Study on Forming Process of Automobile Anti-collision Beam Based on Dynaform

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Abstract. The mechanism of the automobile anti-collision beam forming was studied, and the forming process was analyzed by using Dynaform and the finite element simulation in view of the defects such as wrinkling and cracking. The blank holder force and drawbead layout for the quality of the parts were further researched in drawing process. The results show that the simulation analysis provides the basis for the improvement of the mold structures and the optimization of the forming process parameter, and it can greatly shorten the die manufacturing cycles, reduce the production costs and improve the production efficiency.

Keywords: Automobile anti-collision beam, Drawing, Simulation analysis, Dynaform.

1. Introduction

Automobile anti-collision beam belongs to the category of automobile covering parts, compared with the general stamping parts, automobile covering parts have complex shape, thinner materials, larger structure size and higher surface quality requirements [1]. With the automotive industry increasingly competitive environment, products require higher quality, which demands the continuous improvement of forming technology of the automobile covering parts. However, because of the complexity of covering parts structure and deformation process, wrinkling, cracking and other defects often occur in the forming process, which put forward higher requirements for the forming technology.

With the rapid development of computer simulation technology, the numerical simulation of sheet metal forming has made great progress [2, 3]. With the help of the advanced forming simulation software to simulate the entire stamping process, defects that may occur are predicted, and the die structure and forming process parameters are optimized, thus it can greatly shorten the product development cycles and costs.

2. Drawing forming mechanism and mechanical calculation

The forming process of automobile anti-collision beam is deep drawing. In the process of drawing, as the function of the punch drawing force, radial direction of flange blank produces tensile stress, while tangential produces compressive stress. Under the combined action of tensile and compressive stresses, plastic deformation occurs in flange material, and flange material is constantly pulled into the die to form drawing parts [4].

Defects often appear in the process of drawing including wrinkling in the flange deformation region and cracking in the force transmission area. Wrinkling is caused by tangential compressive stress that leads to sheet instability to produce bending, while cracking is due to tensile stress exceeding the tensile strength to cause sheet metal fracture.

In order to reasonably select stamping equipment and design drawing die, the blank holder force (BHF), drawing force and other parameters must be determined during the drawing process.

BHF is exerted on the blank holder in drawing process, which can be used to solve the wrinkling problem, and it can be calculated by the following formula (1):

$$Q = Fq \tag{1}$$

Where, F is the area of the pressure side (mm^2); q is for unit blank holder force (MPa), its value is determined by experiment, unit blank holder force of different materials is selected according to table 5.3 in the reference [4].

The drawing force is often calculated by the following experience formula (2) in the production:

$$P = Lt\sigma_b K \tag{2}$$

Where, L is the cross-sectional peripheral length of the blank (mm); t is the sheet thickness (mm); σ_b is the tensile strength of the blank (MPa); K is the correction coefficient.

Deep drawing process has been studied by the existing theories, but in order to intuitively understand the drawing forming process of sheet metal, this paper will be based on the theory to simulate the forming process of automobile anti-collision beam by using the finite element method to obtain the forming characteristics.

3. CAD/CAE collaborative simulation of automobile anti-collision beam

3.1. Establishment and process analysis of automobile anti-collision beam 3D model.

The three-dimensional model of automobile anti-collision beam is established by using surface feature operation in Pro/Engineer [5] as shown in Fig. 1, and the model is saved as .igs format file for the forming analysis.

Fig.1 Pro/Engineer model of automobile anti-collision beam

The automobile anti-collision beam material is ST14 steel plate with thickness of 1.8mm and material size of 1200 mm ×300 mm, and the product belongs to large stamping parts with simple and smooth shape, deeper drawing depth, stamping negative angle does not appear by using reasonable stamping direction, so once deep drawing method can be used. In the forming process, the addendum is added to compensate for the shortages of parts, including inner addendum for filling holes in internal parts and outer addendum along the outer contour. According to the conditions whether use blank holder in the literature [4] table 5.1, this forming process requires the use of blank holder. It also needs to determine whether use the drawbeads on the basis of the actual forming situation to ensure product quality.

3.2 Forming process simulation of automobile anti-collision beam.

(1) The establishment of finite element model Import CAD model of automobile anti-collision beam into Dynaform software, select the appropriate unit size to mesh the model, and inspect and repair the mesh.

(2) Die face engineering Consider forming process of sheet metal, determine the correct stamping direction; add inner addendum and outer addendum; create binder surface. The generated die surface is shown in Fig.2.

