Operations Manual

Team 13

No Contact Gap Measurement

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ABSTRACT

This project arose from the necessity of measuring a micro gap between two cylinders that are used to hot roll raw material into thin films. The thickness of these films varies between 80 to 200 microns, and it is important to accurately gauge the thickness of the film samples as they are used in material property testing. The rollers used in this process are about 30 cm long, 6 inches in diameter, and are made of highly polished steel, making them expensive to manufacture and important to keep from scratching or denting. The current method used in measuring the gap employs the use of feeler gauges, which are thin metal wands with known thickness that are placed in the gap. Initial ideas for a non-contact method leaned heavily on the concept of laser triangulation systems or micrometers that would shine light through the gap to determine its thickness, however, laser products proved to be entirely too expensive for the project budget of $2,000. The final design involves rigidly mounting arms to the roller positioning blocks and measuring the gap with strain gauge based load cells. The displacement and bending of the designed load cell will result in voltage variances that can be used to determine the gap between rollers. A microcontroller is necessary to handle inputs of the capacitance sensors and the device will be calibrated to account for thermal expansion and irregularities in the rollers through experimentation and analysis.

ACKNOWLEDGEMENTS

Thank you to the lab assistant Steven for helping tremendously in the application and calibration of the device. We would also like to thank Dr. Gupta for his help throughout the entire year long process and coding towards the end of the design.

1. Introduction

General Capacitance is the company sponsoring this project, and the problem they presented to the design team stems from measuring a micro gap between two polished steel cylinders used to hot work raw material into thin films. These thin films are made of a variety of materials that are used in batteries, and they are fabricated with the intention of doing material property testing, specifically capacitance. The specifics of the materials being used and the details of their future application was spoken of in general terms to protect the intellectual property. This operations manual will highlight the important aspects of the design and other technical information.

