ABSTRACT

A sensor is a device which receives and responds to a signal when touched. A sensor's sensitivity indicates how much the sensor's output changes when the measured quantity changes. It measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. Here we have used a simple low-cost sensor system for measuring the thickness of metallic plates by using a high-resolution laser mouse navigation sensor. An experimental prototype has been developed, which includes a survey freely on the plain surface of metallic plates. A signal is generated from the laser mouse during the experiment. The first minima of the signals determines the thickness of the metallic plates.

Keywords:

I. INTRODUCTION

Sensors are used in nearly all ABB products and systems. They deliver the input information for the control of processes and the protection of systems. Sensors transform a physical measurement into an electrical signal. The subsequent signal processing transforms the raw electrical signal into useful information. While in the past this information was just the measured physical value like temperature, future devices will deliver additional information like the condition of the device itself or even the condition of the process they are connected to.

One can measure thickness on many scales. Closer to home, Earth’s atmosphere is a spherical shell about 40 km thick; the weather occurs in the troposphere, about 12 km thick. The outermost shell of the solid Earth is the crust, about 35 km thick. The ocean has a mean depth of 3.9 km. In terms of the man-made environment, industry must contend with thickness varying from meters, for construction projects, to millimeters on assembly lines, to micrometers and nanometers for the solid-state, optical, and coatings industries.

Bruno Silva, et al in their paper titled “2D Magnetic Field Mobile Sensing System for Eddy Current Testing” described the use of two computer mice for location identification system, coupled to eddy current system, which can be used for non destructive testing of aeronautical wing testing automatically. The eddy current probe is used to identify flaws in the area beneath the probe, whereas the two mice system is used to identify the location. Basically the mice system is meant for identifying the location. T.w.Ng et al., in their paper titled “The optical mouse for harmonic oscillator experimentation” explained about the optical mouse application. As per the discussion, the optical mouse is an extremely cost effective displacement sensor. Due to the economies of large volume production, the cost of an optical mouse is extremely low. In several applications, the optical mouse has been demonstrated to be a practicable optical displacement sensor beyond its use as pointing device. The optical mouse may be applied to measuring vibratory displacements with reasonable accuracy if the vibration frequency was limited to below 10Hz. In their experiment they used the mouse to measure low frequency mechanical oscillations using an optical mouse. They described the experimental set up using the optical mouse for measuring the mechanical oscillator motion and depicting the waveform on computer screen.

Nadir Nizar Ali Charmiya, et.al. Presented in their work, the design and development of a “simple low-cost system for thickness measurement of metallic plates using laser mouse navigation sensor”. The design consists of a high resolution laser mouse navigation sensor, which is released on the plain surface of metallic plates under test. The first minima of the signals are related to thickness of the metallic plates. This work in the present project is further extended to provide the measurement using the microcontroller based system to process the data coming from the mouse and a proximity sensor and
the reading is provided on the LCD for direct reading.

T.W.Ng et al published another paper titled “the optical mouse for vibratory motion sensing”. In his work he concludes that the optical mouse technology currently available is workable, but has a confined scope of low frequency and low amplitude application in vibration motion sensing. Never the less, this range still makes it useful as a dynamic sensor in a reasonable number of applications where low cost is particularly required.

In the present work, we used the optical mouse for the detection of vibratory motion sensing and try to measure the thickness of metallic plates.

II. LASER MOUSE SENSOR

Optical sensors are small cameras (Illustration 4.3) that sit under the mouse and takes picture during small intervals. The sensors take up to 5250 pictures per second and sends them to the image-sequencer.

The resolution of these pictures are usually measured in cpi (Counts Per Inch). It works in two modes, 400 cpi and 800 cpi. The resolution can be changed via the USB interface with proprietary messages without resetting the mouse. The mouse defaults to 400 cpi after a reset message or power reset. The cameras have slightly different picture-sizes and mice working at the same speed will therefore report slightly different speeds. This difference is not huge and does not have much impact on the topspeeds of the mice and rescaling the mouse-readings is a fairly easy task if there are reference readings of the mice.

On the robots in the AIR-Lab they are also placed in different angles so there is a need to “rotate” the readings for all mice to get the actual direction of the robot.

III. WORKING MECHANISM

A PC based on an Intel Celeron microprocessor running at 1.6 GHz was used for the experiment. The monitor display area was 1280 pixels wide by 800 pixels high. The thickness measurement sensor system consists of a laser mouse and a lightweight cylindrical displacement probe that is made of steel. To guide the vertical movement of the probe, an open-ended minimum friction tube with a hole is used (Figs. 4–6).

