Forming Analysis for the Thickness and Diameter of the Bent Pipe Decreases Prediction

Seong-hun Ha, Joon-hong Park, Mok-tan Ahn and Dae-cheol Ko

***Abstract*—This paper deals with finite element analysis to know the thickness and diameter reduction of a single pipe. The tube forming process begins with a straight pre-cutting tube. There are many variables in the pipe bending process. In particular, there is a difference in the accuracy of the bend depending on the shape of the mandrel. Through this analysis, we want to find the part where the reduction direction of the mandrel drastically occurs. In this process, the more the number of mandrill, the better the reduction in diameter. Also, it was concluded that the movement speed of the pressure die should be controlled to reduce the thickness.**

***Index Terms*—Bending, Tube Forming, Curved Tube, Forming Load**

I. INTRODUCTION

Globally, stainless steel pipes are required in various fields besides offshore plants and automobile exhaust parts for transportation due to advantages of corrosion resistance and rigidity. In addition, since the pressure resistance performance and the vibration and noise suppression required in special environments are also excellent, the interest of the manufacturer and the willingness to hire are increasing in various fields in recent years. This study deals with the rotary draw bending process of steel pipe without molding auxiliary (mandrel).

This process is the most commonly used method, and basically it is a process that is performed using a mandrel. However, since the mandrel is used, it is essential to design the number and shape of the mandrel. In this study, the CAE analysis is performed without the mandrel, and the design direction of the mandrel is proposed through thickness reduction and diameter change according to the position.

II. ROTARY DRAW BENDING

A. Bending with Mandrel and Mold

As a method for bending, fix the mold and the mandrel to the mold as shown in Figure 1, and then chuck the tube by molding to remove the mold and the mandrel. The tube thus extracted can suppress the eccentricity and the problem of poor thickness flatness which are problematic in the curved tube forming.

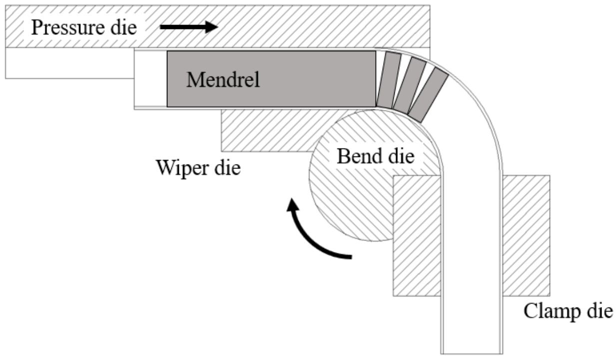

Figure 1 Rotary Draw Bending

B. Rotary Draw Bending without Mandrel

In this study, we will remove the mandrel from the above process and proceed with Pressure die, Wiper die, Bend die, Clamp die only. For modeling for finite element analysis, Bend die and Clamp die are assumed to be one die.

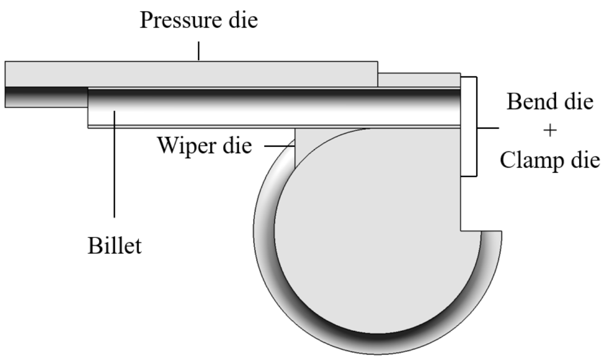

Figure 2 Finite Element Model

III. FINITE ELEMENT METHOD(FEM)

In order to quantitatively analyze the curved forming load, Figure 2, the finite element analysis was performed using the simulation model. The analysis program uses the commercial program Deform 3D and the boundary conditions are as follows.

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The friction conditions of clamp die and billet not shown in the TABLE I are fixed by sticking conditions. And the pressure die actually pushes the billet at the same speed considering the rotation speed from the outside. Therefore, it is assumed that the sliding condition is not influenced by the rotation.

TABLE I.
Boundary Condition

Analysis type	3D Cold Forging
Billet Material	SUS316L(Cold)
Billet Diameter	88.9 mm
Billet Thickness	6 mm
Processing speed	15 RPM
Processing displacement	90˚
Friction condition with die	Sliding
Temperature	25 ℃

IV. Analysis and Result

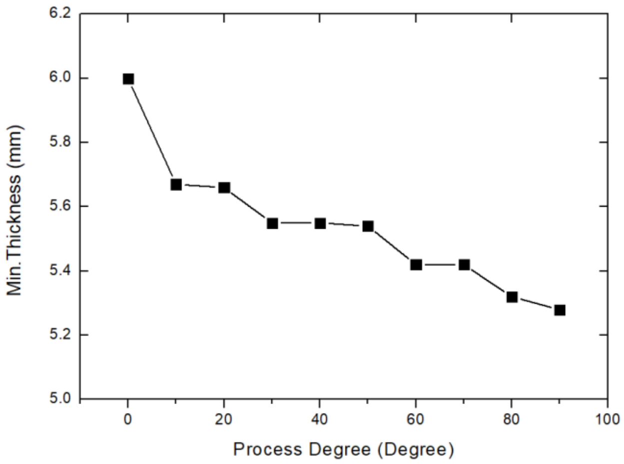

Figure 3 Min.Thickness Curve

As a result of the finite element analysis, the minimum thickness according to the progress angle was as shown in Figure 3. The thickness gradually decreased with the progress of machining, and the decrease in diameter appeared as soon as machining started. The thickness at the end of machining is about 82.3mm, which is about 7% less than the conventional 88.9mm. As shown in Figure 4, the load was distributed at a maximum of about 10 to 30 degrees in the whole section of the process, and the load was about 900 MPa.

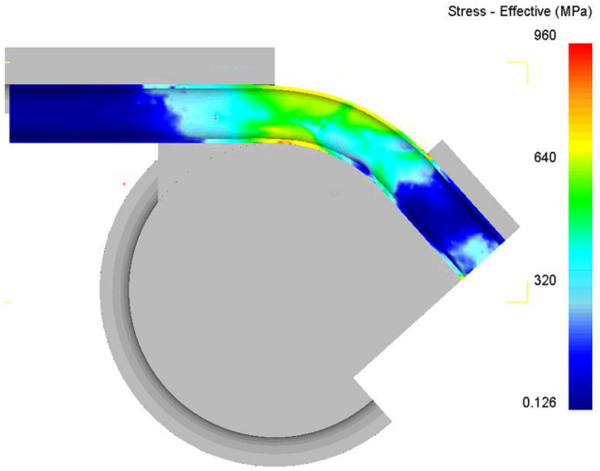

Figure 4 Process at 60 Degree

V. Conclusion

In the rotary draw bending process for bending, finite element analysis was carried out for the influence of thickness variation tendency and diameter reduction according to the progress angle of the analysis excluding the mandrel. As a result, it is considered that the thickness decrease occurs at the maximum load point. The reduction in diameter appears from the beginning of machining, so if possible, it is advisable to enter the mandrel from the beginning of machining.

The thickness reduction was reduced to about 5.2 mm from the original 6 mm, which is about 15%. If you use the mandrel in the actual process, it will decrease more than the analytical thickness decrease. In order to solve this problem, it is necessary to control the progress speed of the pressure die, which acts as a pushing force.

Appendix

Appendixes, if needed, appear before the acknowledgment.

Acknowledgment

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