Diversification of Used Cooking Oil into Biodiesel as an Attempt to Increase BumDes Mangesti Sejahtera's Revenue in Gentan Village, Baki District, Sukoharjo Regency

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ABSTRACT

One of the types of waste produced by the Gentan community is used cooking oil. Previously, the people and the business actors in Gentan reused it in their daily activities. However, they acknowledge that it may damage food nutrition and even cause cancers for its fatty acids. In response to such problems, the Regency Government worked jointly to construct a waste recycling technology called TPS3R. In 2021, the head of Gentan stated that they had started an activity called GELIMPAH (*Gentan Peduli Sampah,* the community's action of concern towards waste) program by collecting wastes from households and converting those into gold savings under the waste-to-gold program supported by PT Pegadaian. BUMDes *(Badan Usaha Milik Desa* or Village-Owned Enterprise) also collected used cooking oil from residents and business units as much as 30-50 m^3 per week—even collected 70 m^3 in the last week of March 4th, 2022. The collected oil was expected to be appropriately processed and economically valuable for the community. Together with the head of Gentan, the team worked in diversifying used cooking oil to become a biodiesel fuel. This activity was expected to be a parameter or benchmark for the collaboration's fruitfulness regarding constructing a biodiesel development zone from used cooking oil. Furthermore, it was also expected that there would be the re-establishment of the used cooking oil processing technology into biodiesel (using biodiesel refinery technology) by building a biodiesel reactor with 100 L capacity. This application aimed to develop Gentan as a biodiesel or bio-energy development zone in Sukoharjo, as it produces a reactor as a technological handover from the university to the community, along with establishing cooperation between universities, other higher education institutions, and the community or BUMDes. This appropriate technology's implementation has resulted in a reactor for processing used cooking oil into biodiesel with the characteristics according to SNI-2015.

Keywords: Biodiesel, BUMDes, Diversification, Gentan, Reactor

1 Introduction

Gentan is one of the fourteen villages in Baki District, Sukoharjo Regency, Central Java. Its population continues to grow annually, which in 2015 reached 0.74% as the district had 55,875 residents. In terms of economic development, based on the GRDP per capita, its economy was dominated by manufacturing, agriculture, and trade industries, all of which significantly contributed to regional income [1]. However, such economic activities have brought an environmental problem concerning waste hoarding and accumulation. Baki District in 2015 reported that the waste produced by people's economic activities reached 18 m^3/day [2].

An evaluation of the Water Supply and Sanitation sectors' performances in Sukoharjo Regency showed that the amount of waste transported to landfills in 2015 was 421 m^3/day, while the waste that was not

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transported was 1,704.98 m^3/day [1], leading the area to face numerous environmental problems. One of the types of waste was used cooking oil.

Used cooking oil is waste containing carcinogenic compounds that emerge during frying [3]. It comes from repeatedly used cooking oil in the frying process, thus categorized as waste, which can damage the environment and cause disease for those who consume it. Constant use of used cooking oil may damage food nutrition and even cause cancer (carcinogenic) due to free fatty acids and radicals. Several studies concluded that people who consume and cook using cooking oil are at high risk of developing hypertension. Disposal of used cooking oil directly into the environment can clog waterways and damage soil's pore structure, thus requiring proper processing. Using a fairly high amount of free fatty acids, cooking oil needs two-stage processing: the esterification and transesterification processes [3].

In response to this problem, the head of Gentan (2021) stated that they had started a program called GELIMPAH (*Gentan Peduli Sampah,* the community's action of concern towards waste) by collecting wastes from households and converting those into gold savings under the waste-to-gold program supported by PT Pegadaian. BUMDes (Badan Usaha Milik Desa, Village-Owned Enterprise) also collected used cooking oil from residents and business units as much as 30-50 m^3 per week—even collected 70 m^3 in the last week of March 4th, 2022. The collected oil was expected to be appropriately processed and economically valuable for the community. Hence, together with the Head of Gentan, we were working to process used cooking oil to become one of the biodiesel fuels.

