

Temperature effect on the biodiesel quality from waste cooking oil by induction heating

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Abstract. Increased energy consumption in Indonesia encourages energy conservation in the field of renewable energy. One form of energy that has been increasingly developed is the use of biodiesel as vehicle fuel. The process of biodiesel production can be done by various methods, such as the use of induction technology as a heat supply media in the transesterification reaction. This induction technology uses a non-contact process that utilizes magnetic field radiation in the metal so that it will generate heat from inside the metal material. The raw material used in this research is waste cooking oil by varying the reaction temperature used. Based on research that has been done, obtained high yield results at the use of a temperature of 60 degree C for the use of used cooking oil is 86.95 percent and the biodiesel products obtained are by the applicable quality standards in Indonesia.

1. Introduction

Population growth every day has an impact on various sectors, including the energy sector. Final energy consumption in Indonesia is still dominated by fuel oil (BBM) which reaches 41.7% followed by electricity (19%), natural gas (14.6%), coal (9.1%), LPG (8.1 %) and non-energy use (7.5%) [1]. To meet the ever-increasing energy needs, one of the government's steps is to carry out a mandatory use of biodiesel (BNN) in the form of biodiesel. The mandatory biodiesel is regulated in ESDM Regulation No. 12/2015 with the use of biodiesel (B100) in 2025 at least be at the level of 30%. From 2015 to 2050 the need for biodiesel will grow with a growth rate of 8.4% per year following the lower limit and 9.4% per year following the upper limit of the 2017 Draft State Budget. A study was conducted to produce biodiesel from biomass feedstock with high amounts in time short ones.

Research on making biodiesel has been carried out before. Astuti has researched the production of biodiesel with raw material for coconut oil using conventional heating methods [2]. The use of ultrasonic waves in biodiesel production has also been carried out by Santos *et al.* [3]. The development of biodiesel production has also been carried out by Amalia *et al.* using the subcritical alcohol method [4]. The use of fixed bed reactors used in making biodiesel has been investigated by Susila [5]. Researchers have researched the making of biodiesel from Crude Palm Oil (CPO) using the use of microwaves, followed by research into making biodiesel from waste cooking oil by electrostatic methods [6,7]. Therefore, through this research, the researchers carried out development in the making of biodiesel by using induction technology on raw materials for CPO and used cooking oil.



Induction heaters generate heat from metals that are induced by magnetic fields due to eddy currents in a circular direction surrounding the magnetic field [8]. Induction heating is commonly known as a heat transfer process that occurs in non-contact by using electricity that has a high frequency so that it will produce electrically conductive heat. Because the process occurs non-contact, the induction heating process does not affect the material being heated. The process is also very efficient because heat is generated in the material being heated. The power source is used to drive a large alternating current through an induction coil adapter.

Current flowing through the coil adapter will produce a very strong and rapidly changing magnetic field in the work coil. The material to be heated is placed in this magnetic field with a very strong alternating current. When a load is placed on a work coil that is flowed by an alternating current, the value of the current flowing will follow its magnitude according to the load value. A high magnetic field will cause a load over the work coil to release its heat so that the heat generated by the load can heat the load itself because the heat experienced by the load will be higher until it reaches its melting point value. Induction technology has been applied both in the industrial and household sectors. One of the equipments that have used induction as a heater is an induction cooker.

2. Methods and materials

The raw material used is used cooking oil with free fatty acid 4.32%. The catalyst used is a sodium methoxide solution with a concentration of 1% of the weight of the oil used. The use ratio for this experiment is 1:7. The main component in the process of making biodiesel is located in the transesterification reactor that uses the principle of induction to supply heat in the reaction that occurs. Coiling coil at the bottom of the reactor is electrified with high frequency so that it will produce a magnetic field. This magnetic field will induce the metal contained in the reactor so that heat will be generated from the metal material. This heat will then be transferred by conduction to the mixture of materials inside the reactor. The time needed to react the oil with methanol and catalyst is 15 minutes. The mixture is homogeneous with a stirrer inside the reactor. The process of making biodiesel is done by varying the reaction temperature used. The biodiesel products obtained were then analyzed for quality such as density, viscosity, flash point, and acid number to compare with the existing quality standards in Indonesia. The instrumentation used in this study is shown in Figure 1.

