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DESIGNING AUTOMATIZATION FOR INTEGRATION OF NON-CONSUMABLE COOKING OIL AND BIODIESEL REACTOR STATIC MIXER TYPE

(PERANCANGAN OTOMATISASI INTEGRASI SISTEM PENDETEKSI KETIDAKLAYAKAN MINYAK DAN REAKTOR BIODIESEL TIPE STATIC MIXER)

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ABSTRACT

The automatic oil unsuitability detection system was developed because of the urgency of helping users know when cooking oil is unhealthy for reuse in the cooking process due to health factors. Physical parameters in oil color and turbidity using color sensors and photodiodes were selected using the classification method used in the form of Bayes computing. Through using this tool, the resulting oil will be detected as suitable and unsuitable. Used oil produced from the cooking process or Used Cooking Oil (UCO) will be processed into new fuel, namely biodiesel. The method of making biodiesel, which involves a transesterification reaction, is carried out in a device containing a stirrer known as a reactor. This research aims to design the integration of these two tools: an oil unsuitability detection system and a static mixer-type biodiesel reactor.

Keywords: Biodiesel; Detection System; Integration; Oil unsuitability

ABSTRAK

Sistem deteksi ketidaklayakan minyak otomatis dikembangkan karena urgensinya membantu pengguna mengetahui kapan minyak goreng telah tidak layak untuk digunakan kembali dalam proses memasak dikarenakan faktor kesehatan. Parameter fisik berupa warna dan kekeruhan minyak dengan memanfaatkan sensor warna dan fotodioda dipilih dengan metode klasifikasi yang digunakan berupa komputasi Bayes. Dari penggunaan alat tersebut nantinya, dihasilkan minyak terdeteksi layak dan tidak layak. Minyak bekas yang dihasilkan dari proses memasak atau Used Cooking Oil (UCO) akan diproses menjadi bahan bakar baru yaitu biodiesel. Proses pembuatan biodiesel yang melibatkan reaksi transesterifikasi dilakukan dalam alat yang didalamnya terdapat pengaduk (mixer), dimana alat tersebut dikenal dengan reaktor. Penelitian ini bertujuan merancang integrasi kedua alat tersebut, sistem deteksi ketidaklayakan minyak dan reaktor biodiesel tipe static mixer.

Kata Kunci: Biodiesel; Integrasi; Ketidaklayakan minyak; Sistem Deteksi

INTRODUCTION

For centuries, fossil fuels have powered power generation, transportation, residential consumption, and industrialization (Qin et al., 2018). The high consumption rate of conventional fossil fuels is also the ultimate contributor to the energy emergency and environmental pollution dilemma (Huang et al., 2014). The decreasing amount of fossil fuel has been making energy savings being launched in many countries (Zhao et al., 2020). Utilizing renewable energy for fossil fuel substitutes is one of the finest choices to meet the high energy demand (Stančin et al., 2020). It is then indispensable for Indonesia, a diverse nation with abundant natural resources, to utilize it optimally for alternative energy (Ferdinandsyah et al., 2022). Among different renewable vitality assets, biodiesel, or greasy corrosive methyl ester (Popularity) is favored as a petroleum-based diesel fuel substitute since it is simple to produce employing transesterification of triglycerides utilizing liquor. Besides, biodiesel has prevalence over petroleum-based diesel fuel owing to its invaluable characteristics such as moo particulate matter, unburnt add up to hydrocarbon outflow, carbon dioxide and carbon monoxide, biodegradability, moo sulfur and fragrant substance, and tall flash point. Separated from that, Notoriety is currently utilized as grease-added substances and solvents for inks, polymers, and oils (Farobie & Hartulistiyoso, 2022).

As the driving palm oil maker universally, with palm oil generation of around 43.5 million tons in 2020, Indonesia holds the potential to utilize palm oil assets in biodiesel. The current utilization of palm oil is for nourishment items (16.4%), oleochemical (3.3%), biodiesel (14.1%), and trade (66.2%).

