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Submission date: 20-Mar-2023 09:44AM (UTC+0700)
Submission ID: 2041184992
File name: eding_2021_Modification_of_the_analyzer_on_electrooptics_for.pdf (558.55K)
Word count: 2171
Character count: 10658

Journal of Physics: Conference Series

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To cite this article: H Sugito *et al* 2021 *J. Phys.: Conf. Ser.* **1943** 012018

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Modification of the analyzer on electrooptics for cooking oil quality testing

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Abstract. The importance of cooking oil for human consumption makes cooking oil needs to be aware of its quality. This research aims to design electrooptic devices by making modifications to the analyzer. The results of the ink design are used to test the quality of cooking oil. The method used in this tool is based on the electrooptical properties of cooking oil. Because the optical properties or the polarization angle used as an indicator of the quality of cooking oil is relatively very small, it is necessary to modify the analyzer on the existing electrooptics to avoid parallax errors and increase the effectiveness in measurement. Modifications were made by adding a stepper motor as an actuator, gears that intersect with certain radius ratios, and an ATMega 328P microcontroller for data controller and processing. in the cooking oil quality test, it can be distinguished oil that has expired and is still suitable for consumption based on the average value of the change in the polarization angle.

1. Introduction

Cooking oil is a food ingredient that is consumed by humans around the world. The importance of cooking oil for human consumption makes cooking oil a quality concern. Starting from the manufacturing process, time of use, and after becoming waste oil, cooking oil can cause quite complex problems for everyday life. It is well known that when oil is used, it can produce free radicals that are harmful to cancer in the human body. This problem is one of the factors that so far, especially in Indonesia, has not been paid much attention to by the public, especially in the repeated use of oil. Recent findings show that when using oil, a toxic hydrocarbon in the form of alkylbenzene is produced [1].

Based on these things, it is necessary to test the quality of cooking oil before consumption by the public. According to the National Standardization Agency [2], the measurement of cooking oil quality is based on parameters such as smell, taste, color, moisture content, acid number, linoleic acid, and metal contaminants (Pb, Hg, Cu, As), respectively. Each of these parameters is tested with different equipment. Simultaneous testing is not easy and requires a lot of money and time.

Existing quality testing equipment is very expensive, plus maintenance is complicated and expensive when equipment breaks. For this reason, it is necessary to design a simple but reliable electrooptic equipment system that can be used to test the quality of cooking oil, which is easier, more accurate, and relatively cheaper.

The method for determining the quality of cooking oil, which includes various parameters into one parameter, has been studied through the optical properties of cooking oil [3]. Although not explicitly all parameters are directly related, at least the optical properties of cooking oil can accommodate various parameters that are considered to cause a decrease in the quality of cooking oil [4]. In previous studies,

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this method has succeeded in distinguishing cooking oil which is still suitable for consumption from cooking oil whose quality has been degraded. In addition, this method has been used as a preliminary test to determine the level of halalness of a food ingredient derived from animal fat [4].

Various applications and developments of electrooptic devices to test the quality of cooking oil have been carried out. Sugito (2018) designed an integrated polarizer for the detection of pork oil contamination in cooking oil [5]. in 2020, electrooptic tools were developed again with the addition of a magnetic field produced by colloidal silver solution [6].

However, it should be noted that in the results of previous studies, the polarization angle or optical properties of cooking oil are too small, so a more accurate instrument is needed to avoid parallax errors in making measurements. This research aims to design electrooptic devices by making modifications to the analyzer. The results of the ink design are used to test the quality of cooking oil. In this research, the analyzer will be digitized using a microcontroller as one of the devices.

2. Methods

The first stage carried out in this research is the design and realization of a digital analyzer instrument that includes functional and non-functional aspects. After the instrument is realized, a calibration is carried out on the arc scale (mechanical) and the OLED (Organic Light-Emitting Diode) display contained in the instrument before it is implemented to determine the quality of cooking oil using the angle polarization method that has been carried out in previous studies.

The stages in this research begin with the calibration of the digital analyzer instrument using Malus Law. The calibration is done by comparing the results on the arc scale and the display on the OLED. Then carried out by implementing a digital analyzer instrument in a sucrose solution with a predetermined concentration. The next step is to make cooking oil preparation, then measure the average polarization angle of the selected cooking oil using a digital analyzer instrument. This study uses a laser pointer with a wavelength of 532 nm as a light source. After that, the test data is obtained from the instrument in the form of the polarization angle value.

The design of a digital analyzer instrument consists of two main parts, namely the data acquisition (mechanical) part and the data processing (electronic) part, as shown in Figure 1. In the mechanical part, there are motorsteppers, gears, and analyzers that are linked to rotating each other. On the other hand, there is an electronic section that includes a microcontroller, motor driver, and OLED which functions to inform data to the user (as an interface). This designed instrument has a function to measure the polarization angle obtained from the rotation of the analyzer linked to the gear with a predetermined radius ratio. The electronic components or modules of this instrument include the KY-023 Joystick Module, 0.96 inch SPI OLED, ATMega328P Microcontroller, Motor Driver, and Bipolar NEMA 17 MotorStepper.The software used to program this instrument is to be able to be controlled according to the gear rotation ratio. is the Arduino IDE v1.8.7 which is integrated with the ATMega328P microcontroller.

