Numerical analysis of automobile front floor forming

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Abstract. In this paper, DYNAFORM software was used to simulate and analyze the stamping and forming process of automobile front floor parts. In addition, through ETA post-processing software, the animation simulation of the front floor forming process, the forming limit diagram (FLD), the change of thinning rate and the flow of materials are obtained, according to the law of change, some parameters are adjusted to obtain the optimal results. Three groups of subjects were set up: blank holder force, blank shape and draw bead, by controlling the material and the friction coefficient and other parameters are the same, respectively to compare the result of the experiment data, to get the best forming solution. Through DYNAFORM simulation and analysis, the overall forming effect of automobile front floor parts is the best under the scheme of 240 tons of blank holder force, rectangular blank shape and sectionalized sectional draw bead.

1. Research background
With the rapid development of era, the rapid development of science and technology, the cars have already become important in human life and the work of transportation, as an important pillar of all countries - car industry, but also represents the strength of the comprehensive national strength, because the auto industry development involving machinery, materials, electronics, materials, chips, electronic control, such as a wide range, and in the auto industry, the manufacture of automobile covering parts is very important. Most of automobile cover parts are large sheet and complex shape cover parts. Through stamping technology and numerical simulation, it is the key in the process of sheet metal stamping.

The distribution of stress and strain is intricate and complex, which is a complex drawing forming process. The simulation technology of auto cover stamping has great advantages, which greatly improves the surface quality of parts, effectively reduces the material usage rate and reduces the manufacturing cycle of parts. Stamping forming simulation with several important parameters, including grid density, sheet shape, draw bead setting, blank-holder force and other factors, thus to achieve quality better stamping simulation results that guarantee, then through ETA post-processing software to numerical simulation of car before the floor, can better get to the good simulation results, which are widely applied to the industrial design and manufacture, and to provide the reference scheme.
2. The drawing forming process of a car front floor

The length of the front floor of the car is 2150mm, the width is 1620mm and the maximum height is 108mm. There is a certain height difference at both ends of the parts. As the material thickness of this part is 0.7mm and the dimension of length and width is 2150 1620, it belongs to complex large deformation forming. This part is completed together by four processes of drawing, trimming, shaping and flanging. Using CATIA and UG software to build a physical model of the front floor of the car, as shown in figure 1, the file that will build a physical model is preserved in the "*.igs" format.

![Figure 1. Detail drawing of car front floor.](image)

The model of automobile front floor is the finite element model. In layman's terms, the more dense the grid, the more accurate the calculations will be, and the larger the scale of the calculation, and therefore the grid will be divided according to the actual production requirement.

Blank shape and size of the car floor single action before an important impact factor in forming process, generally speaking, only need a car before the surface of the floor area and the area of the blank are equal, but because of the parts are space geometry, the area is difficult to accurately calculate the parts, so be realistic and calculation accuracy, according to this part, three blank grid design, research, first by using CATIA software to design three kinds of sheet metal line, import respectively, and then respectively set up sheet metal grid. The first is a rectangle (2150mm long and 1620mm wide), and the second is an opposite shape as shown in figure 2.

![Figure 2. Special shape size.](image)

In sheet metal forming, the material fluidity is the decisive factor of the quality of deep drawing parts. In order to ensure uniform deformation of the material during the deformation process, it is necessary to increase the resistance setting in the area where the material is easy to flow and reduce the resistance setting in the area where the material is difficult to flow. In order to improve the tension of sheet forming process, it is necessary to set up draw tendons reasonably, so as to improve the mechanical deformation of each point of sheet forming. In the large and complex stamping of drawing parts, the setting of drawing bar is helpful to control the pressing surface effectively and plays a very...
important role. In the analysis of the drawing forming of the front floor of the car in this paper, two sets of conditions of the integral drawing tendons and sectional drawing tendons are respectively set (drawing tendons are on the blank ring).

In this paper, the car front floor parts are made of BUFD cold-rolled steel plate with a thickness of 0.7mm.

3. The forming schemes
Other parameters are set through sheet forming function, as shown in table 1.

| Process                  | Tool reference surface | Coefficient of friction | Stamping speed | Forming force |
|--------------------------|------------------------|-------------------------|----------------|---------------|
| Single-acting forming    | Upper die              | 0.15                    | 2000m/s        | 1000 tons     |

In order to get satisfactory results, three variables are used in front floor stamping. So set up three options, as shown below:

The first one takes the size of the blank holder force as the object of study, adopts the integral tensile reinforcement, the shape of rectangular blank, and adopts BUFD and other parameters.

The second one takes the blank shape as the research object, adopts the integral tensile reinforcement, 240 tons of edge pressing force, and adopts BUFD and other parameters.

