Simulation Research on Deep Drawing Process of Box-Shaped Parts of 2B06-O Aluminum Alloy

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Abstract. Based on the finite element analysis software Pamstamp, the box-shaped parts deep drawing process of 2B06-O aluminum alloy is simulated analysis. By comparing die corner radius and blank holder force of the box-shaped parts, a reasonable determination of the die corner radius and blank holder force are of great significance in improving the formability.

Introduction

2B06 aluminum alloy is a high-purity version of 2A06 aluminum alloy and it belongs to Al-Cu-Mg series. Through strictly controlling impurities such as Fe and Si, the content of impurity is reduced that 2B06 aluminum alloy has a satisfied plasticity, breaking tenacity and other comprehensive performance [1]. Along with the development of lightweight formation technology, aluminum alloy has been widely applied in the fields of aerospace, aviation, automobile, etc[2].

Formation of metal plate is a deep process of materials and the method and parameter of formation have a great influence on the strength, longevity and shape of products. A long period is needed to design and develop mould as well as the difficulty to forecast the formed parts accurately have upset mould designers for a long time. It is hard to prevent defects from happening while the only approach is to utilize the current technique materials or experience and through constant mould test and mould amendment [3-4]. Along with the development of computer technology, finite element software can be applied to analyze the formation technology in advanced so as to optimize this process program.

This paper will analyze the technique of drawing formation of 2B06 aluminum alloy box-shaped pieces through Pamstamp finite element software so as to provide a positive theoretical basis for qualified parts.

Analysis on Formation Characteristics of Box-shaped Pieces

It is difficult to form box-shaped pieces and many researchers have studied the related aspects [5]. When metal plates are applied to form box-shaped pieces, the straight flange is bended and circular bead is to form cylinder. Since straight flange and circular bead are linked together that restriction must occur when drawing. In this way, the characteristics of box-shaped pieces are formed [6].

Construction of Finite Element Model

The size is 400mmX400mm. The thickness is 0.8mm. The material is 2B06-O aluminum alloy. The shape and size of finished box-shaped piece are shown as figure 1.

Catia software can conduct 3D modelling according to the actual size of box-shaped piece and convert into igs file. Finally, this model will be imported into Pamstamp software. Due to symmetry, 1/4 of this box-shaped piece will be modelled so as to save time and improve calculation efficiency. During the period of modelling, adaptive grid optimization function of this software is applied. Some parts will be optimized independently. The finite element 3D model is shown as figure 2. Parameters of 2B06-Oaluminium alloy such as mechanical property are obtained during the period of unidirectional tensile test and then input into database.

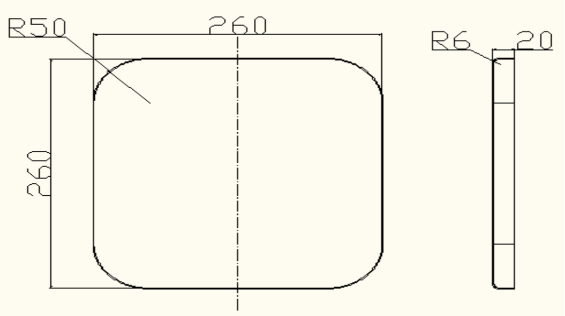


Fig.1 Structure and Size of Box-Shaped Piece

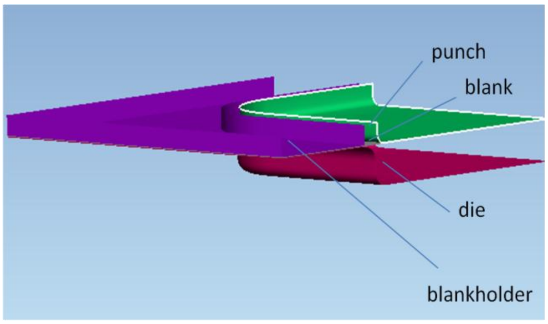
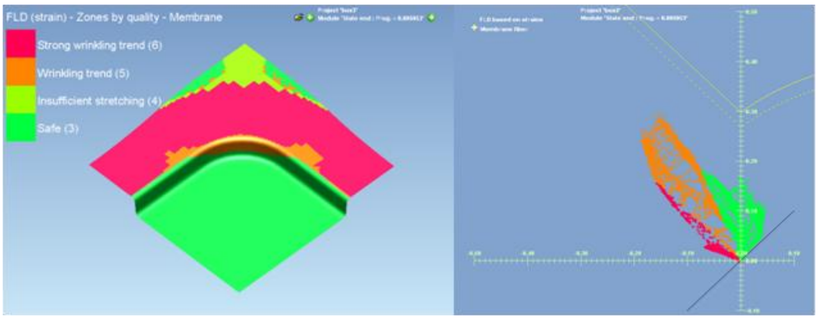


