UNIVERSITY TEKNIKAL MALAYSIA MELAKA

IMPROVEMENT ON ROTARY DRAW TUBE BENDING'S PARAMETER BY DESIGN AND ANALYSIS USING FEA APPROACH

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) with Honours

By

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DECLARATION

I hereby, declared this thesis entitled "Improvement on Rotary Draw Tube Bending's Parameter by Design and Analysis using FEA Approach" is the results of my own research except as cited in references.

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ABSTRACT

This report represents a design & analysis case study on tube bending for metal forming industry. Where, tube bending is a widely used manufacturing process in the aerospace, automotive, and other industries. During tube bending, considerable in plane distortion and thickness variation occurs. The thickness increases at the intrados (surface of tube in contact with the die) and it reduces at the extrados (outer surface of the tube). The present project focuses on additional loadings such as axial force and internal pressure which can be used to achieve better shape control and strength of the tube. Based on plasticity theories, a FEA model is developed to predict displacement and stress of tubes under various loading conditions. Results from FEA model indicated that at the intrados the increase in thickness for bending with internal pressure and bending with combined axial pull and internal pressure was nearly the same. A parametric study was conducted for the case of bending with axial pull and it was seen that with proper selection of load and wrinkling defects can be eliminated, displacement the tube can be optimized, and fracture of the tube can be predicted. Predictions of model's results are in good agreement with finite element simulations. Thus, the proposed model can be used to evaluate tooling and process design in tube bending. Lastly, the prediction's model of FEA can yield more precise dimensional of tube bending and quality of tube bending shall be increase into optimum level.

ABSTRAK

Report in merujuk kepada satu kajian rekabentuk terhadap pembentukan tiub dalam industry pembentukan logam Di mana, pembengkokan tiub adalah satu cara yang digunakan dengan meluas dalam proses pembuatan logam, eroangkasa, automotif, dan industri-industri lain. Semasa proses pembengkokan tiub, perubahan pada pelan dan jurang kekonsisten ketebalan tiub berlaku. Ketebalan tiub bertambah di intrados (permukaaan tiub yang dipadatkan pada 'die' dan ia mengurang di extrados (permukaan luar tiub). Projek sekarang menumpukan pada tambahan loadings ibarat daya paksi dan tekanan dalaman yang boleh digunakan untuk mencapai lebih baik kawalan rupa bentuk dan agihan ketebalan tiub Berdasarkan teori-teori keliutan plastik, model FEA adalah salah satu cara termaju untuk meramalkan herotan keratan rentas dan perubahan ketebalan tiub dengan tambahan pemuatan yang pelbagai. Ramalan dari keputusan dari FEA menunjukkan bahawa di intrados peningkatan dalam ketebalan untuk dibengkokkan dengan tekanan dalaman dan pembengkokan dengan tarikan paksi bergabung dan ekanan dalaman adalah hampir sama. Tetapi dalam kes pembengkokan dengan gabungan tarikan paksi dan tekanan dalaman terdapat satu pengurangan signifikan pada ketebalan di extrados. Satu kajian berparameter telah dikendalikan untuk kes pembengkokan dengan tekanan dalaman dan paksi bergabung tarikan dan ia adalah telah menyatakan dengan pemilihan sesuai tekanan dan tarikan paksi, kecacatan-kecacatan tiub boleh dielakkan , agihan tebal sekitar tiub boleh dioptimumkan, dan herotan keratan rentas tiub boleh dikurangkan. Ramalan-ramalan model adalah hampir sama dengan simulasi-simulasi elemen terhad. Oleh itu, model cadangan boleh digunakan untuk menilai mencorakkan dan proses direka dalam pembengkokan tiub. Akhirnya, ramalan model FEA boleh menghasilkan dimensi yang lebih tepat untuk pembengkokan tiub dan kecacatan-kecacatan pembengkokan tiub akan dikurangkan ke tahap optimum.

DEDICATION

This report is dedicated to all my loved, and the God above.

