Development of IoT to regulate burning in FCC regenerators

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Abstract. Fluid catalytic cracking (FCC) is a conversion process used in petroleum refineries to convert high-fuel hydrocarbon fractions into other low FCC hydrocarbon fractions. Our research team is researching the FCC using palm oil so that it can become fuel. Regenerators are controlled and monitored by using the Internet of Things technology. The thermocouple sensor in the regenerator and stepper motor 28BY J-48 as an actuator on the ejector valve is controlled by Arduino Mega 2560 and ESP8266 for data reading and processing. The results of this study show that the design of IoT on the FCC regenerator uses Blynk applications have been running properly. The sensor and data actuator can be read by ESP8266 which is then sent to the Blynk server via the cellular network. This shows the ability of a data logger can used in the range’s internet wifi smartphone.

Keywords: fluid catalytic cracking (FCC), IoT, blynk, system control

1. Introduction
Fossil fuels around the world are running low and Indonesia is trying to make biofuel fuel so that in the future Indonesia can use biofuel as a renewable fuel. Biofuel fuel is made from palm oil. One process to convert palm oil into fuel is the Fluid Catalytic Cracking (FCC) process [1]. Fluid catalytic Cracking (FCC) is a conversion process used in petroleum refineries to convert high-fuel hydrocarbon fractions into other low hydrocarbon fractions [2]. Catalytic cracking is a continuous process for converting high-boiling, high-molecular-weight components of distilled crude oil into lower-boiling, lower-molecular-weight materials such as gasoline [3]. This processing adds economic value to the oil. Our research team is researching the FCC using palm oil so that it can become fuel. In running the FCC, a system needed to determine the processes that occur in the FCC, especially regenerators. The IoT system applied to the FCC regenerator so it can being controlled and acquisition data from the FCC regenerator. Blynk is used to regulate and monitor
process in FCC regenerators such as temperature regenerators, and ejector valve openings in smartphone.

1.1. Fluid catalytic cracking
Fluid Catalytic Cracking (FCC) is one of the conversion processes used in petroleum refineries to convert high molecular weight high hydrocarbon fractions into other hydrocarbon fractions [2]. The FCC system consists of several components namely regenerator, riser, cyclone, heat exchanger, stripper, and feed injector. The FCC system can be seen from the Figure 1.

![FCC system](image)

*Figure 1. FCC system*

The regenerator is the combustion reaction process of LPG gas compounds namely propane (C₃H₈) and butane (C₄H₁₀) which will produce thermal energy. The reaction that occurs in the regenerator is exothermic (producing heat) with temperatures ranging from 650-678 °C[4]. In this study mounted several actuators and sensors on the regenerator to control and retrieve data.

1.2. IoT (Internet of Things)
IoT (Internet of Things) is a network area connected through the Internet that allows the system to send and receive data[5]. IoT helps share information from sensors and actuators for identification and exchange of information in open networks. This IoT can be used across multiple platforms, one of which is smartphone media. The FCC Regenerator uses IoT as the data sender and receiver, so the FCC Regenerator can be monitored through the smartphone.

1.3. Blynk application
Blynk made complex IoT technology simple. It can actuate hardware remotely, it can display sensor data, it can store data and visualize it using Internet data communication with smartphones [6]. Blynk can also save data and display data visually using graphs and numbers [7]. In the Blynk
three most important components are App, Server and Libraries. App can help to create the interface. Server is responsible for all the communication between app and the hardwires. And Libraries enables communication for hardware with the server using commands [5]. Figure 2 is a picture of the Blynk application on a smartphone.

Like the IoT app, it usually uses servers for collection or Storage of captured data. Blynk uses the server that has been provided by BLYNK application and the connection from the laptop to Blynk app on smartphones using ESP 8266 with a WiFi connection or can also with tethering connection.

2. Methodology

2.1. System design
This research starts from a literature study related to FCC and control systems, then the selection of actuators and sensors to control and acquire data. Arduino programming according to the actuator, sensor and module as well as the Arduino connection and the Blynk application in the smartphone. Arduino Mega 2560 is used as a microcontroller to process input and output signals from sensors and actuators. The ESP 8266 module is used to connect to WiFi or the internet so that Blynk applications can be connected to Arduino mega on a laptop or PC. The following is a data communication scheme Figure 3.
2.2 Sensor and actuator installation

The sensor functions as detection of changes that occur within the plant that is operating and the actuator serve as a controller so that the processes that occur in the plant work as desired. Type K thermocouple sensor is installed in the regenerator then the actuator used is a stepper motor. Stepper motor mounted on the ejector valve which serves to control the rate of suction airflow so that air can enter the regenerator so that it can regulate combustion air in the regenerator. The following is a scheme for installing sensors and actuators in Figure 4. With the tools and materials used, a valve regulating system with a 28BY J-48 stepper motor is made as shown below in Figure 5. Installation of type K thermocouple sensors to determine the temperature of the regenerator can be seen in the Figure 6.

