Abstract

Our objective was to design a 3-Dimensional automated tube bending apparatus capable of bending indicated wall thicknesses into helixes without crimping or crushing. The focal goal was to bend 1/4” copper tubing at a 9/16” bend radius. We collaborated with an Electrical Engineering team to ensure the future implementation of motor control. The design consists of two components: the driving mechanism and the bending instrument.

Methods

Customer requirements had to be assessed and then applied to the House of Quality. The House of Quality aided in identifying and prioritizing the customer needs for the design. Each customer requirement was given an importance weighting to compare in the concept selection matrix. After participating in concept generation activities such as brainstorming and 6-3-5 methods, five methods were left to be compared and evaluated. After assessing our methods, we chose to go with the Capillary Bending method. Capillary Bending applies similar techniques to roll bending with the addition of the moving dies to implement the 3 dimensional aspect.

Results

Ultimately, when the copper tubing is bent up to 80 degrees (from the initial starting point) the tube bending device can produce a quality bend of around a 1.5 inch bend radius. Results of a 70, 80, and 90 degree bend are shown below, respectively from top to bottom.

Conclusion

After testing the finished manual tube bending machine, it could be concluded that the manual bending device is successful in terms of bending the copper tubing. We still have a few challenges to overcome in our design. A primary concern is material removal. Since this is a manual apparatus, we must return the system back to its original parameters in order to extract the bent coil. Another challenge we faced is the length limitation. Currently, we can only bend 10 inches of material. Our next goal is to amend the coil removal issue and expand the machine’s drive mechanism in order to bend a larger length of material.

Acknowledgements

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Design Process

3D Tube Bender
Sponsor: RH systems
Nicholas Loftis, Marisa Downey, Corbin Womack, Samantha Burkhart

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Concept Selection Matrix

<table>
<thead>
<tr>
<th>Customer Requirement</th>
<th>Die 1</th>
<th>Die 2</th>
<th>Die 3</th>
<th>Die 4</th>
<th>Die 5</th>
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<tr>
<td>Weight</td>
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<td>21.6</td>
<td>15.1</td>
<td>18.3</td>
<td>17.8</td>
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</tbody>
</table>

Concepts:
- Die 1: Restrict pipe from bending in the positive X-direction
- Die 2: Stationary die which determines the inner bend radius
- Die 3: Outer die which bends tubing around the stationary die
- Die 4: Moves in +/- Z-direction to change pitch of the spiral

Objectives

Goal: Bend copper tubing with a wall thickness between 0.020” to 0.065” into a helix without crimping or crushing tube
Material: Copper - Nom. 1/4” Type L 0.030”
Guidelines:
- Eliminate repeatability issues with hand bending
- Save time
- Increase complexity of bends
- Stay within tolerances

Introduction

Applications of bended tubing are heating, ventilation, and air conditioning (HVAC), and the automotive industry. Presently, tube bending is performed manually. For large tubing, automation has become a satisfactory approach, however small diameter tubing still requires hand bending. RH Systems has recruited Texas State University to design and prototype a 3D automated tube bending machine. We will be working in collaboration with an Electrical Engineering team providing them with necessary calculations along with ensuring the design is compatible with implementing motorized control systems. This project will take place over the next 2-3 semesters, each with different scopes. Our primary goal for this semester is to design the necessary dies, work piece holder, and technique for the operations to take place.

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