The Stamping Springback Compensation Technology Study for An Auto B Pillar

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Abstract: The stamping spring back problem of a sheet metal is always a difficult point to solve in production, and it also becomes a hot issue in academic circle. This paper introduced a method to reduce the springback deformation of an auto B pillar. A Handy Scanner was used to acquire the points cloud datum of a drawn B pillar; afterwards, all surfaces of this part were reconstructed in the Geomagic Studio software, taking advantage of this datum. Consequently, the dimension difference between the reconstruction and primitive numerical model was obtained by using the Geomagic Qualify Probe software, and it was the springback value of this auto B pillar after drawn. To reduce the springback value of this part, according to the positions presenting springback maximum, some offset dimensions on stamping die surfaces were compensated. Finally, DYNAFORM software was used to simulate the forming process with the improved die, to analyse the improved springback results of this part. The result shows this method is effective to reduce springback.

1 INTRODUCTION

The forming precision is an important indicator to the qualification of a stamping part, and it is badly influenced by the spring back problem. In realistic stamping production, the spring back of a sheet metal is always difficult to predict and solve. To reduce the spring back of a sheet metal, many researchers have been doing a great deal of work. Luc Papeleux, Jean- Philippe Ponthot[1] detailedly studied several parameters' influence on spring back with FEA method, including BHF(blank holder force), friction, spatial integration, time integration scheme and constitutive laws, using a 2D U-draw bending case. Michael Krinniger, Daniel Opritescu[2] et al. studied the influence to the springback behaviour with different bending parameters, punch velocity and materials by some experimental investigation, and they developed an extendable metal model, then they advised that we should consider these factors' influence to spring back in the design process, so that we obtained a sheet metal with enough dimensional accuracy. L. Komgrit, H. Hamasaki[3] et al. introduced a new technology to eliminate spring back, they pushed up the bottom of the sheet metal with a counter punch, and they testified their method by experiment and simulation; H. Naceur, Y.Q. Guo[4] et al. introduced a method in order to reduce the springback effects by optimizing the geometry of tools in sheet metal forming, they made optimized design to tools' radii, thickness distribution and material parameters according to a new response surface method and their experiment. Finally, they validated their results by using STAMPACK and ABQUS software.

With the progression of science and technology, nowadays we can use Reverse Engineering to acquire exact difference between the end product and primitive numerical model, and we also can use CAE technology to simulate stamping process, and analyse the springback of an end product. These new techniques break a new path to solve this problem.

The B pillar is a main part supporting a car's body structure, meanwhile, it bearing the pressure from the front door and rear door, so it must has sufficient strength and stiffness. The B pillar has a complicated surface construction, it's manufacturing processes including drawing, triming, reshaping and punching, among which the drawing process has an important influence on its' final forming precision. Aiming at a whole car having more light weight, this B pillar was made of high strength steel, which allowed much less thickness to ensure sufficient mehcanical properties, and in this case the thickness of part was 1mm. The parameters of the material of this B pillar was illustrated as follow table:

Table 1: Mechanical Properties of Material.

Metal Grade	Density [Kg/mm^3]	Young's Modulus [Mpa]	Hardening Exponent	σ_b [MPa]	σ_s [Mpa]
HC350 /600CP	$7.8X10^{-6}$	$2.1X10^5$	0.18	600	350

2 SPRINGBACK DETECTION

2.1 Part Drawn Numerical Modelling

After the B pillar was manufactured in drawing process, a stamping springback would occur in some locals of this part. Springback is an inevitable phenomenon in forming process, and it directly influences dimensional precision and final shape of a sheet metal [5]. Springback causes difference in dimension between the final product and the primitive numerical model designed by engineer. To acquire this difference value, we can use Reverse Engineering Technology. Handy Scanner is a device which is in common use in optical scanning field. In this study case, we used a handy scanner whose type was Handy Scan 700, its resolution ratio running up to 0.05mm, and maximum precision was 0.030mm. After some adjusting and pre-processing work was done, we used this instrument to scan the drawn part. Our site work was shown as follow:

Figure 1: Using Handy Scan 700 to scan a drawn part.