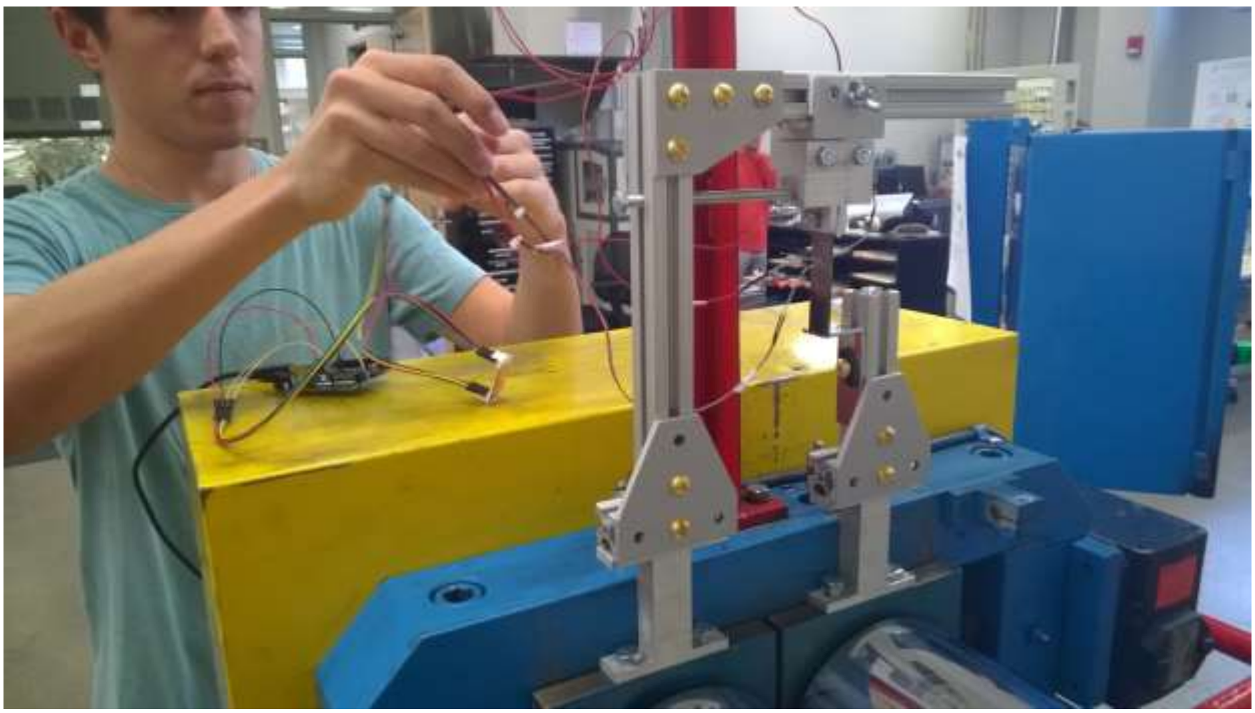

Figure 1. The design implemented on the rolling machine.

1.1 Functional Analysis

The basic function of the project is to be able to measure the gap between two hot rollers. The gap is measured by bolting two arms onto the machine. These arms will be mounted on parts of the machine independent from each other. These arms hold a small piece of metal known as the shim stock. The shim stock has four different strain gauges connected to it that measure the difference in bending of the metal. The metal shim is mounted to one of the arms while the other arm's main function is to bend the metal shim when the rollers are moved. The information that the strain gauges acquire will be sent first to an amplifier and then to a microcontroller. The amplifier is necessary because of the minute distance that the shim stock will be straining. The information will then be sorted by a code that will determine the amount that the rollers have moved. This code will compensate for the thermal expansion of the heated rollers. After the distance is calculated, the gap width will be displayed on the LCD display connected to the microcontroller. There will be buttons on the microcontroller's LCD screen that will allow the user to cycle through the temperature of the rollers. There will be a housing mounted on the safety rails of the machine that will hold the wires coming from the strain gauges and the microcontroller, amplifier, and the LCD screen. This housing will be bolted on to ensure easy removal of the housing and total design.