The modified analyzer that has been realized has a size of 30 cm x 15 cm x 15 cm with an acrylic case as shown in Figure 1. The mechanical part of this instrument includes bearings of type 6202-Z and 6910-ZZ, which function as a rotary shaft, in addition, there are three gears with a radius of 6 mm, 27 mm and 44 mm respectively, that intersect each other. A 6 mm radius gear is mounted on a NEMA 17 Stepper Motor with 400 steps per revolution (0.9 ° per stroke) which results in a turnover ratio of 0.2 ° in a gear of 27 mm radius and 0.1 ° to a gear radius. 44 mm.

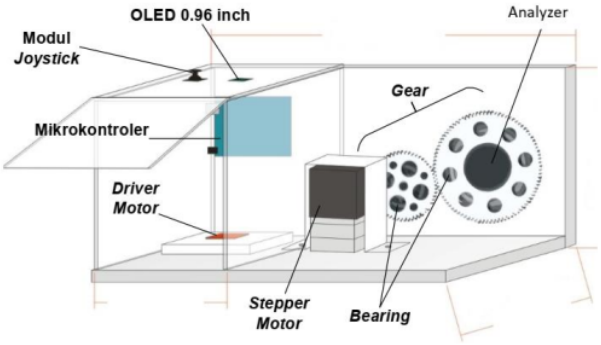

Figure 1. Design modification analyzer

3. Results and Discussion

3.1 The calibration testing by comparing the results on the arc scale and the display on the OLED Display on Stepper Motor Steps

In this test, measurements are made based on the results shown by the arc scale and OLED display contained in this instrument. The measurement results of the stepper motor towards the angle formed by the arc scale and the OLED display are shown in table 1. The largest difference in the angle value formed by the arc scale and the OLED display occurs in the 240th step, which is 1.02 °, the 400th step is 1, 2 °, the 640th step is 1.72 °, and the 720th step is 1.06 °. This is thought to occur because it is quite difficult to read the scale of the arcs that are pressed together (parallax error), so the error value tends to be large. The average difference in the angles formed by the arc scale with the OLED display is 0.696 °.

Table 1 Results of the arc scale test and the OLED display of the instrument againststepper motor

	Angle (°)		
Step	**Arc Scale**	**OLED display**	**difference in angle**
0	0	0	0
80	10	9,84	0,16
160	20	19,68	0,32
240	28,5	29,52	1,02
320	39	39,36	0,36
400	48	49,2	1,2
480	58,5	59,04	0,54
560	68	68,88	0,88
640	77	78,72	1,72
720	87,5	88,56	1,06
800	98	98,4	0,4

3.2 Implementation of tools for testing cooking oil

The cooking oil used in this test was extra olive oil with an expiration date of 23 April 2015 and 27 February 2020, rice oil with an expiration date of 11 September 2016 and 20 March 2020, and palm oil with an expiration date of 7 October 2016 and 19 November 2019. the room temperature was kept

constant throughout the test at 16 ° C. The test was carried out 20 times using a laser measurement with a wavelength of 532 nm for each position of the polarisator angle of 0 °, 30 °, 60 °, and 90 °. Based on the data from this test, the quality of cooking oil is presented in Table 4.2.

Table 2 Quality of cooking oil based on mean change in angle polarization

Sample	$\Delta\theta$Average (°)
Extra Olive Oil (EXP 27 February 2020)	0,161
Rice Oil (EXP 20 March 2020)	0,181
Extra Olive Oil (EXP 23 April 2015)	0,258
Palm oil (EXP 19 November 2019)	0,291
Rice Oil (EXP 11 September 2016)	0,323
Palm oil (EXP 07 October 2016)	0,647

The three types of cooking oil that have expired have resulted in a greater average change in the angle of polarization of similar cooking oils that have not expired. This indicates that cooking oil that has expired has decreased in quality [4]. The decline in the quality of cooking oil is thought to have undergone hydrolysis, pyrolysis, oxidation, or polymerization, which generally produces free fatty acids and polar molecules [7].

4. Conclusions

Based on the research that has been done, it can be concluded that the modified analyzer instrument can be realized with an OLED display value per stepper motor step of 0.1 °, this value is more precise than conventional analyzer instruments which have an accuracy of 0.5 °. for application to cooking oil, the instrument can distinguish the quality of similar cooking oil that has expired and that which has not expired based on the average value of the change in the angle of polarization.

Acknowledgments

The authors acknowledge the Research Grant of Physics Department, Faculty of Science and Mathematics, Diponegoro University for financial support of this project.

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