Then we used this points cloud datum acquired from Handy Scan 700 to reconstruct a numerical geometric model of the drawn B pillar in the reverse modelling software, Geomagic Studio. The following drawing was the reconstructed model.

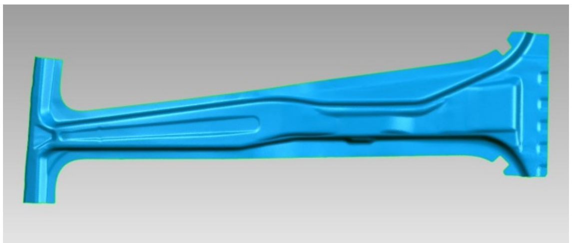

Figure 2: The reconstructed model of a drawn part.

2.2 Springback Detection

In this section, we used the Geomagic Qualify Probe software, to detect the difference between the drawn model and the primitive numerical model. Inputting the both numerical models into this software, the primitive model as reference model and the reconstructed model as test model, aligning these two models, clicking 3D contrasting menu, we can obtain the difference value in dimension as the following figure.

From this figure, we can observe the maximum differences was +3.64mm and minimum -5.21mm, representing the springback values were 3.64mm and 5.21mm on the local positions, and Geomagic Qulify Probe already marked the positions by two highlight points. Additionally, we also can see most of the difference values be from -1.91mm to 1.91mm, the average dimensional difference of these two models was ±0.66mm, and the standard deviation was 0.87mm, so these deviations were acceptable in general. The next work was to reduce the oversize deviations by some means.

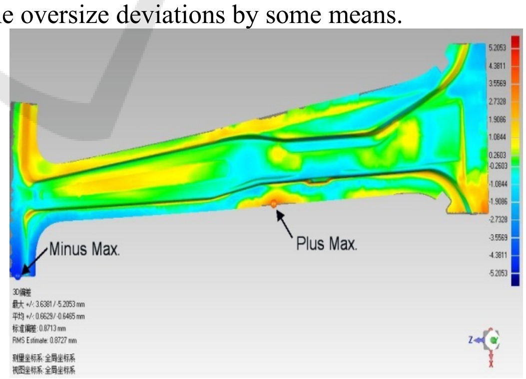

Figure 3: Springback value contour.

3 SPRINGBACK COMPENSATION

3.1 Springback Value Quantization

Using Geomagic Qualify Probe to make some sections crossing the local positions in which the maximum springback and oversize springback were located, we got some section boundary lines from the reference model, and some points around these lines from the test model. Along each of these section boundary lines we selected some reference points from the test model, then projecting these points to the section line along the line's normal direction, we can obtain the crossover points on the section boundary lines; dimensioning the distance from each point to the opposite crossover point, we can obtain the springback value of each point on the primitive geometry model designed by engineer. The springback plus maximum and minus maximum sections were shown by the following graph:

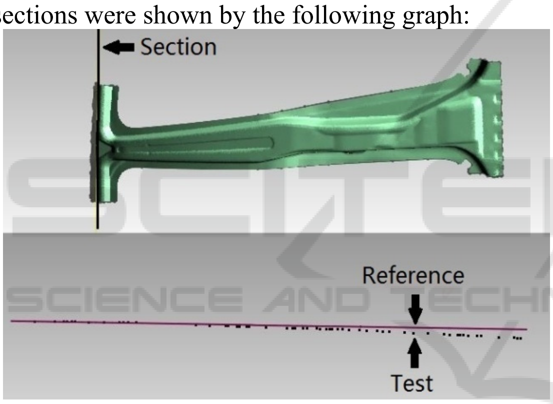

Figure 4: Springback plus maximum section.

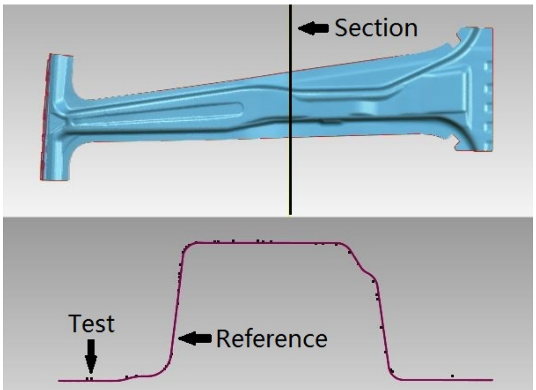

Figure 5: Springback minus maximum section.

