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ECONOMICAL INDUSTRIAL RADIOGRAPHIC FILM ANALYZER FOR NON-DESTRUCTIVE TESTING

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ABSTRACT

Radiography Test (RT) interpretation is done by using two major devices; x-ray film viewer and densitometer. The process has many repeatable steps which consumed longer time period to produce a final result. To reduce this time waste, a hybrid RT device was designed and developed. Industrial Radiographic Film Analyzer, tested over international Non-Destructive Testing instrument standards and met the required accuracy conditions properly.

Keywords: Densitometer, Non-destructive testing, Radiography Film Viewer

1. INTRODUCTION

Every Non- Destructive Testing (NDT) perform under an international standard to make sure the accuracy, quality and safety[1]. A radiography test (RT) perform according to the 2010 ASME Boiler and Pressure Vessel Code and film quality checking process take place by using x-ray film viewer and densitometer.

To accept a film for interpretation, its density should lie between 2.0 to 4.0 in the concerned area beside visibility of IQI wires[3]. Whenever to produce the final result, films accepted by densitometer has to be interpreted by using x-ray film viewer as many times it required until end of full set of x-ray films which may consists hundreds in count. This high repeatable process causes lot of time consumption as well as man power.

To overcome this long analytical process, a hybrid device was designed and developed. The device consists of an x-ray film viewer and inbuilt densitometer which reduce the number of repeatable steps considerably achieving low processing time with high flexibility.

Further, it was calibrated using a step tablet[2] according to the ASME Boiler and Pressure Vessel codes to meet the industrial standards[4].

At the early stage of the designing of the system, a uniform light intensity distributing reflector was modeled and simulated using TracePro Ray simulator. Atmega32 micro-controller based main controlling unit was developed to achieved flexibility and accuracy at considerably low cost. For construction of unity intensity reflector four 10W Light Emitting Diode (LED) array was used.

Commercially available ray files of the LEDs were simulated using TracePro ray simulator to generate irradiation plots for analyzing the light intensity distribution at the reflector surface.

CdS Light Dependent Resister (LDR) was used in the density measurement probe for measuring the density of the x-ray films.

