Fluid Viscence Measurement With Capiler Pipe Based On Internet Of Things (IoT)

Herry Sufyan Hadi, Putri Yeni Aisyah and Achmad Mabrur

July 16, 2021

Fluid Viscence Measurement With Capiler Pipe Based On Inthernet Of Things (IoT)

H S Hadi, P Y Aisyah, A Mabrur

Instrumentation Engineering Department, Vocational Faculty, Sepuluh Nopember Institute of Technology (ITS) Surabaya, East Java

sh_herry@yahoo.co.id, putriyeniaisyah@gmail.com, achmadmabrur8989@gmail.com

Abstract. Capillary tube viscosity gauges or viscosities can measure the viscosity of fluids such as water, oil, and oil. Currently, there are still a lot of fluid viscosity tools that are done manually when measuring the impact of which there are many Human Errors caused by human errors. In addition, a fluid viscosity device with a capillary tube is also in the absence of an automatic and IoT-based system (Internet of Things). From these problems, an automatic fluid viscosity measuring device is designed to minimize human error or Human Error with a measurement system using a fluid pressure sensor and fluid velocity sensor which can measure the viscosity of a fluid automatically In this study, two methods were conducted, namely simulation and experimentation. Simulations were conducted using CFD while experiments were conducted by designing viscometer measuring instruments using IoT-integrated capillary pipe methods.From the simulation results obtained a constant fluid speed along the pipe from input to output while for fluid pressure obtained a value that decreases from input to output with a maximum fluid velocity value of 505.129 cm/s and a maximum value of 0 cm/s while for pressure the maximum value is 1.5e+07 dyne/cm² and a minimum value of 2e+0d dyne/cm².While from the test results of the tool that has been designed to wake up, the results of fluid viscosity are constant, for the speed and pressure are also obtained constant results with a water viscosity value of 21 Pa.s, Oil Vvskosity 28 Pa.s, and oil viscosity 29 Pa.s.

Keyword: Viscometer, Capillary metod, Monitoring, IoT, CFD software

1. Introduction

The greater the influence of physics on everyday life. This quantity has been widely used for the standardization of food, health, and pharmaceutical products. Application of viscosity in product standardization, for example, viscosity in the food industry, paint industry, pharmaceutical industry (Eka Jati & Rizkiana, 2015). Given the current technological advances, it is growing rapidly. So that many things can be used to make a measuring instrument work automatically [1].

Viscosity can take measurements manually or automatically, viscometers that measure manually have low accuracy and validation because they are influenced by human error. [2]. The technology that can overcome research weaknesses, especially in measuring fluid viscosity, is a fluid viscosity measuring instrument with a capillary tube using a through-beam type optical sensor that can measure fluid viscosity automatically.

Measurement of the coefficient of viscosity of liquids with a viscometer generally uses three methods, namely: (1) free-falling ball method based on Stokes law (2) fluid flow method in a capillary tube using Poiseuille's law (3) axis cylinder rotation method. The method most often used to develop a viscometer in determining the viscosity of liquids is the free fall ball method [2]. The application of viscosity in product standardization, for example, viscosity in the food industry, paint industry, pharmaceutical industry. While the application of viscosity in the health sector, among others, is to determine the viscosity of blood in the body and the viscosity of urine [3]. Departing from this problem, a viscosity measuring instrument with a liquid flow sensor and liquid pressure sensor type optical sensor was created that can measure fluid viscosity automatically so that it can make it easier when measuring fluid viscosity compared to manual-based measuring instruments which are still influenced by human error.

2. Methodology

2.1 Procedure

In this chapter, the steps of the design research flow of the fluid viscosity measuring instrument will be described. The following is a final project research flowchart as an outline of the workflow which can be seen in Figure 3.1