Biodiesel is an alternative fuel that is usually used for diesel engines. This fuel production requires a transesterification reaction between vegetable oil or animal fat containing triglycerides and alcohol. Converting triglycerides into ester compounds in the transesterification reaction requires a strong base catalyst such as sodium hydroxide or potassium hydroxide [4]. Indonesia has abundant sources of used cooking oil, which can be used as biodiesel since it contains high levels of free fatty acids. However, used cooking oil becomes household waste eventually [5]. The fatty acids it contains can be esterified with alcohol and catalysts to maximize the yield or triglycerides, which can then be transesterified with alcohol and a catalyst to produce biodiesel, triglycerides, and glycerol. Quality standards for the biodiesel manufacturing process are set according to SNI 7182: 2015 as seen on Table 1.

Table 1: *Biodiesel Quality Standards According to SNI 7182:2015*

No.	Test Parameter	Unit	SNI (Min./ Max.)
1	Density (40°C)	g/mL	0.85 – 0.89
2	Viscosity	Cst	2.3 – 6.0
3	Water content	%-vol	Max. 0.005
4	Flash point	°C	Min. 100°C
5	Acid number	mg-KOH/g	Max. 0.5
6	pH	-	6 – 8

The Directorate General of New and Renewable Energy explained that used cooking oil potentially has a high market value if processed into biodiesel as a substitute for diesel oil. A collaboration was planned to continue the assistance and mentoring program, which has been successfully performed by the head of Gentan and the Chemical Physics Laboratory activity implementing team of the Department of Chemistry

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of the Faculty of Mathematics and Natural Sciences in 2021 in processing used cooking oil into biofuel. This activity was expected to be a parameter and benchmark for the collaboration's success regarding the construction of a biodiesel development zone from used cooking oil and the re-establishment of the technology for processing used cooking oil into biodiesel (biodiesel refinery technology) by building a biodiesel reactor with a capacity of 100 L.

2 Research Methodology

The program to diversify used cooking oil into biodiesel can directly increase the knowledge and income of BUMDes Mangesti Sejahtera of Gentan, Baki, Sukoharjo. Used cooking oil produced in large quantities from community activities must be processed to prevent it from becoming waste detrimental to the environment. This program can be a new economic income for Gentan if optimally implemented.

In this research, the reactor used consisted of a cylinder with a capacity of 100 liters, a condenser, a gas stove, and a container for the diversification reaction results. Using a gas stove instead of wood aimed to shorten the diversification process time because the heat produced could save energy and costs. The system was equipped with a water flow valve and a thermometer. The reaction was tested at CV Fruitanol Energy before being transferred to Gentan's BUMDes. Figure 1 shows the reactor.