2. EXPERIMENTAL

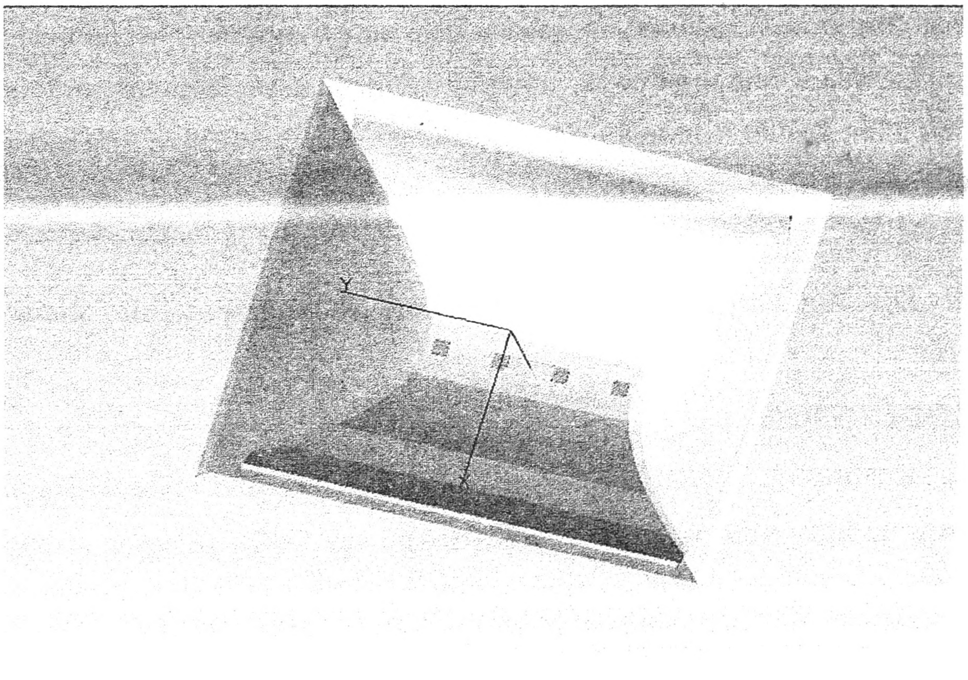

Figure 1: Design of the simulated reflector model

Figure 1 shows the simulated reflector design. It was designed using acrylic plastic (with refractive index of 1.49207) as construction material and 90% diffuse reflecting white paint as the main reflection surface. Four LEDs were mounted in the central area of the reflector with equal distance. Two mirror like surface, side reflectors were added to reflector so that it will cause to increase the light reflection in corner areas

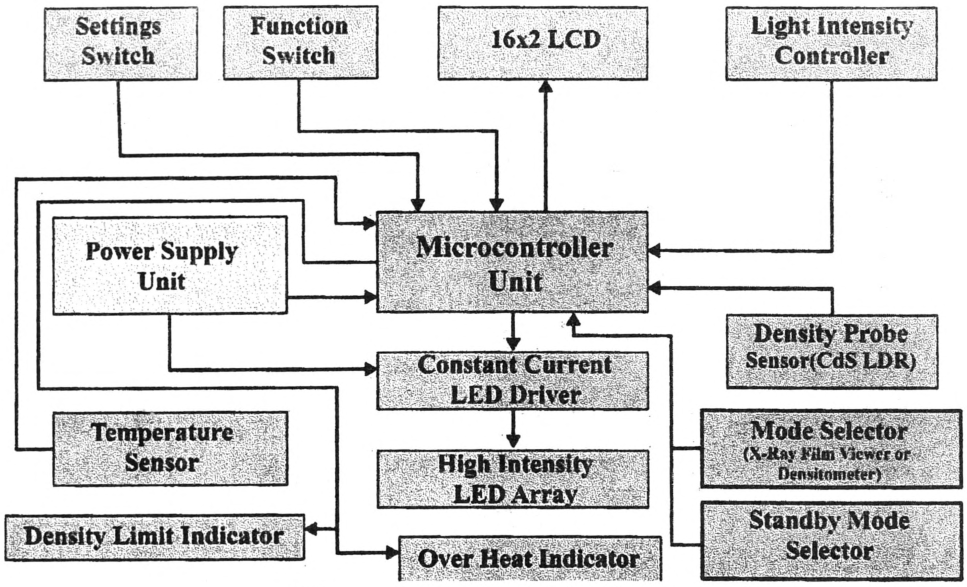

Figure 2: System block diagram

The developed device block diagram shows in the figure 2 and there operation as follows;

Microcontroller Unit: An atmega32 microcontroller was used as the brain for the system.

Power Supply Unit: Dedicated power supply unit for controlling unit and high intensity Light Emitting Diodes (LED) separately.

Settings and Function Switches: Two main switches were added to handle different user functions and settings over time.

16x2 Liquid Crystal Display (LCD): As an output device to print the information.

Light Intensity Controller: A potentiometer to change the light intensity.

Density Probe: Density probe to determine the density in x-ray films.

Mode Selector: As a densitometer and as an x-ray film viewer.

Standby Mode Selector: This function simply change the device state to standby mode.

Constant Current LED Driver: High intensity LED driving unit.

High Intensity LED Array: Four 10W cool white LED array.

Temperature Sensor: A temperature sensor for monitor the heat state in the system.

Density Indicator: A LED indictor was used to indicate out of range density readings.

Over Heat Indicator: If the system over heated at any state, this indicator will be triggered.

The density probe was developed using commonly available CdS Light Depend Resistor (LDR). The sensor was mounted in a fully sealed pen type probe while only allowing light from a 2mm hole. Since density is a linear response for incident light intensity, it can directly calculated by using LDR analog reading value.

