Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 14, No. 1, 2025

Analysis of Plate Forming Process Based on Dynaform

Guangpu Hu[1], Xia Liu[2]

[1]School of Mechanical Engineering, Tianjin University of Technology and Education, Tianjin, 300222, China
[2]Hebei Locomotiver Technician College, Hebei, 063000, China

Abstract: By analyzing the structural characteristics of the product, it is determined that the main body of the plate needs to be processed by drawing, and the features around the plate have a large flanging angle, which requires two flanging operations to complete. The final forming process for the plate is determined to be:deep drawing,blanking, single flanging, and secondary flanging. According to the forming principle, 3D software is used to model the analysis models of each, and the mold structure is preliminarily determined. The Dynaform software is used to analyze the plate forming process, to check the FLD diagram and material thickness distribution diagram, and to analyze the possible locations of cracks and wrinkles during the forming process. The causes of defects at different locations are analyzed, and by the analysis model multiple times and adjusting the forming process parameters, reasonable forming parameters and mold structures are obtained, which effectively reduce the risk of cracks and wrinkles during the process, providing a reference for mold design and prevention of production defects.

Keywords: Dynaform, Deep drawing, Flanging, Forming process.

1. Introduction

The dinner plate is a commonly used tableware. In the production process, it is essential to ensure that the dinner plate meets the usage requirements while to the visual and tactile senses of the users. Therefore, during production, it is necessary to minimize the defects of cracking and wrinkling that may occur during the process, thereby ensuring the overall quality of the dinner plate. Through finite element analysis, the forming process can be accurately simulated, and the potential locations of defects can predicted in advance, allowing for early prevention. This also helps in preliminarily determining the corresponding structure and parameters in the mold forming process.

2. Product Analysis

According to the performance requirements, the material of the plate is selected as AISI304, with a thickness of 1mm, which good corrosion resistance, heat resistance, good mechanical properties, and good stamping and bending processing properties[1].

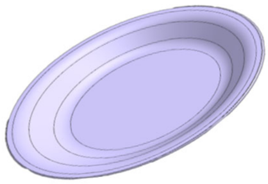


Figure 1. Front side of the plate

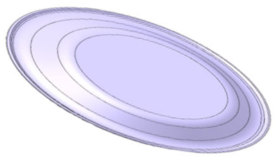


Figure 2. Back side of the plate

As shown in Figures 1 and 2, the dinner plate is a shallow drawn cylindrical part, and its front appearance reflects its quality. The back of the plate has a circular flange feature at the edge, which is prone to wrinkling during production, affecting the overall quality.

3. Plate Pressing Process

The dinner plate is a shallow cylindrical part that requires deep drawing to achieve its initial shape. After the deep drawing process, excess material will appear on both, which needs to be trimmed. Due to the large flanging angle, it is difficult to achieve the desired shape in one operation in the mold. Therefore, flanging process is carried out in two stages[2].

Through analysis, the formation of the plate is completed in four steps: deep drawing, blanking, single flanging, and secondary flanging, as shown Figure 3.

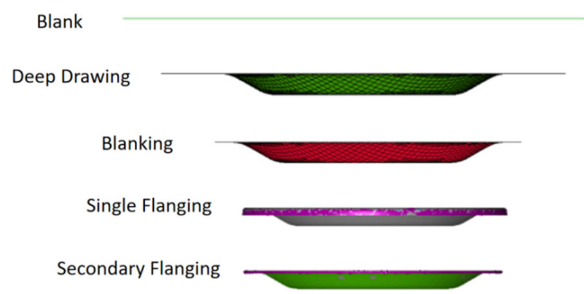


Figure 3. Plate pressing process

4. Finite Element Analysis of Tableware Forming Process

DYNAFORM software, jointly developed by ETA and LSTC companies in the USA, is a specialized software for numerical simulation of sheet metal forming, of simulating various complex issues in sheet metal forming. The stamping forming process of the dinner plate was simulated using Dynaform software[3],Predicting the forming problems of different processes, optimizing the forming parameters and mold structure.