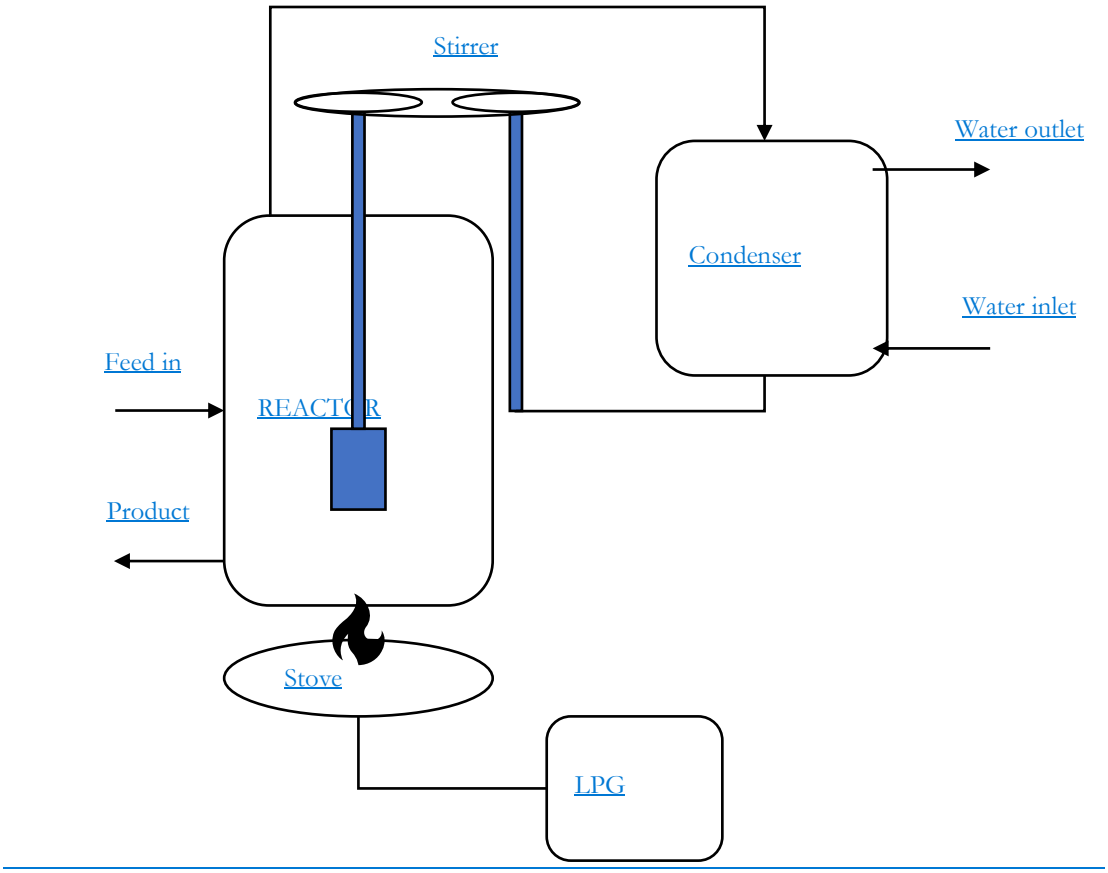

Figure 1: *The design of the reactor used for diversification of used cooking oil*

The Biodiesel synthesis made from used cooking oil coming from households in Gentan Village, Baki District, Sukoharjo Regency was divided into 3 stages: (1) pre-treatment; (2) filtering, transesterification, purification, and characterization on a laboratory scale; and (3) technology application. The scheme of the diversification process is shown in Figure 2.

