Midterm 1

Group #13
General Capacitors – No-Contact Gap Measurement

Team Members:

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Problem Statement

The current use of feeler gauges to determine the distance between two hot rollers is inconvenient and potentially damaging. There needs to be a different and more effective way to determine the distance. This new method needs to be quick, efficient, and accurate. The hot rollers have been damaged before by the current measuring method. These rollers cost thousands of dollars, because they are custom made, and cannot be replaced anymore.

Project Scope

The objective of this project is to design a device that measures the gap between two steel rollers without contact. The two steel cylinders are heated to around 300°F and then used to roll material into thin films. The motivation behind this project is finding a more efficient and precise way of measuring the gap between the rollers, as the current method is touch based and employs the use of a strip of material with known thickness to estimate the thickness of the gap. The goal of this project is to design, build, and test a device that uses optical means to measurement of the gap.

Project Objectives

- Maximize maneuverability in the applied system.
- Use optical sensors to measure the gaps of the rollers up to two microns.
- Must be removable or detachable and easily reassembled.
- No contact with the rollers themselves.
- Reliable with a life of up to ten years.

Overall plan / Methodology / Approach

The device will be able to be easily installed onto the existing rolling machine and will utilize lasers and sensors to detect the amount and intensity of light that passes through the gap at several points down the length of the rollers. The prototype developed will comply with the spatial conditions of the current machine, the desired resolution, and the budget restrictions of the project.

Project Constraints

- The sensor or sensors cannot come in contact with the rollers, nor can any other system or piece in the design.
- The sensors or sensitive pieces in the design must not come too close to the rollers under heated operations.
- The total cost of the new system must not exceed $1,400.
- The design must be light enough to mount on the supportive braces on the top of the machine, or around another part of the machine.
- The design must be precise, up to two microns, and purely accurate.
- The design and structure must be simple enough to install or uninstall accordingly.
- There must be some sort of outside battery pack or power connection because the device cannot draw power from the machine it is being installed on.
- There must be as few pieces as possible, or the entire design must be one piece.

Project Background

Rolling mills have been used in many different projects and companies to crush, grind, and coat different materials. These materials can then be used for many different applications. The materials can be tested for specific properties and then used for applications that need those properties. The rolling machines have controlled, measured gaps that can be changed for different applications. In this experiment, the gap ranges from eighty to two hundred microns in length. The rolling machine has two chrome rollers that are approximately thirty centimeters long and around seventeen or eighteen centimeters in diameter. They are also heated to three hundred degrees Celsius to ensure the material that is pressed through them is as flush as possible.

Figure 1. The rolling machine that will have the device mounted on it.

Figure 2. A full picture of the rolling machine with the red bars included above.

The red bars, shown in Figure 2, are important in this project because they are one of the few places that the device can actually be installed. These are meant to be safety off switches for the rolling machine. The two outside bars swing down and activate the emergency shut off for the machine. The bars only need to swing down a few degrees to activate the switch so if something were to be installed in the middle of the bars, it would not affect the actual function of the bars. The created device, whatever it may be, will be small and lightweight enough to be mounted on those red bars. This way, they could easily stare directly down into the gap that is made from the two rollers. Also, if the device were to be mounted on the bars, then the device could be hooked into some railway system that could potentially ferry the device across the lateral length of the rollers. This would make measurements from both ends of the rollers easier to take and can lead to an easy way of measuring the angle of the rollers. For some applications, one end of the material that comes from the rolling machine needs to be thicker than the other end of the material. This can be for multiple reasons or for simply testing the different properties.