1.2 Project Specification

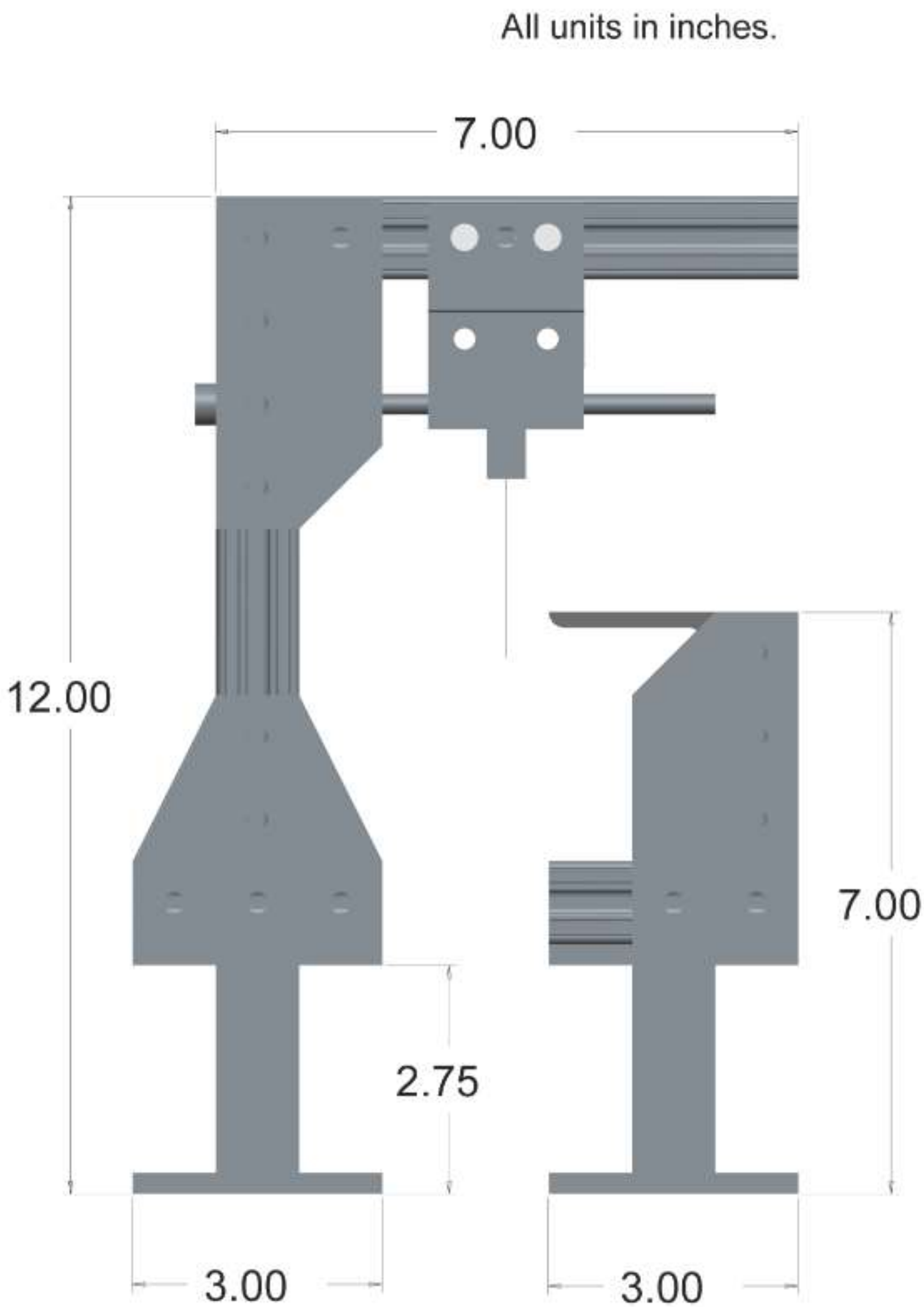

Figure 2. The main dimensions of the design that was implemented onto the machine.

There was a major constraint when designing the arms. This constraint was the height of the arms. The arms needed to be high enough to hide from the heat of the rollers but not be too high to hit the top of the red safety rails. The constraint was taken into consideration and a design was created to satisfy the constraint. The height is high enough to escape the heat but does not affect the normal operation of the machine in any way.