![Figure 4. Sensor and actuator installation scheme](image)

![Figure 5. Installation of actuator](image)
2.3 Creation of Arduino program

The creation of the program starts from creating a program to control the stepper motors on the ejector valve and acquires the temperature data on the regenerator and then creates a program to connect the Arduino with a Blynk application using ESP 8266. Following is the programming flow for data acquisition and control of sensors and actuators in Figure 7.

Figure 7 explains that the program is made for automatic and manual control. The automatic control of the stepper motor on the ejector valve runs according to the temperature conditions namely temperature <1000C and 101 OC <temperature <765 OC. Manual control runs when the user of the Blynk application presses the virtual button on Blynk to adjust the open and close of the ejector valve. In Figure 8 in the Arduino program, there is an authentication token that functions so that the Blynk server can recognize the device used, then the process of sending data
to the server is also regulated in the firmware program. For each sensor and actuator, a virtual channel is created for sending sensor data and actuator controls that will be recognized by the Blynk server.

```c
#include <ESP8266_Base.h>   // wifi library from blynk
#include <BlynkSimpleShieldEsp8266.h> // wifi library from Blynk
#include "msh6676.h"        // thermocouple library from adafruit
#include <AccelStepper.h>   // stepper motor library from AccelStepper

void myTimerEvent() {
  // don't send data more than 10 times in 1 second
  if (param.asInt() != 1) {  // if the button is pressed
    myStopper.setMinSpeed(1000);  // maximum stepper speed
    myStopper.setAcceleration(1000);  // maximum stepper acceleration
    myStopper.setSpeed(100);  // stepper speed
    steps += 150;  // add a step that will be headed for -150
  }
}
```

**Figure 8. Firmware program to connect Blynk**

In **Figure 9**, thermocouple sensor data is sent via virtual channel V1 and ejector valve control is sent via virtual channel V2 to open the ejector valve then virtual channel V3 is used to close the ejector valve and virtual channel V4 is used to sends ejector valve position data.

```c
Figure 9. Firmware program for virtual channel Blynk
```
2.4 Blynk application settings
The first thing to do is to set Devices on Blynk by creating a project on Blynk and then determine the hardware mode and connection type. Then send the authentication token through the email provided. More details can be seen in Figure 10.

![Figure 10. Blynk Device Settings](image)

Next, the selection of controllers and displays are used such as buttons, labelled values, value display and supper charts. Labelled Value on Blynk is used to display the V1 output of the temperature regenerator. The Button on Blynk is used to control the open and close ejector valve with the output V2 to open the ejector valve and the V3 output to close the ejector valve. The Value display is used to display the position of the ejector valve openings with a V4 output. Supper
chart is used to display the temperature regenerator in the form of graphs. More details are available in Figure 11.

3. Testing and result
After completing the setup and making of the controller and displays on Blynk then an attempt to retrieve data and control via Blynk. First, connect Blynk on a smartphone with the internet, then share the tethering network on a laptop or PC. In the Arduino program, there is the same SSID and WiFi password as the tethering network on the smartphone. When ESP8266 has an internet connection, the Blynk program will access the Blynk Server using a unique token code as an authentication code to maintain the security of the device’s connection to the server. Then a notification will appear on the Blynk application, which indicates Arduino online. After that, the temperature and control of the ejector valve data are taken and the test results can be seen in Figure 12.

![Figure 12. Testing and result from Blynk](image)

4. Conclusion
From this research can be prove that the IoT design on the FCC regenerator by using the Blynk application has been running properly. Data sensor can be read by ESP 8266 which is then sent to Blynk servers over a mobile network. This demonstrates the ability of this data logger can be used from the range of the internet tethering range on smartphones. This is certainly making an easy user to monitoring and control of the FCC regenerator. For development, it is necessary to analyze sensor data more comprehensively by performing calibrations using standard measuring devices and more sensors and actuators can be installed on the FCC plant so that they can control and monitor the FCC plant only with a smartphone.

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