

# Simulation of Drawing Process of Anti-collision Beam of Vehicle Front Bumper

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**Abstract:** The drawing forming process of anti-collision beam of vehicle front bumper was researched. Aimed at the possible wrinkles or cracks during the forming process, the finite element simulation of the process was carried out based on Dynaform. The forming limit, thickness change, and strain state of anti-collision beam of vehicle front bumper were studied according to the simulation results and a comparison of the simulation results and actual forming part was made. A comparative analysis of thinning rate in some large deformation parts between simulation results and actual forming part was carried out, and a consistency was achieved. The results show that simulation analysis can greatly reduce the production costs, shorten the manufacturing cycle of the mold design, and improve the level of design and production.

**Keywords** anti-collision beam of vehicle front bumper, deep drawing, simulation

## INTRODUCTION

As one of the pillar industries of national economy, vehicle industry plays an important role. Its design level and manufacturing quality determine the market competitiveness of vehicle products. In the whole process of vehicle body development, the design, manufacture and debugging of vehicle cover mold takes the longest time, which is an important link of new model development. The front bumper anti-collision beam belongs to the category of vehicle cover, which has complex shape, large structure size and high surface quality requirements. This determines the difficulty of its mold design, longer cycle, higher mold manufacturing costs. In the process of deep drawing and forming of anti-collision beam of front bumper, unreasonable die structure and technological parameters often cause wrinkles or cracks and other defects.

Many scholars have studied the forming technology of vehicle front bumper and similar vehicle covering parts. [Guo yihui, et. al.,2013] used ls-dyna software to conduct numerical simulation analysis on the thermal forming process of car front anti-collision beam, and compared the numerical simulation results with the test results. [Wang xiangzhi,et.al.,2008] conducted numerical simulation analysis of the stamping forming process of vehicle bumpers by using Dynaform sheet metal finite element analysis software, and revealed the plastic deformation law of the part deformation process.[Xu jianmin,et.al.,2011] studied the bumper bracket, designed a reasonable process plan by using the numerical simulation method, and solved the forming

and springback problems of the workpiece in the bending process. [Xue song, et. al. ,2011] studied the forming process of front bumper reinforcement plate, and analyzed the springback phenomenon in the forming process by using finite element analysis. [Wang ganting, et. al. ,2008] studied the wrinkling and cracking defects in the drawing process of anti-collision beam of front bumper, and proposed the calculation method of blank holder force in the forming process. In this paper, metal sheet forming analysis software Dynaform is used to simulate the forming process of car front bumper anti-collision beam, and to predict the possible defects in the forming process, so as to provide a basis for mold structure optimization and process parameter adjustment.

## TECHNOLOGY ANALYSIS OF FRONT BUMPER ANTI-COLLISION BEAM

The structural diagram of front bumper collision beam is shown in figure 1.



Figure.1 Model of anti-collision beam of vehicle front bumper

The workpiece material is St14, the model is cold-rolled steel plate with deep drawing and deep grade, the thickness is 1.6mm, the yield strength of the material is 220MPa, the tensile strength is 270~350MPa, the elongation is 36%, the hardness is less than 50HRB. It can be seen from the schematic

diagram of workpiece structure in figure 1 that the workpiece has complex shape, deep drawing depth and difficult forming, so it belongs to large stamping parts. In the actual forming process, it needs to go through the process of drawing, cutting edge, shaping, punching and trimming, among which drawing is the most difficult process step. In the process of deep drawing forming, due to the force between the plate and the die, compressive stress is generated at the flange, which usually causes the plate to wrinkle. The tensile stress in the transfer zone exceeding the tensile strength of the plate will cause the plate to crack.

Since the workpiece is the final shape of the shape, in the analysis of the forming process of the front bumper anti-collision beam, it is necessary to add process complementary surface, including the internal process complementary surface filled with holes inside the workpiece and the external process complementary surface along the outer contour of the workpiece. After deep drawing and forming, the final shape of the workpiece can be obtained by trimming and punching.

**DRAWING FORMING SIMULATION**

**Finite element modeling**

The artifact model shown in figure 1 is saved as a igs file and imported into Dynaform software for shaping analysis.

Considering the overall size of the workpiece as well as the calculation time and accuracy, set the size of the grid element to 10mm, and conduct mesh division of the model. On this basis, check the mesh and stamping direction.