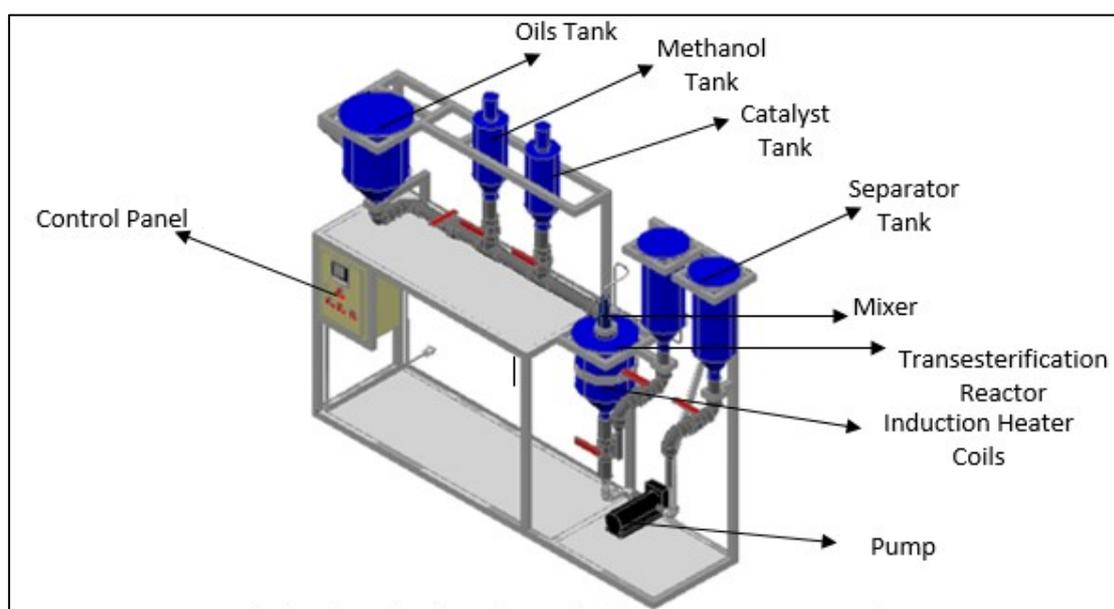


Figure 1. Biodiesel Production using induction heater instrumentation.

3. Results and discussion

3.1. Effect of reaction temperature on biodiesel yield

The reaction temperature is varied for each raw material used, 40, 45, 50, 55, and 60°C. The relationship between the use of reaction temperature for each raw material used to the yield of biodiesel produced is shown in Figure 2.

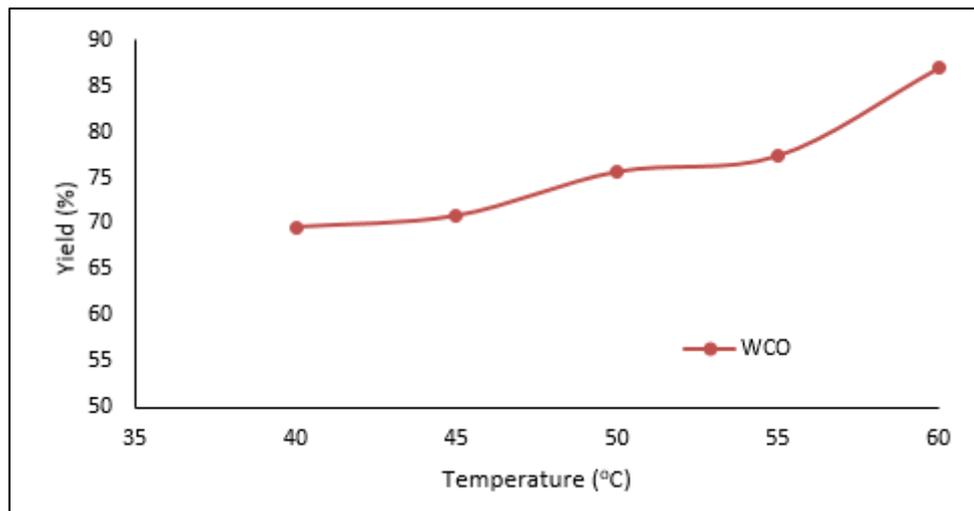


Figure 2. Relationship between reaction temperature and biodiesel yield.

