Research on Forming Technology of Automobile Rear Wheel Cover Panels

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Abstract. Based on the basic principles of production process and process design for automotive panels, this project develops the stamping process for automotive rear wheel cover panels, and uses CATIA software to draw out the three-dimensional digital models of parts, and then uses the Autoform software to perform numerical simulation analysis. The software analyzes and calculates the stamping direction, the pressing surface, the process supplementary surface, the blank size, the forming limit diagram of the part, the main strain diagram, and the thickness variation, and finally optimizes the blank holder force, friction coefficient, and blank size. To Get the best punch results.

1. Introduction

With the rapid development of automobile industry, sheet metal forming technology has been highly valued in many developed countries[1]. If the engine is the core of the car, the car body is the outer shell of the car's wrapping core[2]. Forming process of automobile panel, drawing is the most important step, whether the drawing process can be reasonably designed is the key to produce qualified automobile panel steadily and rapidly[3]. Automotive panels can be divided into three categories according to their functions and positions: external panels, internal panels and skeleton panels[4]. Due to wrinkling, hairing and cracking, the drawings are not qualified, so consider carefully every step from the layout of stamping process to the manufacturing process of die[5]. In the manufacturing process of a factory, when debugging the drawing die, It is also necessary to analyze the wrinkling and cracking phenomena of failed stretching parts, Mould modification is also carried out for these defects. So there is a great demand for talents in automobile panel die design[6]. It is very difficult to design dies by traditional methods, lacking of uniform design specifications, therefore, a lot of analysis and calculation should be done, and the quality of finished products is difficult to guarantee. So it takes very little time to design the right die, at the same time, it also has the best design scheme of lower waste rate, it's the desire of automobile panel designers[7]. The traditional test method has long test cycle, unstable product quality and low accuracy[8]. Computer Aided Design(CAE), which combines numerical simulation analysis, sheet metal forming and computer simulation, can overcome this problem perfectly, this technique simulates the stamping process of the panel, the deformation rule and defect of sheet metal can be observed intuitively in the simulation result, engineers can optimize die and process parameters based on simulation results, ultimately get qualified products, thus, the time of fixer's repairing in the process of die test is reduced, reducing the cost and cycle of development[9]. Reasonable drawing process parameters are put forward to guide production[10]. The core technologies of AutoForm software include implicit incremental algorithm, contact search, plate

and shell theory, grid and computer automatic adaptation technology, etc, and the software can easily transform data with CAD software, it greatly facilitates users[11]. Using three-dimensional design, the shape and structure of the die can be visually observed, non-interference between parts can be adjusted in the design process, it guarantees the realizability of the die greatly[12,13].

2. Forming process analysis of rear wheel cover

The material type of rear wheel cover is DC04, it is a kind of common cold rolled low carbon AL killed steel, surface quality is good, having good stamping formability. Application in stamping manufacturing complicated parts, with good deep drawing performance. The thickness of sheet metal is 1.5mm, the dimension of drawing parts is 1056mm×1481mm×1250mm. In order to facilitate process supplement, select stamping direction and save material, using pair drawing forming, have higher productivity. The three-dimensional model of rear wheel hood is shown in Figure 1. The chemical composition and mechanical properties of the material are shown in Table 1 and 2.The forming process of rear wheel cover can be divided into the following five process: blanking-drawing-trimming-shaping-punching.

Table 1. Chemical constituents of DC04 (%)

Material	C	Mn	P	S	Al
DC04	≤0.080	≤0.4	≤0.025	≤0.02	≥0.015

Table 2. Mechanical properties of DC04

Material	σ_s / Mpa	σ_b / Mpa	n	R	K	v	R_0	R_{45}	R_{90}
DC04	176	320	0.22	1.96	715	0.3	1.82	1.7	2.39

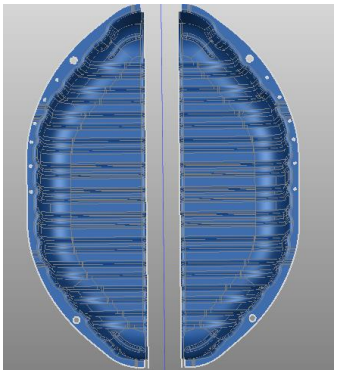


Figure 1. Three-dimensional model of automobile rear wheel cover panels

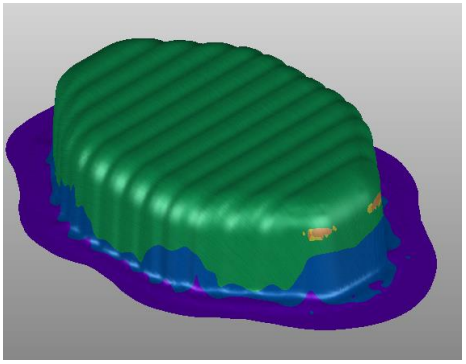


Figure 2. Preliminary drawing result

Table 3. Process parameters of preliminary simulation

Material	Material thickness (mm)	Gap between punch and die (mm)	Friction coefficient	Blank holder force (KN)	Stamping speed (mm/s)	Drawing method
DC04	1.5	1.5	0.15	1600	1000	Single action deep Drawing