Design and Analysis

There are little design specifications for the no-contact measurement system, however, there are plenty of specifications that were not explicitly stated by Dr. Zheng. The design specifications that were specified are that the device needs to have no contact with the rollers themselves, the device needs to be able to read gap distances from 80 to 200 micrometers, it needs to be able to traverse the entire 300 centimeter lateral distance of the rollers, it must have a resolution of 2 micrometers, and it has to be created within a budget of $1,400. Finally, the device needs to be able to measure the rollers during their normal operation. The rollers may be moving while the measurements will be taken. There are more specifications that were not stated by Dr. Zheng that needed to be taken into consideration. These specifications are more in depth than the previously stated requirements. The device needs to be able to last ten years or more, the normal wear in a machine shop that the device will be placed in must not destroy the device itself; there will be a temperature gradient in the air around the rollers because they will be heated up to three hundred degrees Celsius so the device needs to be far enough away to not be affected by the heat; the device needs to either be removable and easily attachable, or out of the way of the normal operation of the rollers (including the safety bars on the top of the machine); the device needs to have an internal power source or needs to be run off a computer or other external source (except the machine itself); and the device and the software that will be used for it must be easy and simple enough for anyone to be able to use. The software cannot contain complicated elements and must be user friendly.

There are a couple of design concepts that have been created. The two main design concepts are the laser sensor and the high resolution photography. These two design concepts have been taken into consideration and steps to choose between which of the two is better has

been started. Both of these concepts have been placed into a house of quality and other engineering tools to determine their effectiveness.

The laser sensor that was proposed has elements in mechanical systems. The laser may be mounted on a rail system that will allow the device to move parallel to the rollers during or before operation. This will require motors and extensive work in programming to accomplish. This also shows some promise in the field of electrical systems because of the circuits that will be integrated into the system. The second option, the high resolution camera system, can also be mounted on a rail system; however, this method would allow a much higher field of visibility than the laser system. Because of the rail system and the motors that would go hand in hand, this concept has roots in both the mechanical systems and the electrical systems. The thermal portion of this project is the potential for the temperature gradient that will progress through the surrounding environment. The temperature has to be measured throughout the safety rails on the top of the machine and through the air that the device will rest in. If the device is placed too close in the temperature gradient, then the pieces, or the entire system, will fail. Different pieces may melt or, because of thermal expansion, become too large to operate properly.

During the concept selection, a couple different engineering methods were utilized. A house of quality was created to rate the different engineering characteristics that were needed in the design. Along with the house of quality, a Pugh matrix was created to further the concept selection and to solidify the outcome.

		Engineering Characteristics						
Customer needs	Importance	Material	Precision	Portability	Durability	Software/User Compatibility		
No Contact	5	1	5	5	1	2		
Easily Maneuverability	3	3	1	5	2	1		Key
Able to Perform in High Heat Environment	2	5	3	1	5	2		5 - Strong Relationship
Accuarte Readings	4	1	5	2	1	5		1 - Weak Relationship
Internal Power Source	1	1	4	5	2	2		
	Priority Σ (Importance*Ra	29	58	55	27	39		
	Ranking	**4**	**1**	**2**	**5**	**3**		

Figure 3. The House of Quality used to determine the most effective concept.

At this moment in the project, there cannot be CAD drawings of the designs because the pieces have not been ordered yet and the final design has not been selected.

Scheduling and Resource Allocation

Team Leader: Forrest Parker

- The Team Leader will coordinate regular meetings and will be the main point of contact with the project sponsor and team advisor. He will be responsible for aiding in the development of a project schedule and making sure every member is on task.

Lead ME Designer: Sam Giaquinto

- The Lead ME Designer will evaluate and make the final decisions on the mechanical portion of the team's design. He will be responsible for keeping an organized record of design development.

Financial Advisor: Matt Nagy

- The Financial Advisor will initiate and keep records of the project budget, and will stay on top of adjustments that need to be made in budget planning.

All Team Members

- Actively provide feedback and suggestion toward design.
- Show respect to all other team members at all times.
- Attend scheduled meetings.
- Communicate effectively.

