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Modifying Internal Pressure and Axial Feeding Loading Path in Hydroforming Process of Cylindrical Stepped Tube to Improve Thickness Distribution

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ABSTRACT

Internal pressure and axial feeding are the most important factors in tube hydroforming process. The internal fluid pressure and the material feeding that are produced by punch axial loading, form tube. Simultaneously applying of these two parameters affects the quality, thickness distribution and forming limit of final workpiece. In this paper, effects of internal pressure and axial feeding path are investigated to improve thickness distribution of cylindrical stepped tubes. In addition, wrinkles in loading path were used to create a new method for removing tube wrinkles. Firstly, constant pressure loading paths with various pressure levels were investigated by performing experiment and simulation. Then, pressure levels in which parts did not burst and formed properly or deformed with wrinkles, were chosen and effect of axial feeding on these paths was examined separately with simulation and then by experiment. The results showed that the axial feeding in initial step of increasing fluid pressure improves the part thickness distribution in final step. Moreover, through using this new and effective method, the wrinkles on the tube body were eliminated at the end of the process by changing the direction of axial feeding, and consequently, a sound part with better thickness distribution was obtained. Furthermore, using stepped loading path improved thickness distribution uniformity through applying this new method of wrinkle elimination.

KEYWORDS:

Tube Hydroforming, Internal Pressure, Axial Feeding, Using Wrinkles, FEM Simulation

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1- Introduction

Common defects in hydroforming are bursting, buckling, wrinkling, folding and incomplete filling of die corners. Each of these defects can arise due to inappropriate selection of process parameters such as internal pressure and axial feeding. Sometimes in finals step, wrinkling can be eliminated by increasing the internal pressure [1]. If the proper combination of axial feeding and internal pressure are applied, the defects can be avoided.

Yuan et al. [2] investigated the wrinkling behavior and control as well as using wrinkles in tube hydroforming. They pointed out that not all wrinkles are defects and in some cases, tube can also be formed after wrinkling and reach to desired shape.

In this paper, a new method is presented to improve the thickness distribution of part in hydroforming process of cylindrical stepped tubes, in which creating wrinkles is considered as a perfect condition. Through using this new method and reforming loading path, dead wrinkles that are not removable with the previous methods were eliminated. Also the different loading paths and their effects on improving the thickness distribution are investigated. Furthermore effect of axial feeding versus pressure levels has been showed on thickness distribution in the process.

2- Methodology

Mechanism of die used in this study was selected like the same die that presented in reference [3]. Unlike the conventional dies that are made of two constant semi parts, this die is composed of a body and two movable bushes inside it.

In order to simulation, the finite element (FE) software, ABAQUS/Explicit 6.10 was used.

3- Results and Discussion

First constant pressure loading paths, as one of the easiest type of loading path in tube hydroforming were examined to investigate the effect of pressure path and to get the possible ranges of forming pressures. After simulation, the results of constant pressure path showed that the wrinkles created on tube in the pressure less than 18.5 MPa. Also, in pressure which is more than 20.5 MPa, tube is burst. So in following study, pressures ranging from 18.5 to 20.5 MPa were studied. Thickness distribution with the maximum pressure 19.5 MPa is uniform. In this part the maximum thickness reduction of the tube in forming area is 21.6%.

Not applying the axial feeding in bulge step causes thickness reduction in tube deformation zone. So in the next study, the axial feeding was started simultaneously with the pressure increasing in bulge step and pressure was increased to 19.5 MPa, then the pressure was kept constant in the maximum amount and axial feeding was continued to fill the die cavity. In this case, the rate of thickness reduction has reduced the amount of thickness, 4.6% lower than the previous case.

According to the obtained results and comparison of minimum thickness in sound part and wrinkled part, it can be seen when forming pressure is higher, the rate of thickness reduction is more. In order to achieve more thickness in forming zone, it is enough to keep the pressure on the lower level and also apply more material feeding to the forming zone.

More feeding and lower pressure increases possibility of wrinkling. Numbers of researchers have used tiny wrinkles as the preform to raise forming limit. Therefore; creating wrinkles can be considered as a good idea to improve thickness reduction, if it will be removed in next forming stage. So the constant pressure loading path with maximum pressure level which was equal to 18.5 MPa is selected in this case. Increasing pressure in end of process examined as a way to eliminate wrinkles created in the primary stages of this loading path. Existed wrinkles in the midsection area of the tube were removed by increasing pressure. But wrinkles existed at the corners of the tube weren't eliminated by this loading path. These wrinkles are dead wrinkles. In order to remove these types of wrinkles, a new method is presented in this paper.

In this approach in the end of the process with increasing pressure level for removing wrinkle, punches move in the opposite direction (return backward); simultaneously tube is expanded longitudinally by increasing pressure and movable bushes are guided to back and create space to eliminate wrinkles. Then punches move forward again to complete filling of the die. This loading path is shown in Figure 1. Steps of tube forming with the new technique to eliminate wrinkles with presented loading path are shown in Figure 2. The new idea was done first by simulation and in order to verify the results, the experimental tests were done.