3. RESULTS AND DISCUSSION

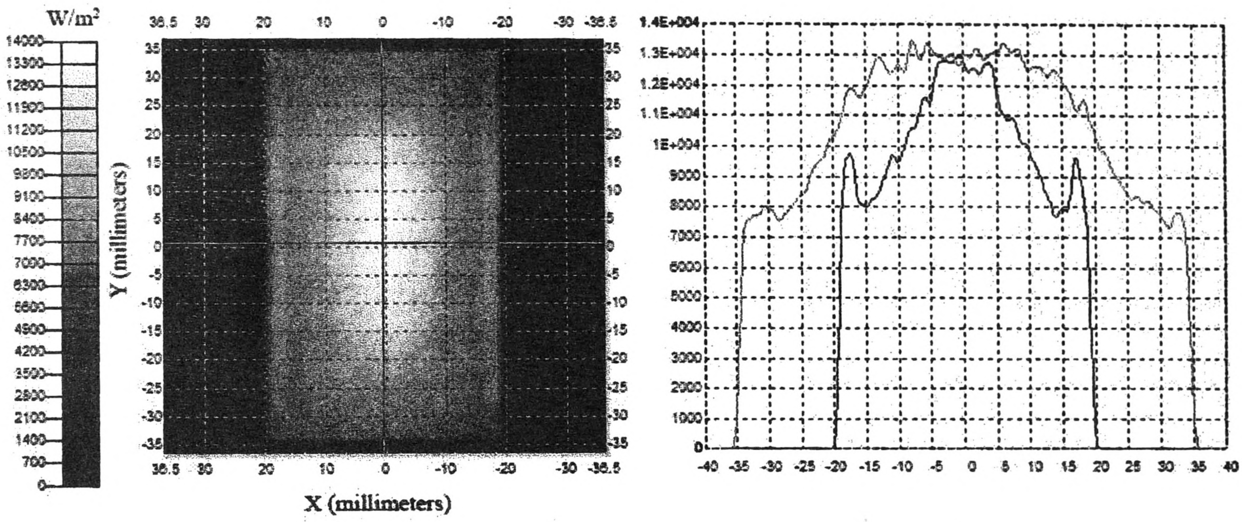

Figure 3: Simulated Reflector Design Irradiation Plot

Figure 3 represent the irradiation plot for the simulated reflector design using TracePro simulator. This simulation was done by using 400000 light rays. The plot indicate intensity change in the middle area. But it was expected that this change does not high enough to make false results in the density calculation. Depending on this hypothesis, reflector was fabricated and practically measured another irradiation plot using the LDR.

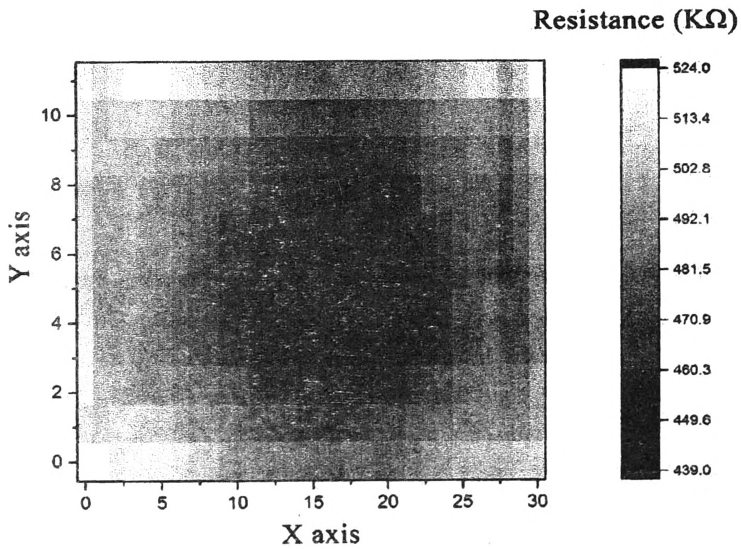

Figure 4: Practically observed irradiation plot

Figure 4 shows that the intensity diff erence was small and hence light distribute over the viewer surface is even for this application scope.

