International Journal of Marine Engineering Innovation and Research, Vol. 9(4), Dec. 2024. 734-740
(pISSN: 2541-5972, eISSN: 2548-1479)

Evaluation Prototype of B30 Diesel Fuel Heater Using Arduino

Parabelem Tinno Dolf Rompas[1], Metsi Daud[2], Ahmad Tubagus Tsani Risqi Aji[3*], Barokah[4], Dwi Dharma Arta Kusuma[5], Ahmad Ilham Ramadhani [6]

(Received: 23 October 2024 / Revised: 19 November 2024 /Accepted: 29 November 2024 / Available Online: 31 December 2024)

***Abstract*— Utilizing B30 as diesel fuel has the advantage of being heated to a specific temperature. Manually setting the temperature during the heating and fuel-filling process in the heating tank causes fuel performance to become less effective and efficient. This research aims to evaluate the capability of the prototype as a B30 fuel heater. The research method was carried out experimentally by testing variables for the temperature sensor (DS28B20), distance sensor (VL53LOX), heater control system, fuel filling system, and performance of the B30 diesel fuel heater prototype on a 7 HP single-cylinder diesel engine. The research results show that the fuel heater prototype can regulate the desired temperature and fill the heating tank automatically. The fuel temperature tested starts from 28^{0}C to 65^{0}C with an average multiple of 50C and tolerances of +2^{0}C and -1^{0}C. At the same time, it can automatically fill fuel from the main tank to the heating tank set from 800 ml to 1200 ml. B30 performance on a 7 HP single-cylinder diesel engine with 100 ml of fuel heated at 28^{0}C - 65^{0}C each shows the longest fuel consumption time at 35^{0}C and the fastest at 45^{0}C.**

Keywords— Keywords: prototipe, B30, sensor, Arduino, Preheating.

I. INTRODUCTION

The use of fuel oil to produce heat or power in the industrial world is still the focus of researcher attention. Fuel quality, performance, emissions, and economic factors are several parameters that need to be considered for various types of fuel [1]. In Indonesia, the government has launched the use of alternative fuels to reduce dependence on fossil fuels that were harder to find [2].

Biodiesel is a fuel-type alternative made from a mixture of fossil fuels, namely diesel fuel, and organic materials known as biomass, such as palm oil [3], plant waste [4], [5], or organic waste. The processing of biodiesel fuel involves processing the organic material with fossil fuels. This mixture is usually also called biodiesel or biofuel. Biodiesel fuel can exchange fossil fuel in diesel engines.

Research on heating B20 fuel was carried out by manually setting various temperatures of 30ºC, 35ºC, 40ºC, 45ºC, and 50ºC using a 4-stroke, 4-cylinder, 1500 rpm 18 kVA engine with a diesel engine under no load conditions shows that the higher the fuel temperature lower the consumption. So, it can be concluded that fuel heating affects fuel consumption efficiency [6].

In Indonesia, B30 diesel fuel is the fuel most widely marketed for both vehicle use and industrial activities. B30 diesel fuel also has a cheaper price compared to other diesel fuels sold on the market.

One of the fundamental problems with B30 biodiesel fuel is that its consumption is relatively more wasteful compared to Dexlite and Pertamina Dex fuel, which are the diesel fuels that are most widely used by the public [1].

In response to developments in the automotive world, many ideas for modifying motorbikes to perform better. One of them is heating the fuel on a diesel motor. Fuel heating can increase thermal efficiency, reduce specific fuel consumption and reduce exhaust emissions [7]. The B30 warm-up carried out so far still uses manual fuel-filling settings.

Manual settings have limitations in the filling and heating process, so the diesel engine's performance could be improved. This is because the temperature and amount of fuel still require specific settings to obtain optimal performance.

The main problem with B30 fuel can be solved by heating it to a certain temperature. The heating phenomenon can change the main characteristics of B30 when used. Diesel fuel preheats to a specified temperature that will increase engine performance [8], [9]. Preheating the fuel before the injection pump on a diesel motorbike increases engine power and torque and reduces fuel consumption if heated to a specified temperature.