**Die surface engineering**

Fill the inner hole in the workpiece, create the pressing surface at the same time, select the appropriate type of section line of the process supplement surface, generate the process supplement surface, on this basis, cut out the outside pressing surface. After finishing the die face project, the die face diagram of the front bumper beam is shown in figure 2.

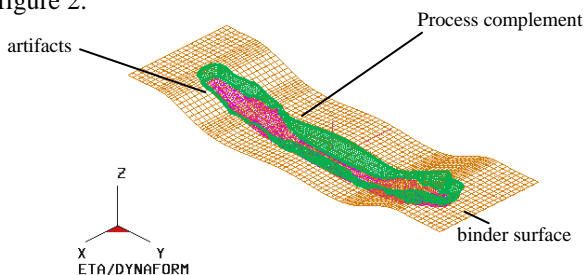


Figure.2 Die-face of anti-collision beam of vehicle front bumper

**Blank work**

Since the average thickness of the workpiece is not much different from that of the blank after deep drawing, the change of thickness can be ignored, so the size of the blank can be calculated according to the principle that the surface area of the blank and the

workpiece is the same before and after deep drawing. The blank diameter of simple cylindrical parts can be calculated according to the following formula [Wu shichun, et. al. ,2002] :

$$D = \sqrt{(d - 2R)^2 + 2\pi R(d - 2R) + 8R^2 + 4d(H - R)} \quad (1)$$

In the formula: D is the blank diameter, D, R and H are the diameter, fillet radius and depth of cylindrical parts respectively.

However, due to the complex shape of the workpiece, it is not possible to accurately calculate the size of the blank by this method. The blank can be expanded by using BSE in Dynaform software, and the shape of the blank can be obtained by inverse method, as shown in figure 3. As can be seen from figure 3, the size of the original blank of the workpiece is 1517mm×336mm, and the inverted blank is gridded.

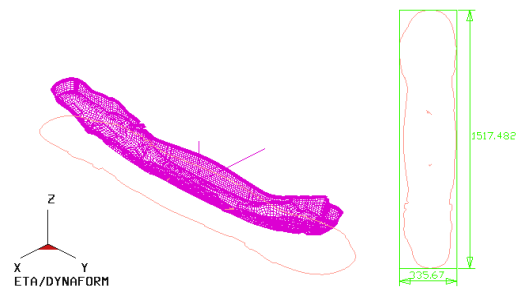


Figure.3 Blank size of anti-collision beam of vehicle front bumper

**Setting solution**

In the quick setting solver, punch, blank-holder and blank-holder are set. At the same time, appropriate stamping speed and blank-holder force are selected and the work is submitted for solution.

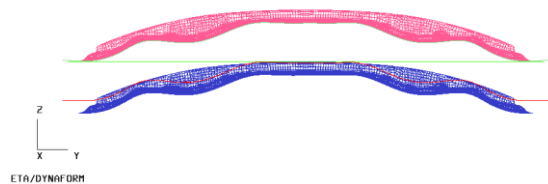


Figure.4 Simulation model of anti-collision beam of vehicle front bumper

**ANALYSIS OF SIMULATION RESULTS**

After the solution is completed, enter the PostProcess post-processing program, read the d3plot file, close all the other parts except the sheet material, and visually observe the billet deformation animation. The post-processing module can also draw the forming limit diagram of parts, analyze the thickness change of parts and the stress and strain state of parts in the process of drawing.

**part forming limit diagram**

Select a single frame in the forming limit graph (FLD) control panel and click on each frame to observe the sheet metal forming situation. Now we need to observe the final forming situation and select the last frame. The result is shown in figure 5.

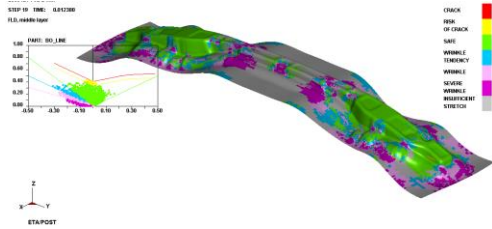


Figure.5 Forming limit diagram of anti-collision beam of vehicle front bumper

According to the simulation results shown in FIG. 5, the FLD (forming limit diagram) was studied, and it was found that some of the workpiece edges were in the critical wrinkling state, which did not have a great impact on product quality and use in actual production, and edge trimming would be carried out in the next cutting process. Most of the middle part belongs to the safe forming area, and there is no tension crack phenomenon. That is to say, this product can be formed under the research of forming limit diagram.

