Effect of Initial Thickness Deviation and Reduction on Longitudinal and Cross-sectional Precision after Tube Drawing Using Plug

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ABSTRACT

This paper clarified the effect of initial thickness distribution and area reduction on longitudinal and cross-sectional precision of tube, which is drawn using mandrel. Tube drawing is an important and common metal forming process, which is located near the end of process lines. Even though straightening processes might be located after tube drawing in some cases, the straighter does not have the function of correcting thickness deviation, and could not satisfactorily straight the tube if heavy warp existed on the drawn tubes. Therefore, it is important to secure both longitudinal and cross-sectional precision in tube drawing for achievement of final product qualities.

A plug in tube drawing is effective to improve the tube qualities. The Plug enhances surface integrity, and would uniform the thickness distribution if the plug is stiffly fixed at the centre of the die hole. However, in actual tube drawing process, the plug is attached at the end of a very long pole, the rigidity of which is very low in both longitudinal and flexural aspect. The initial thickness deviation, which inevitably exists due to the previous processes, would cause the asymmetric pressure on the plug, resulting in eccentricity of the plug position inside the die hole. As a result, the initial deviation should affect the thickness deviation after drawing. This would also might cause warp and asymmetric residual stresses. If the complex mechanism on the plug behaviour is clarified, the tube-drawing condition, such as area reduction and die angle, would be able to be optimized for the improvement of the tube qualities. However, there are very few research works on the mechanism, and the drawing condition are determined according to the technicians' interpretation.

In this research, 2D and 3D FEM models are composed for the clarification of the effect of initial thickness distribution on its distribution after drawing and the residual stresses. In the 2D FEM, the minimum bare mesh dimension was determined in terms on both residual stress precision and calculation time. Based on the results of 2D FEM, the mesh division in 3D FEM was determined. Using the obtained 3D FEM, the effect of initial thickness distribution was clarified with the combination of area reduction. Some of the numerical results were verified by experiments.