Fig. 2 Finite Element 3D Model

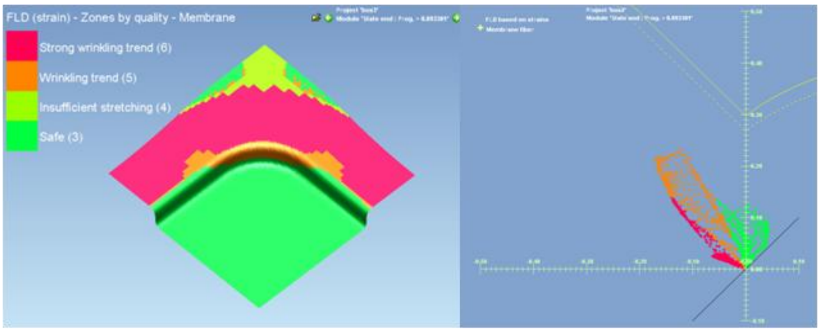
Test Plan and Analysis

Influence on Formation by Die Corner Radius

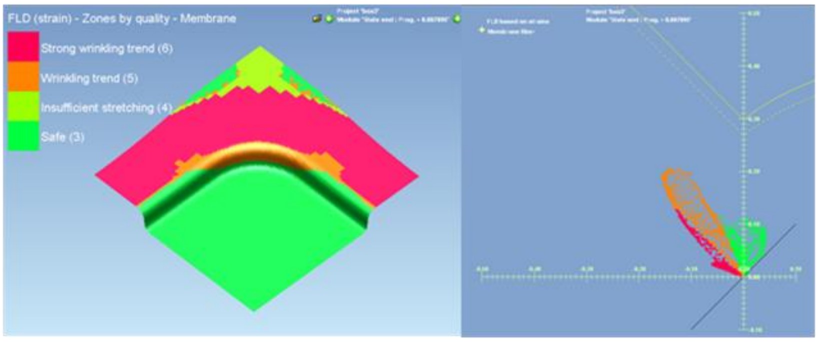
When blank flows past the oral area of die, the flow resistance of blank increases along with the increase of radius of die corner. However, if the radius of die corner becomes larger, there will be wrinkles on the surface of blank as die corner may be affected by bending and reverse bending. In order better control the quality of formation, different radii of die corner will be selected to test and analyze. The radii of die corner are 4mm, 6mm and 8mm. When finishing formation, the influence on formation by die corner radius is shown as follow:



A R=4mm



B R=6mm



C R=8mm

Fig.3 Influence on Formation by Die Corner Radius

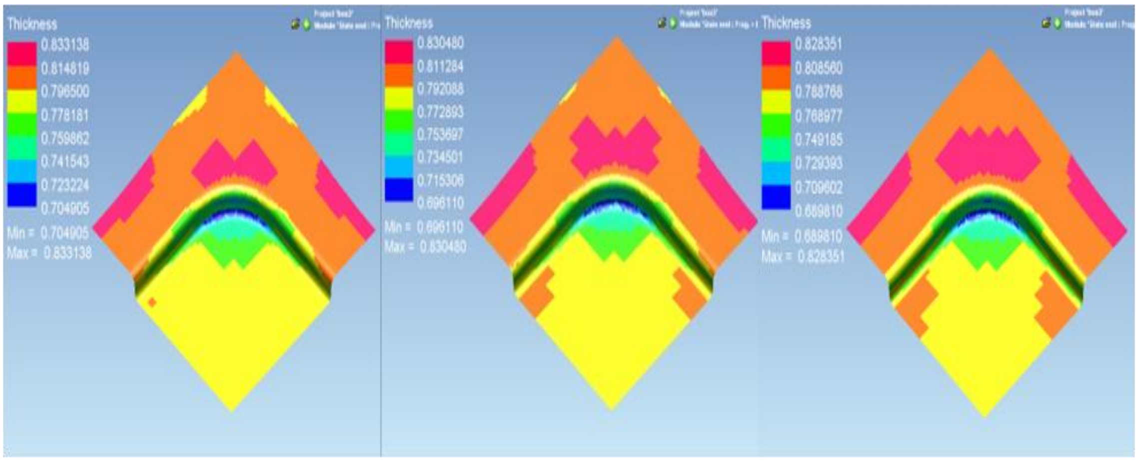


Fig.4 Forming Thickness Distribution of Box-Shaped Pieces with Different Radii

Tab. 1 Thickness with Different Radii

Radius of Die Corner R/mm	Minimum Thickness/mm	Maximum Thickness/mm
4	0.672	0.832
6	0.696	0.830
8	0.699	0.829