Fatty Acid Methyl Ester (FAME), also known as biodiesel, is a widely used alternative energy source. Biodiesel is a good substitute for fossil fuels since it is non-toxic and biodegradable with the aid of other microorganisms, and it can replace solar-diesel fuel without further modification. The Indonesian government has required the usage of biodiesel based on palm oil from 2018. The present implementation is known as B30, a mixture of diesel fuel and FAME at a 30:70 ratio.

FAME can also be produced using cooking oils (UCO), other vegetable oils, animal fats, and palm oil. If its potential is realized, UCO might one day make an excellent commercial decision. Biofuels are a promising alternative to fossil fuels when considering sustainable and environmentally friendly principles. However, the mass production of bioenergy crops brought on by rising energy demands always comes at the expense of food crops, leading to food storage and skyrocketing crop prices (Tan et al., 2011). Due to their high yield potential and affordable availability, side-produced or waste oils, such as used and waste cooking oil (WCO), can lower such hazards. Daily, it is produced significantly by businesses, restaurants, and households (Rincón et al., 2019).

UCO handling biodiesel, mainly by communities, will bring numerous financial, well-being, and natural benefits. From the well-being point of see, biodiesel generation from UCO can diminish the utilization of reused UCO for cooking so that it, by implication, decreases the chance of expanded HNE (a harmful compound shaped in unsaturated oils due to warm treatment and oxidation) in nourishment, which has been known to cause stroke, Alzheimer's, and Parkinson's. From the natural side, UCO handling for biodiesel can emphatically decrease dangerous and harmful (B3) squander. UCO dumped carelessly dangers expanding the level of Chemical Oxygen Request (COD) and Natural Oxygen Request (BOD), a degree of the sum of oxygen required to expel squander natural matter from water within the prepare of deterioration by high-impact microbes, or microbes that live as it were in an environment containing oxygen. Oil layers covering the water surface piece out sunray, causing the passing of water biota and possibly contaminating groundwater (Agung Pribadi, 2020).

The complete preparation of biodiesel requires a human administrator to run and screen the Transesterification system and interfere whenever required. To create the method quicker, a progressed and keen framework is required. Consequently, numerous analysts have created a mechanized plant to deliver biodiesel at least exertion (Ullah et. al., 2017). Daniyan et al. (2019) set a keen multi-feedstock biodiesel plant to incite biodiesel. Highina et al. (2011) delivered Biodiesel from Jatropha oil, where 93 % of triglycerides have been changed over to methyl esters due to employing a clump reactor. Leevijit et al. (2006) demonstrated a perfect persistent blended tank reactor. They performed a recreation to optimize a blending execution for creating biodiesel from palm oil and to anticipate the required generation times at the required purities for the transesterification of palm oil. Samad et al. (2018) outlined a versatile biodiesel plant that can deliver biodiesel up to 99.8 % with a generally shorter time from squandering cooking oil.

Waste cooking oil could be converted into Biodiesel and several previous researchers have successfully developed many technologies to convert waste cooking oil into biodiesel (Rashid & Kader, 2022).

Hence, it is necessary to construct a tool that integrates a system of non-consumable oil detection and subsequently processes it into biodiesel. This research will use microcontrollers and sensors to convey a design of the automation.

METHODS

a. Data and Information Collection

To help with writing, data and information are compiled by researching in books and online, looking for sources, and putting together data. The information comes from a thesis, electronic sources, and relevant books and articles.

As for technique data collection carried out are:

1. Before data analysis, a literature study is first carried out, providing consideration and additional insight for the author regarding the scope of activities and concepts included in the writing.
2. To discuss the analysis and synthesis of the data obtained, a reference is needed that is used as a reference, where the data can be developed further to be able to find the unity of the material so that a solution and conclusion can be drawn.

b. Data and information processing

Several secondary data and information are collected and then analyzed using a descriptive analysis method.

c. Analysis and synthesis

The aspects to be analyzed are the need for designing an integrated fryer with a biodiesel biodiesel-producing automation system. The synthesis described is an alternative solution to overcome the problem analyzed. Moreover, to make the design, a sketch-up application is utilized.