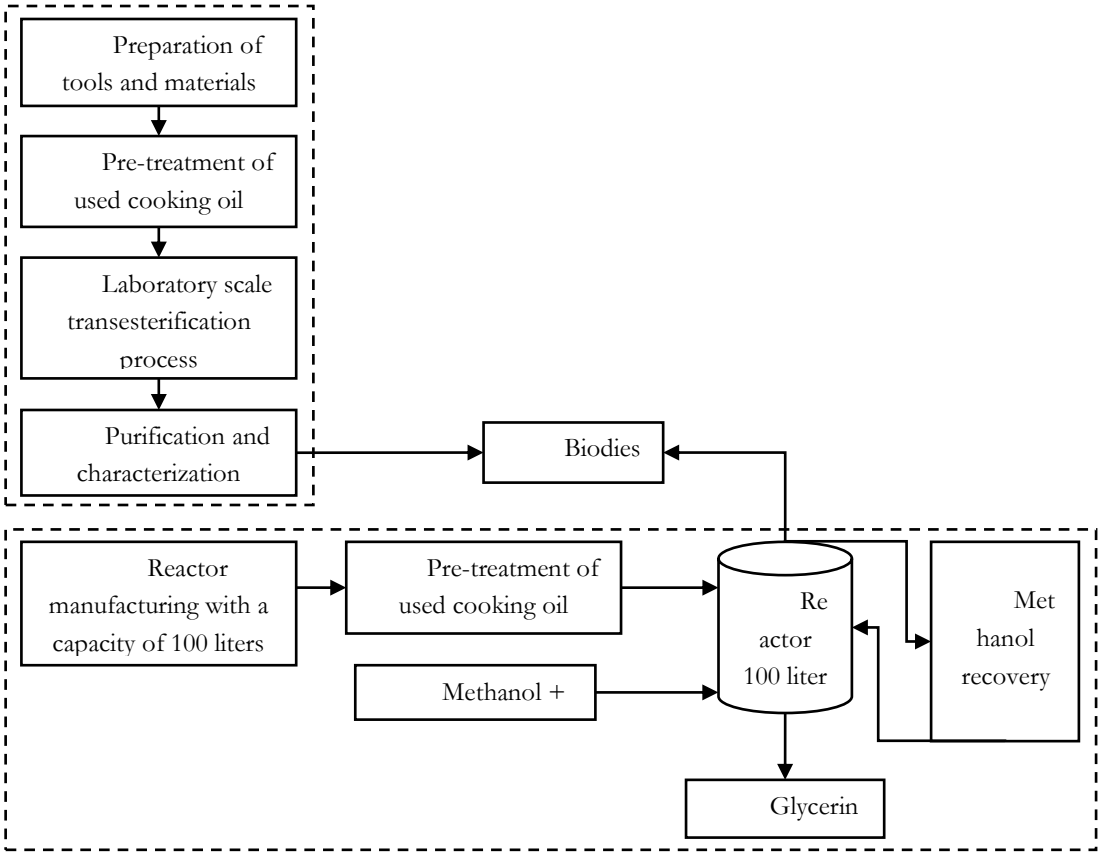

Figure 2: *Block flow diagram of the research process*

2.1 Pre-treatment

The initial process of manufacturing biodiesel from used cooking oil was to collect used cooking oil from residents and put it in jerry cans. The oil was then prepared through filteration using a filter to separate impurities to get good biodiesel as depicted in Figure 3.

Figure 3: *Pre-treatment of the biodiesel production process*

2.2 Transesterification of used cooking oil on a laboratory scale

The transesterification process was carried out using an alkaline catalyst. As much as 4 g NaOH catalyst was dissolved in 200 mL methanol and stirred until evenly. 1 L of used cooking oil was heated to 80°C. The dissolved catalyst was mixed in hot used cooking oil in a reflux reactor and then stirred for 60 minutes.

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After reflux, the biodiesel was washed with distilled water and let stand for 24 hours. The glycerol produced after the transesterification process was separated and then distilled for purification.

2.3 Application of biodiesel manufacturing process technology

The application process on a large scale using a reactor with a capacity of 100 L, shown in Figure 4 was the transesterification process's continuation of used cooking oil on a laboratory scale. 50 L of used cooking oil was filtered; NaOH and methanol were put into the reactor tank, then tightly closed. The condenser tank was filled with water while connected to a water pump until the water flew from the top hose. The oil in the tank was heated to a solution temperature of 60–80°C and stirred for 2 hours. The oil resulting from the transesterification reaction was tested for physical properties to determine whether or not it complied with the standards. The oil that complied with the standards was collected in a container to stand and form biodiesel and glycerol layers.

Figure 4: *Used cooking oil diversification process.*

3 Results and Discussion

The technique used in processing used cooking oil by Gentan's BUMDes was not fully effective because it took quite a long time and required a large workforce. The biodiesel produced did not meet one of the SNI requirements since the manufacturing process released enormous energy into the environment, leading to less effectiveness. Therefore, the 2022 Community Service Grant based on Research and Utilization of Appropriate Technology organized by the Directorate of Community Service of Universitas Gadjah Mada facilitated the research team development and introduction to appropriate technology to Gentan's BUMDes as an attempt to overcome the problem of waste generated by residents' households.

3.1 Used cooking oil diversification reactor

The research team succeeded in creating an energy-efficient tank reactor technology with a capacity of 100 L equipped with a heating system directly integrated with the condenser, stirrer, and outlet of biodiesel and residue to produce biodiesel that meets SNI standards (Figure 2). The device was equipped with a used cooking oil storage tank with a capacity of 100 liters. With the aid of Liquified Petroleum Gas (LPG), the oil and catalyst mixing process could be completed in two hours. Furthermore, including the KOH catalyst increased reaction efficiency and allowed for producing high-quality biodiesel that complies with SNI standards.

The device assembled in CV. Fruitanol Energy, as seen in Figure 5, was tested by carrying out a diversification reaction of used cooking oil from BUMDes of Gentan. The process could run for 2-3 hours, while the conventional process took more than 5 hours. The reaction was accelerated by adding KOH as the catalyst. It differed from the conventional method, which is less effective due to the blocking process between methanol and triglycerides that causes a saponification reaction. Moreover, the conventional method's results need high methanol (feed) and result in difficulty in separating biodiesel from by-products [6].