Experimental results on biodiesel heating show that increasing the temperature of biodiesel fuel affects the performance improvement of diesel engine operation

[1]Parabelem Tinno Dolf Rompas is with Department of Technology and Vocational Education, Universitas Negeri Manado, Tondano, 95618, Indonesia. E-mail: parabelemrompas@unima.ac.id
[2]Metsi Daud is with Department of Technology and Vocational Education, Universitas Negeri Manado, Tondano, 95618, Indonesia. E-mail: mtesidaud@unima.ac.id
[3]Ahmad Tubagus Tsani Risqi Aji is with Department of Technology and Vocational Education, Universitas Negeri Manado, Tondano, 95618, Indonesia. E-mail: ahmadtubagustra@gmail.com
[4]Barokah is with Department of Mechanical and Fisheries Engineering, Politeknik Kelautan dan Perikanan Bitung, Bitung, 95521, Indonesia. E-mail: barokah@poltekkp-bitung.ac.id
[5]Dwi Dharma Arta Kusuma is with Department of of Mechanical and Fisheries Engineering, Politeknik Kelautan dan Perikanan Bitung, Bitung, 95521, Indonesia. E-mail: dwi.d.a.kusuma@gmail.com
[6]Ahmad Ilham Ramadhani with Department of of Mechanical and Fisheries Engineering, Politeknik Kelautan dan Perikanan Bitung, Bitung, 95521, Indonesia. E-mail: ahmadilhamramadhani@poltekkp-bitung.ac.id

[10]. Furthermore, heating the biodiesel fuel can also improve the combustion characteristics [11].

Increasing the temperature of the biodiesel has the effect of decreasing the viscosity so that the fuel flows more easily through the fuel injection system causing better atomisation and combustibility [12].

However, the manual settings for the heating and fuel-filling process result in the process being less effective and efficient for use or use by the public. Based on these conditions, it is necessary to conduct evaluation research on the B30 biodiesel fuel heater prototype using Arduino.

Fuel heating at a specific temperature is necessary to obtain appropriate fuel performance. Temperature regulation and automatic filling of B30 fuel using a heating device are required to make B30 utilization more effective and efficient. Based on the existing background, this research aims to evaluate the B30 fuel heater prototype by evaluating the prototype's capabilities as a B30 fuel heater by analyzing the performance of the temperature sensor (DS28B20), distance sensor (VL53LOX), heater control system, fuel filling system, and performance of the B30 diesel fuel heater prototype on a 7 HP single cylinder diesel engine.

II. METHOD

This research uses several equipment and materials. The equipment includes heating elements, mercury thermometers, temperature sensors, fluid surface level sensors, fuel pumps, Arduino, and computers. Meanwhile, the material used is B30 diesel fuel.

Figure 1 shows the research flow for evaluating the B30 biosolar fuel heater prototype using Arduino. The first step was a literature study regarding the characteristics of B30 diesel fuel and the sensors used in the prototype.

Next, make a fuel tank by attaching a heating element below the tank. The fuel tank consists of a height sensor, temperature sensor, pipe connection from the main tank, and pipe connection to the engine combustion chamber. The engine combustion chamber is attached to an opening and closing tap.

