



CNC Retrofit of Mandrel Tube Bender

Transfer Flow, Inc.

Jared Berry, Daniel Cliffe, Brendan Green, Jordan Schwarz, Tyler Watson

Nick Repanich and Matt Simkins, Ph.D.

PROJECT OVERVIEW

The purpose of this project was to improve the tube-forming operations of Transfer Flow, Inc.'s aftermarket fuel tank manufacturing processes.

PROJECT REQUIREMENTS

- To hold a linear positional tolerance of ± 0.635 mm (± 0.025 in) or better.
- To hold a rotational positional tolerance of $\pm 0.5^\circ$ or better.
- To have a set up time of 5 minutes or less for equivalent diameter tubing.
- To utilize software and hardware familiar to the TFI production floor.

PROJECT OBJECTIVES

- To increase throughput and product quality.
- To add two degrees of CNC automation control.
- To develop a safe and affordable design solution.



HOW IT WORKS

The retrofit design implements automation mechanics, motors, drivers, a motion controller, digital encoders and an optically isolated I/O board in order to fully automate the tube forming processes at Transfer Flow. This leads to significant increases in throughput, quality, and robustness of the existing mandrel tube bender, while eliminating scrap and waste.



SYSTEM CONTROL

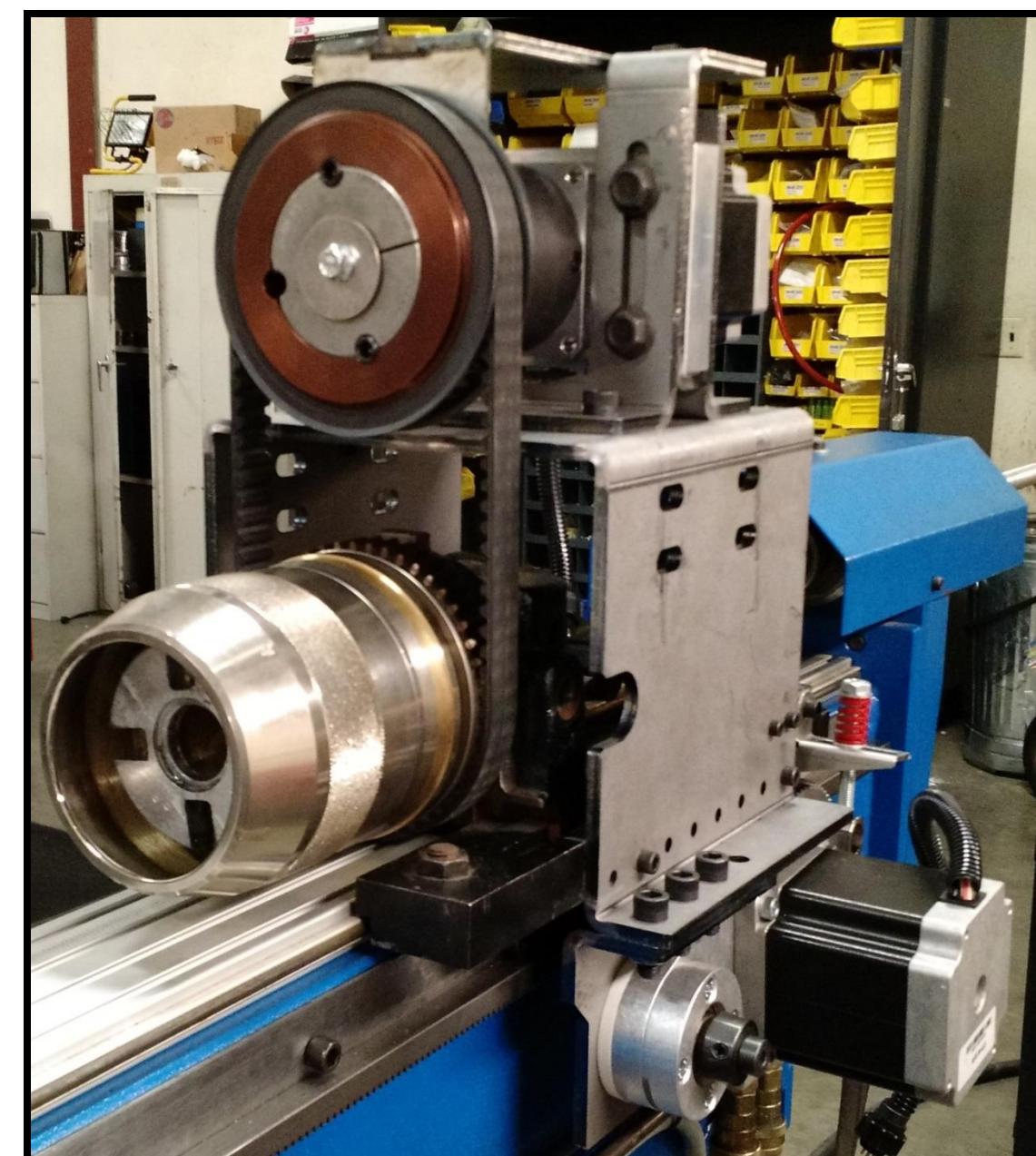
- **KFLOP** (motion controller): performs digital signal processing, real-time motion control, motion profile tuning and USB communication.
- **SNAPAMP** (multi-axis amplifier): increases the output current of the KFLOP controller and provides differential inputs for the linear and rotational encoders.
- **KONNECT** (I/O expansion board): allows for communication with the original proprietary control circuits of the mandrel bender through the replacement of the operator's control interface with I/O pins controlled by the KFLOP.
- **MACH3**: converts a standard PC into a fully featured 2-axis CNC controller.

AUTOMATION MECHANICS

- **Linear Motion System:** consists of a rack, pinion, 3.2:1 belt and pulley, belt tensioner, pinion pre-loader, NEMA 34 stepper motor, high-speed linear inductive encoder, and custom mounting bracket.



- **Rotational Motion System:** consists of a timing belt, two timing belt pulleys of the same diameter, a belt tensioner, a 25:1 planetary gearhead, a NEMA 34 stepper motor, and a custom mounting assembly.



TEST RESULTS

- **Linear Positioning Accuracy:** the accuracy of the linear system is ± 0.0035 inches.
- **Rotational Positioning Accuracy:** the accuracy of the rotational system is ± 0.25 degrees.
- **Equivalent Diameter Set up Time:** the set up time for equivalent diameter tubing is one minute.

The final test for the accuracy of the parts is the jig, which is a Go/No-Go gauge for the formed tubing.



USER INTERFACE

- MACH3 is the user interface. The interface is easy to use, familiar to the Transfer Flow employees and visually pleasing.

