Implementing Fuzzy Logic as a Control and Monitor of Oil Quality Using Android

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Abstract. Viscosity oil index becomes the prominent indicator in the process of engine generator set lubrication. This simulation design used to inform the oil quality and switch off the generator set when the oil quality is not moderate. DC motor rotation and rotary encoder utilize as controller of oil viscosity. Optocoupler sensor is an RPM controller, LDR light sensor is an oil brightness indicator. DS18B20 sensor is the indicator of temperature when the oil work is at low state 0°C-30°C, normal 30°C-50°C and overheat condition is 50°C-100°C, microcontroller Arduino Uno and fuzzy logic as the software and android as the display. The feasibility test design of the oil generator set microcontroller base using fuzzy logic was obtained as a result of rotation viscosity, oil color, and temperature on an android display to distinguish the good oil quality, medium and moderate. Therefore, this result applies to the pre-alarm on the generator set.

1. Introduction

The generator set is the power supply backup at in airport and Uninterruptable Power Supply (UPS) works when the primary power supply system (state electric power) is turned off and the generator set is not working. The generator set is a power supply backup system that supplying electric supply to load when the primary power supply is off or having trouble.

Good maintenance is necessary to sustain the reliability of the generator set. The lubrication system is one of the maintenance that should be concerned. The lubrication system is remarkably substantial in the generator set in the order it works optimally and oil selection can make a long lifetime diesel engine because the lubrication system has a great effect of oil quality in the generator set [1].

Consumers can select the oil according to engine specifications and performance if they know the viscosity level, the oil will have viscosity change when the temperature changes. Simply, to discover the oil viscosity is using an estimator stick, looking at the oil color, and using hand touch. The estimator stick is utilized to show the oil capacity in the generator set. This research was made a design to obtain the oil quality in the generator set [2].

2. Basic Theory
2.1. Viscosity Oil

Viscosity is the endurance of fluid flow, friction between liquid molecules with one another. The ability of a lubricant to overcome the changes of viscosity value to temperature changes is known as
the viscosity index. The viscosity index value is a quantity that states the relative ratio between lubricant expressed by percent. High-value viscosity index, states that lubricant is experiencing a smaller change in viscosity values at a certain temperature range, which means that the quality of the lubricant is getting better based on measurement standards American Standard Test and Measurement D567 (ASTM).

2.2. Lubricant Color

Lubricant color generally functioned as identification. The lubricant has several colors, clear color to dark color. Those colors are defined in ASTM standard D1500 (American Society for Testing and Materials), two digits as the color scale total, scale 16 is approximately 0.5 (light, clear) until 8.0 (dark, brown-yellow).

![Color scale of astm d1500 standard](image)

Fig. 1. Color scale of astm d1500 standard

2.3. Color Sensor

The color sensor consists of LDR and LED that used to figure out the oil viscosity because it is still analog signals form so that they can be reprocessed before they must be converted into digital data. LDR (Light Dependent Resistor) light sensor is a resistor that carries out its resistance change if receiving light change. The amount of the resistance value depends on the size of the light received by the LDR itself. LDR resistance in a dark place usually attains around 10 MΩ, and in bright places, the LDR has a resistance that descends to around 150 Ω. Like conventional resistors, the installation of LDR in a series is the same as an ordinary resistor installation.

2.4. Temperature Sensor DS18B20

Most temperature sensors have a narrow rated range and low accuracy but have a high cost. The DS18B20 temperature sensor with waterproof capability is suitable for measuring temperatures in difficult or wet places. Because the output of this sensor data is digital data, there is no need to worry about data degradation when using for long distances. The DS18B20 provides 9 bits to 12 configurable data bits.

![Temperature sensor ds18b20](image)

Fig. 2. Temperature sensor ds18b20

2.5. Android

Writing programs for android applications uses the java framework, but this is not java. Because standard java libraries like Swing are not supported. Other libraries such as timers are not
recommended because they have been replaced with the default library from android which is optimized for use in limited embedded environments. The Android OS is an open source operating system, meaning that developers can see all system source code, including the radio stack. This source code is one of the learning materials to see how Android works, especially when there is a lack of documentation. But Android also has some proprietary software that is impossible for developers to access, such as GPS navigation.

2.6. Fuzzy Logic

Fuzzy logic is used to transcribe a scale that is expressed using language (linguistic), such as the scale of vehicle speed in the form slowly, rather quickly, quickly, very quickly. Fuzzy logic determines which values are true and which values are false.

3. System Design

This design concept has a control system and a remote monitor using android. Firstly, DC motor will spin moving the propeller to stir oil and also rotates the encoder. The spin results speed value. Optocoupler sensor as RPM (speed) sensor that detects the spin speed of the DC motor and derives the data to be microcontroller input, namely viscosity oil. Color sensor consisting of LDR and LED that is functioning to know the viscosity oil [3] [4].

