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ICONIA 2020 IOP Conf. Series: Earth and Environmental Science 662 (2021) 012028 IOP Publishing
doi:10.1088/1755-1315/662/1/012028 1 A Rapid Dry Rubber Content Measurement Device Based on
Photoelectric Sensors A Wibowo1, M Mustangin1, A 1, and D I Pratiwi1 1Mechanical Engineering
Department, Polytechnic LPP Jl LPP no 1A, Klitren, Gondokusuman, Yogyakarta, 55222 E-mail:
arw@poltekklpp.ac.id Abstract. The quality of Natural Rubber Latex (NRL) is indicated by Dry Rubber Content
(DRC), which is a value that shows the percentage of rubber material or rubber fraction contained in a latex.
DRC measurements are generally carried out by two methods, namely manually weighing the sample and ISO
126-2005 method.

This research aims to develop prototype of automatic DRC measurement device based on photoelectric
sensors that are able to measure DRC values accurately, quickly, easily, and environmentally friendly.
Research was carried out by designing and building prototypes based on the theory that latex will absorb the
intensity of light proportional to the rubber content in it. The results of field tests show that the device can show
accurate measurement results with a comparison of measurement methods according to ISO 126: 2005. To
improve accuracy is done through least square analysis. The measurement ranges of the DRC values that
have been tested with this prototype is 15-22% with an average error of only 1.56% or with an accuracy of
98.44%.

The results of this test indicate that the prototype of a photoelectric-based DRC measuring device can be used
as an alternative to the DRC measurement tool in a rubber factory with accurate, fast, easy and
environmentally friendly measurement results. 1. Introduction Natural rubber is a very important plantation

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commodity, where Indonesia is listed as one of the largest rubber producers in the world [1]. This rubber raw material is produced by tapping a rubber tree (*Hevea brasiliensis*) and the sap is obtained in a liquid form which is commonly called latex or Natural Rubber Latex (NRL). This latex sap will coagulate when exposed to free air and form a chewy lump known as a coagulum or slab. NRL consists of several compositions, including rubber fraction, Frey-Wyssling particles, C-serum fraction, and bottom fraction [2].

Figure 1 shows the composition contained in NRL. The amount of composition of each fraction can change, depending on several factors such as the type of variety/clone, age of the tree, tapping time, season, air temperature, and also the height of the rubber plantation from sea level [3]. NRL from the field or coagulum can be processed into various natural rubber products such as Ribbed Smoked Sheet (RSS), Crumb Rubber, Brown Crepe, Concentrated Latex, and so on [4]. In the production process, the most important component in latex is the rubber fraction. The percentage of the rubber fraction against the total latex is usually called the Dry Rubber Content (DRC).

In other words, this DRC shows how much rubber material is contained in the latex. By measuring the DRC, it can be predicted how much potential the final product can be produced. ICONIA 2020 IOP Conf. Series: Earth and Environmental Science 662 (2021) 012028 IOP Publishing doi:10.1088/1755-1315/662/1/012028 2 Figure 1. Composition of natural rubber latex [4] For example, in the RSS processing process [5], the latex that has just come from the field must be diluted and then agglomerated with the addition of formic acid chemicals. Latex DRC measurements determine the amount of water and chemicals that must be added for dilution [6]. The chemicals in rubber processing are only as catalysts, and will eventually be disposed of as waste.

Thus, this DRC measurement becomes important to predict the exact amount of chemicals used. If the amount of chemical is insufficient, the process will run slowly, on the other hand, if it is excessive, it will result in high production costs and also greater potential for pollution. In addition, the accuracy of the calculation for the dilution also affects the quality of the product. Adding too much water as a diluent will result in a coagulum that is too soft. This soft coagulum will be difficult to process in a sheet mill, which is easily torn and damaged, thus reducing the quality of the product. On the other hand, lack of water as a diluent will result in a hard coagulum.

When ground, the hard coagulum requires more power. Likewise, drying and smoking processes require more time and fuel. This affects the quality of RSS rubber which is based on the green book of the International Rubber Quality and Packing Conference (IRQPC) [7]. Thus, the measurement of DRC on field latex is very important in the rubber production process. In general, rubber factories measure DRC using the manual measurement method, which is by taking a latex sample and then coagulating it and drying it. The mass of the coagulum produced is then compared with the mass of the original latex. Measurements using this method are

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actually inaccurate, but it is an approach to get DRC values quickly. Accurate standard testing is based on the ISO 126: 2005 method [8], carried out in a laboratory, and takes 6-8 hours to obtain an accurate DRC value.