Liquified Petroleum Gas (LPG) in the reactor served to heat the feed in the tank to speed up the used cooking oil diversification reaction. Instead of using firewood, using LPG could reduce carbon dioxide produced by heating [7].

Figure 5: *Used cooking oil diversification reactor with a capacity of 100 L*

3.2 Biodiesel production

Biodiesel obtained from diversification using a tube reactor with a capacity of 100 L is shown in Table 2.

Table 2: *Biodiesel Characterization Results Based on SNI 2015*

No.	Parameter	Unit	Biodiesel Testing Results	Testing Method
1	Specific Gravity at 60/60°F	-	.8793	ASTM D 1298
2	Kinematic Viscosity at 40°C	mm^2/s	6.257	ASTM D 445
3	Flash Point PM.c.c.	°C	134	ASTM D 93
4	Pour Point	°C	9	ASTM D 97

a. Specific Gravity

The specific gravity of biodiesel means the ratio of the biodiesel's density and a standard fluid (water, with a density of 1 g/cm^3). This value is related to the perfection of the combustion process [8]. The specific gravity value of the biodiesel produced was 0.8793, meeting the 2015 SNI standards.

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b. Kinematic Viscosity

Oil viscosity is the time (in seconds) the oil takes to flow through a hole of a specific diameter [8]. It has an essential role in fuel injection, pumping, and the size of the fuel sprayed into the combustion chamber [9]. A viscosity under the standards can cause a leak in the fuel injection pump. If too high, it can affect the operation of the injection device and make it hard to agitate the fuel [10]. The obtained kinematic viscosity value of 6.257 did not match the value set by SNI 2015 of 2.3 – 6 due to the operating conditions during the reaction.

c. Flashpoint

An oil flash point indicates the lowest temperature of an oil when a flame almost appears if its surface is brought close to a fire. This value is used in the safety of oil storage and transportation [11]. The biodiesel has a flash point that is 134°C in line with SNI 2015, making it appropriate for use as fuel.

d. Pour Point

An oil pour point represents the lowest temperature of an oil that allows it to flow due to the force of gravity [12]. The pour point of the biodiesel produced was 9, meeting the SNI 2015 standards, which state a maximum value of 18. An extremely low pour point affects the material's flowing smoothness in the filters, pumps, and injectors [13].

3.3 Transfer of the technology to BUMDes Gentan

The tube reactor with a capacity of 100 L was tested at CV Fruitanol Energy by the research team, and representatives of Gentan's BUMDes succeeded in producing biodiesel. The device was then handed over to Gentan's BUMDes to process used cooking oil into biodiesel. In addition, training was also carried out on processing used cooking oil into biodiesel with members of BUMDes Gentan at CV. Fruitanol Energy, Yogyakarta. . This transfer of the technology process is depicted in Figure 6.

Figure 6: *Briefing and handover of the reactor for used cooking oil diversification*.

4 Conclusions

A reactor for diversifying used cooking oil into biodiesel with a capacity of 100 liters has been successfully made and applied at CV Fruitanol Energy and Gentan's BUMDes. Its advantages include reduced

production costs, conversion time, heat loss, and labor efficiency. The biodiesel produced almost meets the SNI 2015 standards regarding specific gravity, pour point, and flash point. However, its kinematic viscosity does not meet the standards due to factors that affect the reaction time. This technology needs further refinement, especially regarding the cooling condenser and the stirring speed. A condenser pump that can drain water effectively with a higher stirrer speed is needed to allow the diversification process to run effectively.

5 Declarations

5.1 Study Limitations

The biodiesel's characteristics are analyzed from the diversification of used cooking oil only on specific gravity, kinematic viscosity, flash point, and pour point. The technology handover is carried out by socializing the use of the reactor and ending with the handover of the reactor to Gentan's BUMDes Mangesti Sejahtera.

5.2 Acknowledgments

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