Thickness reduction of sound part with this loading path is improved 10.4% than sound part obtained from loading path with constant pressure at the point where the minimum thickness has. But the thickness distribution of forming zone is not uniform and the difference between the highest and lowest values in deformed area of the tube in the simulation is about 2.6%. Therefore; to achieve to more uniform thickness distribution, another loading path examined.

A new loading path with stepped pressure increase and presented method for removing wrinkle was tested. In this case, the difference between the lowest and highest values of thickness in forming area is 1.9%.

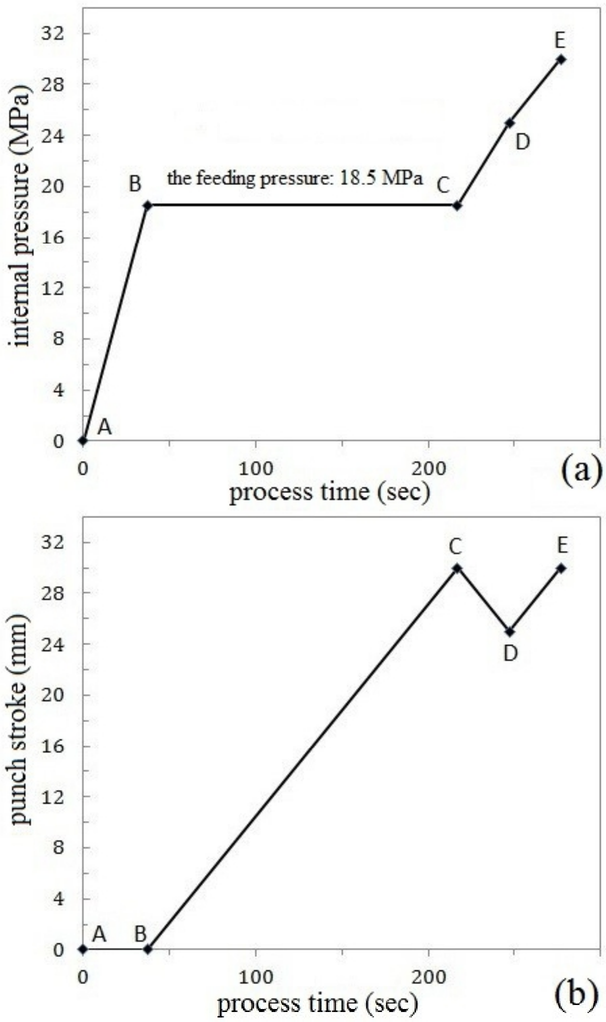

Figure 1. loading path of reverse feeding with increased pressure in the final stage (a) pressure path and (b) axial feeding versus processing time

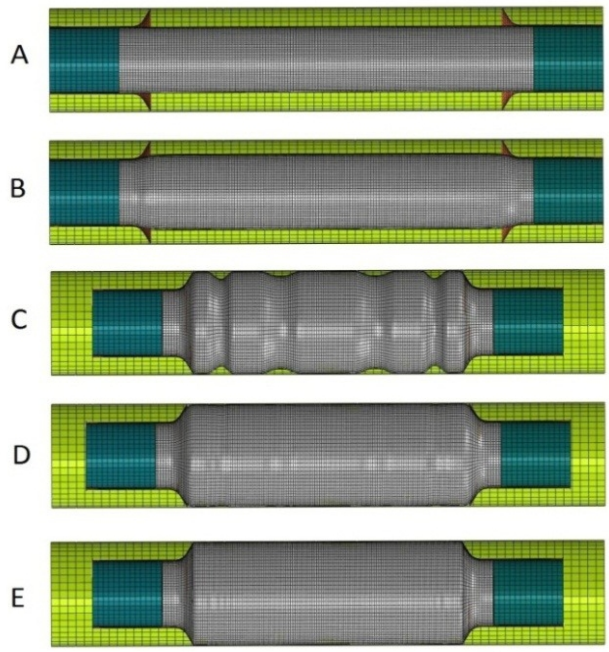

Figure 2. the results of the simulations corresponding specified points in Figure 1

4- Conclusion

The following conclusions are generally obtained from this research:

1. By modifying loading paths, it is possible to obtain sound parts with improved thickness distribution.
2. It is illustrated that creating wrinkles can be considered as a good idea to improve thickness reduction, if it could be removed in next stage of forming.

5- References

[1] Dohmann F. and Hartl C., 1997. "Tube hydroforming-research and practical application", *Journal of Materials Processing Technology*, 71, No. 1, pp. 174-186.

[2] Yuan S., Wang X., Liu G. and Wang Z., 2007. "Control and use of wrinkles in tube hydroforming", *Journal of Materials Processing Technology*, 182, No. 1, pp. 6-11.

[3] Elyasi M., Bakhshi Jouybari M. and Gorgi A. H., 2010. "A new hydroforming die design for improvement of die corner filling of stepped tubes", *Journal of Modares Mechanical Engineering*, 10, No. 3, pp. 87-98.