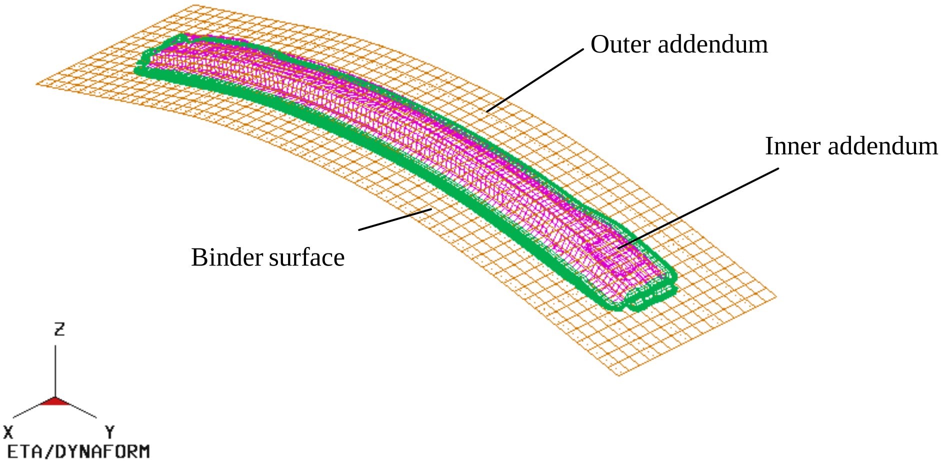

Fig.2 Die-face of automobile anti-collision beam

(3) Blank engineering   Since complex shape of automobile anti-collision beam and difficult to directly determine the blank surface shape and area, blank engineering module in Dynaform software can be used to conveniently calculate size and shape, and mesh reverse blank.

(4) Generate drawbead curve   Setting drawbeads in forming can increase the radial tensile stress, reduce compressive stress and prevent wrinkling.

(5) Submit to solve   Setting solver parameters, such as adaptive meshing, output control parameters to generate solver input file, submit to the solver to calculate [6, 7].

4. Analysis of simulation result

4.1. BHF impact analysis on forming.

According to BHF theory calculation formula (1) and unit BHF values, unit BHF of the material is about 3MPa. Import the blank holder model into the Pro/Engineer software can directly measure the area of blank holder is 702416 mm^2, which can obtain BHF of the automobile anti-collision beam forming for 2100kN.

In order to get a better forming quality, through adjusting the value of BHF, analyzing influence of different BHF on formability of automobile anti-collision beam, set different values of BHF to conduct analysis. Fig. 3 shows the forming limit diagram of automobile anti-collision beam when BHF is equal to 2100kN.

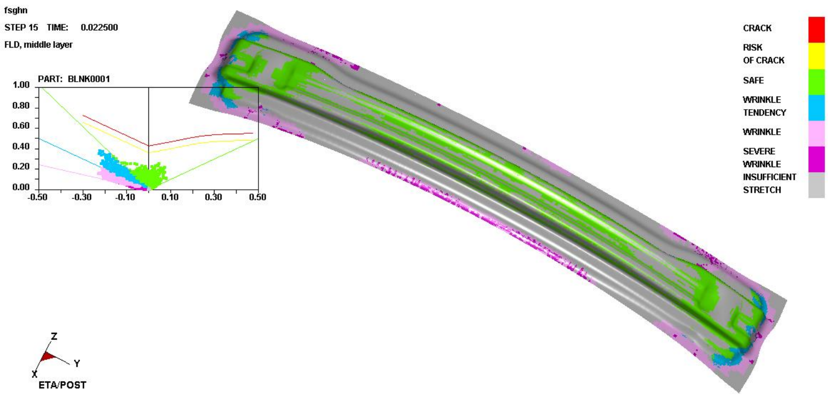

Fig.3 Forming limit diagram Ⅰ of automobile anti-collision beam

From the forming limit diagram in Fig.3, it can be seen that overall forming effect of parts is better, but some wrinkling occurs in the part edge. For better forming effect, the simulation is carried on again by increasing BHF, the forming limit diagram as shown in Fig. 4.

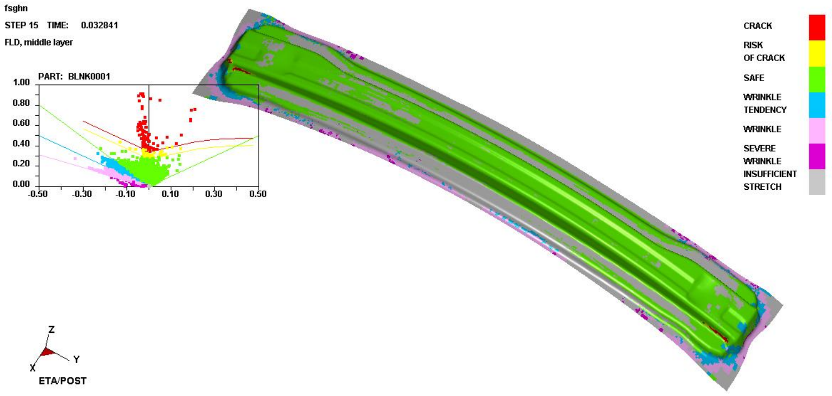

Fig.4 Forming limit diagram Ⅱ of automobile anti-collision beam

As can be seen from Fig.4, although increasing BHF can improve wrinkling defects, parts are at the risk of cracking. In this case, the mold structure is required to change and forming effect can be improved by setting drawbeads.