The third kind takes draw bead as the object of study, adopts the shape of rectangular blank, 240 tons of edge pressing force, and adopts BUFD and other parameters.

4. Analysis of automobile front floor test data

4.1. Analysis of blanking force experimental data
The setting of increased edge force is 100T, 120T, 140T, 160T, 180T, 200T, 220T, 240T, 260T, 280T and 300T respectively, as shown in the figure 3, to study the effect of edge force on drawing forming performance respectively.

![Figure 3. The forming conditions of different belling forces.](image-url)
According to the results, in the 240 tons of edge forming force, there is the least wrinkling, no cracking in the middle part, the least unformed area, the best overall shaping effect, and the least wrinkling. Therefore, 240 tons of edge forming force is the best solution in the drawing process of automobile front floor.

4.2. Analysis of blank shape experimental data
Plan 2 takes the shape of blank as the object of study, adopts the integral draw bead, 240 tons of edge pressing force, selects BUFD and other parameters of the material unchanged, and the shape of blank is divided into rectangle and opposite.

![Figure 4. The forming conditions of different belling forces.](image)

It is shown in the figure 4 that under the condition that 240 tons of blank shape is different, the whole sheet is fully formed, but there are a few wrinkles in the middle, and there are problems of tension cracks around. However, on the flange ring, the shaped flange ring appears serious wrinkle or even distortion, but the overall forming effect of sheet material is basically the same.

On the whole, the difference in shape of blank has little influence on the reduction rate, which is 34% of the maximum reduction rate of rectangle, and 35.8% of the maximum reduction rate of opposite-sex. Meanwhile, the maximum flow rate of opposite-sex sheet is lower than that of rectangle, which is due to the large size of opposite-sex blank, but has little influence on the overall forming effect. In summary, the overall effect of rectangular and anisotropic blank shape is not significant. However, in order to save the material and the possibility of simple processing of blank bar and reduce forming time, it is better to choose rectangular blank shape.

4.3. Analysis of draw bead experimental data
The Plan 3 takes draw bead as the object of study, adopts the shape of rectangular blank, 240 tons of edge pressing force, and adopts BUFD and other parameters.
Figure 5. The forming conditions of different draw bead.

It is shown in the figure 5 that the maximum thinning ratio of the integral type was 34%, and the maximum thinning ratio of the sectional type was 33.6%, which all met the thinning ratio of less than 35%. At the same time, the maximum flow rate of slab is larger than that of slab, which indicates that the sheet flow is sufficient. In the case of the integral tensile reinforcement and the sectional tensile reinforcement, the integral tensile reinforcement crumples and cracks at the edge of the sheet material, which does not meet the forming requirements. Causes above, because before the car floor covering parts shape is complex, monolithic draw bead situation that is not reasonable to improve the flow of the sheet metal parts, so the solution is the improvement of the reasonable draw bead resistance, change of draw bead layout, by the integral change for sectional draw bead, so as to change the material in the flow of the concave die situation, optimize the draw bead resistance distribution. Therefore, when the sectional drawing tendons are formed on the front floor of automobile, the sheet material flow is sufficient, and there is basically no cracking and wrinkling. The overall forming performance is good, and the forming quality is ideal, which meets certain dimensional accuracy and surface quality. Therefore, the manufacturing process can be further optimized.

5. Conclusion
In this paper, according to the modeling characteristics of automobile front floor parts, the simulation was carried out through the DYNAFORM software and the analysis of the experimental data of three schemes was carried out, and it was concluded that in the case of 240 tons of edge force and rectangular blank shape, the sectional drawing tendons were better than the integral drawing tendons, and the forming surface quality of automobile front floor parts was better.

In the process of gradually increasing the edge pressing force, in the drawing forming process of automobile front floor parts, the wrinkling gradually decreases and the forming effect becomes better and better, but the trend of tension cracking becomes more and more obvious. Blanking force in 100 tons to 220 tons of plate flow not composition, has occurred wrinkle, in 220 tons to 300 tons of plate
flow more sufficient, wrinkle reduction, forming effect, so the choice of the blanking force should be in 220 to 300 tons.

The change of blank shape has no obvious influence on forming effect. The larger the size of blank, the more likely it is to wrinkle and twist, and the waste of materials is easy to be caused. However, the rectangular and anisotropic shapes of this paper have little influence on sheet forming. In order to save economic Angle, the rectangular blank is selected for easy processing.

The setting of draw tendons has a greater influence on drawing forming. The greater the strength of draw tendons, the more resistance to feed will increase, and it is a decisive factor for the flow of materials. The integral-type drawbead is easy to break around the floor in front of the car, and the piece-type drawbead can effectively reduce the feed resistance around the sheet metal, thus making the sheet metal forming effect good, so the piece-type drawbead is optimal.

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