In addition, it also requires a large amount of money, of course, so it is not suitable to be applied in a rubber processing factory. Based on this, this research was carried out with the aim of designing and building a DRC measuring instrument that is accurate, fast, easy, and environmentally friendly using photoelectric sensor technology. In recent years, research on the DRC analysis method has developed and led to the use of microcontroller technology as an innovation in determining dry rubber content in latex with high effectiveness and accuracy results [9]. Several techniques and technologies have been previously studied to obtain the most precise method for measuring DRC, including using light scattering technology [10], microwave technology [11], high-frequency alternating current technology [12], and contaminant detection on latex [13]. Meanwhile, the DRC measurement technology based on photoelectric sensors has also been developed with applications in concentrated latex products [14].

The test results on this concentrated latex show that the output voltage generated from the measurement is proportional to the DRC value of latex. ICONIA 2020 IOP Conf. Series: Earth and Environmental Science 662 (2021) 012028 IOP Publishing doi:10.1088/1755-1315/662/1/012028 3 2. Design and Development of the Measurement Device The working concept of this DRC measuring device is shown in Figure 2. The system consists of three main parts, a light source module, a photoelectric sensor, and a data processing unit. The light source will produce a light beam that is directed to the latex sample in the sample chamber. This light beam will partially be absorbed by the latex sample and the rest will be reflected. The reflected light is received by the lens and focused to be captured by a photoelectric sensor. As a result of this light intensity, the sensor will respond to changes its resistance that is proportional to the amount of light entering.

This change in resistance is then amplified and processed by the transducer circuit to indicate a certain voltage value. This voltage value then becomes input to the data processing unit in the form of a microprocessor. With the input voltage that is proportional to the resistance of the photoelectric sensor, changes in light intensity can be processed in the algorithm on the microprocessor to show the sensor measurement results. To obtain a stable measurement, the sample space is also maintained at the set-up temperature, for that a temperature sensor and a Peltier heating actuator controlled by a microcontroller are added. Figure 3. shows the electronic circuit diagram used in this DRC measurement system. Figure 2. The working concept of the DRC measuring device The research of Zhao et. al.,

2010 [14] showed that the measurement results from this photoelectric sensor are proportional to the DRC number of the latex samples tested. Thus, the data that goes to the microprocessor can indicate the level of DRC present. The next data validation process needs to be done to get the correct algorithm equations according to the results of the DRC latex test with the standard method. From the system design that has been made, it is then developed into a prototype. The electronic circuit design is then compiled into a printed

circuit board (PCB) as the basis for system development. the components are then assembled on the PCB. As previously stated, the light source module uses four LEDs with a capacity of 10 Watt which is installed in parallel in the four corners of the sample chamber and directed to the sample.

As a photoelectric sensor, it uses a light dependent resistor (LDR), which is reactive to changes in incoming light. Arduino Uno is used as a microcontroller to manage all incoming data. With this programming on Arduino, the voltage data from the sensor is processed into the DRC number which is displayed on the LCD display. The temperature setting with the thermocouple sensor and the Peltier actuator module is also controlled on the Arduino. The ICONIA 2020 IOP Conf. Series: Earth and Environmental Science 662 (2021) 012028 IOP Publishing doi:10.1088/1755-1315/662/1/012028 4 temperature setting and the sample room temperature reading are also displayed on the LCD display. The main components are shown in Figure 4., and in Figure 5. shows the prototype of DRC measurement device. Figure 3. The electronic circuit diagram used in the DRC measurement device Figure 4.

The main components of DRC measurement device ICONIA 2020 IOP Conf. Series: Earth and Environmental Science 662 (2021) 012028 IOP Publishing doi:10.1088/1755-1315/662/1/012028 5 Figure 5. The prototype of DRC measurement device 3. Measurement Validation The prototype that has been made is then tested in the laboratory to show that each part can function properly. Starting from the light module, sensors, microprocessors, temperature settings, and also the display system. The photoelectric sensor sensitivity test is carried out by changes in light intensity and the system response to these changes is seen. In this stage, it was found that the initial prototype was less responsive to light changes, so modifications were made with zero span settings and Rf amplification, to get a more sensitive signal.

The temperature actuator test was carried out by setting the temperature setting and checking its accuracy using a thermometer. This module is sufficient to show a pretty good response in the first prototype. For algorithm testing in the microprocessor, it must be done by conducting a direct validation test on the latex sample which is compared with the test results using the ISO 126:2005 method The experimental prototype test was carried out at the Getas Plantation RSS factory, PT Perkebunan Nusantara IX, in Semarang Regency. The test was carried out by comparing the DRC value in the latex sample with the ISO 126: 2005 method and compared with the measurement value with the prototype DRC measuring instrument made.

The first type of sample was garden latex which was directly tested by both methods. From the test results of this first sample, modifications were made to the algorithm in the microprocessor so that the same value was obtained from the laboratory test results and from the prototype. Furthermore, to see the sensitivity of the tool, measurements were made with sample variations. To get the variation in the DRC value, the latex sample was diluted from one latex tank, with the addition of water-based on the percentage volume of the latex sample.