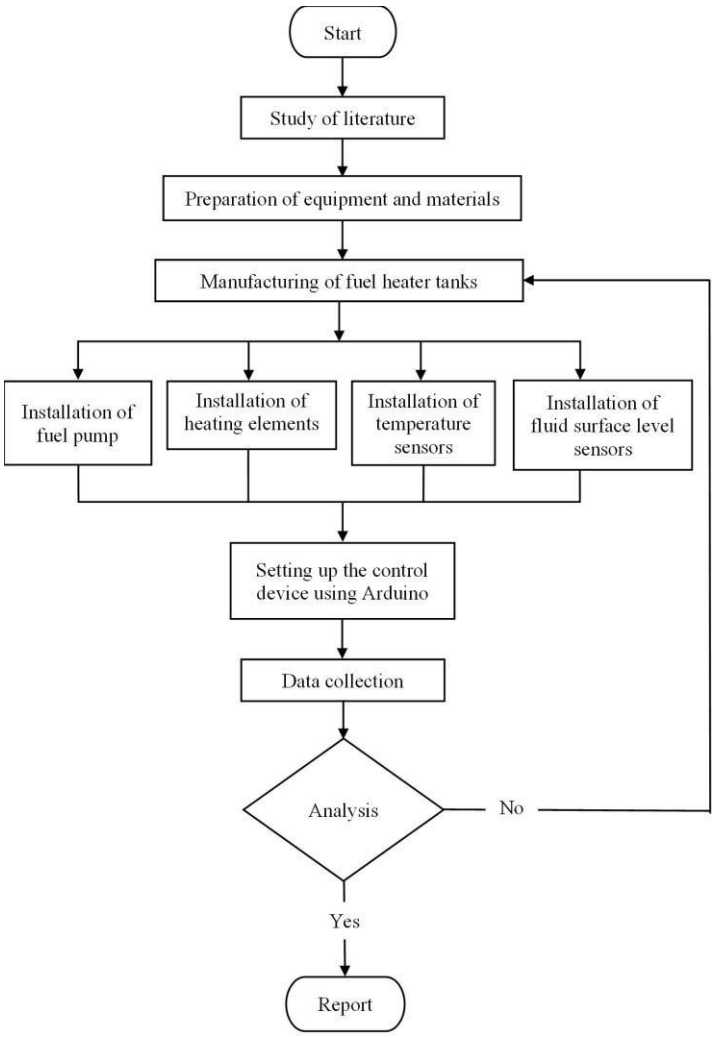

Figure. 1. B30 heater prototype research diagram

After that, the main tank will connect to a 12-volt fuel pump, which will be used as a tool to help flow fuel from the main tank to the fuel heating tank.

All sensors, measuring instruments, and pumps in the system will synchronize with the Arduino circuit [13], which is assisted by using relays . The system requires power supplied by a 12-volt battery. All sensor data reading results will displayed on the computer.

Some of the sensors used are the DS18B20 temperature sensor [14] and the VL53LOX light distance sensor [15]. The DS18B20 temperature sensor is a temperature sensor that has a digital output. The DS18B20 has a fairly high level of accuracy, namely 0.5°C in the temperature range -10°C to +85°C. Temperature sensors generally require an ADC and several port pins on the microcontroller, but the DS18B20 does not require an ADC to communicate with the microcontroller and only requires one (1) wire[16].

The light distance VL53LOX sensor is a laser-ranging module housed in the smallest package available on the market. It operates using time-of-flight technology. It integrates a 940 nm IR VCSEL laser and a ranging sensor with an advanced embedded microcontroller, with no additional optics required for operation. It can detect objects and absolute distances for up to 2 meters. It enables easy integration with the I2C interface for device control and data transfer[17].

III. Results and Discussion

The assembling result of the B30 diesel fuel heater prototype uses Arduino in Figure 2. The assembled prototype uses a main tank connected to a fuel hose using a pump to the heating tank. The pump uses a relay controlled by an Arduino. So, it will automatically turn on and off as desired.

The fuel heating tank is located at the top or higher than the main tank (bottom). This location determination is in line with the location of the daily tank which is generally placed higher than the main tank.

Figure. 2. B30 Bio Solar Fuel Heater Prototype Using Arduino

The working mechanism of the B30 fuel heater prototype is that fuel is pumped to the heating tank as needed. The fuel is heated in the tank using a heating element attached to the bottom. The heater will automatically turn on and off if the fuel temperature has been reached according to requirements.

When the circuit is running, fuel always flows towards the engine so that the level in the fuel tank will fall in line with the fuel consumption used in the engine. The height sensor will send a signal to the Arduino to control the pump in the daily tank so that the fuel pump will start again.

The phenomenon that occurs in the B30 fuel heater prototype shows that there is an automatic working mechanism using the Arduino system. This indicates that temperature regulation and fuel filling are always carried out to maintain optimal engine performance.