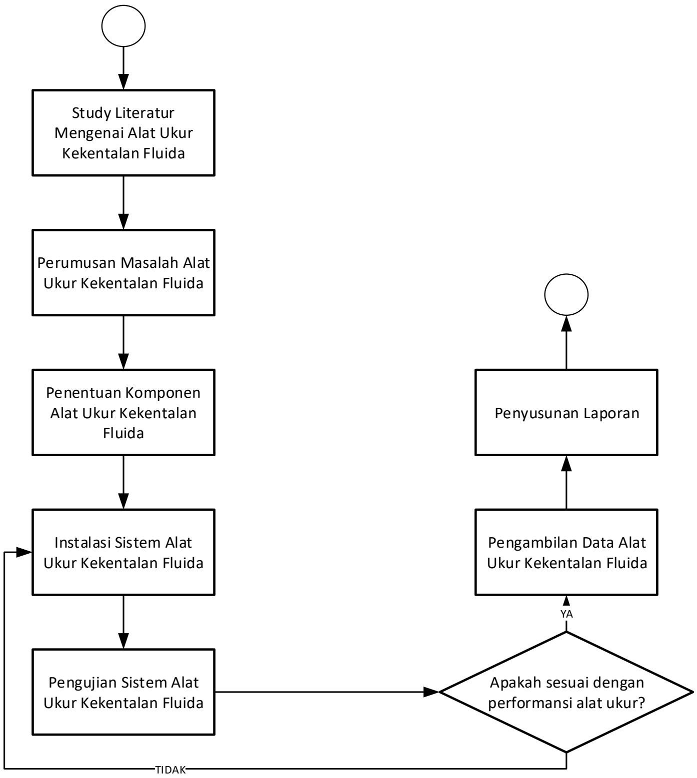

Fig 2. 1 Final Project Flowchart

To achieve the goal of completing the planned final project, it is necessary to take steps in completing this final project. The steps are as follows:

- Literature study related to previous research with the topic of fluid viscosity measuring instruments as the background exposure of this Final Project.
- Literature study on basic theory search about the fluid viscosity measuring system which underlies this Final Project.
- Requirements study is to support component selection and hardware and software design work.
- Hardware design on fluid viscosity measuring instrument.
- Software design on fluid viscosity measuring instrument using ESP 32 microcontroller using C language.
- Hardware and software testing on fluid viscosity measuring instruments for testing system performance by taking experimental data.

2.2 Design of Rotation Viscometer System Model

In making the IoT-based fluid viscosity measuring system, there is a measuring instrument system design shown in Figure 3.2.

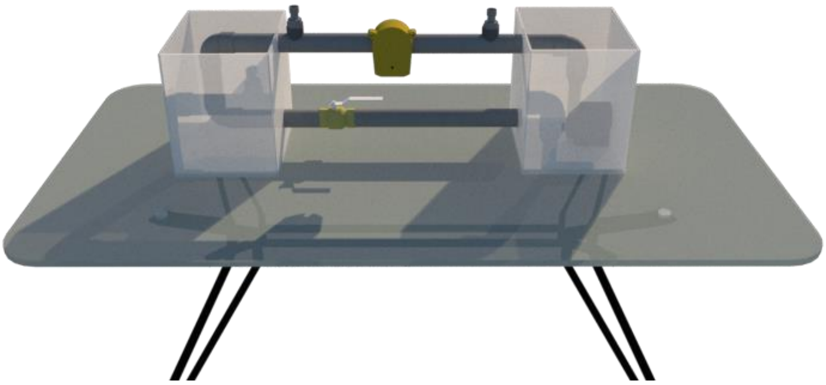

Fig 2. 2 3D design prototype design

The prototype for the fluid viscosity device uses a pipe placed between containers one and two, where the pipe contains a Liquid Flow Sensor and a Liquid Pressure Sensor to measure the viscosity of the fluid flowing from container one to container two.

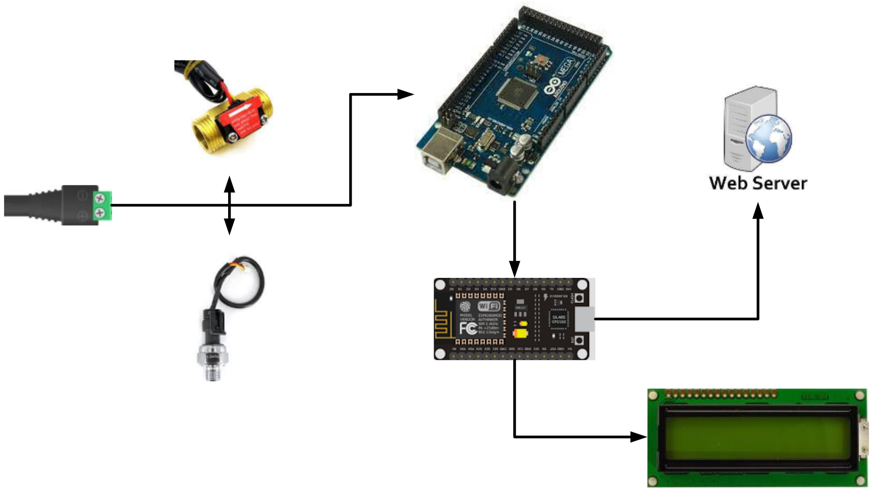

Fig 2. 3 Fluid Viscosity Measuring Instrument System Modeling Schematic

In the schematic of the system shown in Figure 2.3, measurements of the fluid in the pipe are carried out by the Liquid Flow Sensor and Liquid pressure sensor. Then it is connected to the Arduino Mega controller and the Node MCU ESP32 and there is an ESP32 wifi module that functions to connect to the web so that it can be accessed anywhere via the web.

