Conversion of Manual PM-727V Milling Machine to CNC

(Technical Paper)

Protection for 3D Files

(STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

With technology progressing at an exponential rate, especially in the past couple centuries, many new and great ideas have come into fruition through various inventions. One of these ideas is creating 3-dimensional parts and currently, the two biggest methods in machining that are used to create these parts are milling and 3d printing. 3D Printing is a process where a machine is used to heat up and melt various polymers. These polymers are then extruded in a specific pattern in order to form and create a previously designed object. Milling works in almost an opposite way, where milling focuses on removing material rather than extruding it and actually creating it. A block, typically made of some sort of metal, is placed in the machine and from there, the milling machine uses a bit that rotates similarly to a drill in order to remove material into the desired final shape. Both of these methods can be done with either manual machines, where they are primarily controlled by the user, or computer numerical controlled (CNC) machines, where the user inserts a file of a 3d drawing and the machine automatically creates the part on its own. With CNC machines, the machine movements are powered by motors and the machines, themselves, are coded to follow specific toolpaths depending on the file they were given. CNC machines have greatly increased the ease of use of these machines, allowing even the most uneducated or uninformed users to create parts without a problem. Countless designs and drawings can be found online to download and use. On the other hand, creating one's own part is definitely more complicated, as it requires computer-aided design (CAD). In order to use CAD properly, much learning and experience is required. Designing an original 3d drawing with the idea of later creating that part, introduces the idea of patents. A 3d drawing itself, while it can be shared and used by other people, cannot be patented. However, a

patent can be obtained for the actual part, in which case, drawings are required to obtain the patent. With all this being said, our capstone project involves converting a Precision Matthews (PM) 727 milling machine from a manual to CNC. This led me to choose to research the rise of complications with patents for parts. The number of these complications increase as using these machines becomes easier as time goes by and technology progresses.

Technical Topic

Manual milling is rather challenging and requires significantly more knowledge and experience than CNC milling. For this reason, our group decided to convert a PM 727 manual milling machine into a CNC milling machine. The University of Virginia's Mechanical Engineering Building has two PM 727 manual milling machines. One will remain manual, while our group will convert the other one to be CNC. This serves the purpose of teaching future classes the basics of manual milling on one PM 727 and then they can later use the same exact model milling machine only with CNC in order to complete their milling projects more efficiently and to gain a greater appreciation for CNC machinery. In order to complete this goal, a list of smaller tasks would need to be completed along the way. These tasks consist of a complete breakdown and disassembly of the current machine, replacing the lead screws with ball screws, milling out motor mounts, installing motors, couplers, limit switches, and a touchscreen display, and downloading and running a software to communicate between the touchscreen display and the different motors.

The very first step is to completely disassemble the machine and break it down to its bare bones. This is required in order to get access to the lead screws, to put in the new ball screws, and reassemble it properly. After this has been completed, the next step is to measure and acquire the size of the three lead screws, found in the x, y, and z axes, in preparation for ordering appropriately sized ball screws. A lead screw is similar to a traditional screw, while a ball screw has a shaft with semicircular threads acting as helical raceways for very small balls found in the ball screw nut. The desire to use ball screws rather than lead screws can be explained by their greater accuracy than lead screws. Much of this is due to them having a lack of backlash, which is the lack of movement of the nut before catching the threads of the screw when it is being turned in one direction (Frey, 2010). Our group is required to design our own motor mounts via CAD and then to create them using some type of machinery, such as another milling machine or a water jet. All measurements are based off the NEMA 34 stepper motor, which will be used for the x, y, and z axes ball screws. The next step from there is to install the motor mounts, motors, couplers, and limit switches. Couplers are the joining parts that connect the motors to the ball screws. Limit switches give the machine its physical limitations, so it does not automatically go too far in one direction and eventually off the screws. Finally, a touchscreen display is to be installed and Mach 4, a software for CNC motion control, will be downloaded and run on that display. The display is where USB drives with files of 3d drawings will be inserted (Koren, 1976). The user can then select the proper files and the Mach 4 will automatically control and operate the three different motors.

STS Topic

While the wide increase of availability of 3d printing, milling, and CAD may allow for a greater usage of parts, it does in fact bring up some legal issues. This is where patents are introduced, in which many problems lie with our modern technology. Countless inventors, in the past, would want to obtain a license giving them the title and right to privatize their new product, ensuring others could not make, use, or sell it. This problem was rather smaller and worked without detrimental problems up until the late 20th century and early 21st century.

This time period introduced not only more accessibility to these technologies, but also the sharing of the files themselves. The mechanical device patent field was already somewhat complex compared to other patent systems such as the chemical patent field. The aspect that plays the biggest role in this complication is the lack of consistent terminology and a general naming system. The patent system of chemistry serves as a good counterexample, wherein every single discovered atom, molecule, and compound is given a specific name, listed, filed, and cataloged (List, 2007). This issue in the mechanical device field is not a complete dilemma, but it does create an already unsteady base for the whole system. The issue gets tremendously larger when recent technologies allow for the sharing of files of these devices or parts even when they are patented. Manufacturers no longer need to create, sell, and send their products to individuals, when the file can simply be shared and the item can be produced in one's own home. The internet in its current state makes finding any desired part file exceptionally easy, even if it is patented. Downloading the file and creating it without the user's permission serves as a rather troublesome loophole to the current legal system, as the individual who obtained the file is not "making," "selling," or "using" the patented device or any "component" of it either (Brean,

2013). This goes to show that there is a colossal foundational problem with the way our current legal system deals with patents in this field. If movies or songs were downloaded and used in this way, it would be considered piracy; however, individuals downloading files for already patented devices are essentially committing no crimes and therefore are given no punishment.

The United States Constitution Article I, Section 8, Clause 8 states that Congress has the power "To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." (U.S. Const. art. I, § 3, cl. 8.). There is no possible way that the founding fathers could have predicted where technology would have progressed in order to cover this idea of files of 3d drawings. This is why this dilemma has formed, because the Constitution claims to protect these inventors, but the specific wording it currently uses allows for these transactions to occur. There are a few solutions to this problem, two of them being changing the wording to include these digital drawings as "components" of the parts or to alter the patent system and specifically allow this sharing of files in order to progress society and these developments. Both of these solutions would go about resolving the issue, now it is simply down to deciding which one to choose.

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