3.1 Temperature Sensor Test

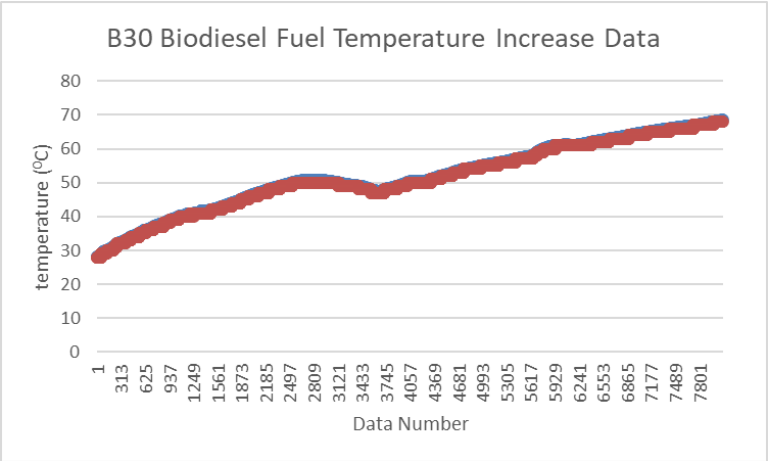

Figure. 3. Testing DS18B20 Sensor (blue) and Mercury Thermometer (red)

Testing was carried out to compare the temperature read by the DS18B20 temperature sensor with the temperature read by the Mercury Thermometer. In addition, tests were carried out to determine the time needed to heat B30 biodiesel fuel.

Tests were carried out on the same substance, namely B30 biodiesel fuel, over the same time period. This aims to find out whether the DS18B20 temperature sensor has measuring capabilities commensurate with a mercury thermometer so that it can be used for temperature measurements in this research process, especially in terms of fuel heating.

In Figure 3, it can be seen that temperature measurements using the DS18B20 sensor produce graphs that are almost the same as the graphs resulting from temperature measurements using a Mercury Thermometer. When the temperature increases or decreases, both produce equivalent values, this is shown by a very close graphic line between the two. Based on the data recorded from the computer, the DS18B20 sensor produces values up to two digits after the comma. The suitability of the DS18B20 temperature sensor test results with mercury temperature shows that the temperature sensor can be used optimally in determining the heater temperature.

3.2 Height Sensor Test

TABLE 1.
FUEL VOLUME ALTITUDE MEASUREMENT DATA

No.	Volume (ml)	Proximity Sensor VL53LOX (mm)
1	700	128
2	800	122
3	900	118
4	1000	110
5	1150	102
6	1200	99
7	1300	93
8	1400	86

The height sensor test is carried out to determine the fuel content in the heater tank. The height sensor used is the VL53L0X Sensor. This sensor will measure the distance from the fuel heater tank cover to the fuel surface. The test was carried out by filling the B30 biodiesel fuel heating tank using a measuring cup as a measure. Inside the tank, a measuring pipe is made which is provided with a float in the form of a flat cross-section, a distance sensor is fired into the cross-section to read the distance of the sensor placed on the tank lid to the cross-sectional surface which is parallel to the fuel surface.

It can be seen from the sensor reading data in Table 1 that the volume of fuel filled into the heater tank is 700 ml, read on the VL53LOX distance sensor as 128 mm. Then the volume of fuel filled into the 1400 ml heating tank reads 86 mm. The greater the volume of fuel added, the smaller the value produced by the distance sensor, so this sensor can be used to determine when the fuel is full or empty. In this prototype, the lower limit point of 700 ml or equal to 128 mm and the upper limit of 1200 ml or equal to 99 mm are used as safe points for accurate height distance readings.