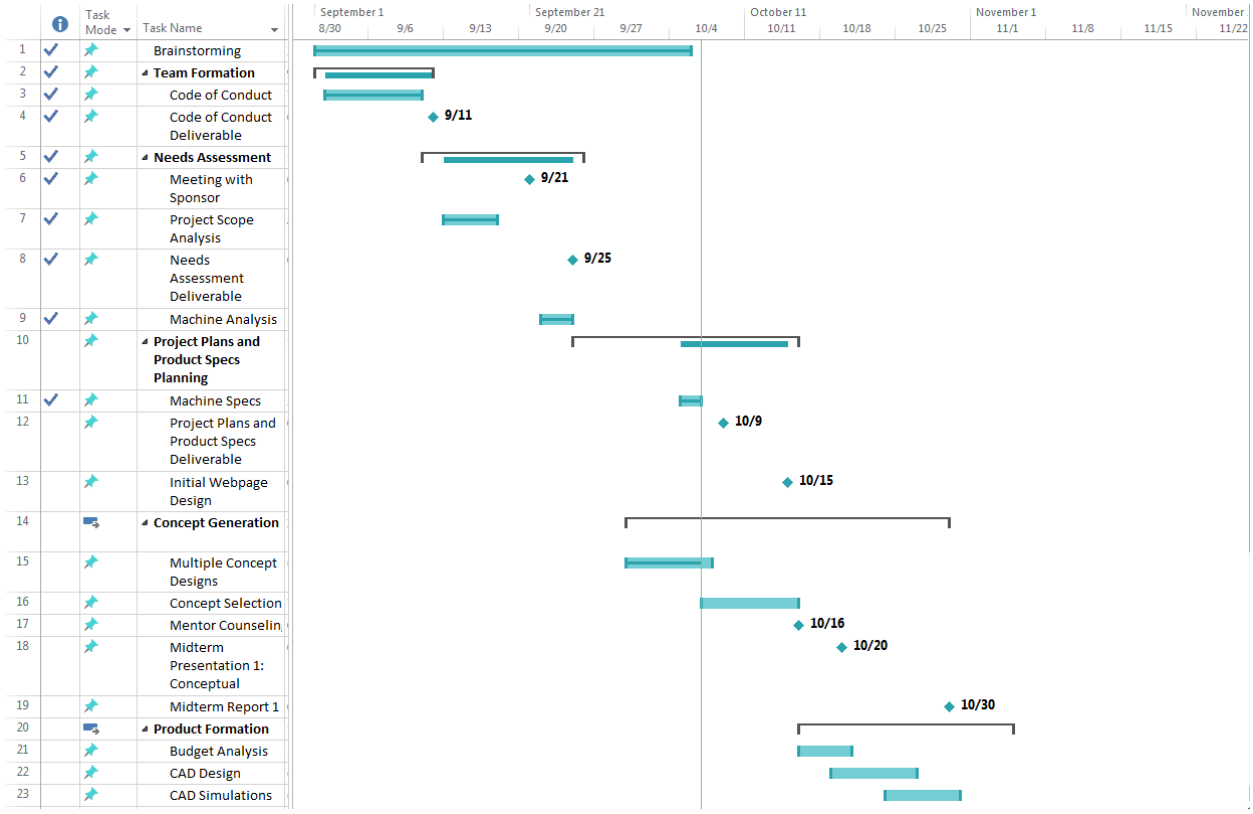

Figure 4. First portion of the Gantt chart.

