycle. Computer simulation has become an important means of tool design in the sheet metal forming industry.

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