3.3 Test the Heating Control System

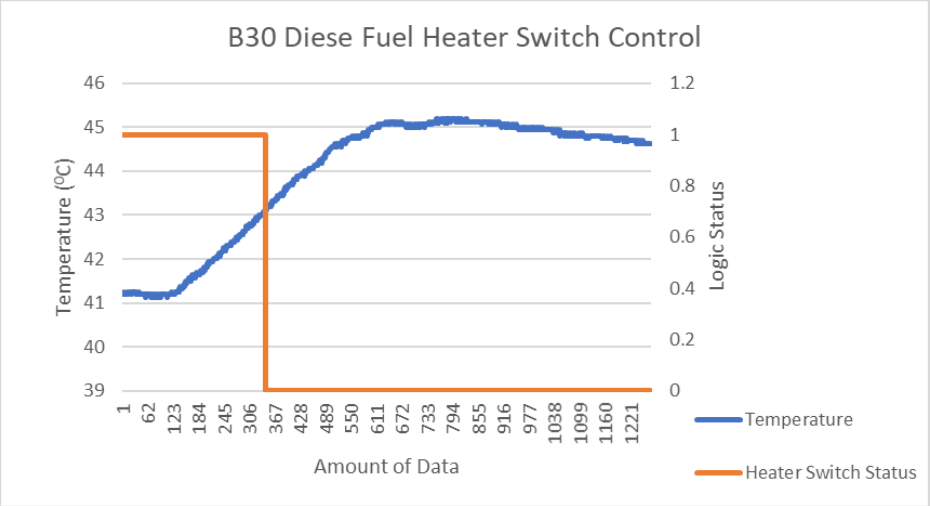

Figure. 4. B30 Diesel Fuel Heating Control System (blue color is Temperature Sensor red color is switch control)

The fuel heater control system evaluates the prototype's capabilities during operation. In Figure 4, the upper limit setting is 43.1^{0}C, where the initial fuel temperature is 41.19^{0}C. So, the Arduino gives a signal to the relay to turn on the heating element (1 = on ; 0 = off). When the fuel temperature reaches 43.13^{0}C, the Arduino will signal to the relay to turn off the heating element. A phenomenon was found in the heater element, where the fuel temperature did not immediately drop when the heater was off. The fuel temperature still increases up to 2^{0}C, namely from 43,13^{0}C to 45,19^{0}C. So, to maintain heat in a specific temperature range, the upper limit Arduino value setting is reduced by 2.

3.4 Refueling Control System Test

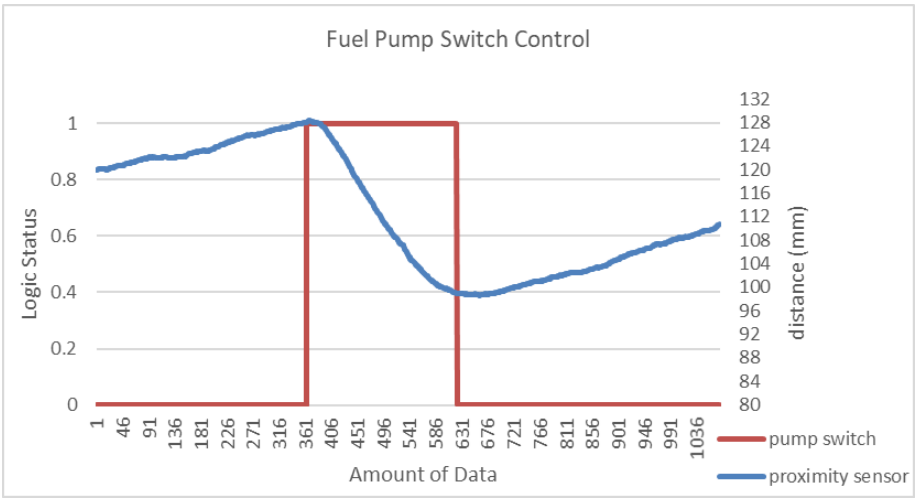

Figure. 5. Refueling Control System

The fuel-filling control system was experimented with by regulating the desired volume of fuels to fill the heating tank. Using a relay and Arduino, the fuel pump controller uses the upper and lower limits settings for the height sensor readings. The automatic filling system in fuel heating devices is determined by "on" and "off," denoted by the values 0 and 1. The experimental results of automatic fuel filling are shown in Figure 5.

In Figure 5, it can be seen that when the sensor reading is at a distance of 128 mm, the Arduino gives a signal to the relay to turn on the pump. Then, when the height is 99 mm, Arduino gives a signal to the relay to turn off the pump. The pump used is a Denso 056200-0570 pump with a power source of 12 volts.

The volume upper limit setting is 1200 ml or 99 mm, and the volume lower limit setting is 700 ml or 128 mm, as described in Table 1.

3.5 Analysis the Performance of Biodiesel B30 Fuel on a Single Cylinder 7 HP Diesel Engine

Observation of B30 diesel fuel consumption on a 7 HP single-cylinder diesel engine uses a prototype with a load of 100 W. Heated B30 diesel fuel is used to power the DEIN Model FA-3 phase 1 Electric Generator. which is driven by a Jiang diesel engine Fa R175A 7 Hp single cylinder. The generator is a source of electricity from a simple electrical panel to which a 100 W light load has been attached. The voltage produced by the generator is 220 V or constant.