4.1. Analysis of Drawing Process

Import the IGES file of the mold structure model into the software and carry out preliminary settings. Pay attention to the reasonable division of the mesh size, check for overlaps, sharp corners, and voids to avoid affecting the analysis results. After setting the parameters through the quick setup method, submit the solution and check results[4].After multiple rounds of finite element analysis and optimization, the Dynaform deep drawing process die structure is shown in Figure 4. The deep drawing process an inverted die structure and employs an upper ejection method. The punch speed is 4000mm/s, the blank holder force is 75000N, and other parameters are set to system defaults. The analysis results are as follows:

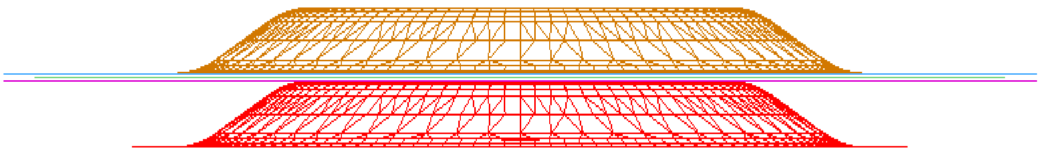


Figure 4. Dynaform deep drawing process mould structure

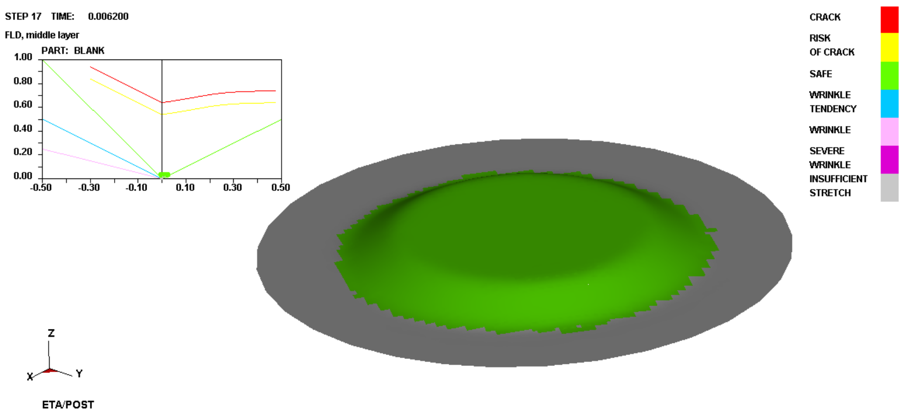
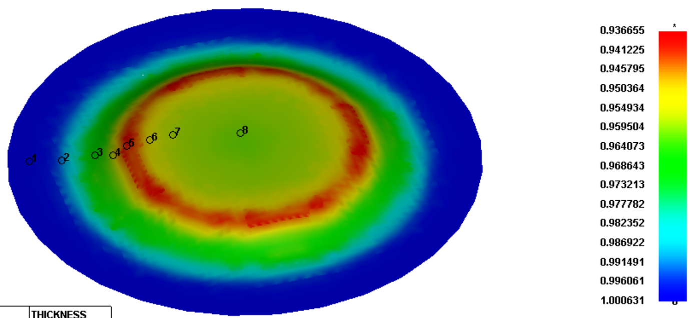


Figure 5. FLD diagram



Index	NodeID	THICKNESS
1	1842	1.000102
2	4421	0.991805
3	1874	0.967435
4	1904	0.955915
5	1905	0.940645
6	6855	0.951946
7	1908	0.957767
8	1941	0.960481

Figure 6. Thickness distribution map

As shown in Figure 5 and Figure 6, the entire deep drawing area of the material is green, indicating a safe region. The material thickness the bottom fillet of the deep drawing is the smallest, approximately 0.936mm, with a low thinning rate, making the possibility of extremely small. The flange areas are all gray, with a maximum material thickness of approximately 1.001mm, and the risk of wrinkling is extremely. Comprehensive analysis shows that the drawing process is reliable.