With this dilution, four types of samples were determined, namely without dilution, with a dilution of 10%, 20%,

and 30% of the volume. Each type of sample was then measured for its DRC value using two methods, ISO 126: 2005 as a comparison and with a prototype. Each type of sample was tested five times. The comparison of the DRC value from the ISO 126: 2005 analysis result with the prototype can be seen in table 1. The DRC measurement results using the ISO 126: 2005 method have a value close to the test results using a prototype, with fairly proportional data. This initial measurement shows that there is an average measurement error of 3.84% in the prototype data.

To obtain more accurate data, a least square analysis was carried out on the data, as shown in Figure 5.

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doi:10.1088/1755-1315/662/1/012028 6 Table 1. Comparison of DRC values with ISO 126: 2005 method and with prototypes

No	Sample	Latex Type	DRC Value	Initial Error	Least Square DRC Value	Least Square Error
1	Without dilution	21,60%	23%	6,48%	22,18%	2,69%
2	Dilution 10%	22,95%	23%	0,22%	22,18%	3,35%
3	Dilution 20%	22,55%	23%	2,00%	22,18%	1,64%
4	Dilution 30%	21,85%	23%	5,26%	22,18%	1,51%
5	Dilution 40%	21,30%	23%	7,98%	22,18%	4,14%
6	Dilution 50%	20,25%	20%	1,23%	19,82%	2,14%
7	Dilution 60%	19,90%	20%	0,50%	19,82%	0,42%
8	Dilution 70%	19,95%	20%	0,25%	19,82%	0,67%
9	Dilution 80%	19,70%	20%	1,52%	19,82%	0,59%
10	Dilution 90%	19,70%	20%	1,52%	19,82%	0,59%
11	Dilution 100%	17,90%	17%	5,03%	17,45%	2,51%
12	Dilution 110%	17,95%	17%	5,29%	17,45%	2,78%
13	Dilution 120%	17,55%	17%	3,13%	17,45%	0,56%
14	Dilution 130%	17,60%	17%	3,41%	17,45%	0,85%
15	Dilution 140%	17,50%	17%	2,86%	17,45%	0,28%
16	Dilution 150%	15,10%	14%	7,28%	15,09%	0,09%
17	Dilution 160%	14,70%	14%	4,76%	15,09%	2,63%
18	Dilution 170%	14,80%	14%	5,41%	15,09%	1,93%
19	Dilution 180%	15,00%	14%	6,67%	15,09%	0,57%
20	Dilution 190%	14,90%	14%	6,04%	15,09%	1,25%
21	Dilution 200%	15,09%	14%	6,04%	15,09%	1,25%
22	Dilution 210%	15,09%	14%	6,04%	15,09%	1,25%
23	Dilution 220%	15,09%	14%	6,04%	15,09%	1,25%
24	Dilution 230%	15,09%	14%	6,04%	15,09%	1,25%
25	Dilution 240%	15,09%	14%	6,04%	15,09%	1,25%
26	Dilution 250%	15,09%	14%	6,04%	15,09%	1,25%
27	Dilution 260%	15,09%	14%	6,04%	15,09%	1,25%
28	Dilution 270%	15,09%	14%	6,04%	15,09%	1,25%
29	Dilution 280%	15,09%	14%	6,04%	15,09%	1,25%
30	Dilution 290%	15,09%	14%	6,04%	15,09%	1,25%
31	Dilution 300%	15,09%	14%	6,04%	15,09%	1,25%

Error Rate 3,84% 1,56% Figure 6. Least Square Analysis of the DRC test results ICONIA 2020 IOP Conf.

Series: Earth and Environmental Science 662 (2021) 012028 IOP Publishing doi:10.1088/1755-1315/662/1/012028 7 From this analysis, the least square equation has been obtained, $y = 0.7883x + 0.0405$ with linearity R of 0.996. If the least square equation is used in the DRC measurement results from the prototype, where the measurement results show a smaller error difference. The measuring error before the least square is 3.84% and becomes 1.56% after the least square. The least square equation is then entered into the microcontroller algorithm programming as a data correction equation. 4. Summary A photoelectric sensor-based DRC measurement device prototype has been designed and built. Experimental test results show that the equipment can show fairly accurate measurement results with comparable measurement methods according to ISO 126: 2005. To improve accuracy, it is done through least square analysis.

The measurement ranges for the DRC value that has been tested with this measuring instrument prototype is 15-22% with an average error of only 1.56% or with an accuracy of 98.44%. The results of this test indicate that the photoelectric-based DRC measuring device prototype can be used as an alternative to measuring DRC in rubber factories with accurate, fast, easy, and environmentally friendly measurement results. 5.

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