Based on Figure 2, it was found that an increase in temperature would increase the yield of biodiesel products. The highest yield for waste cooking oil was obtained at 60°C, 86.95%. The use of high reaction temperatures will result in high conversion so that the biodiesel yield obtained will increase. Higher temperatures increase the dissolution of methanol and accelerate the reaction [9]. However, the methanol vapor pressure will increase rapidly at temperatures above 80°C.

3.2. Effects of reaction temperature on biodiesel density

The density value will affect the combustion process of the fuel in the diesel engine used. The relationship between the reaction temperature for each raw material used to the density of the biodiesel product produced is shown in Figure 3.

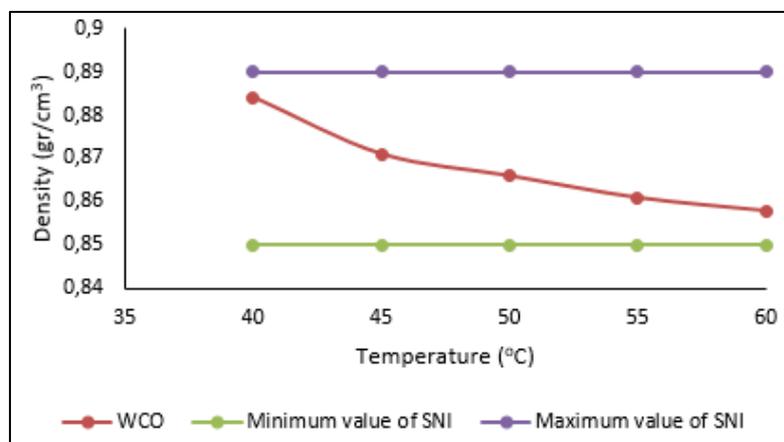


Figure 3. Relationship of reaction temperature to density.

Figure 3 shows that the use of the reaction temperature affects the density of the product produced. The higher the reaction temperature used, the lower the density. In the transesterification process, changes in reaction temperature cause molecular movements to accelerate [10]. Increasing temperature causes the movement of molecules to be faster due to the kinetic energy of reagent molecules, which is greater so that collisions between molecules also increase. More collisions indicate a higher conversion process. This increase in conversion makes the value of biodiesel density lower because triglyceride molecules that have high densities are converted to biodiesel.

3.3. Effect of reaction temperature on biodiesel viscosity

The viscosity of biodiesel will affect the fuel injection process in the combustion chamber of the vehicle. The relationship between the use of the reaction temperature with the viscosity of the product produced is shown in Figure 4.

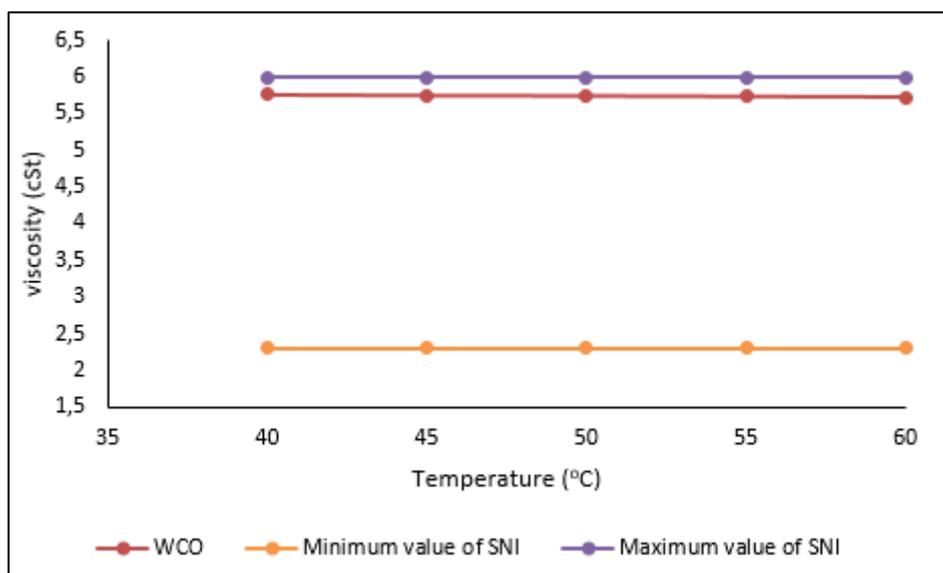


Figure 4. Relationship of reaction temperature to viscosity.