1.3 Product Assembly

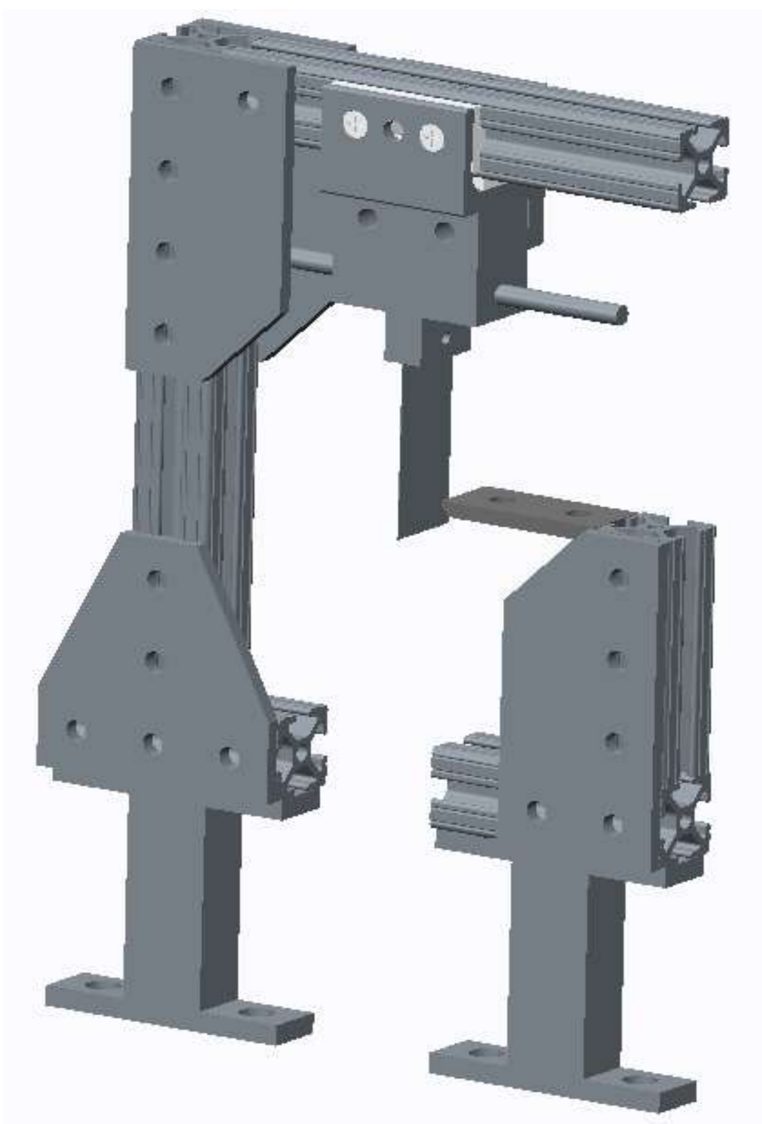

Figure 3. The full completed drawing in Pro-engineer.

Figure 3 shows the full model. This is the prototype that was carried out and installed on the machine. This figure shows everything from the feet to the top railing. The design was carried out with aluminum 8020. Aluminum 8020 is a type of aluminum bar that has a distinct cross section. The cross section can be described as having T-slots.

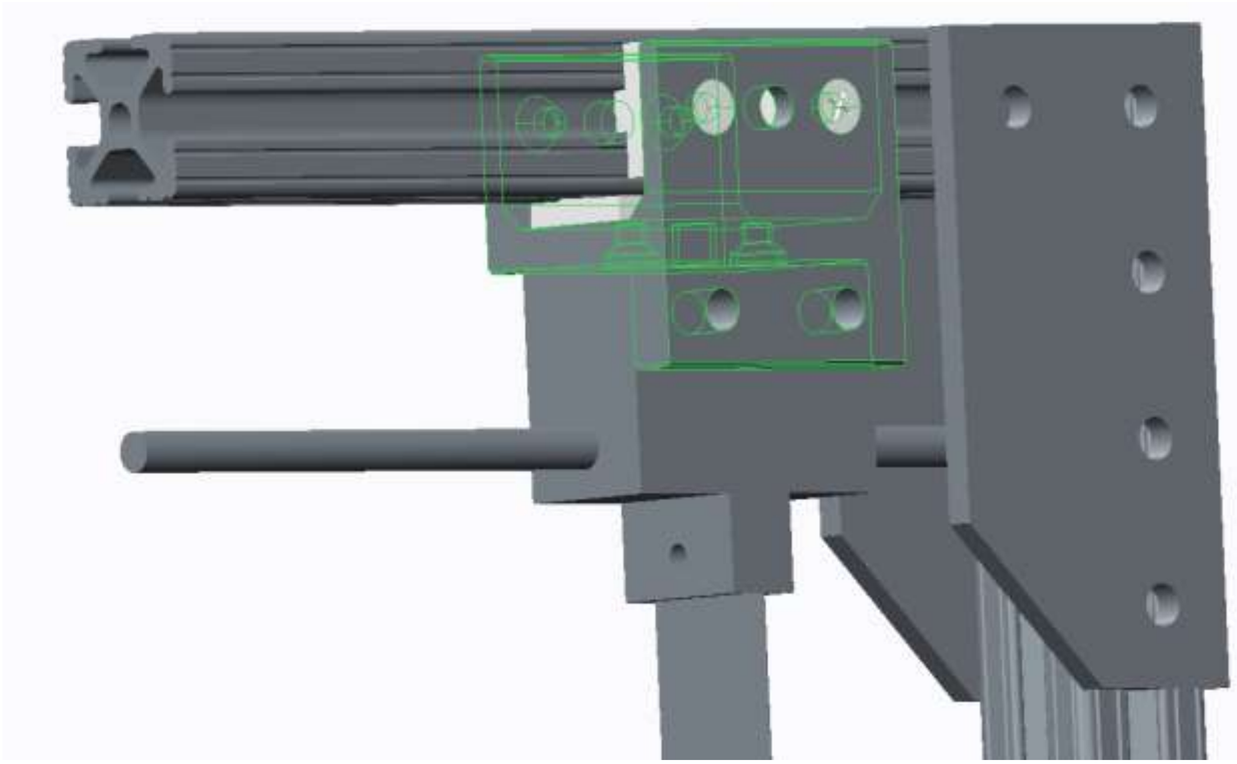

Figure 4. The rail system shown in green highlighting.

