Research on the Drawing Process Parameters of Kitchen Sink Based on Numerical Simulation

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Abstract: The finite element analysis model is established for the kitchen sink deep drawing. The drawing process was simulated and analyzed with the Dynaform. Comparing different condition simulation results with the experiment, the thinning rate, spring back for solving the sink drawing problems by finite element method has been validated. The effect of binder force on the result of simulation is also discussed. The thinning rate value would increase with the binder force increase. And, the spring back value would be the smallest if the holder force near 20KN.

1. Introduction

Kitchen sink, as one of the most widely used stainless steel sink, is deeply appreciated by most consumers for its excellent performance such as corrosion resistance, wear resistance, heat resistance, polishing performance and so on. Although stainless steel has many excellent properties, there are also negative sides for drawing, such as low drawing rate, large elastic modulus, poor tensile properties. This restriction of stainless determines that the high depth kitchen sink is difficult to form in one single forming. As today competitive business environment demands reductions in product development time and cost, the need for faster time and more efficient producing have been development. Virtual manufacturing is one of the most efficient ways of reducing the manufacturing times and improving the quality of the industrial products. Numerical simulation is a important component of the virtual manufacturing, which has a very important contribution to modern manufacturing. The finite element method is thought to be one of the most important numerical methods in the analysis of numerical simulation. Simulation of sheet metal parts forming process is considered as just suitable for predicting the deformation process and the failure modes, such as wrinkling and thinning of metal sheet[1-3].

Simulations of sheet metal parts forming process with finite element methods can improve manufacturability of the sheet metal part and obtaining vital information on optimum parts and mold design. Today, The finite element method is currently the most widely used numerical procedure for sheet metal forming. Wrinkling ,tearing and spring back are considered the main defects in deep drawing . Many researchers' efforts have been dedicated to predicting these defects' occurrence and location[4-6]. This study gives a presentation of the Kitchen sink research. During

the process of the deep drawing of the sink, the key process parameters were simulated by the software dynaform. The influence of the binder force was investigated and analyzed.

2. Analysis Process

2.1. Material

In this work, material was stainless steel SS304 sheet of 0.7 mm thickness. This steel could resist general corrosion because of higher chromium(Cr) and Nickel (Ni) content. It contain a lot of austenitic phase and small quantities of ferrite. Due to the presence of these metal phases it has excellent toughness besides higher strength. So it has excellent mechanical properties. The mechanical properties of SS304 sheet metal was listed in Table 1.

Table1: Mechanical properties of SS304.

Item	Value
Mss Density	78500
Young's Modulus(MPa)	207
Tensile Strenth(MPa)	515
Yield Strength(MPa)	205
Strain hardening exponent(MPa)	498
Poisson's Ratio	0.28
Anisotropy coefficient(R)	1.2

2.2. Drawing Model

In this simulation, the blank was placed between the die and the holder which had a gap. The punch was positioned at the bottom of the sheet with the upper plane in contact with the sheet surface as shown in Fig.1. Meanwhile, the punch was fixed. The binder which has draw bead on the surface is arranged to control the flow of the material into the die and provided with a downward holding force of fixed value. Friction coefficient between tools and blank was taken as 0.125. the load velocity of blank holder and die were 2000 mm/s. The blank holding force was 20KN during the initial drawing process. The die was moved with a velocity of 2000mm/s, in negative Z direction in order to minimize computational time and the motion was defied using a trapezoidal profile.

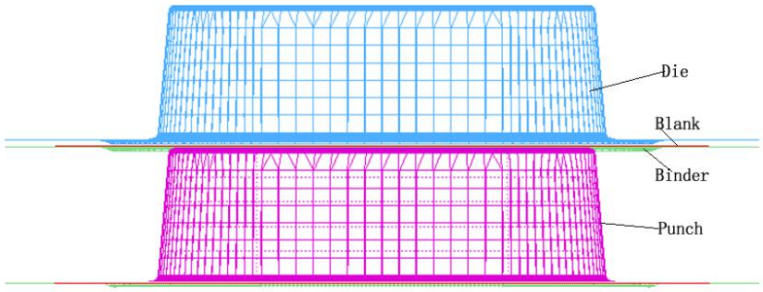

Figure 1: An assembled meshed model for metal sheet processing.

