CNC Table for Routing A

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Abstract

Vertical 3 axis mills are capable of completing the same tasks as a CNC machine. A CNC machine can perform the same tasks as a skilled machinist but without human aid, and typically at a higher speed than a mill because they occasionally run a high-speed spindle. A significant difference between mills and CNC machines is that CNC machines have increased efficiency. By using computers, CNC machines complete complex and numerous calculations in fractions of a second to replicate operations that would take much longer to complete on a manually controlled mill.

Our client David Willy requested a portable desktop CNC router capable of also using a 3D printer and a laser cutter in future iterations and accuracy within .001”. The team used Solidworks, ANSYS, and hand calculations to analyze parts of the machine that would be critical such as the overall deflection generated by the weight of the gantry and z-axis, as well as the force acquired during use including the speed and feed rates of the tool head. The team was challenged to use open source software to convert a solid model into G-code, which is a series of commands that tells a motor controller to move the tool head to specified locations at desired speeds, this conversion process is also called CAM (Computer Aided Manufacturing). The interface for the end user will be a Raspberry Pi (Linux computer) touch screen interface with the capability of running G-code created in the software or imported from CAM software.

Background

The purpose of this project was to design and construct a computer numerical control (CNC) table. The CNC table was built with multiple functions in mind that include routing, 3D printer, and a laser cutting. CNC machines currently perform functions and movements, which were traditionally performed by skilled machinists. CNC machines are designed to meet the requirements of high production rates, uniformity and consistent quality of parts. Programmed instructions are converted into output signals, which in turn control machine operations such as spindle speeds, tool selection, tool movement, and cutting fluid flow [1].

Project Goals

- Capable of routing, laser cutting & 3D printing.
  - Routing was this year's focus
- Table travel of 12"W x 12"L x 3"H
- Router or Dremel tool as spindle
- Robust to minimize deflection
  - Cut tolerance within .001"
- Ability to cut wood and aluminum parts
- Ability to clamp typical work pieces
- Uses open source software on windows operating software
  - BCNC, Smoothieware, Pronterface, etc...
- Uses standard 120V 60Hz
- Uses commercially available control boards and motors
  - Smoothieboard & Nema 23 motors
- Safety Shielding
- Safety kill switch

Design Approach

- Brainstorm multiple approaches
- CAD rendition of most desirable design choice
- Machined parts
  - 40 Team machined, work ordered and water jetted parts
- Assembly
- Testing

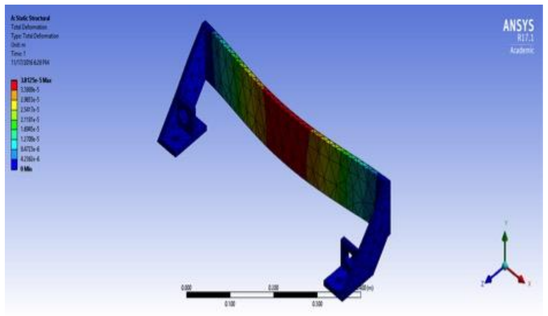

Figure 1: FEA analysis of gantry.

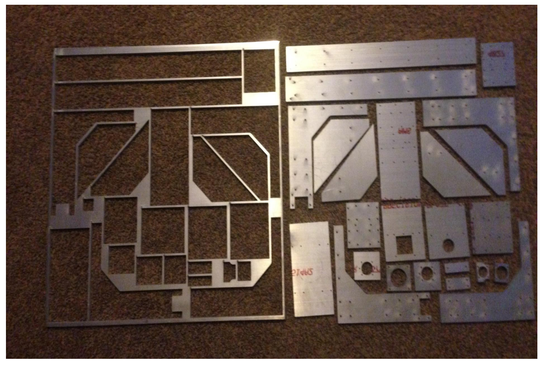

Figure 2: Parts cut from Southwest Waterjet & Laser.

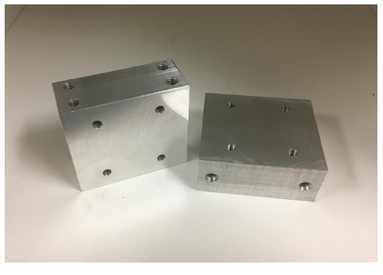

Figure 3: A small number of parts machined by the team.

Testing & Results

- Tolerance: Use the machine to cut parts dimensioned in a CAD program and measure the difference from the CAD drawing to actual part.
- Table Travel: Use of a tape measure and ensuring measurements read to at least 1/8th of an inch while measuring maximum travel of the tool head.
  - 13.75"L x 13"W x 3.5"H
- Frame and bearing deflection: Applying an equivalent force to the maximum value of the expected cutting force applied to the bottom of the spindle using a hanging mass or pull scale then, a measurement with a dial indicator will be made at the spindle tip of total deflection when force is applied and compared against static values.
- Set up time: Complete initiation and set up of the machine on the table to the time when the machine is ready to receive G code will be tested by using a stopwatch
  - 1 min 30 seconds
- Weight: Tested by using a scale
  - 120 pounds

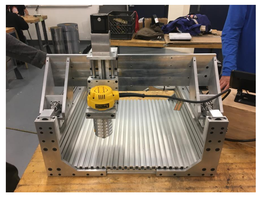

Figure 4: Final Machine

Figure 5: Testing the machine on plywood.

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- NAU
  - Fabrication Shop
  - Mechanical Engineering Professors
    - David Trevas
    - David Willy

References

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