

Research on the mechanism of weld-line movement of U-shape TWB parts

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Abstract. Application of finite element method, the mechanism of metal flow and weld line movement of U-shape parts with transverse welding line and U-shape parts with longitudinal welding line was investigated, respectively. Research results show that: for U-shape parts with transverse welding line, amount of material pulled in is the main factor that affects the weld line movement, control the blank holder force of thin side is an effective method of control weld line movement. For U-shape parts with longitudinal welding line, amount of material stretch is the main factor that affects the weld line movement, application of segmental blank holder can achieve the purpose of control weld line movement, and pressurization of larger blank holder force on the thick side than thin side.

Introduction

A TWB is consists of two or more base metal sheets with different materials and/or thicknesses and/or coatings welded together in a single plane prior to forming. However, due to the presence of hard and brittle weld region and strength/thickness difference between dissimilar base materials, formability of tailor-welded steel blanks are lower than those of the parent materials. Aiming the problems in the process of the forming of tailor welded blanks, many researchers have carry out the research. For example, Jiang et al. [1] start from the simple transverse and longitudinal weld line U-shape parts, the mechanism of metal flow and weld line movement of box-shape TWB parts was investigated. Analysis of the box bottom, side wall and flange and U-shape weld line movement differences, and combined with the blank holder force, original position of weld line, analysis of box-shape parts of bottom, side wall and flange on the weld line movement law and reason. Zhou et al. [2] the springback of the U-shape parts of the differential thickness tailor welded blanks with transverse weld line was investigated. Analysis of relationship between blank holder force to control springback.

In the actual production, the cross section of a lot of parts of tailor welded blanks are U shape. However, there is little research on the mechanism of weld line movement of U-shape TWB parts. For this reason, this paper application of finite element method, the mechanism of metal flow and weld line movement of U-shape parts with transverse welding line and U-shape parts with longitudinal welding line was investigated, respectively.

Transverse welding line movement of U-shape part

Forming process of U-shape part with transverse welding line. Transverse welding line is

defined as direction of weld line is perpendicular to direction of sheet metal stretch. Assume transverse welding line of U-shape part is in the middle of sheet metal, and both sides parent materials were divided into 5 deformation zone, show in Fig.1. On both sides blank holder force under the same value, a-c segment of the thin side base material is always flow from the a point to the c point, materials overall flow from thin side to thick side, cause the weld line is shifted from the thin side to the thick side. But when appropriate increase of pressure of the thin side, the material of the a-c segment of the thin side is still flow from the a point to the c point. However, flow direction of the e-d segment is changed from e to d. Therefore, appropriate increase of the pressure of the thin side can be control weld line movement within a certain range. But when the thin side pressure is too large, thin side base material is less involved in the deformation, and thick side base material to start more involved in deformation. The D-E segment of the thick side is changed from E to D. This has aggravated the possibility of breaking up the U-shape part. In summary, for U-shape parts with transverse welding line, effective control amount of material pulled in is a direct method to control weld line movement. By adjust the blank holder force on both sides, could be achieve the purpose of control weld line movement.

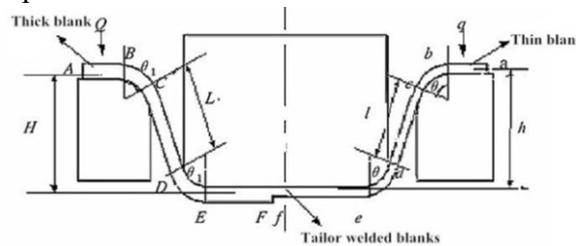


Fig.1 Schematic diagram of bending forming of U-shape TWB part

Simulation of Weld line movement of U-shape part with transverse welding line.