4.2. Analysis of Blanking Process

The Dynain file for the drawing is trimmed, retaining the internal parting line, and then calculated. The untrimmed effect is shown in Figure7 , where the red is the formed part after drawing, and the gray is the parting line. The effect after trimming is shown in Figure 8, which the initial piece for the single flanging. The Dynanform software is unable to simulate the punching process and can only simulate the punching effect, providing an initial piece for the next process.

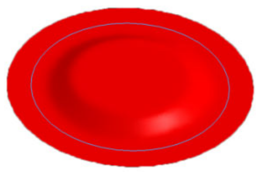


Figure 7. Blanking line

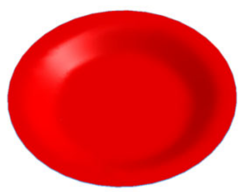


Figure 8. Blanking effect

4.3. Analysis of the Single Flanging Process

The IGES file of the die structure model was imported into the software, with initial settings carried out, including mesh division and inspection. The traditional method was used to define the tools: die, blank, binder, punch, as well as the motion curves of the concave die and the blank holder. solution was then submitted, and the results were reviewed. After multiple simulations and optimizations, the optimized single flanging die structure, as shown in Figure 9, adopts an elastic unloading and top ejection method. After optimization, the concave die stamping speed is 400mm/s, the clamping force is 200000N, and the pressure ring stroke is 10mm, while other parameters default. The analysis results are as follows:

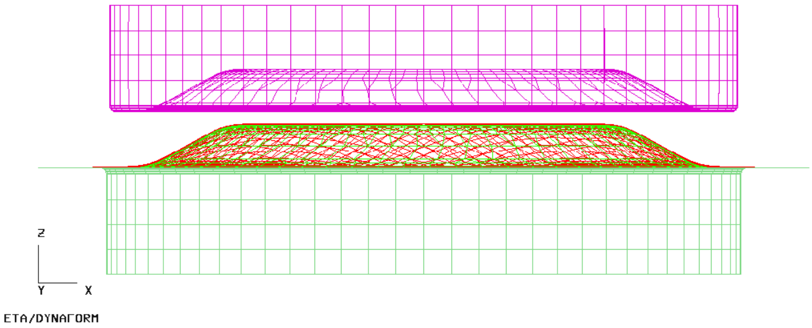


Figure 9. The initial flanging die structure in Dynaform

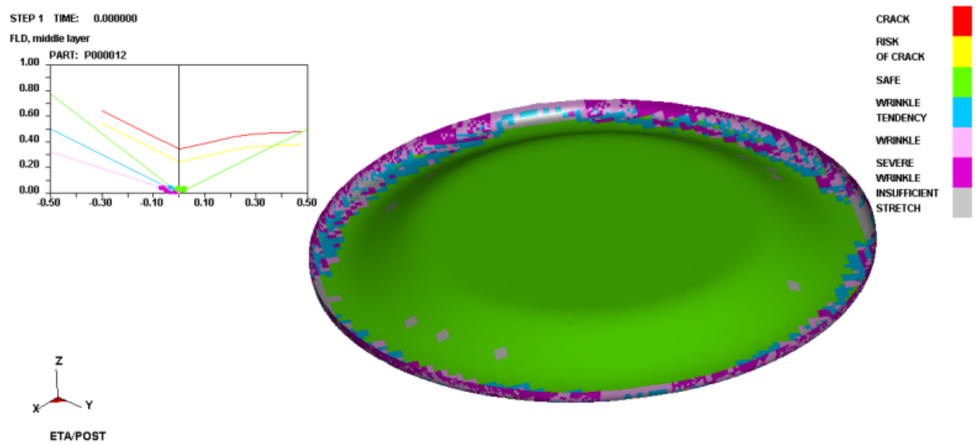
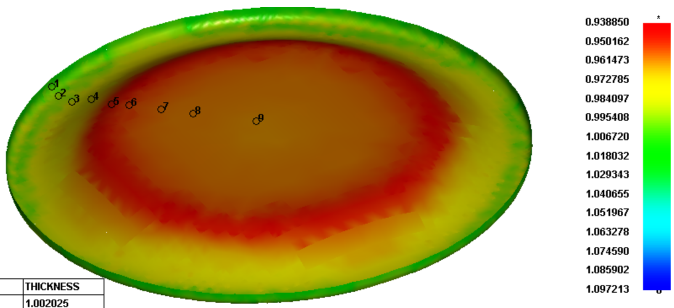


