DEVELOPMENT OF A DATABASE FOR SPRINGBACK PREDICTION IN TUBE BENDING MACHINES

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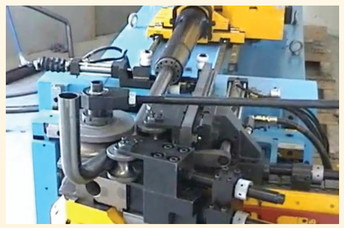
ABSTRACT

Tube bending is a manufacturing process which is performed by bending machines to bend the circular hollow tubes into certain angle and provides permanent forming. It is used in various industries such as automotive, aerospace, boilers and heat exchangers, etc. One of the easiest ways of having high quality tube formed end-products is using CNC tube bending techniques. The most common problems encountered during tube bending operations are thickness reduction, ovalisation, wrinkling and springback. Especially; springback, is an undesirable condition that causes some difficulties in the assembly process.

The main objective of this study is to develop a springback database in tube bending techniques by using finite element method (FEM). For this purpose, tube bending and springback simulation models for rotary draw and push rolling bending processes are developed, and the simulation results are validated with the analytical results, previous simulation and experimental results.

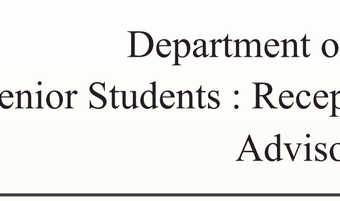


DESIGN

The design of the tooling is crucial for a good bending quality. Also, obtaining desired dimensions and geometries is a necessity to develop finite element models of bending processes, and achieve good simulation results. Therefore, the geometry of the tooling must be designed.

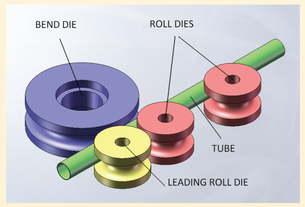
1. DESIGN OF ROTARY DRAW BENDING TOOLING

Rotary draw tube bending, which is used for bending tubes in small radius, is the most flexible, versatile and precise bending method among the types of tube bending process. The tooling of this method includes bend die, clamp die, pressure die, and wiper die. Also, mandrel is used in worst cases. The tooling is designed in respect of the design parameters and the deformation results are validated with the previouss studies.



2. DESIGN OF PUSH ROLLING BENDING TOOLING

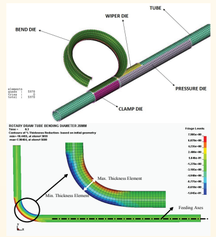
Push rolling bending process is used for bending the tube in large radius, spirals, and tube sectios of different diameters. The tooling of the method consists of a bend die and three roll dies. The best design for tooling is determined by comparing the simulation results of different die geometries.

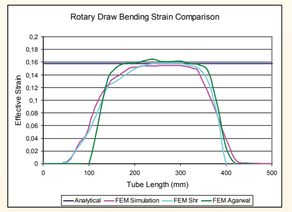


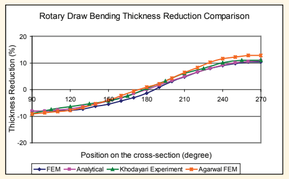
FINITE ELEMENT ANALYSIS

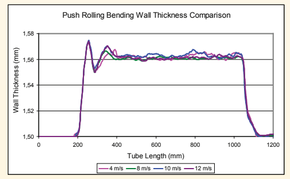
DEFORMATION ANALYSIS

The finite element models of bending processes were developed by using the dynamic explicit FE code LS-DYNA. Firstly, simulation model of bending is developed since the springback simulation model can be created after bending simulation. The CAD data of the bending process is meshed by using the program ANSA before preparing the simulation model. After the simulations are performed, the strain, thickness and thinning distribution results of bent tubes, which are obtained from simulations are validated with the analytical results calculated, and both simulation and experimental results in the literature.



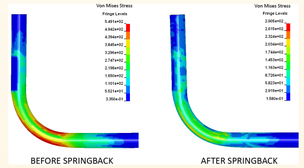


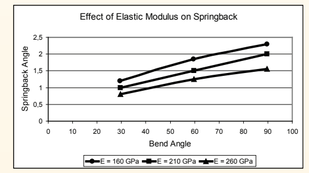


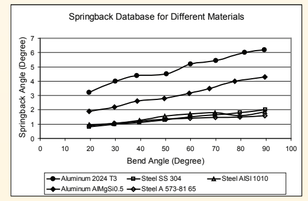


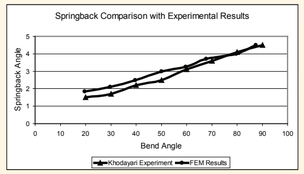
SPRINGBACK ANALYSIS

Springback prediction by analytical methods may not give satisfactory results due to the several parameters involved such as geometrical, mechanical and forming parameters. It is therefore necessary to use the finite element method to predict the springback angle. The springback simulations can be performed after the bending simulations since the initial stresses on bent tube are necessary for springback. A parametric study is performed in order to determine the effect of material and geometrical properties on springback angle of bent tube. Furthermore, springback database for different materials and different tube geometries were developed in respect of the finite element analysis.









CONCLUSIONS

This project has achieved the following results after all work of literature review, design of the tooling, and development of analytical equations and FEM simulations of tube bending and springback prediction.

- The design of toolings and FE simulation models for rotary draw bending and push rolling bending techniques were developed by using the dynamic explicit FE code LS-DYNA. The deformation analysis of these simulation models with different tube dimensions and tooling setup were proved to have good agreement with analytical methods, and published experimental data.
- The FE simulation model for springback of the bent tube was developed, the FE results were validated with the analytical and experimental results in the literature, and the effect of geometric and material parameters on springback angle was investigated.
- Springback database for rotary draw bending and push rolling bending methods were developed for different materials and different tube geometries.