3. Results and Discussion

3.1. Forming Limit Diagram

The forming Limit Diagram is an important tool to find the limit stains at which defects occurs in sheet metal processes. It is usually corresponding between major stress and minor stress measured on the surface of deforming blanks under different load paths. It fully reflects the local forming limit of sheet metal under one way and two way tensile stress. And it is a practical tool to evaluate the forming ability of sheet metal. Adopting forming limit diagram, the stain and stress, thickness distribution, as well as force could be obtained based on the finite element model. For this purpose, the forming limit diagram of metal sheets of ss304 has been experimentally determined(shown in fig.2). Wrinkling could be observed near the part mouth because of the minor stress exceeded the instability limit of the sheet metal.

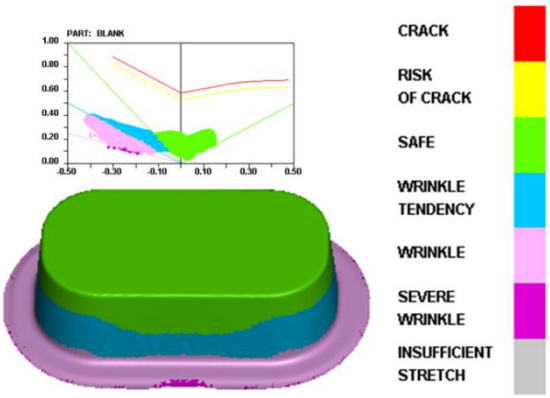

Figure 2: The forming limit diagram of kitchen sink.

3.2. Effect of Binder Force on Forming Quality and Spring Back

Finite element simulation results show that the peak binder force are the most influential process parameters affecting formability of SS304 in forming kitchen sink. Fig.3A shows the influence of binder force on maximum percent thinning rate in simulation. Maximum percentage thinning has always been appeared at the two bottom corners of sink. As the binder force was increased, more deformation occurred in the bottom corners in the final stage and hence the stress increased. So, thinning also increased and maximum percent thinning in the sink increased to nearly 40-44% for a maximum peak holder force of 40KN. According to practical experience, safe thinning rate should be less than 20%. However, the experiment results show that mouth wrinkling will be very obvious when the thinning rate is less than 26%, and fracture will occurs when the thinning rate is more than 45%. It was found that the sink quality is the best, when the binder force is between 25KN and 30KN and this part's best binder force is 27.5KN.

According to experiment, the relationship between spring back values and binder force were shown in Fig.3B. It was found that trend of resilience value exhibited a character of first rise and then drop. The spring back value is the minimum when the binder force was near 20KN. This trend is mainly caused by the change of the binder force. When the holder force increases, the stress state on the sink surface also changes. The main stress of flange near top mouth increases with the increase of binder force. It could be seen form the major stress near mouth part. Lager binder force will affect the flow of material into die, and the major stress will also increase. For this kitchen sink, control the binder force is a main method to control spring back.

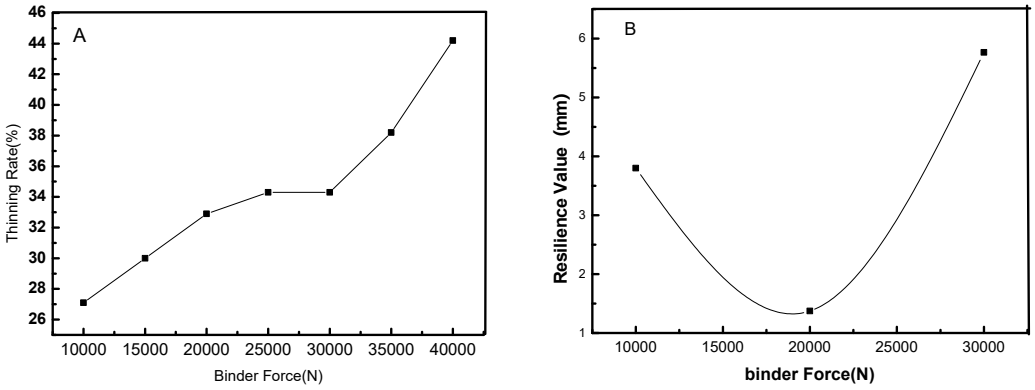

Figure 3: A.The relation graph between thinning rate and holder force. B.The relation graph between resilience value and holder force.

4. Conclusions

In this study, formability of stainless steel 304 has been investigate by finite element analysis. Deep drawing was simulated in finite element software. It was found that wrinkling mainly be observed near the part mouth because of the minor stress exceeded the instability limit of the SS304. As the binder force was increased, the thickness reduction of the sink was increased also. The experiment results show that mouth wrinkling will be very obvious when the thinning rate is less than 26%, and fracture will occurs when the thinning rate is more than 45%. When the binder force is between 25KN and 30KN and this part's best binder force is 27.5KN. the sink quality is the best.

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