Needs Assessment

Group #13
General Capacitors - No Contact Gap Measurement

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Abstract

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℉ 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 srip 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. 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.

1.0 Introduction

The rolling mill is used to roll material into thin film layers. It is important that the thickness of the film be known and repeatable. The machine was purchased by the Aero-Propulsion, Mechatronics and Energy (AME) Center at the Florida State University. The technique currently employed to measure the gap between the rollers is touch based, and involved placing strips of material that have a known thickness between the rollers. This process is simple and practical but not precise, and is limited by the inability to get physical rulers that will be single digit microns in thickness. Other difficulties in gap measurement that the machine introduces include the rollers being made of highly reflective, polished steel that is heated up to a working temperature near 300℉, making traditional, contact based measurement devices unpractical. Not only is there such a precise resolution needed in measuring the small gap, but the high temperatures threaten to damage the measurement devices because of their proximity. A no-contact gap measurement device is the ideal solution to this issue, as it offers precise, repeatable measurements from a distance.

There are dozens of laser and sensor based gap measurement system manufacturers that sell packages of the necessary hardware and software to analyze gaps of all shapes and sizes, such as Micro-Epsilon.[1] The task of designing the software and advanced algorithms necessary for gap measurement will not be the primary responsibility of the design team, but rather their focus will be designing a method for incorporating these pre existing resources into a device that will optimize their application toward the specific project needs. The roller mill lends itself to having a sort of linear translation track installed above it, as it is spatially constrained primarily from the sides. The high reflectiveness of the rollers will be an anticipated issue to tackle in using optical equipment. Specular triangulation systems must be used on highly reflective materials, which requires directing the laser at an angle rather than directing it directly at the material, resulting in it bouncing straight back.[2] Designing a gap measurement device that tackles the challenges mentioned will be the main objective of this design project.

2.0 Project Definition

2.1 Background Research

Measuring the gap between two objects, whether they are rollers or car doors, is a popular necessity. This project has been done before on many different subjects; however, the one of the main differences is that our project requires a resolution that is many times more precise than the next project. When researching gap measurement tools for information on this project, the only results that showed were systems that measured gaps or distances in lower bounds of centimeters. This project requires the use of a resolution that is 2 micrometers, or simply a fraction of what the tools will show. This provides plenty of obstacles in the project. Designing of a brand new type of sensor or measurement tool may be completely necessary.

There is not many literature or background research on resolutions at the level that we need. There also is nothing that led to this project, for instance, no one has worked on this problem before. This is a brand new problem that has no obvious solution. This project will be aiming to provide aid to others in the lab, therefore, there is no controversy over this project.

2.2 Need Statement

The sponsor for this senior design project is Dr. Jim P. Zheng who is a Professor and Sprint Eminent Scholar Chair. He proposed a design project that would help increase the effectiveness of measuring the gap between two hot rollers. The current means of measuring was slow, unreliable, and potentially damaging. It required the use of metal feeler gauges that could, and sometimes did, dent or damage the rollers before operation. The rollers in question cost in upwards of $15,000 and were not easily replaceable.

The current use of feeler gauges to gap a pair of rollers is unreliable, time consuming, and damaging.

2.3 Goal Statement and Objectives

Design a non-invasive method of accurately measuring the distance between two hot rollers.

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.

2.4 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.

2.5 Methodology

There are multiple ways to start the design process for this proposed project. One of the most effective ways to establish the relationship between customer needs and engineering characteristics is to build a house of quality. A house of quality uses a matrix to determine the relationship between the constraints of the product and the actual engineering characteristics that will be used to design the optimal prototype and final product. The house of quality can be seen in Table 1.

Table 1: House of quality

	Engineering Characteristics						
Customer needs	Materials	Laser sensor	Number of parts	Latch on capability	Linear motion	Motor	Power source
No Contact	1	5	2	5	3	2	2
Lightweight and portable	5	2	5	4	1	5	3
Heat resistant	5	2	2	2	1	1	1
Accurate readings	1	5	2	1	4	2	2
Internal power source	2	1	4	1	3	4	5

By looking at table 1, it is possible to see the correlations made between the customer needs and the engineering characteristics. In the matrix, numbers can be seen and each of this numbers represent the degree of relation between the needs and characteristics. 5 represents a strong correlation and 1 represents a weak correlation. By examining table 1 it is apparent that the need for the device to be lightweight and portable, and the characteristic of the material of device have a strong relationship. This is an obvious deduction, as the assumption is that the material of the device will directly affect the weight of the device. Another example is the relationship between the need for the device to be heat resistant and the characteristic of linear motion. This has a weak correlation, and this is because the ability for the device to move linearly does not have much, if not any, affect on weather the device is heat resistant. By using the information gathered in the house of quality, it will be much easier to determine which characteristics are most important to satisfy the customer needs.

3.0 Conclusion

The first step in the design process is to establish the needs of the consumer and the future device. The consumer was established to be a the sponsor of the senior design group, Dr. Jim P. Zheng. He presented the group with an initial framework of the scope of the project, and what were the expectations for the design. The next step after establishing the needs of the consumer was to identify the goal statement and objectives of the project. The goal of the project is to design a non-invasive method of accurately measuring the distance between two hot rollers. After that the objectives were listed, and this gave the group a better idea on how to achieve the goal statement, as well as the needs of the customer. The next step is to establish the constraints of the project. By understanding the constraints of the project, the group will have a much better idea of what is possible and within the reach of the final design. The constraints also help to identify the limitations as well as the expectations of the project. After the constraints are identified, the methodology is established. The methodology is the way that the design process will be implemented. The project is still at very early stages, so the only methodology that was chosen by the group was a house of quality. The house of quality identified a relationship between the customer needs and the engineering characteristics of the device by using a matrix. This is a very useful tool in the design process. The needs assessment is a paramount part of the design process as a whole. This assessment will be used as a framework for the rest of the project, and will also be used as a reference throughout the project.

References

1.) **Micro-Epsilon PDF**
http://www.micro-epsilon.com/laser-scanner/gapCONTROL/index.html

2.) **MTI Instruments - Laser Triangulation**
http://www.mtiinstruments.com/products/lasertriangulation.aspx