3.2 Die Profile Compensation

From the above several chapters, we already obtained the actual precise difference values in dimension between the primitive geometry model and the drawn model, to compensate these difference values, in this paper we adopted one method which changed the molded surfaces of the die and punch. According to the springback value of each point, we changed these points position to the reverse side of the section boundary, in other words, we giving two times of difference value along the normal direction of the section line to compensate springback value. Based the original model and these changed points, we can generate a new model whose surfaces were renewed with springback compensated points, and this model constituted the new die. By using the CATIA software, inputting the original model and carrying out the same operations, assigning the original model as the entity to be changed, selecting the generated line from those compensated points as target entities, on condition that all curves were continuous by its' tangents, taking advantage of the function of CATIA which reconstructs surfaces from fitting NURBS curves, subsequently, we got the new die whose surfaces can offset the springback.

The section boundary lines cut from primitive model and compensated model were compared as following graph:

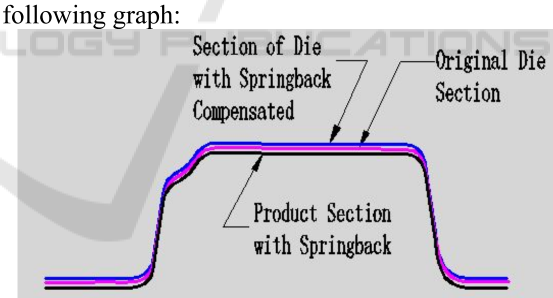

Figure 6: Die profile reconstructed with Springback compensation by CATIA software.

4 COMPENSATION EFFCT TEST

4.1 Simulation Model Establishment

We had obtained the compensated die model in CATIA, and the next work was to test whether our improvement to the die was effective, and whether the springback of the B pillar drawn from a drawing die was reduced to meet our expectation. All these work would done in the DYNAFORM software, which took a simulation to the forming process.

In CATIA, we saved the compensated die surface as *.igs format, inputting this *.igs file to the software DYNAFORM, off seting this shell model with a distance equal to the thickness of a blank, so we got the punch shell model; meanwhile we extracted surfaces from the blank and blank holder in their primitive solid structures to save as *.igs format files, also inputting these files to DYNAFORM as the blank and blank holder shell models, meshing and positioning these shell models including die, punch, blank, blank holder, the established models in DYNAFORM as following :

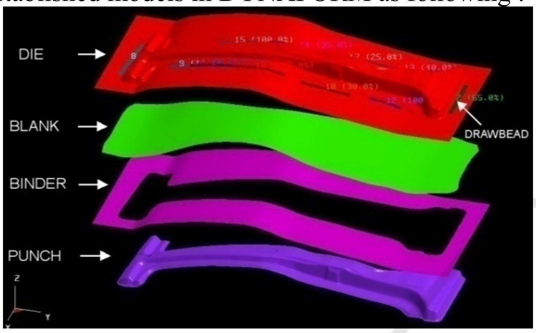

Figure 7: Dynaform simulation models.

4.2 Forming Simulation

4.2.1 Simulation Process Parameters

According to the practical condition, we set some process parameters in drawing simulation process as following table:

Table 2: Simulation Process Parameters.

Analysis Type	Blank Thickness [mm]	Friction Coeffecient	Stamping Velocity [mm/s]	Blank holder Pressure [t]	Termination Gap[mm]
Crash Form	1	1.25	2000	50	1.1

4.2.2 Simulation Results

After simulation completed, we used the postprocessor module of DYNAFORM to open *.d3plot file generated to observe forming results. The following figure was the FLD (Forming Limit Diagram) of the B pillar, and from this FLD we can see the forming properties be good in general, there being no crack and serve wrinkle happened on the B pillar surface, most of its surface being in sufficient drawing state, a small quantity of crack which happened on the border of this B pillar would be trimmed in later process, having no influence to the whole forming quality. In brief, the whole forming was well distributed, and the drawing process was qualified.