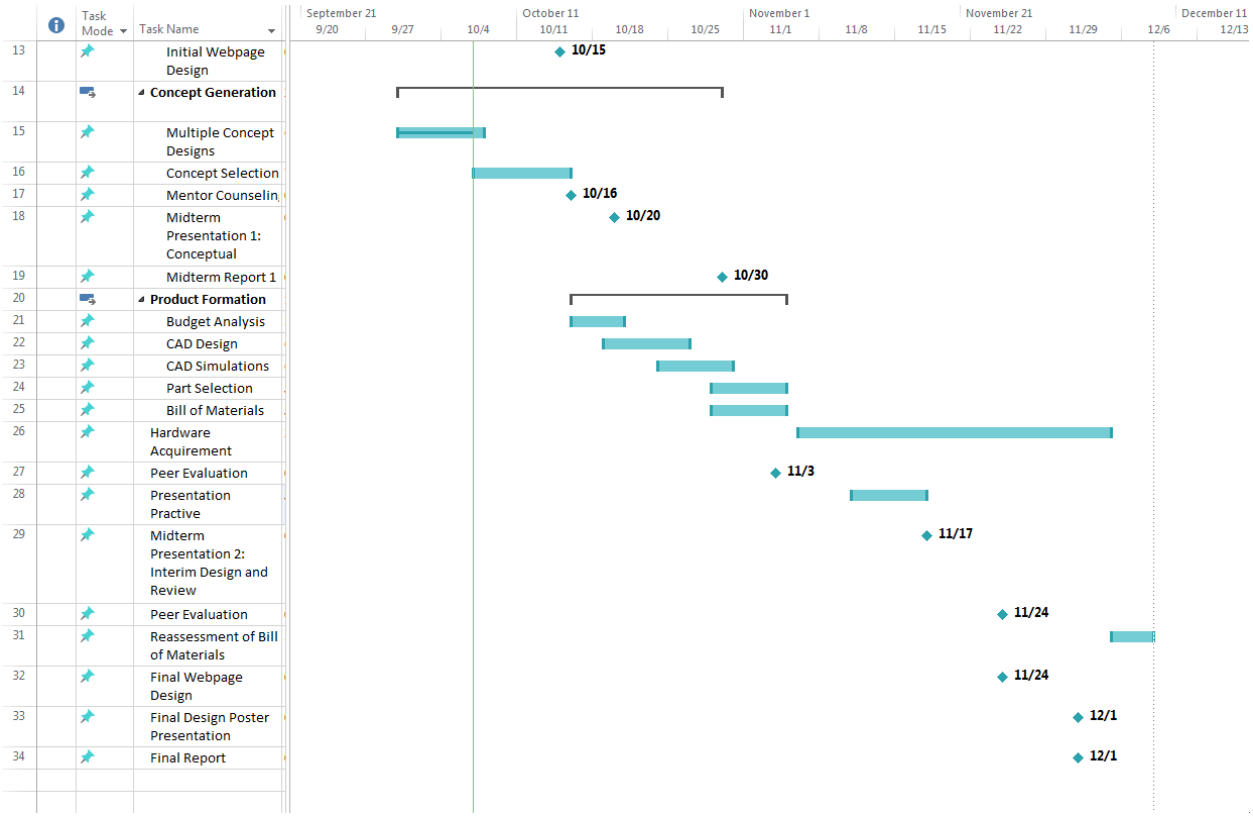

Figure 5. Second portion of the Gantt chart.

The above two figures represent the timeline that Team 13 will follow. Most of the days have been given plenty of extra time to account for any unexpected results. For instance, if the design concept that has been assigned is concluded to be far too expensive, then there will be enough days for the project to step back and then continue.

Results

After some thorough research on the two main concepts that were presented for the design, there have been some unexpected results that were found. While researching the potential for laser sensors, the price ranges have been in upwards of $10,000. This is obviously far above our actual price range and budget. This may lead to the actual concept being trashed altogether. This will lead to having simply one concept remaining: the high resolution photography. There are many obstacles and constraints in using this technology. The focal point needed in this setup, at most about two feet away, is longer than any microscope can accomplish. Also, to acquire a camera that can focus on something as small as 100 microns from that distance away will be a decent amount of money and may be out of our pay range. These constraints lead in a very precarious situation and we are almost back at square one for the project.

Conclusion

Unfortunately, there have been quite a few setbacks in the research portion of the project. This leaves us very far behind in our schedule. The laser sensor information that was provided to us by Dr. Zheng was determined to be far too expensive and the high resolution photography was quickly determined to not be able to work. These two ideas were the main concepts for the solution to the project. Without these, we will be set back into the research stage of the project. Perhaps there can be different laser systems that are far less expensive than the current system or there can be some sort of miracle microscope system that can be used for the exact range that we need. These are all questions that need to be answered in the research section and will be addressed within the next week. We plan on having a couple more solutions or different concepts to the no contact gap measurement within the next week.