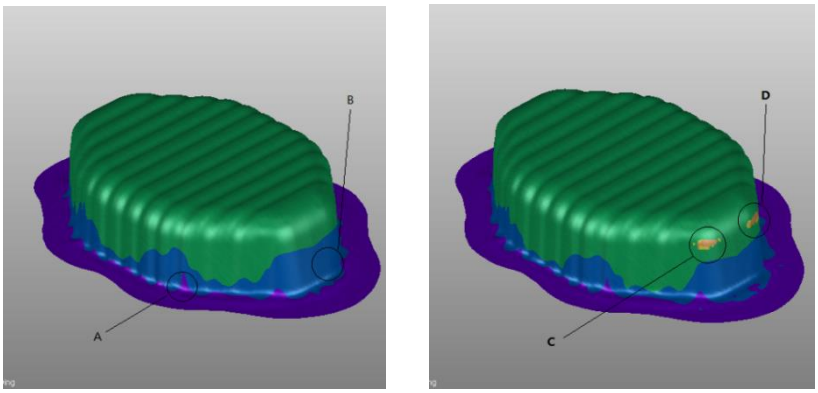
3. Preliminary simulation and process optimization of rear wheel cover

3.1. Preliminary simulation

3.1.1.Drawing process simulation Establish finite element model, the material is DC04, the thickness of sheet metal is 1.5mm. In this paper, the drawing mode is selected as single-action drawing, stamping direction downward. After setting up, check the motion of the tool body in the calculator, verify that the tool body does not interface during movement, the process parameters are shown in Table 3, then carry out simulation analysis, finally, the simulation results shown in Figure 2 are obtained. Illustrated by graphs, there are many defects in the initial simulation, there is also a clear risk of rupture. Follow-up process optimization is needed to improve these defects.

3.2. Process optimization

3.2.1. Selection of blank holder force The simulation of automobile rear wheel cover plate in this design, adjust blank holder force, the blank holder force is set to 1400KN, 1600KN respectively, other process parameters remain unchanged, the final simulation results are shown in Figure 3. Figure 3 shows that when the blank holder force is 1400KN, A and B have obvious wrinkling tendency, with the increasing of blank holder force, the wrinkling trend in these two places is gradually decreasing; when blank holder force increases to 1600KN, the C and D parts at the corner tend to break down, but there has been no rupture yet. The influence of the above two blank holder forces on the forming of automobile rear wheel cover plate is analyzed, when blank holder force is 1600KN, there is a risk of cracking, it is concluded that the best blank holder force should be 1500KN,in the following process optimization, the blank holder force is 1500KN.