RESULT AND DISCUSSION

The automation of the tool is designed to carry out several integrated work functions, including detecting unhealthy cooking oil, flowing unhealthy oil into the biodiesel reactor, and from the biodiesel storage tube to the stove, as well as processing biodiesel efficiently. The series of tools designed consists of 3 parts. The installation of each main element is presented in Figure 1.

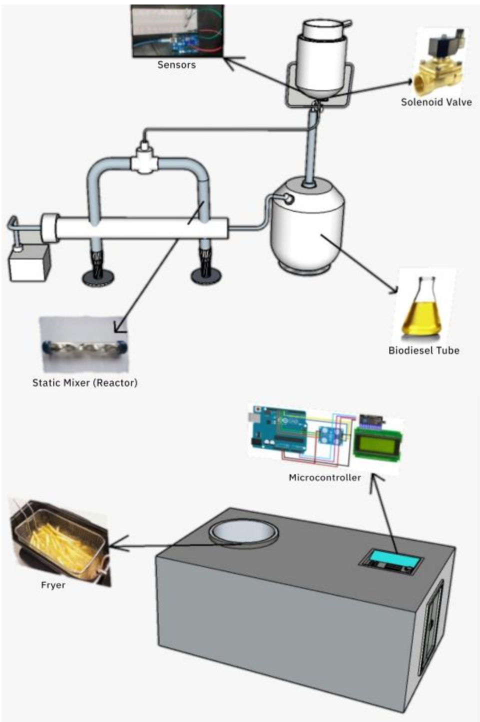

Figure 1. Design of the integrated tool using sketch-up

The first part, detecting unhealthy cooking oil in the fryer, is based on sensor readings of the physical characteristics used (as seen in Appendix 1). This system is installed on the fryer. The exact type of fryer chosen is a deep-fat fryer. Parameters of non-consumable oil are the color and level of turbidity of cooking oil. This section consists of input in the form of a TCS3200 sensor as a color input and a photodiode sensor as an input for cooking oil turbidity, which is calibrated to the initial sensor reading value on Arduino Uno, which is programmed with the Bayes classification method.

Prototype testing data on the unhealthy oil detecting system section resulting from previous research is shown in Table 1 below.

Table 1. Accuracy of the unhealthy oil detecting system

Amount test data	**Data results classification following the system**	**Percentage accuracy**
35	25	71.42%

The data in the table shows that from a total of 35 cups of cooking oil samples tested, 25 cups were accurate or declared appropriate and met the parameters of non-consumable cooking oil (Marofi et al., 2017).

The Bayesian computational method to detect oil that is still or not suitable for use will be forwarded to the following process. In the following process, when the oil is detected as unhealthy, the microcontroller will give the command to *the solenoid valve* to open so that the oil will go to the pipe that will deliver it to the following process. Apart from frying to the biodiesel reactor, flow and pumping are also carried out from the reactor to the biodiesel tube before heading to the stove. The design of the connection between a microcontroller, and sensor as input and output is as shown in Figure 2.

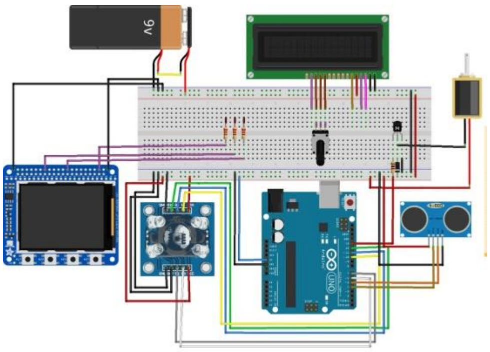

Figure 2. System design

Third, the system for processing used cooking oil into biodiesel through a transesterification reaction that occurs in a *static mixer typed biodiesel reactor*. After going through this process, the biodiesel product will flow to the stove to produce a flame that is a heat source in the cooking process. The process of testing the performance of the reactor is carried out in the transesterification process. Transesterification is influenced by several factors, among others are temperature, catalyst, stirring, molar ratio, and time. After testing and calculating (as seen in Appendix 2 and 3), the resulting biodiesel product has the characteristics shown in Table 2 below.

