

The design of addendum surfaces for automotive back light holders based on the software Dynaform

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Abstract: This article analyze characters of automotive back light holders. It simulates the deep drawn forming process to optimize blanks by the software Dynaform which used for analyzing plat materials' in three dimensions- formation. It analyzes the formed result, comparing with the graph FLD and then modifies the local surfaces, which achieves the aim of optimizing process formed surface. Then we get the reasonable deep drawn surface of the die. Finally, the eligible products are produced.

Foreword

The manufacture of covering parts is the key link of the whole automotive body. The traditional methods of repeatedly stamp and repairing model are not conducive to shorten the production circle and reduce the production cost, which hinders the development of new automotive models. In recent years, the numerical simulation of sheet material forming process has been widely used among companies. It can deal with high degree of geometric nonlinearity, material nonlinearity and complicated contact friction problems in the process of covering parts forming. It can also precast the fold and the crack in the forming process. This numerical simulation has been the key tool in the design of complicated covering parts.

This article focuses to simulate the deep drawn forming process of an automotive back light holder by the numerical simulation software Dynaform. It optimizes the addendum surface according to the simulated result, and then designs the model for finally getting the eligible products.

Parts' analysis in the process and their finite element models

1.1 The light holder is a part which keeps the position of a light and connects the power supply. Two light back holders of one car are bilateral symmetric. Their sheet materials are SPH440(36) from Japan. The thickness of this sheet is 2 mm. The hardening exponent $n = 0.125$ and the hardening modulus $k = 694.5$. The yield stress $\sigma_s = 397.8\text{Mpa}$. As shown in Fig 1, we can see their shapes are complicated and deep depths drawn. If the process of stamping the single part is adopted, this process will suffer high lateral forces, which will make forming difficult. To ensure the quality of products, we form these two parts at the same time in a symmetrical layout. This process can save the cost of production and be good to facilitate the material's flow.



Fig1 The CAD Model of the Part

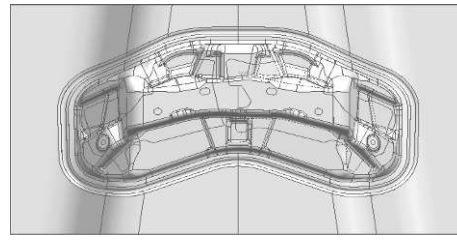


Fig2 The Model of the part for stamping

Many factors must be considered such as the design principle of the drawing direction of covering parts, the distribution of drawbeads and forming factors in the follow-up process. We preliminary design the process' Addendum part of automotive parts according to above factors and then get the die model of process' Addendum part, as shown in figure 2.

1.2 Parameters setting and finite element module

1.2.1 Materials' yield module

There are three materials' yield principles which are often used for stamping forming analysis of sheet materials. They are Von Mises isotropic yield model, Hill orthogonal anisotropic yield model and Barlat polycrystalline material yield model. This article adopts Hill module in the deforming simulated analysis of a certain automotive front Bumper bracket holder. In the state of plane stress, Hill yield criterion can be expressed as:

$$\sigma_x^2 + \sigma_y^2 - \frac{2r}{r+1} \sigma_x \sigma_y + 2 \frac{2r+1}{r+1} \sigma_{xy}^2 = \bar{\sigma}^2$$

Note:

$\bar{\sigma}$: The equivalent stress along the rolling direction

x: The rolling direction of sheet material

y: horizontal direction

r: Anisotropic average value

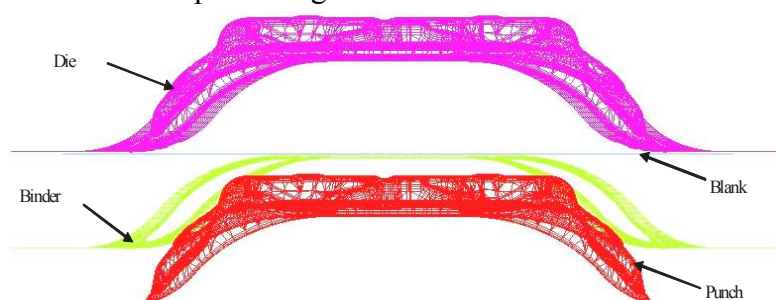


Fig 3 The FE model of the simulation system

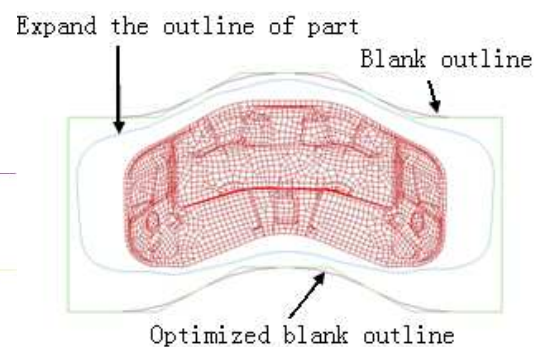


Fig 4 Blank optimization one step simulation

1.2.2 Other parameters

Clearances between pun and die: $C = 1.1$

Material thickness: t ;

Coefficient of static friction between blank and mould's components: $f_s = 0.12$,

Coefficient of kinetic frictional: $f_d = 0.12$;

Press edge speed: $V_1 = 2000 \text{ mm/s}$;

Forming speed: $V_2 = 5000 \text{ mm/s}$

1.2.3 The finite element model

The finite element model is shown in figure 3. The structure of the die adopts an inversive structure. Sheet blank adopts isotropic index strengthening module. So, the mathematical expression of the stress and strain is :

$$\sigma_y = K(\varepsilon_{yp} + \varepsilon_p)^n$$

In this formula, n and K are constants of materials. $K > 0$. n is the hardening exponent.

