304 스테인리스 용접 강관을 이용한 액압성형 공정 해석의 정밀도 향상을 위한 연구

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Abstract

In this study, the effect of anisotropic circumferential material properties, bending properties and hydroforming process parameters on the deformation characteristics of 304 stainless steel tube were characterized by both experimentations and finite element method adopting crystal plasticity model. In the experimental investigations, the effects of anisotropic circumferential material properties, bending properties and hydroforming process parameters on the deformation characteristics of 304 stainless steel tube were evaluated by tensile test, tube bending test and hydroforming test. The variation of mechanical properties around the tube circumference were primarily evaluated by tensile test. And the effect of anisotropic circumferential material properties on hydroformability such as expansion height, thinning were estimated by tube free expansion test. Different deformation behaviors at inner and outer bounds of the tube during bending process enhance a non-uniform plastic deformation around the circumference of bent tube. Therefore the deformation behaviors of bent tube such as springback, ovality, thickness distribution, hardness variation were evaluated by rotary draw bending process. The effect of the process parameters such as feeding amount, internal pressure and coefficient of friction on the hydroformability such as expansion ratio, bursting, wrinkle, thickness variation were investigated by free expansion test and T-shape expansion test. The friction coefficient between tube and die at various internal pressure and lubricant conditions were also estimated by self-developed measuring method. The rate-dependent crystal plasticity model was used to predict anisotropic deformation response of 304 stainless steel tube in tube hydroforming process. The polycrystalline model based on crystal plasticity was suggested in this study because it was a very appropriate model for the tube material description. The development of texture was analyzed by the electron back-scattered diffraction(EBSD) to prove the predictive capabilities of the constitutive model. The rate-dependent crystal plasticity model was implemented into the user-subroutine UMAT of a finite element program ABAQUS. The initial crystallographic texture measured by orientation imaging microscopy and material parameters obtained from stress strain curve fitting were used as input values to this FEA model. The constitutive model was used to analyze the tube hydroforming process applying internal pressure and axial feeding. Both strain distributions along longitudinal and circumferential direction of tube and internal pressure predicted by the crystal plasticity model were in good agreement with experimentally measured values. The results obtained from the rate-dependent crystal plasticity model have been well confirmed by actual hydroforming experiment and the modeling technique proposed in this study has been proved to be very useful for the precise prediction of non-uniform tube hydroforming process.

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