**analysis of parts thickness change**

The thickness change of parts is analyzed in the post-processing, and the final thickness change of parts forming is shown in figure 6.

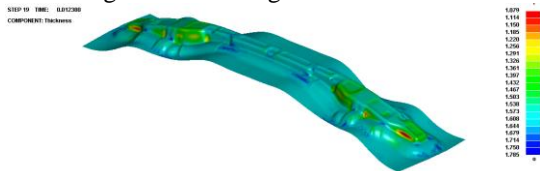


Figure.6 Thickness diagram of anti-collision beam of vehicle front bumper

It can be seen from figure 6 that the thinned part is 1.079mm in the thinned position, the original sheet thickness is 1.6mm, and the maximum thinning rate of the material is:

$$\bullet \frac{1.6 - 1.079}{1.6} = 32\%$$

However, the thinning rate of most parts is less than this value, which shows that the product is in good shape and in accordance with the technical rules.

**strain state analysis of parts**

The main strain cloud graph of the formed part is read, and the result is shown in FIG. 7. It can be seen from the figure that the strain of parts in the forming process, the maximum strain occurs in the deep drawing side, where is the difficult part of forming, the forming state here should be paid attention to in the actual drawing process.

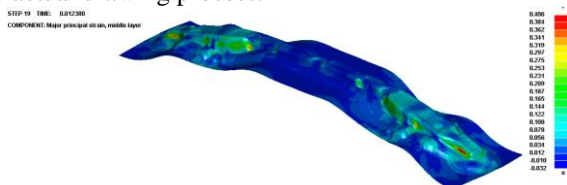


Figure.7 Major strain of anti-collision beam of vehicle front bumper

**comparative analysis of actual formed parts**

After completion of the workpiece deep drawing process of the actual product as shown in figure 8,

can be seen from the graph forming workpiece's overall in good condition, only has some wrinkling in the edge of the workpiece, the analysis and simulation results are consistent, the wrinkled edges are next in the trimming process for removal of waste, will not affect the whole quality of the workpiece.

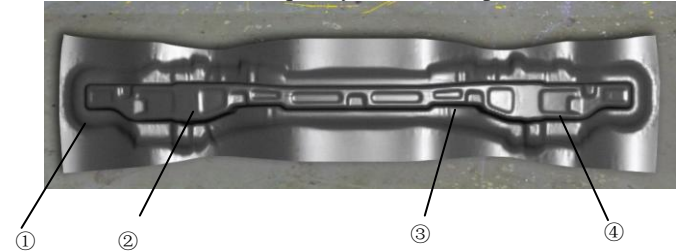


Figure.8 Product of anti-collision beam of vehicle front bumper

Take four points (1 to 4 in FIG. 8) where the thickness of the actual forming workpiece changes greatly, measure the thickness after forming, calculate the thinning rate, and compare with the simulation analysis results, the comparison results are shown in FIG. 9 (the shadow represents the actual thinning rate). As can be seen from the figure, the simulation analysis results are consistent with the actual forming situation. Numerically, the thinning rate of the actual forming workpiece is slightly smaller than the simulation analysis results, which is related to the wear of the mold during the actual forming.

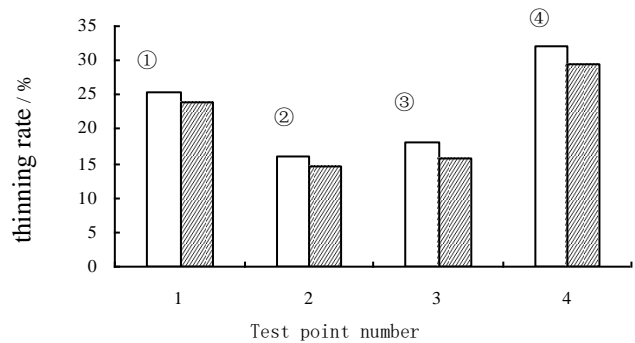


Figure.9 Compare results of thinning rate

**RESULTS AND CONCLUSIONS**

Using Dynaform software, the forming process of front bumper beam is simulated and analyzed. According to the simulation results, the forming limit, thickness change and strain state of parts are studied. The results of simulation analysis predict the forming process of deep drawing, and for the possible defects such as wrinkling and cracking, it can be improved by controlling the technological parameters and modifying the die structure, so as to avoid the occurrence of such defects. Simulation analysis can greatly reduce the production cost, shorten the mold manufacturing cycle, and improve the design and production level.

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