Thesis Project Portfolio

Creating a CNC Machine from a Manual Drill Press

(Technical Report)

The Implications in Design of Rapid 3D Design & Manufacturing

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

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Sociotechnical Synthesis

Both additive and subtractive manufacturing machines provide businesses and customers alike with easy-to-use tools to produce a physical prototype or product from a three-dimensional model. To make these processes possible, advanced 3D software must be used in conjunction with the machinery so that the design can be communicated for autonomous manufacturing purposes. While this technology can be used for trivial purposes such as making a desk ornament out of plastic, it is often used to validate preliminary model designs and even produce parts-for-sale directly. These manufacturing capabilities have taken the manufacturing and engineering worlds by storm, allowing users to create a fully-functional model from scratch in a matter of hours. As a result, this groundbreaking technology has had a direct impact on the design process, and the evolution of manufacturing has changed the way that engineers and designers think as a whole.

The technical component of this report explains how a manual drill press can be converted into a fully autonomous CNC (Computer Numeric Controlled) machine. My team completed the project with the use of stepper motors attached to each of the machine's axes, allowing them to rotate independently without the need of manually rotating the crank of an axis. Rather than adjusting each axis independently by hand prior to the conversion, a user is now able to simply upload a 3D model to the machine, start the print, and have a completed design in a matter of hours. This advancement adds a number of benefits to the machine's capabilities, allowing multiple axes to be adjusted at once, minimizing human error, reducing the risk of a drill bit breaking, and cut more accurately due to the lower amounts of backlash produced from my team's replacement of the lead screws with ball screws. This technology is very valuable to the University of Virginia's Mechanical Engineering department because prior to this

conversion, the department had no means of machining aluminum parts without doing it by hand, and conventional CNC machines can cost upwards of $50,000.

For the STS component of this research, I investigate how 3D printing software and manufacturing directly changes the way that engineers and designers think, and how particular advancements in this technology have continued to change that over the years. In order to do this, I first examine the pros and cons of the technologies and the influence that they have on design. I next consider how these technologies have evolved over the years, and what design and manufacturing looked prior to groundbreaking advancements within 3D printing specifically. I then research how engineers with real-world work experience feel about 3D printing technology, and describe how these technologies have impacted their design work throughout their careers.

Overall, my team was able to convert the X and Y axes of the milling machine, but could not finish the Z axis within the time constraints. As a result, the vertical axis of the machine must be manually moved up and down to cut material from the part. However, my team did provide machined parts required for the Z axis conversion as well as assembly instructions for the remaining work. Furthermore, the team provided the G code required to allow the Z axis to function autonomously to help a machinist to come in and finish the conversion.

Lastly, I would like to acknowledge my teammates Isaac Buell, John Cooper, James Pincus and Ben Stein, all of whom contributed significantly throughout the duration of the conversion. I would also like to thank Sean Ferguson for guiding and supporting me throughout the development of my STS report.