Figure 4 shows the effect of the reaction temperature used on the viscosity of the product produced. The higher the reaction temperature used, the viscosity of the biodiesel product produced will be lower. This decrease in viscosity is caused by an increase in reaction temperature, which increases the conversion of triglycerides to biodiesel. High conversion will reduce the product viscosity because triglyceride molecules which have high viscosity more and more are converted to biodiesel. The higher conversion will decrease the viscosity value because FAME has a lower viscosity than triglyceride [11].

3.4. Effect of reaction temperature on flash points of biodiesel

The high flash point will facilitate the process of storing biodiesel fuel because it is difficult to ignite. The relationship between the use of the reaction temperature to the flash point of the product produced is shown in Figure 5.

Based on Figure 5, it is obtained that the increase in reaction temperature will reduce the flash point of the biodiesel product produced. Increased conversion of triglyceride molecules to biodiesel along with the increase in temperature will cause a decrease in viscosity in the product. Products that have a low viscosity value have a low flash point [12]. This is because fluids which have high viscosity values are more difficult to ignite. Low reaction temperatures cause the conversion process to be less than perfect between triglycerides and methanol.

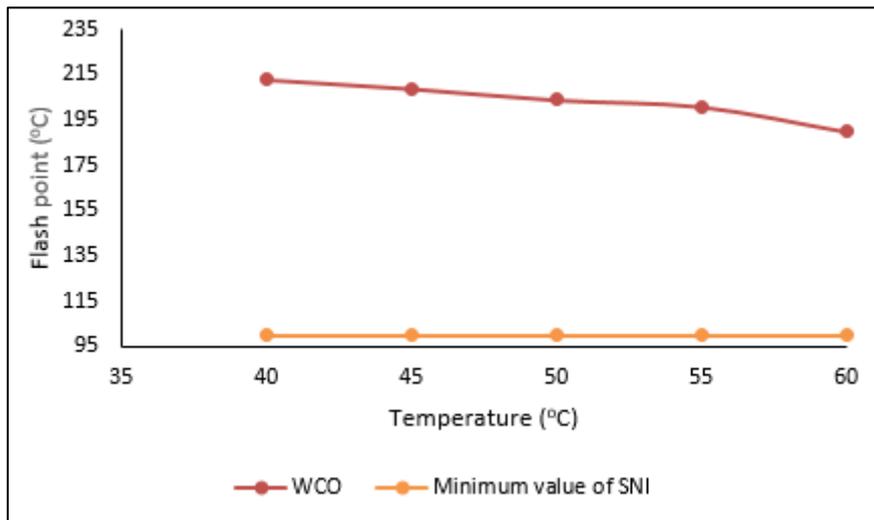


Figure 5. Relationship of reaction temperature to flash points.

3.5. Effect of reaction temperature on acid numbers of biodiesel

The acid number is a parameter that shows the amount of free fatty acids contained in a fuel and the content of acids and free fatty acids in fuel degradation [13-16]. The relationship between the use of the reaction temperature to the acid number of the product produced is shown in Figure 6.