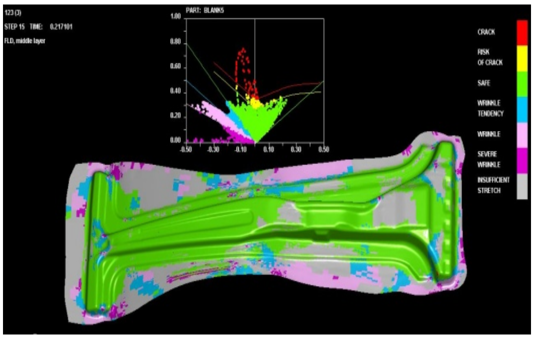

Figure 8: FLD of the B pillar drawing simulation.

4.3 Springback Analysis Based on Die Dimension Compensated

The purpose of all work above was to decrease the springback of the B pillar by changing die molded surface, and whether our purpose would achieve can be confirmed though using springback analysis module in DYNAFORM software. Dynaform simulates forming process with dynamic explicit algorithm and calculates springback process with static implicit algorithm, ensuring calculating efficiency in simulation and calculating precision in springback analysis [6]. Inputting the *.dynain file generated with drawing simulation above to DYNAFORM, after setting all parameters related with analysis, submitting mission to solver to calculate. After DYNAFORM solver finished this mission, we can open *.d3plot file to see analysis results in DYNAFORM postprocessor. The results contained two frames *.d3plot files, one was the starting model and the other was the model with springback. Exporting each frame result file, we obtained numerical model of each frame. The springback was the difference between the starting model and the springback model. We also used Geomagic Qualify Probe to compare the different value between the two models. The springback results which located the springback maximum and minimum positions were displayed with highlighted points as following figure. The difference values were displayed in the meanwhile.

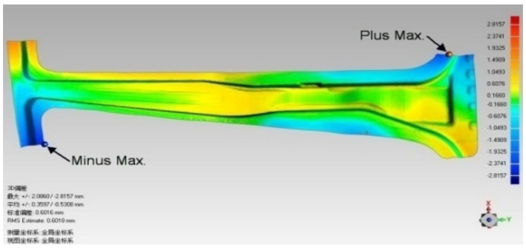

Figure 9: Springback of a B pillar stamped by an improved die.

From this figure above, we can recognize the maximum springback value was +2.09mm and the minimum was -2.82mm, which were largely reduced, compared with the original springback values which were +3.64mm and -5.21mm. Additionally, we also can see most of the difference values locate in the interval from -1.05mm to 1.05mm, the average dimensional difference of these two models was changed to be ±0.53mm, and the standard deviation was 0.60mm; That was to say, all deviations were reduced in some extent, so the analysis results supported our improving work to be effective.

5 CONCLUSIONS

Taking a comprehensive survey on our whole work in this paper, we introduced a systematic method to reduce springback of a car B pillar, and we used optical scanner, HandyScan 700, to obtain points datum of a drawn B pillar, contrasting difference between the points datum and primitive model in Geomagic Qualify Probe to obtain springback values; According to these springback values, we changed die surface with a compensation value in CATIA; Afterwards, we used DYNAFORM to simulate the drawing process with the reconstructed die model, and analysed the springback of the B pillar which stamped with new die and punch whose surfaces were compensated. The results confirmed that our improving work to die was effective. This method solves the problem which is difficult to predict and measure the springback of a final sheet metal, so it can be valuable in some engineering projects.

Because of the springback phenomenon, the dimensional precision of a car B pillar is very difficult to ensure; To obtain a qualified B pillar, the traditional method to debug press tools mainly depends on the experience of a bench worker. In that case, the workload of the worker is very heavy; moreover, it takes the worker enormous amount of time to find where the press tools must be modified, so that the traditional method lengthens the cycle of press tools' development and manufacturing. By using our method introduced in this paper, we can accurately find where the press tools should be modified with a high efficiency, so it can shorten press tools debugging cycle; Besides this, as the case mentioned in this paper, we decreased the average deviation value of the B pillar from 0.66mm to 0.53mm, so the results also satisfied us, thus it can enhance the forming qualification and precision of a sheet metal.

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