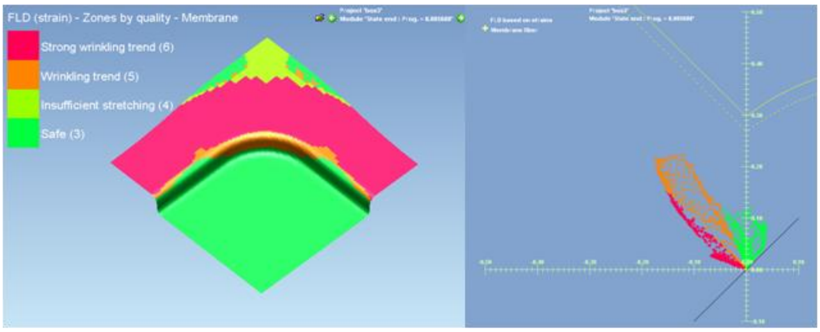
From table 1, figure 3 and figure 4, it can be seen that the minimum thickness is 0.672mm when R=4mm. The thickness reduction rate reaches 16% which is the maximum value. When the thickness reduction rate increases, it shows that this part has the cracking tendency. The area of wrinkle around the corner of die reaches minimum value. When R=8mm, the minimum thickness is 0.699mm and the thickness reduction rate reaches 12.6% which is the minimum value. The area of wrinkle around the corner of die reaches maximum value. When R=6, the minimum thickness is 0.696mm and the thickness reduction rate reaches 13% which is proper.

From the simulation result, it can be seen that the radius of die corner controls blanks to flow into inside. The larger the radius of die corner is, the smaller the resistance which is suffered by blank when flowing from flange to the oral area will be. Meanwhile, tensile stress will be smaller and the reduction of thickness will not be obvious. Pull cracks will be less frequent which is caused by necking. However, when the radius is larger, blank will leave blank holder and then flow into the oral area of die more quickly that it is much easier to cause wrinkles. Therefore, a proper radius of die corner can effectively control the influence on formation.

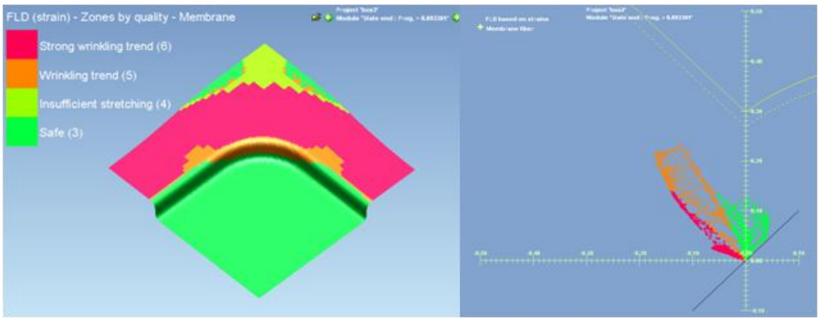
Influence on Formation by Blank Holder Force

During drawing period, blank holder force is a vital technological parameter. Flange is unstable due to blank holder force that wrinkles will be caused. Once there are wrinkles, blank will be cracked when passing the gap between punch and die. Though there is a slight wrinkling, there will also be apron marks on the surface of blank that the surficial quality of parts will be adversely affected. Blank holder is a commonly-used method to avoid wrinkling. The flange part is pressed on the surface of groove. Blank holder force has a great influence on formation technology. If the blank holder force is very large, the risk of cracking will be increased that the blank will become much thinner and even cracked. If the blank holder force is very small, it is not effective to prevent wrinkling.