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My supervising lecturer, En.Taufik of which me had a good working relationship, and who offered me tremendous help and guidance along the completion of this project,

My family, who inspired me weather through the storm and carry on,
My beloved, who kept me through it all

Lecturers and relevant personnel who helped me in one way or other;

Friends and peers who are good companions in times of need.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Tube bending processes are widely used to manufacture parts in aerospace, automotive, oil and other industries. Tubes are used as components in manufacturing of parts in numerous industries. Their application ranges from simple household items to sophisticated aerospace parts. Wherever tubes are used, accurate bend angle and uniform cross section are often desired. In recent decade, tubes have found many new applications in the automotive industry.

Tube hydro forming has been identified as a new technology to manufacture parts. Tube hydro forming has many advantages in comparison with conventional manufacturing via stamping and welding. It can reduce the weight of the component, retain and even improve the strength and stiffness, reduce tooling cost due to fewer parts and tube hydro forming requires fewer secondary operations. In most cases, the first step of tube hydro forming is bending of the tube to the required shape. The tube is bent to the approximate centerline of the final part to enable the tube to be placed in the die cavity.

1.1.1 Tube Bending Process

There are many ways by which a tube can be bent into the required radius. The main techniques by which tube can be bent into the desired shape are rotary draw tube bending, compression tube bending, roll bending and stretch bending. The selection of technique depends upon the following factors:

a. The quality of the bend and production rate desired.
b. Diameter, wall thickness and minimum bend radius desired.

1.1.1.1 Rotary Draw Tube Bending

Rotary draw tube bending is the most flexible bending method and is used immensely in industry on account of its tooling and low cost. The tooling consists of a bend die, clamp die, pressure die and wiper die. In this bending technique the tube is securely clamped to the bend die by using the clamp die. The bend die rotates and draws the tube along with it. The pressure die prevents the tube from rotating along with the bend die. The pressure die may be stationary or it may move along with tube. The pressure die provides a boost which pushes the material at the extrados of the tube to reduce the thinning of the tube and can be very helpful when the bending angle is large a

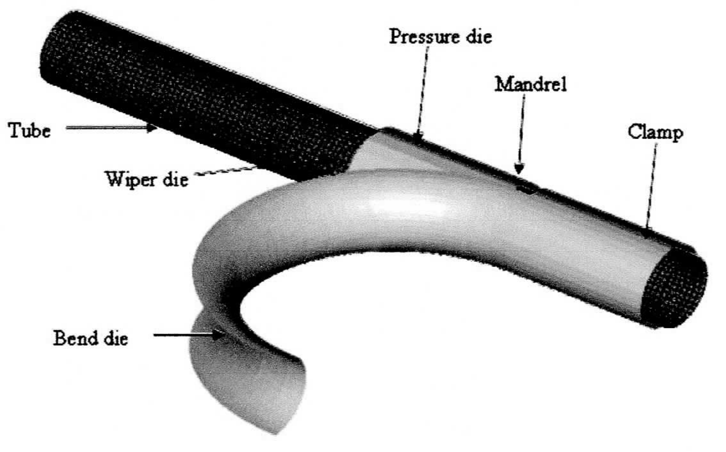

Figure 1.1: Rotary Draw Tube Bending

Figure 1.1 shows the tooling of rotary draw bending process. A mandrel along with wiper die may be used to prevent the wrinkling and collapse of the tube. But the use of mandrel should be avoided if possible since it increases the production cost.

Rotary draw tube bending provides close control of metal flow necessary for small radius and thin walled tube.

1.1.1.2 Compression Tube Bending

The tooling for the compression tube bending is similar to the rotary draw tube bending. It consists of the stationary bend die, a moving wiper shoe and a clamp. The only difference between the rotary braw bending and compression bending process is that in rotary draw tube bending the bend die is movable whereas in the compression tube bending the bend die is stationary.