Application of Dynaform software to simulation forming process of U-shape part with transverse welding line, by change both sides blank holder force value, comparison of the weld line movement at different pressures. Mould specific size of U-shape part is show in Fig.2. Die, punch and blank holder are regarded as rigid materials in simulation, application of Belytschko-Tsay (BT) rigid shell element, and mesh adaptive partition. Moreover, neglect the presence of the weld zone. Finite element model show in Fig.3. On both sides application of same material, selection parent material DC56, material strength $K=530\text{Mpa}$, strain hardening exponent $n=0.236$, thick side base plate thickness is 1.2mm, thin side base plate thickness is 1.0mm. During simulation, fixed thick side blank holder force value in 100KN, and thin side blank holder force values are 100KN, 200KN, 300KN, 400KN. Boundary condition is show in Table 1.

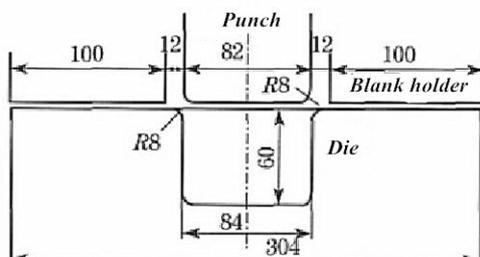


Fig.2 Schematic diagram of mould (unit: mm)

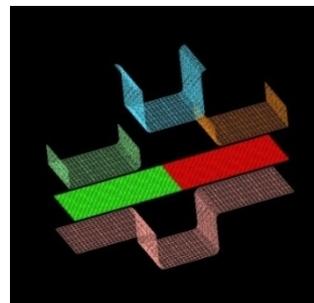


Fig.3 Finite element model

Table 1 Boundary condition

parameter	corresponding value
Friction coefficient μ	0.125
Stamping speed v (mm/s)	1000
Anisotropy index R	1.0

Simulation results show in Fig.4, when both sides under the same pressure, thin side material is more easy to flow into the die, maximum amount of weld line movement is the largest. With increase of the pressure of the thin side, limit the material flow of the thin side, and then increase the trend of thick side material flow into the die. Cause the weld line movement in gradually reduce.

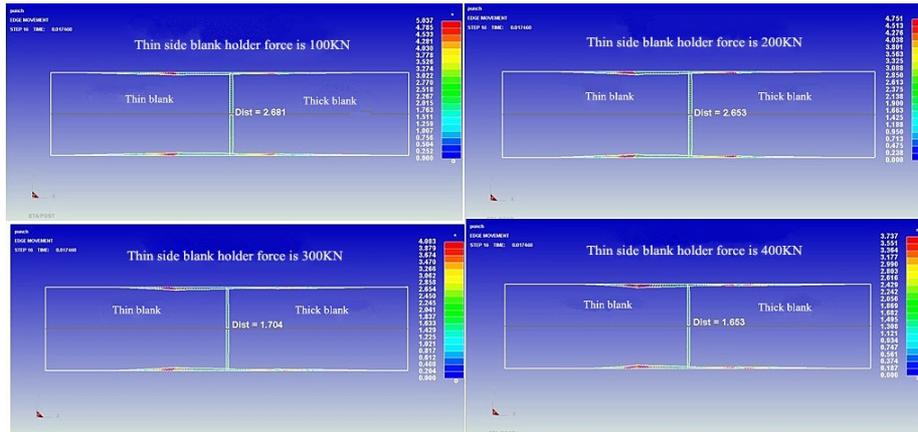


Fig.4 Influence of blank holder force of thin blank to weld line movement

Longitudinal welding line movement of U-shape part

Forming process of U-shape part with longitudinal welding line. Longitudinal welding line is defined as direction of weld line is parallel to direction of sheet metal stretch. Assume longitudinal weld line of U-shape part is in the middle of sheet metal. On both sides blank holder force are the same, materials are the same, and both sides is different only in the thickness. For flange of U-shape part, due to the thickness difference between both sides leads to different deformation, and create bending moment at the flange, change the weld line position. For side wall of U-shape part, material is mainly affected by the reverse bending. Due to the time difference of material reverse bending, cause reverse of the weld line is intensified. For bottom of U-shape part, both sides only affected by tension, it can be seen as a one-way tensile deformation. Through analysis of the deformation of the U-shape part with longitudinal welding line, strain difference of the parent material is the main factor lead to deformation inhomogeneous. One side parent material of larger major strain is hindered by another side parent material of smaller major strain, and move to the side of smaller major strain.