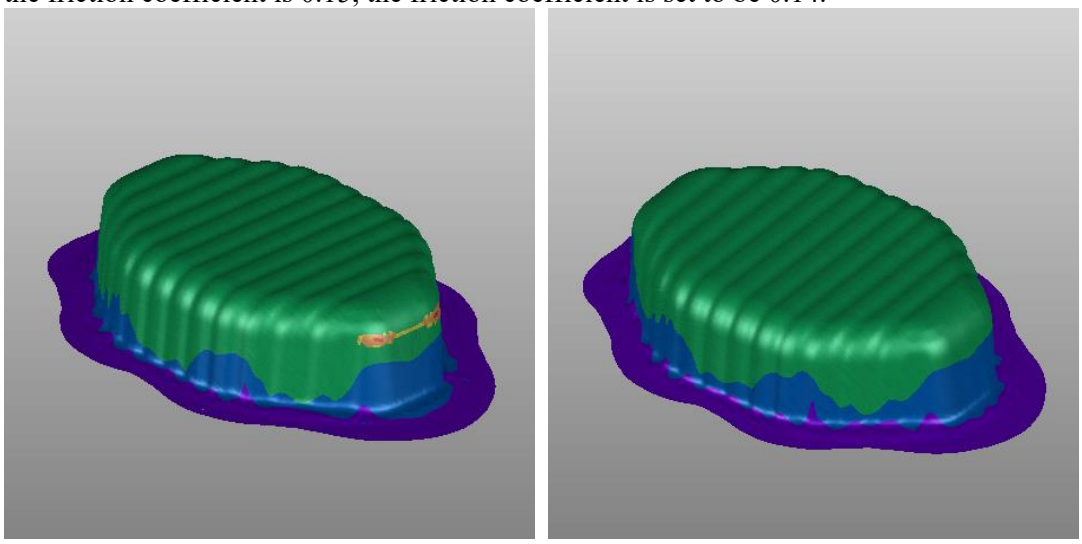


(a)1400KN (b)1600KN

Figure 3. Forming simulation results corresponding to two blank holder forces

3.2.2 Selection of friction coefficient In this stamping design of automobile rear wheel cover, selection of blank holder force 1500KN,two friction coefficients, 0.13, 0.15, were selected, to analyze the influence of friction coefficient on the stamping results of automobile rear wheel cover plate, two different forming results are obtained as shown in Figure 4. When the friction coefficient is 0.13, the rate of billet flowing into the bottom of the cavity is too fast, accumulation occurs at the bottom of the part, thickness increases and even wrinkles occur. With the increase of friction coefficient, when the friction coefficient increases to 0.15, the area of wrinkles is obviously reduced, but there is a risk area of tearing at the corner of the part. As can be seen from this, the greater the friction coefficient of parts is, the lower the fluidity of materials is, the fold phenomenon is obviously eliminated, but the risk of tearing rises sharply. Therefore, when the design of automotive panel with deep drawing for automotive rear wheel cover is necessary, a smaller coefficient of friction should be chosen. For the

design of the rear wheel cover of this automobile, from the above, it is concluded that the friction coefficient should be chosen between 0.13 and 0.15,because there is a risk of tension cracking when the friction coefficient is 0.15, the friction coefficient is set to be 0.14.

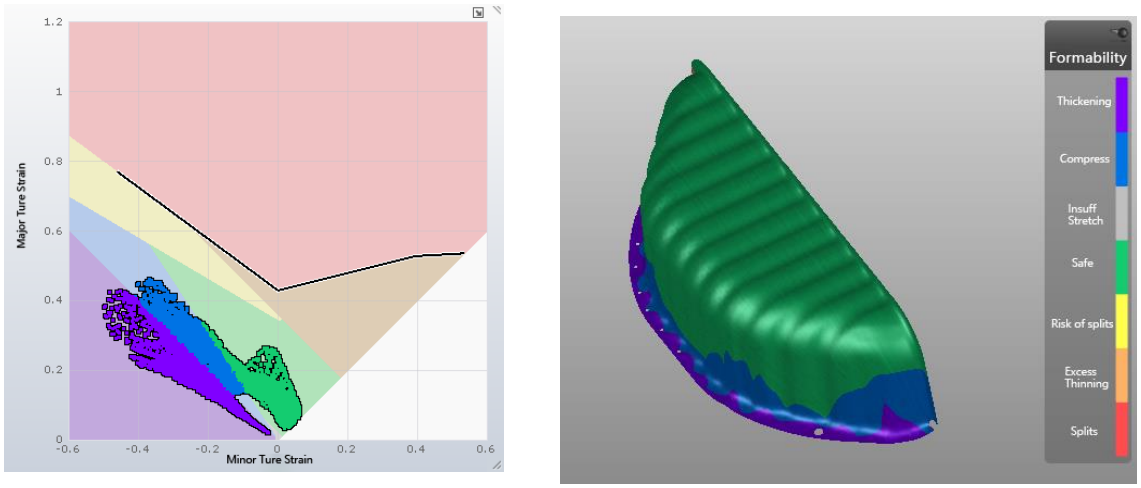


(a)0.13 (b)0.15

Figure 4. Forming simulation results corresponding to two friction coefficients

Table 4. Final simulation process parameters

Material	Material thickness (mm)	Gap between punch and die(mm)	Friction coefficient	Blank holder force(KN)	Stamping speed(mm/s)	Drawing method
DC04	1.5	1.5	0.14	1500	1000	Single action deep drawing



(a)Forming simulation diagram (b)Forming limit diagram

Figure 5. Final simulation result

3.3 Final forming result

Through the above simulation experiments, and the analysis was carried out many times, through comparison, get the best forming effect, the simulation parameters and process parameters are set as Table 4. Finally, the forming simulation diagram and the forming limit diagram as shown in Figure 5 are obtained.

4. Summary

The influence of the above factors on the drawing process is determined by means of comparative experiments, the optimum blank shape and process parameters were determined, and the expected simulation results are achieved, it has a strong reference value for the actual production of this part. Through comparative tests on the selection of blank holder force, friction coefficient, the influence of these factors on the drawing process of rear wheel cover plate is analyzed. Finally, the material of DC04 sheet which is 1.5mm is determined to be used in stamping the rear wheel cover plate of this automobile, the gap between punch and die is 1.5mm, friction coefficient is 0.14, blank holder force is 1500KN, stamping speed is 1000mm/s, single-action drawing die is adopted in drawing mode. Research results of this paper, in addition, it has guiding significance for the optimization of stamping process of automobile rear wheel cover plate, it also has certain reference value for the improvement of stamping process of other symmetrical deep drawing parts.

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