4.2. Drawbead impact analysis on forming.

Layout of drawbeads can adjust the flow properties of materials in order to prevent from the blank wrinkling, the forming process is simulated by setting different drawbead curves to get the best forming effect. Fig.5 is forming limit diagram with the layout of the drawbeads, and thickness variation contour map is shown in Fig.6.

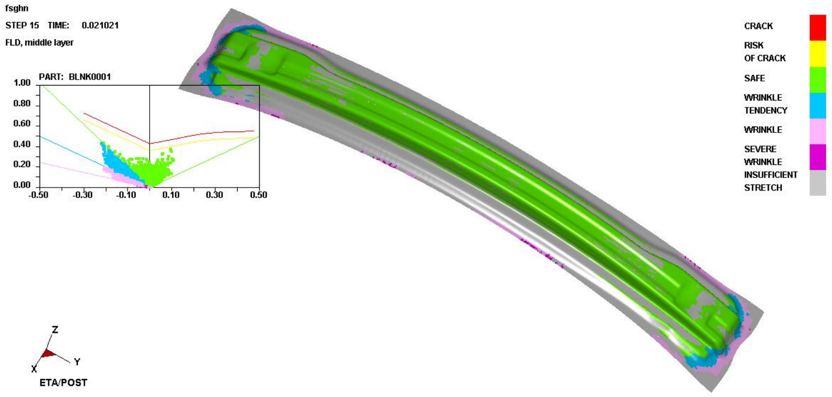

Fig.5 Forming limit diagram Ⅲ of automobile anti-collision beam

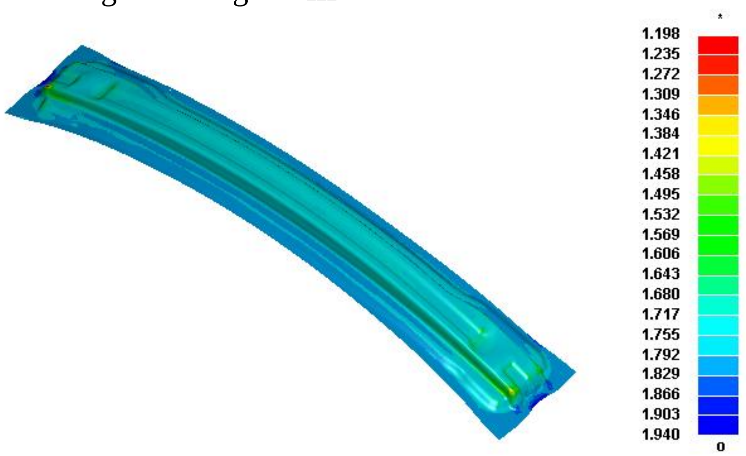

Fig.6 Thickness diagram of automobile anti-collision beam

As can be seen from the Fig.6, after the selection of the appropriate BHF and layout of drawbeads, forming effect is good. Only some parts in the addendum and binder surface are at the critical wrinkling state, the impact on the product quality and use is not great in the actual production, and it will be trimming in the next process. From the thickness variation contour map, the change of thickness is smaller, which can meet the requirements of forming.

5. Conclusion

The drawing process was researched, and simulation analysis of automobile anti-collision beam forming process was conducted by using Dynaform software, which can predict wrinkling, cracking and other defects that may exist in the actual forming process according to simulation results. On this basis, BHF and drawbead layout was analyzed for product quality in the forming process. And as a guide, by optimizing the die structure and forming process parameters, it can greatly shorten the mold manufacturing cycles, reduce production costs, and improve the production efficiency of enterprise.

Acknowledgements

This work was financially supported by Innovation Foundation for Graduate Students of Shandong University of Science & Technology (Grant No. YC140105).

References

[1] L.J. Cui: Stamping Forming Technology of Automobile Covering Parts (Mechanical Industry Press, China 2003).

[2] Y. H. Guo, M T Ma, Y S Zhang, et al. Forging & Stamping Technology, Vol. 38 (2013) No.3, p. 46.

[3] Q. T. Wang, L. A. Ma: China Metal Forming Equipment & Manufacturing Technology, Vol. 5 (2008), p. 74.

[4] S.D. Wu: Stamping Process and Die Design (Northwest Industrial University Press, China 2002).

[5] S.H. Ding, H.X. Wang: Basic Design and Practice of Pro/Engineer Wildfire 3.0 (Tsinghua University Press, China 2007).

[6] C.J. Su, T. Yu: Sheet Metal Forming Analysis and Application of CAE-Dynaform Project Application (National Defence Industry Press, China 2011).

[7] X.F. Liu, W.J. Huang: Hot Working Technology Vol. 42 (2013) No.3, p. 129.