To calculate the density, a response curve was plotted over known range of density values and observed graphs' fitting equation by using Origin graph analyzing tool. Observed graph show in figure 5.

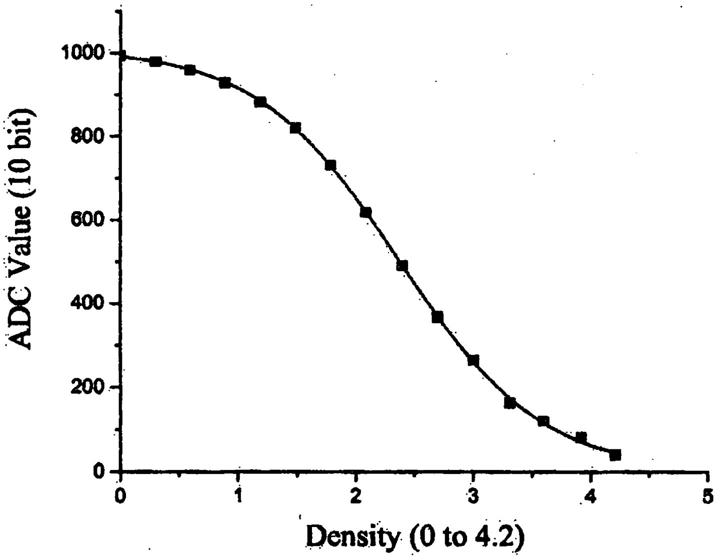

Figure 5: Sigmoid fitting curve for LDR

The corresponding fitting equation 1 was stated as follows;

$$y = \frac{a}{1 + e^{-k(x - x_c)}} \quad (1)$$

Where y = analog input value (ADC), x = density value, k = -1.6518 (coefficient), x_c = 2.3624 (center) and a = 1011.66 (amplitude)

With the help of derived equation, density was measured using developed device and a step tablet. The observed results were plotted as shown in figure 6.

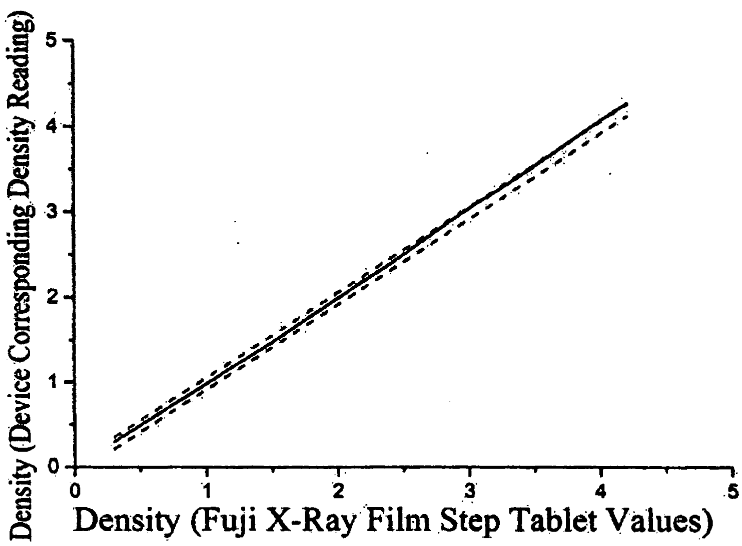

Figure 6: Density reading over step tablet

The curve appear to be linear and error was calculated as 0.03 for density range 0 to 4.2. According to the 2010 ASME Boiler and Pressure Vessel Code, a densitometer error has to be less than 0.05 to accept it as a valid device for calculate film density. Hence, the developed device fulfill the standard that needed as a valid densitometer to interpret the radiographic films.

4. CONCLUSION

By developing economical hybrid device for both Densitometer and X-ray film viewer, it was successfully reduce the interpretation time for a certain radiography tests and increased the efficiency. The device was experimentally tested over international standard and prove that it was qualified as a valid device for RT test interpretation.

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