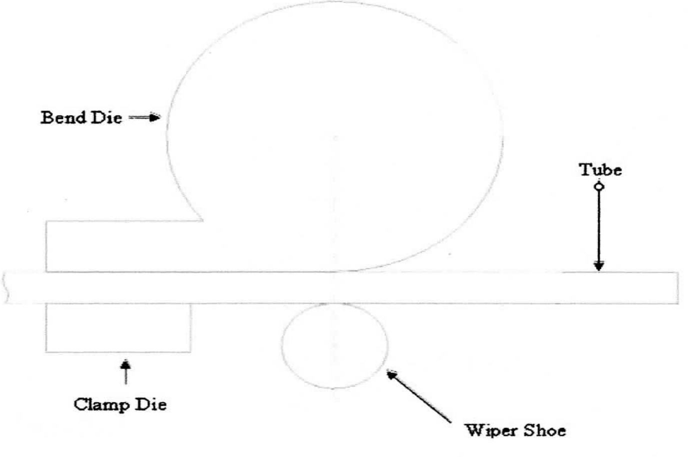

Figure 1.2a: Initial Stage of Compression Tube Bending

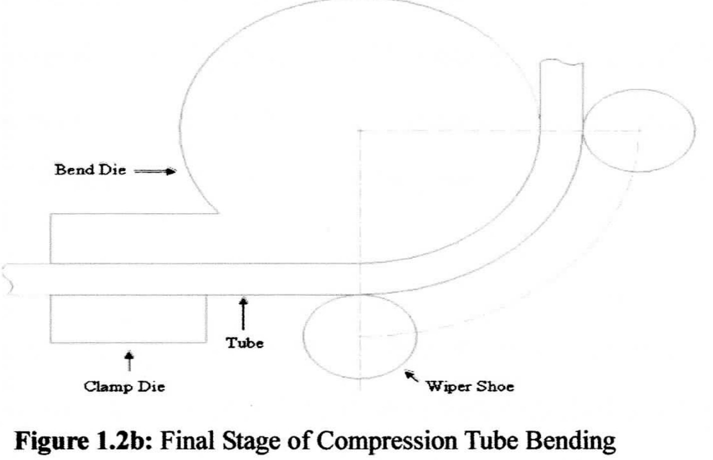

Figure 1.2b: Final Stage of Compression Tube Bending

In compression tube bending the tube is clamped to the bending die near the rear tangent point. The wiper shoe pushes the tube along the bending die as it rotates around it. **Figure 1.2a** and **Figure 1.2b** shows the initial and final configuration of the compression tube bending.

1.1.1.3 Roll Bending

The tooling for roll bending consists of three rolls of the same size arranged in a pyramid pattern, as shown in **Figure 1.3.** Two rolls are fixed and the third center roll is movable. The tube is passed through the rolls and the center roll is lowered onto the tube. This bending technique is usually employed for bending tubes of large radius, spirals and tube sections of different diameters.

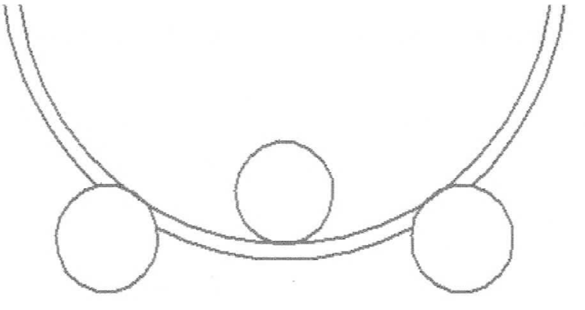

Figure 1.3: Roll Bending

1.1.1.4 Stretch Bending

Stretch bending is one of the newer bending techniques being used in industry. In stretch bending both the inner and outer fibers of the tube are in tension. The outer fiber is stretched more than the inner fiber. In the other bending methods described above the outer fibers are in tension whereas the inner fibers are in compression. The tooling for stretch forming consists of a mandrel, bending die, jaws, and hydraulic actuators.

In this process the tube is first gripped by the jaws which are mounted on hydraulic actuators. The grips also seal the ends. The tube is first stretched axially to a chosen value of tension, and then pressure is increased to the desired level while the tension is kept constant. The mandrel then moves and bends tube. **Figure 1.4a** and **Figure 1.4b** show the initial and final configuration of stretch bending.