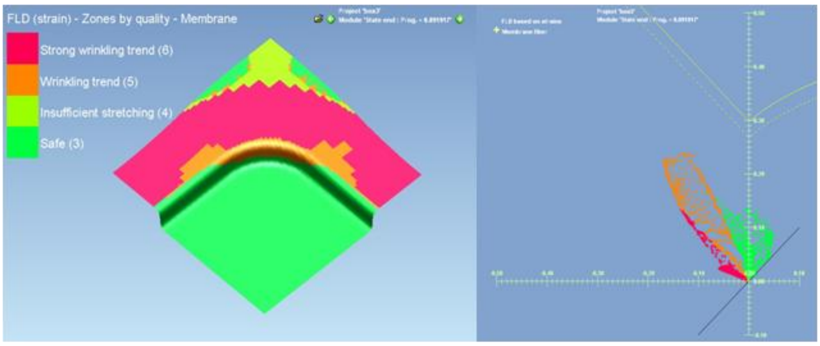
Blank holder forces are 30kN, 40kN and 50kN. When finishing, the influence on formation by blank holder force is shown as follow:



A Blank Holder Force 30kN



B Blank Holder Force 40kN



C Blank Holder Force 50kN

Fig.5 Influence on Formation by Blank Holder Force

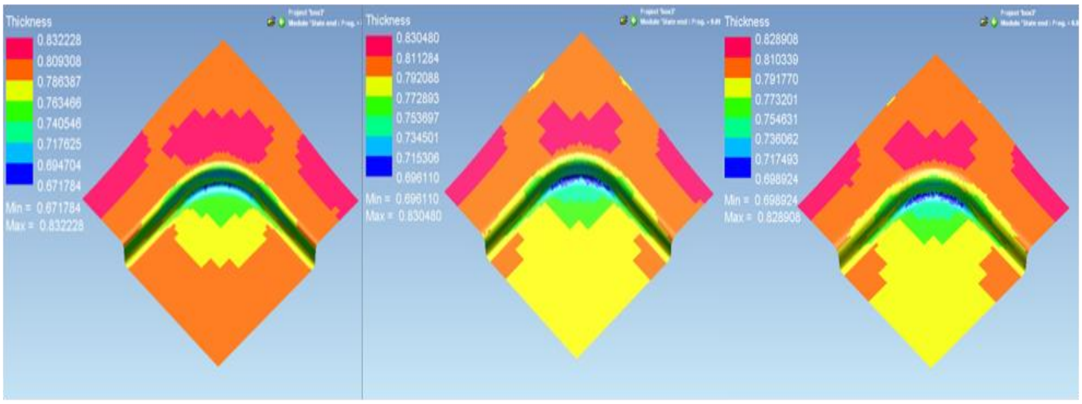


Fig.6 Forming Thickness Distribution of Box-Shaped Pieces with Different Blank Holder Forces

Tab. 2 Thickness with Different Blank Holder Forces

Blank holder Force F/kN	Minimum Thickness /mm	Maximum Thickness/mm
30	0.705	0.833
40	0.696	0.830
50	0.690	0.828

From table 2, figure 5 and figure 6, it can be seen that when blank holder force is 30kN, the minimum thickness is 0.705mm. The thickness reduction rate reaches 11.9% which is the minimum value. There is an obvious wrinkling situation in the parts of die corner and corners. When blank holder force is 50kN, the minimum thickness is 0.690mm and thickness reduction rate reaches 13.8% which is the maximum value. The bottom part is thinnest. There is no obvious wrinkling situation in the part of flange of box-shaped piece. When blank holder force is 40kN, the value of thickness reduction rate and wrinkling area are between the former two values.

From the simulation result, it can be seen that though the increase of blank holder force can restrict the wrinkling tendency of flange, tensile stress in the part of flange will increase which restricts blank to flow into die corner. Along with the drawing of blank, there will be no adequate blank provided for flange and the bottom of die corner will become thinner. It is easy to have necking situation which can cause wrinkles and facilitate the tendency of pull cracks. When blank holder force is decreased, the tangential compressive stress in the part of flange will be increased. Therefore, it is easier to cause wrinkling situation which not only adversely affects the quality of finished products, but also aggravates the abrasion of mould.

Conclusions

Through simulating the drawing formation of 2B06-O aluminum alloy boxes-shaped pieces by virtue of metal plate forming finite element analysis software Pamstamp, the influence on the quality of finished products by radius of die corner and blank holder force is analyzed.

1. Radius of die corner can affect the formation quality of boxes-shaped pieces. Especially, there is an obvious influence on the corner of die. When the radius is very small, it will restrict blank to flow into the oral area and parts will be thinner and even cracked. When the radius is very big, blank will flow into the oral area more quickly that wrinkling situation will be intensified.
2. Blank holder force decides the plastic stability of parts. When blank holder force is very big, it will restrict blank to flow into the oral area and cracking tendency will be intensified along with the increase of drawing height. When blank holder force is very small, the wrinkling situation in the part of flange cannot be controlled properly.

Therefore, it is important for the formation of box-shaped pieces to select suitable radius of die corner and blank holder force.

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