The linear motion system is shown in more detail in Figure 4. This system is a piece that was purchased in the same place as the 8020. The piece slides easily along the length of the T-slot rails and includes a locking mechanism on the side. The locking mechanism consists of a wing nut on a wide head screw. In the same figure, it is easy to see the shim metal and the shim block that holds the metal. This is aligned on a lead screw that follows through the right arm. This allows, but limits, the translational motion in the shim block.

1.4 Operations Instructions

The operation of the measuring device is dependent on the initial preperation done to the rolling machine and the aluminum mounted arms. Before operating measuring device, ensure that the rolling machine is set to its most open position with the largest gap possible. This gap will act as a baseline for the strain gauge loading. Once the rolling machine is set up, ensure that shim stock load cell is touching the arm bracket. It is important that the arm bracket is applying almost no force on shim stock, just barely touching barely touching the shim stock. This is a crucial part of the baseline gap reading previously calibrated. If placed incorrectly, it could lead to inaccurate readings. The translation of the shim stock should be done with lead screw, not the rolling machine. Once proper contact is made between the shim stock and bracket, lock the shim stock into place by tightening the wing nut attached to the holding block. The device is now ready to begin taking readings. Turn on or ensure the power supply is attached. The LCD screen will display the gap in real time. The first reading should be this baseline gap reading, and will be indicated by the display. If the reading is incorrect, it could be to improper placement of machine or arms and should be prepared again. Once the baseline reading is correct, the rolling machine can be set to a desired gap, or read subsequent gap. Make sure to only to move rollers when the readings are taking place, moving the arms could result in incorrect readings. Once the arms are in place, it is not necessary to move them much after the preparation stage because of the calibration of the device. It is recommended to prepare the machine before each use.

1.5 Troubleshooting

The measuring device may experience some issues while in use. Here are some of the issues that could be seen, as well as the possible cause and solution.

Incorrect measurement readings

- Improper setup. Make sure the shim stock is correctly in place with the arm bracket.
- The shim stock is not locked into place. Ensure that the locking wing nut is tight on the holding block.
- Electrical setup issue. Check to make sure all there is no problem with the electrical setup. Look to see all wires are attached and in good condition.
- Calibration issue. This would cause for a recalibration of the device and possible microcontroller. Please note that this will take a significant amount of time, be sure to check all possible causes before implementing.

No readings at all (blank display)

- The power is supply is off. Check to make sure the supply is connected and the batteries do not need replacing.
- Check the electrical setup. Make sure everything is in good condition.
- Strain gauge issues. If this issue occurs, it will cause for a replacement which might require a new shim stock. This option not as likely, and should be considered a last resort.

1.6 Regular Maintenance

The device requires little to no maintenance for its initial life cycle. The amount of time before critical parts begin to fail should be significant. The regular maintenance that will possibly be required at times includes tightening and replacing screws and bolts, and replacing batteries. There are critical parts that, if were to fail, would require significant maintenance. These parts include the shim stock and strain gauges. The strain gauges are very sensitive and must be handled with care. They are expected to have a long life but could fail, and in the event one fails, they must all be replaced. The shim stock is subject to some fatigue, but not much force is applied. In the event the shim stock break or bend improperly, it must be replaced. New strain gauges must be applied as well. Both of these replacements would require recalibration as well. These parts are difficult to replace and expect to be held in good working condition the majority of the life of the device.

1.7 Spare Parts

The spare parts that could be supplied to the lab personnel would be spare shim stock and strain gauges. Both of these items are simple to purchase and cheap. The shim stock can be any small piece of metal that is cut into the proper shape. The material of the strain gauge does not matter because the elastic properties of the metal are not accounted for in the formula for calculating the strain therefore the shim stock can be any material, ideally a piece of scrap metal that has been prepared and is ready. The strain gauges are a particular brand that could be purchased for approximately $17 per gauge. These are the only pieces on the build that have the potential to fail.