Figure 10.FLD diagram



Index	NodeID	THICKNESS
1	143303	1.002025
2	141763	0.992400
3	125790	0.986900
4	128353	0.974150
5	141254	0.947250
6	125893	0.954250
7	125921	0.958500
8	125950	0.960275
9	126010	0.962275

Figure 11. Thickness distribution map

As shown in Figures 10 and 11, after single flanging operation, the flanged area of the material predominantly appears purple, with pink and gray portions. The material thickness is approximately 1.041mm, and there are slight wrinkles, which are common defects in the flanging[5].The minimum thickness of the flange is approximately 0.984mm, with an extremely low risk of rupture. In other areas, there no significant change in thickness since they do not participate in the work. Comprehensive analysis shows that the mold structure and forming parameters of the single flanging operation are reasonable, ensuring reliable forming and achieving good results.

4.4. Analysis of the Secondary Flanging Process

The analysis method for the secondary flanging process is similar to that of the single flanging process. The dynain file model after the single flanging is imported, and the traditional setup method is used to define the tool die, blank, binder, punch, as well as the motion curves of the concave die and the blank holder. solution was then submitted, and the results were reviewed. Through multiple simulations and optimizations, the structure of the secondary flanging die is shown Figure 12. The secondary flanging process uses a double-action die structure. After optimization, the punching speed of the concave die is 400mm/s, and the die stroke is 99.8mm. The pressure ring stroke is 39.9mm, and the pressure force is 200000N, while other parameters are set to default. The analysis results are as follows:

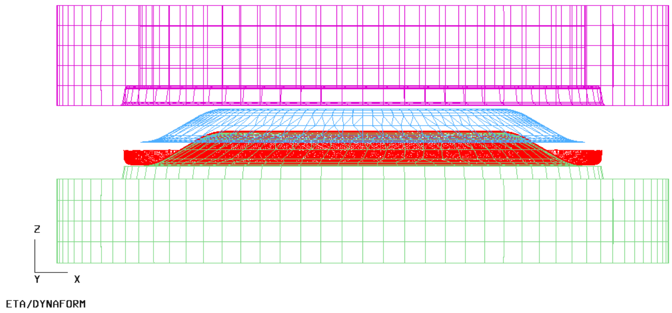


Figure 12. The structure of the secondary flanging die in Dynaform

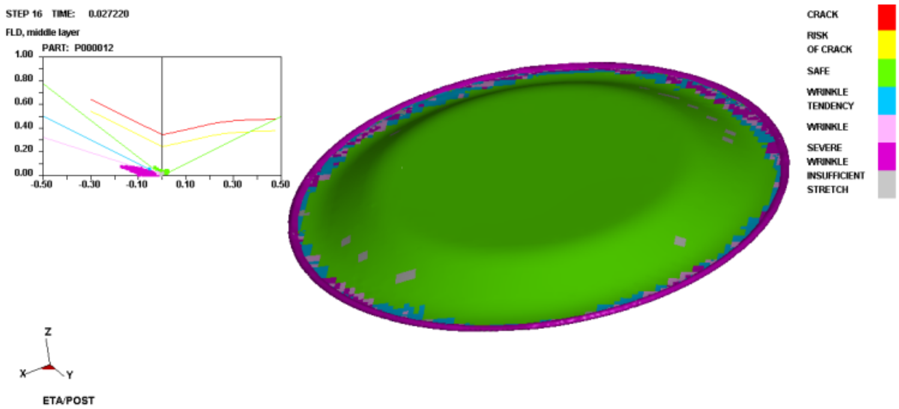
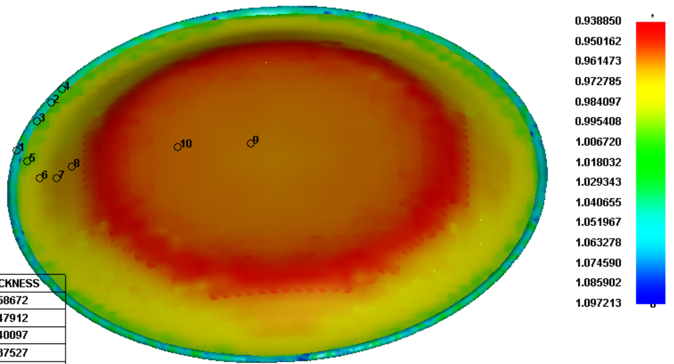