The fuel will be heated at room temperature (without heating) up to 65^{0}C. The heated fuels are used to start the generator and used for testing at each fuel heating temperature in the amount of 100 ml.

The test was carried out in stages, and a stopwatch was used to measure how long it took to consume 100 ml of B30 diesel fuel at each heating. The settings on the Arduino are set at a heating temperature of 27-28^{0}C (without heating) up to 65^{0}C with 5^{0}C intervals. The experiment is carried out in stages at each specified temperature. The settings for fuel filling use a lower limit point of 800 ml or 122 mm and an upper limit of 1200 ml or 99 mm. The Arduino display in the B30 diesel fuel heating and refueling settings are shown in Figure 6 and Figure 7.

Figure. 6. B30 Diesel Fuel Heating Settings

Figure. 7. Diesel B30 Fuel Filling Settings

Figure 6 shows the fuel heater set to turn on if the temperature has reached less than 34.50C, and the heater will turn off if the temperature has reached more than 35.50C. Figure 7 shows the fuel filling set at two points. Arduino will set the relay to turn on the fuel pump if the fuel distance from the tank lid to the liquid surface is 122 mm or 800 ml, and the Arduino will set the relay to turn off the fuel pump if the fuel distance is from the lid tank to the liquid surface of 99 mm or 1200 ml. The results of testing the time to consume 100 ml of B30 diesel fuel at each specified temperature are shown in Figure 8.

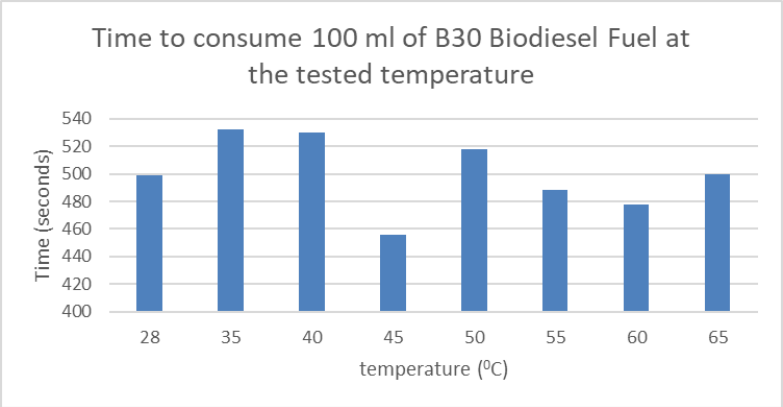

Figure. 8. Graph of the time required to consume 100 ml of B30 biodiesel fuel

Figure 8 shows that the longest time to use up 100 ml of B30 diesel fuel is 35^{0}C. So, the best engine performance occurs at this temperature. On the other hand, the fuel runs out in the fastest time at a heating temperature of 45^{0}C.

IV. Conclusion

The B30 fuel heater prototype has been successfully created using the Arduino system. The utilization of the B30 fuel heater prototype in a single-cylinder 7 HP diesel engine has been tested and analyzed. The tests and analyses carried out are testing and analysis of the DS18B20 temperature sensor, testing and analysis of the VL53LOX distance sensor, testing and analysis of the heating control system, testing and analysis of the fuel filling control system, as well as testing and analysis of the B30 diesel fuel heater prototype on a diesel engine 7 HP single cylinder. The experiment and analysis show that the fuel heater prototype can work at a regulated temperature. The fuel heater prototype can operate at certain predetermined temperatures. The fuel temperature tested starts from 28^{0}C (room temperature) to 65^{0}C with an average multiple of 5^{0}C and tolerances of +2^{0}C and -1^{0}C. At the same time, it can automatically fill fuel from the main tank to the heating tank set from 800 ml to 1200 ml. B30 performance on a 7 HP single-cylinder diesel engine with 100 ml of fuel heated at 28^{0}C - 65^{0}C each shows the longest fuel consumption time at 35^{0}C and the fastest at 45^{0}C.

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