The microcontroller has a fuzzy logic program with the Sugeno method to function as logical control. Fuzzy logic will adjust the rotation and speed of the DC motor according to the viscosity of oil from optocoupler sensor reading, oil brightness is derived from color and temperature sensor coming from DS18B20 that will bring input to fuzzy logic, the output result is the absolute value of the real number. So if a fuzzy set is given in a certain range, then a certain absolute value can be taken as output, the microcontroller will produce an output that will be sent to Android via Bluetooth to display the results.

![Diagram block design](image-url)

**Fig. 3. Diagram block design**

3.1. Motor DC dan Rotary Encoder

The DC motor design is used to move propeller to stir up the oil, a plaque installed in the top tip of the motor rotary axis to follow the rotation of motor rotary, then optocoupler sensor reads the total rotation read, then it becomes input item from motor rotary in determining the viscosity oil. This design does not use full speed in DC motor so buck converter is utilized to lower the voltage.
3.2. Sensor Optocoupler

Optocoupler sensor in this design is used to read the rotation speed of the DC motor, that using for feedback. When the plaque installed in DC motor spins and touches the active optocoupler sensor then functions as an encoder, and will read the magnitude rotation speed of the DC motor.

3.3. Color Sensor

Color sensor using LDR and LED that immerse in lubricant oil container, avoiding the light from outside. When a colored object is exposed to light from the LED, the reflected light from that object is received by the LDR. LDR will change along with the light intensity change that exists around it. The light intensity reading received is an analog signal, then transcribe to be digital value through ADC port in the port A of the microcontroller.

3.4. Temperature Sensor DS18B20

The temperature sensor will read the lubricant temperature. In this research, the oil will be heated up manually to work the sensor. Temperature sensor DS18B20 has sent digital data in the form of a pulsed signal indicating a certain temperature, then the output sensor is received by the microcontroller.

3.5. Arduino Uno and Fuzzy Logic

Arduino will use the analog function, to yield a value between 0 to 1023 that representing the voltage resulted in the analog pin and it automatically reflects the brightness inputted by a color sensor that using LDR and LED, illustrating the input oil temperature from temperature sensor DS18b20 and input result from measuring rotor viscosity [5]. As follow, is the resulting design of using membership function fuzzy logic toolbox when identifying the quality of lubricant.
3.6. Android

Connecting a bluetooth in the system, formerly a user is necessary to hook up between smartphone with a system. After the android is connected with Bluetooth, select HC-05 to be able to run the application as desired by the user.

![Android Bluetooth Connection](image)

**Fig. 7.** (a) Paired bluetooth android, (b) Monitor display in android

4. Testing and Analysis

This test system is intended to find out the characteristic of system performance. The test involved controlling tests and monitoring various oil samples with different temperatures[6].

4.1. Oil Sample Test with Normal Temperature

This test system is intended to find out the characteristic of system performance. The test involved controlling tests and monitoring various oil samples with different temperatures.

![Oil Sample Test Chart](image)

**Table 1.** The test result of the oil sample with normal temperature

| New Oil DC Motor Speed (RPM) | New Oil DC Motor Speed (RPM) | Tempt (°C) | (Second) |
|-----------------------------|-----------------------------|------------|----------|
| SAE 50                      | SAE 40                      | SAE 50     | SAE 40   |
| 42                          | 44                          | 44         | 47       | 26       | 30        |
| 42                          | 44                          | 44         | 46       | 26       | 60        |
| 43                          | 45                          | 45         | 46       | 26       | 90        |
| 42                          | 45                          | 45         | 47       | 26       | 120       |
| 43                          | 46                          | 45         | 47       | 26       | 150       |
4.2. Oil Sample Test with Normal Temperature

This test is aimed to know the viscosity oil with SAE 50 and SAE 40, the test result showed new oil is thicker than old oil.

![Fig. 8. Comparison chart of sae 50 and 40 oil speeds](image)

4.3. Oil Sample Test with Different SAE to Temperature

Temperature affects the viscosity of the oil, the higher the oil temperature, the thinner it will be. In testing new oil with SAE 50 and SAE 40 shows changes in the number of RPM are not too significant.

![Fig. 9. Graph of viscosity against new and old oil temperature](image)

4.4. Testing of New Oil Samples and Old Oil at the same Temperature

Old oil viscosity decreases faster than new oil and it is thinner faster at a certain temperature.

![Fig. 10. New and old oil speed comparison chart](image)

5. Conclusion

The measuring and test of this design were obtained conclusions below:
This design has a temperature effect toward the change of viscosity oil value, the higher oil temperature, the thinner lubricant.

b. The ability of this tool can distinguish the brightness of new and old oil at number display. 0 value to 50 refers to the brightness oil at the limpid condition. 51 value to 89 shows blackish brown color while the value above 90 indicates dark oil condition or pitch black. This design is helped by fuzzy logic to take decision, if the defuzzification output result is less than 40, categorizing the oil is not feasible. the data around 40-80 is moderate or warning while the value data above 80 is categorized as good oil quality.

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