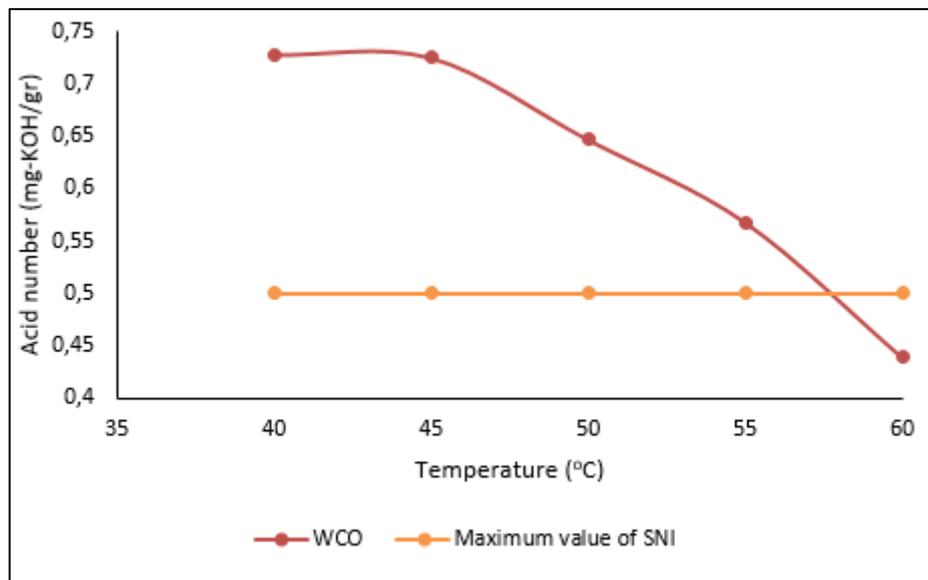


Figure 6. Relationship of reaction temperature to acid figures.

Based on Figure 6, it is found that the acid number will decrease with the increase in reaction temperature used. High acid numbers indicate that free fatty acids are still contained in biodiesel products [14,17]. The increasing reaction temperature causes an increase in the conversion of triglyceride molecules to biodiesel. Free fatty acids contained in triglycerides will decrease along with the increase in conversions that occur.

4. Conclusions

Biodiesel is an alternative energy that has been continuously used by the government up to now. Various methods for producing biodiesel were developed to obtain high conversion results and by applicable quality standards in Indonesia. Induction is a promising form of technology when applied in the process of making biodiesel. The non-contact heating process is a distinct advantage in the use of this technology. Making biodiesel using induction technology with waste cooking oil raw material produces a high yield of 86.95% at temperature of 60°C and the products produced are following the applicable quality standards in Indonesia.

5. References

- [1] Suyono *et al.* 2017 *Kajian Penyediaan dan Pemanfaatan Migas, Batubara, EBT, dan Listrik* (Jakarta: Pusat Data dan Teknologi Informasi Energi dan Sumber Daya Mineral Kementerian Energi dan Sumber daya Mineral)
- [2] Anzar E, Yusi M S and Bow Y 2018 *Journal of Fundamental and Applied Chemistry* **3** 83–88
- [3] Santos F F P, Malveira J Q, Cruz M G A and Fernandes F A N 2010 *Fuel* **89** 275–279
- [4] Refaat A A and Sheltawy S T E 2008 *WSEAS Transactions on Environment and Development* **4**
- [5] Arita S 2009 *Prosiding Seminar Nasional Daun Bahan Bakar*
- [6] Yunsari S, Rusdianasari and Husaini A 2019 *Journal of Physics: Conference Series* **1167**
- [7] Susumu, Rusdianasari and Yusi S 2018 *Journal of Fundamental and Applied Chemistry* **3** 71–76
- [8] Perdana A N 2018 *Analisis Waktu Pemanasan Terhadap Karakteristik Bahan yang Berbeda oleh Pemanas Induksi* (Medan: Universitas Negeri Medan)
- [9] Zhang S, Zu Y, Fu Y, Luo M, Zhang D and Efferth T 2010 *Bioresour. Technology* **101** 931–936
- [10] Wahyuni S, Ramli and Mahrizal 2015 *Pillar Physics* **6** 33–40
- [11] Dias J M, Araújo J M, Costa J F, Alvim-ferraz M C M and Almeida M F 2013 *Energy* **53** 58–66
- [12] Rifwanto A 2018 *Pengaruh Lama Pengadukan Biodisel Menggunakan Temperatur Transesterifikasi 55°C dan 65°C Terhadap Mutu Biodisel yang Dhasilkan dengan Bahan Baku Minyak Jarak (Castor Oil)* (Yogyakarta: Universitas Muhammadiyah Yogyakarta)
- [13] Ferrari R A, Pighinelli A L M T and Park K J 2011 *Intechopen*
- [14] Ploetz R, Rusdianasari R and Eviliana E 2016 *Proceeding Forum in Research, Science, Technology (FIRST)*
- [15] Moulita R A N, Rusdianasari and Kalsum L 2019 *Journal of Physics: Conference*
- [16] Putra J U, Kalsum L and Bow Y 2018 *Indonesian Journal of Fundamental and Applied Chemistry* **3**
- [17] Yusmartini E S and Rusdianasari 2016 *Proceeding Forum in Research and Technology (FIRST)* B10-B13