Table 2. Comparison Quality of Generated Biodiesel with SNI

Test Quality Biodiesel	**Result**	**SNI**
Density (kg/m^3)	864.67	850-890
Viscosity (mm/s)	5.77	2.13-6.0
Water Content (%)	0.03	0.05
Yield (%)	89.67	>90

CONCLUSION

Used cooking oil (UCO) and waste cooking oil (WCO) can be used as biodiesel production feedstock. As a renewable energy, biodiesel can supply daily residential energy in households to exemplify the cooking process. This paper revealed a possible design for the automatic tool that prevents unhealthy oil consumption integrated with biodiesel production from waste oil to become fuel for the following frying process. Applying the cyclic principle, this tool can consequently enhance sustainability.

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APPENDIX

Appendix 1

Non-consumable Oil Detecting System

Appendix 2

1. Biodiesel's Yield Calculation

a. Time 40 minutes

$$\text{Yield (\%)} = \frac{\text{Biodiesel Volume}}{\text{UCO Volume}}$$

$$= \frac{940\text{ml}}{1000\text{ ml}}$$

$$= 94\ \%$$

b. Time 30 minutes

$$\text{Yield (\%)} = \frac{\text{Biodiesel Volume}}{\text{UCO Volume}}$$

$$= \frac{900\text{ml}}{1000\text{ ml}}$$

$$= 90\ \%$$

c. Time 20 minutes

$$\text{Yield (\%)} = \frac{\text{Biodiesel Volume}}{\text{UCO Volume}}$$

$$= \frac{850\text{ ml}}{1000\text{ ml}}$$

$$= 85\ \%$$

2. Biodiesel Density Calculation

a. Time 40 minutes

$$= \frac{(m_{\text{pycnometer + biodiesel}}) - m_{\text{empty pycnometer}}}{\text{Pycnometer volume}}$$

$$= \frac{74{,}1085\ gr - 32{,}0042\ gr}{49{,}55942\ ml}$$

= 0,860 gr/ml

= 857 kg/m^3

b. Time 30 minutes

$$= \frac{(m_{\text{pycnometer+biodiesel}}) - m_{\text{pempty ycnometer}}}{\text{Pycnometer volume}}$$

$$= \frac{74{,}6285\ gr - 32{,}0042\ gr}{49{,}55942\ ml}$$

= 0,860 gr/ml

= 860 kg/m^3

c. Time 20 minutes

$$= \frac{(m_{pycnometer+biodiesel}) - m_{empty\ pycnometer}}{Pycnometer\ volume}$$

$$= \frac{74{,}9250\ gr - 32{,}0042\ gr}{49{,}55942\ ml}$$

= 0,876 gr/ml

= 876 kg/m^3

3. Biodiesel Viscosity Calculation
   η water: 0,654 mm^2/s

   ρ water: 0,997044

   gr/mlt water: 0,62

   second

   t oil: 6,2 second

   ρ oil: 880 kg/m^3: 0,80 gr/ml

Ƞ oil: $\frac{\eta w \times \rho o \ K\ to}{\rho w\ K\ to}$

: $\frac{0{,}6\ mm^2\ K\ 0{,}8 \frac{g}{m}\ K\ 6{,}2\ s}{0{,}9 \frac{g}{m}\ K\ 0{,}6\ s}$

: 5,77 mm^2/s

4. Biodiesel water content calculation

previous mass	:	40,8476 gr
Chemical mass	:	40,7929 gr
Content %		: $\frac{B\ p - B\ c}{B\ p}$ X 100 %
		: $\frac{4{,}7\ g - 4{,}8\ g}{4{,}8\ g}$ X 100 %
		: 0,03%

Appendix 3

The making of biodiesel reactor and biodiesel quality test