Figure 13. FLD diagram



Index	NodeID	THICKNESS
1	139197	1.058672
2	143622	1.047912
3	145484	1.040097
4	142143	1.037527
5	128530	0.997871
6	168962	0.972306
7	168737	0.968179
8	162159	0.964850
9	126009	0.962183
10	126006	0.959718

Figure 14. Thickness distribution map

As shown in Figures 13 and 14, after the secondary flanging, the flanged parts of the material are mainly purple and dark, with a small amount of pink and gray. The maximum thickness of the material is approximately 1.097 mm, and the minimum thickness at theanged parts is about 1.029 mm. There will be very small wrinkles, but there is no risk of rupture, and the non-flanged do not change significantly. Comprehensive analysis shows that the structure of the secondary flanging die is reasonable and the forming effect is good.

5. Conclusion

In the deep drawing process, increasing the blank holding force appropriately can effectively improve the wrinkling defect[6].By increasing the fillet radius at the draw opening and reducing friction at the fillet, the material flow can be improved to prevent rupture[7].The punching process cannot be simulated in Dynaform and needs to be controlled in practice to ensure the quality of the punching. For flanging, reducing flanging gap appropriately can reduce wrinkling. By analyzing the forming process of the plate, the possible locations of defects in the forming process are predicted, corresponding improvement are taken, the structure of the mold and the forming parameters are preliminarily determined, which shortens the cycle and reduces the cost of actual production[8].In actual production, on-site debugging of the mold is also required, and further optimization is carried out based on the actual situation, in order to finally produce that meet customer expectations.

References

[1] Xie Wenzhi. Study on the Mechanism of Deep Nitriding of AISI304 Austenitic Stainless Steel [D]. Southwes Jiaotong University, 2020.

[2] Pan Yuan'an, Li Pengyu, Zhang Xinhong, et al. Analysis and Optimization of Negative Angle Flanging Defect in Fenders[J]. Die & Mould Industry, 2021, 47(06): 33-36. DOI:10.16787/j.cnki.1001-2168.dmi.2021.06.06.

[3] Zeng Ruitie, Wu Yan, Xiong Jinlin, et al. Mudguard forming process based on Dyna finite element analysis [J]. Journal of Wuhan Polytechnic University, 2023, 42(01): 57-65+75.

[4] Yue Luyou, Jiang Yinfang, Chen Wei, et al. DYNAFORM-PC software and its in sheet metal stamping [J]. Journal of Jiangsu University (Natural Science Edition), 2002, (06): 51-55.

[5] Wang Yanshan. Application of Flanging Wrinkling Empirical Model in Stamping Analysis [J]. Mould Technology, 2019, (03): 53-58.

[6] Ye Pengfei, Wang Chengyong, Chen Jinhong, et al. Research on the application of non-circular holes in the plastic forming process of automobile door inner panels based on numerical simulation analysis [J]. Journal of Plasticity Engineering, 2019, 6(01): 33-39.

[7] Luo Min, Li Xiaoping, Zhang Yajun. Influence of Die Fillet on the Limit Drawing Ratio of Tantalum [J]. World Nonferrous Metals, 2018, (19): 190-191.

[8] Sun Li, Li Min. Application of Dynaform Software in Stamping Process Analysis [J]. Mould Manufacturing, 209, 19(12): 4-6.