Simulation of Weld line movement of U-shape part with longitudinal welding line. Application of Dynaform software to simulation forming process of U-shape part with longitudinal welding line. In simulation, single-piece blank holder, stepped blank holder, and segmental blank holder are used to study the weld line movement, respectively. Application of the same mould and boundary conditions with transverse welding line of U- shape part. Application of Belytschko-Tsay (BT) rigid shell element, and mesh adaptive partition. Moreover, neglect the presence of the weld zone. Material model is same with U-shape parts with longitudinal welding line. When research

single-piece blank holder and stepped blank holder, both sides blank holder force values are 100KN. When research segmental blank holder, thin side blank holder force value is 50KN, and thick side blank holder force value is 100KN. Research on the influence of difference kinds of blank holder on weld line movement of U- shape part with longitudinal welding line.

Simulation results show in Fig.5, when application of single-piece blank holder, as show in Fig.5 (a). Due to thin side is not affected by blank holder force, thick side strain is larger than the thin side strain, cause weld line is move from thick side to thin side. When application of stepped blank holder, as show in Fig.5 (b), thin side base material is more prone to deformation, weld line is move from thin side to thick side. When application of segmental blank holder, as show in Fig.5 (c), with increase of thick side blank holder force, when thick side strain larger than thin side, weld line would move from thick side to thin side.

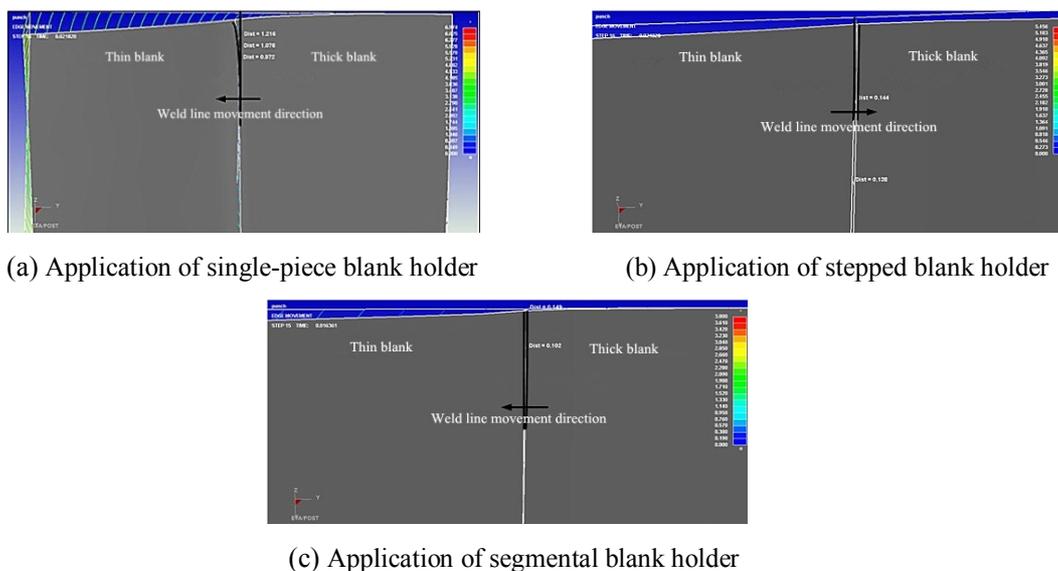


Fig.5 Finite element simulation results of U-shaped parts with longitudinal welding line

Conclusions

1. For U-shape parts with transverse welding line, amount of material pulled in is the main factor that affects the weld line movement. Application of finite element software to simulation forming process of U-shape TWB part, results indicate that when fixed thick side blank holder force, with increase of thin side blank holder force, amount of weld line movement is gradually reduce.

2. For U-shape parts with longitudinal welding line, amount of stretch is the main factor that affects the weld line movement. Application of finite element software to simulation forming process of U-shape TWB part, results indicate that application of segmental blank holder is a effective method to control the weld line movement.

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