This analysis uses the thin shell element theory Belytschko-Tsay. Grids are adaptive division.

The results of simulation analysis and optimization of addendum surfaces

2.1 optimization of blank

Optimize the blank by the software and then divide the grids on the part of the punch. This part is divided into 3408 nodes, 2621 quadrilateral units and 624 triangular units. Parameter setting:

Blank thickness: $H = 2\text{mm}$,

Anisotropic exponent: $\gamma = 1$,

Maximum iteration step number: 200,

Friction coefficient: 0.125.

Therefore, the blank contour optimized is shown in Figure 4.



Fig5 Optimization of blank

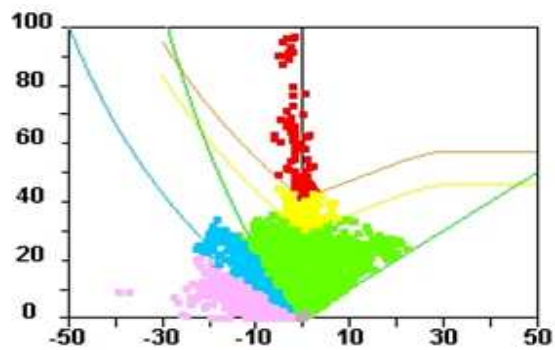


Fig6 The FLD diagram of blank after simulation

Referred to the result of this simulation, we simulate the process of components forming with the blank whose shape is shown in Fig5.

2.2 The result of forming simulation

We can get the forming result (Fig6.) according to simulation with above parameters. As shown in Fig6, we can see there are few cracks in the part according to the shape of the blank simulation optimized. We can see some accumulations in the place B(Fig7).

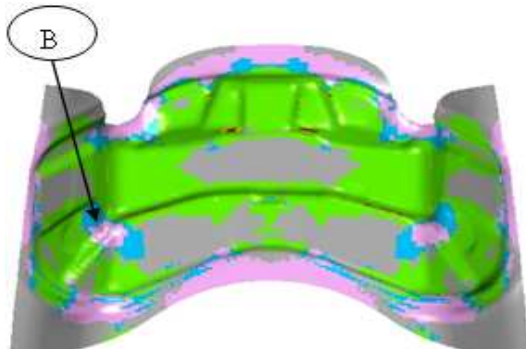


Fig7 The diagram of blank after simulation

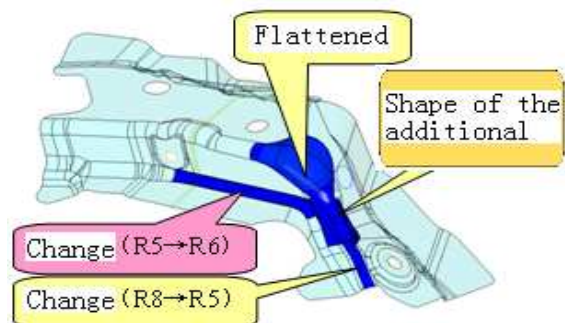


Fig 8 Local optimization of part surface

2.3 Optimize local shaped surfaces

The accumulations in the place B in Fig6 may cause the instability of parts' forming. Moreover, due to parts' complex shape, it is very difficult to optimize the shape of the blank again. Thus, we modify the shaped surface as shown in Fig 8.

We simulate it again after optimizing local shaped surface. We can see those accumulations of materials in the place B mostly disappear from the deforming result in Fig9. This deforming result of parts is very good.

Comparing this result with the figure FLD got by the previous method, we can get that this method greatly reduces the dangerous forming area.

Above all, this method is most feasible.

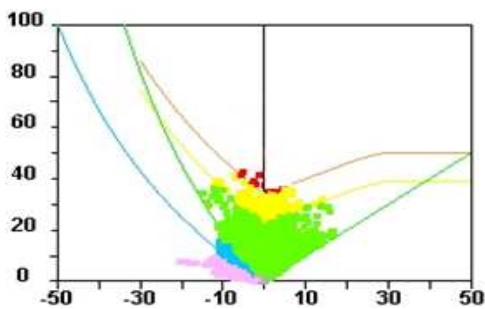


Fig 9 The FLD diagram of blank after simulation



Fig 10 The production parts

2.4 Real product object

According to the simulated results, we design the economic and reasonable structure of the drawn die with the blank optimized and its drawing surface, and then succeed in producing the real product which meets all the requirements such as the shape, the precision and surface quality. It is shown in Fig10.

Conclusions

We do numerical simulated analysis to the forming process of automotive back light holders by the software Dynaform, and then put it into production. We get some conclusions as follow:

(1)The method that one mould produces two parts at the same time, can obviously improve the material utilization rate of materials and productivity. It saves the cost as well.

(2)The drawing surface optimized is reasonable so that the deforming result of parts are good. It doesn't arouse folds and cracks in the forming process. It meets the requirement of good quality products. It is also convenient to carry out the following process.

(3)If the design of the blank size of deep drawn part and process surface can fully combine with the software about finite element analysis, it is benefit to improve the quality and efficiency of the die design. It can shorten the die designing circle, manufacturing circle and testing circle.

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