IV. HARDWARE DESIGN

The Hardware design phase consists of several parts. They are:

- a) Power supply
- b) Micro-controller circuit design.
- c) LCD interface
- d) DC motor interface

The power supply circuit has to provide a 5v-regulated power to the micro controller for its operation. The dc power required is derived from a 230v AC supply mains. The circuit diagram of the designed power supply is as shown in fig 4.1. In the circuit, a step down transformer of rating 230v primary with an isolated secondary winding is used.
The secondary winding provides a 12v ac output, with a current capacity of 500mA.

![Micro controller power supply diagram](image1)

**Fig-4.1 Micro controller power supply**

The average DC voltage value for 0% duty cycle is zero; with 25% duty cycle the average value is 1.25V (25% of 5V). With 50% duty cycle the average value is 2.5V, and if the duty cycle is 75%, the average voltage is 3.75V and so on. The maximum duty cycle can be 100%, which is equivalent to a DC waveform. Thus by varying the pulse-width, we can vary the average voltage across a DC motor and hence its speed. PWM technique also eliminates harmonics. The micro controller has a circuitry in order to generate PWM pulses.

![Circuit diagram for DC motor](image2)

**Fig-4.2 Circuit diagram for DC motor**

V. RESULT AND DISCUSSION

The thicknesses inferred from a number of measurements of the sensors over aluminum and steel plates are given Table I, which verified our model and the measurement method. Standard aluminum and steel plates with thicknesses of 0.5, 1, 5, and 10 mm were used for validation of the experiment. The actual thicknesses are the nominal values for standard plates with thickness precision of ±2% specified in the datasheet. The difference between the actual values and the inferred values is due to the resolution of the image sensor being 8 µm and the limitations of the assembled prototype. From the error analysis, the maximum measurement error as per Table I was found to be ±16 µm from the set of 100 measurements for each standard plate. That is, the magnitude of the maximum relative error was below 1.6%. The results indicate that the thickness values of the plates as per datasheet and those with the present measuring system are in good agreement. It is also seen from Fig. 10 that the relative error decreases with the thickness of the plates. It is due to the fact that the resolution of the laser navigation sensor is limited to 8 µm. This implies that the accuracy of the measurement system is more in case of the thick plates. The error in measurement is shown in the following table.

<table>
<thead>
<tr>
<th>PLATE</th>
<th>ACTUAL THICKNESS</th>
<th>MEASURED THICKNESS</th>
<th>ERROR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALUMINIUM</td>
<td>400</td>
<td>410</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>790</td>
<td>-10</td>
</tr>
<tr>
<td></td>
<td>700</td>
<td>704</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>1006</td>
<td>6</td>
</tr>
<tr>
<td>STEEL</td>
<td>1000</td>
<td>1005</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>585</td>
<td>-15</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>507</td>
<td>7</td>
</tr>
</tbody>
</table>

The magnitude of the relative mean error was below 0.81%. However, the relative mean error decreases with the thickness of the plates. This is because the laser navigation sensor has a resolution that is limited to 8 µm. It was also found that the standard deviation of the thickness values estimated for each plate was less than 11.5 µm.

V. CONCLUSION

In this paper, a simple and low-cost system for thickness measurement of metallic plates using a laser mouse sensor and a displacement probe has been proposed and verified by experiments. The main component used in the prototype system (excluding the computer) is the laser mouse costing as low as $40 due to the economics of large volume production. From the error analysis, it is evident that the accuracy of the system is good enough for the proposed range of measurement. The significance of this paper also lies in the simplicity of the approach and its minimum requirements for computation. It is because the proposed measurement system requires determination and recording of X-coordinates of the mouse and obtaining first minima of the displacement signals. These features may facilitate the realization of this method in small, low-cost, and portable instruments employing microcontrollers instead of using a PC. According to the sensitivity of the laser navigation sensor, the maximum resolution of the measurement system is limited to 8 µm. That is, the measurement accuracy is limited to the pixel spacing of the imaging sensor in the laser mouse. In the future, with advancement in the technology of laser
sensors with respect to the resolution, it will be possible to measure the thicknesses of the plates with error less than 1 µm. The accuracy of the system can be further increased by dedicated precise fabrication of the sensor system in place of the assembled prototype used at present.

REFERENCES