2.3 Hardware and Software Design

The making of a Fluid Measurement System Simulator with a capillary tube is as follows:

Fig 2. 4 Plant Simulator Fluid Measuring System

The design above uses two cube-shaped containers, where one container is the fluid container to be measured and in it, there is a pump that will flow the fluid in the pipe. In the pipe, there are two Liquid Pressure Sensors and one Liquid Flow Sensor which functions to measure fluid pressure and fluid velocity. Two Liquid Pressure Sensors measure the fluid pressure before and after passing through the Liquid Flow sensor, thus the viscosity of the fluid can be measured, and then the results of the measurements will be known via the LCD and the Web.

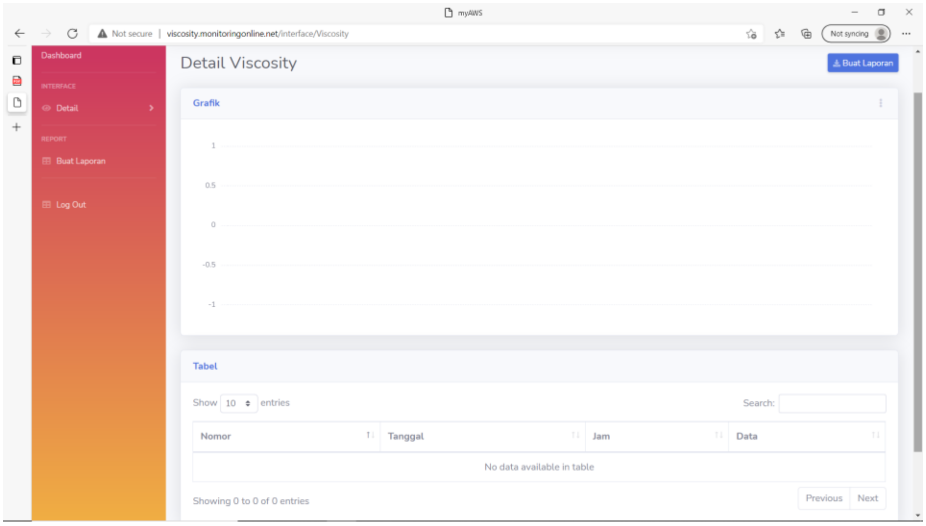

Fig 2.5 Display on the Web

Based on Figure 2.5 is a display on a Web Server in which it can monitor the results of measuring fluid viscosity from the tool.

2.3.1 *Mechanical Design*

The hardware (hardware) of this final project is designed first by consisting of a series of Liquid Flow Sensors and Liquid pressure sensors

a. Liquid Flow Sensor and Liquid pressure sensor design

In the design of the Liquid Flow Sensor and Liquid pressure sensor, the sensor is connected to the ESP32 and Arduino mega 2560.

Figure 2. 6 Liquid Flow Sensor and Liquid pressure sensor design

In this design, the Liquid Flow Sensor is placed between the Liquid Pressure Sensors to measure the flow velocity from container 1 to container 2, while the Liquid pressure Sensor is placed between the Liquid Flow Sensors because it is to determine the fluid pressure at the end of the pipe.

2.3.2 Electronic Design

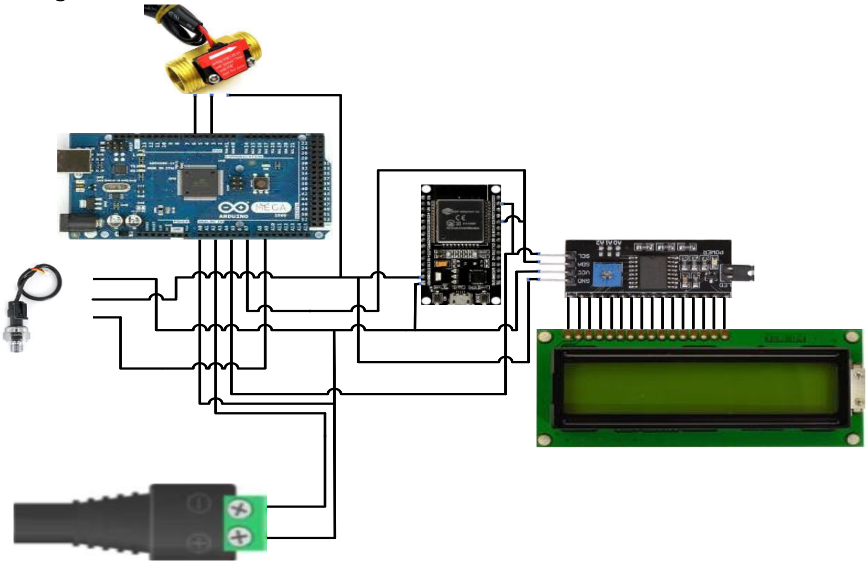

Fig 2. 7 Wiring Diagram

All the components mentioned above are combined into a single circuit to form the desired system. The picture above shows the wiring diagram of the fluid viscosity measuring instrument.

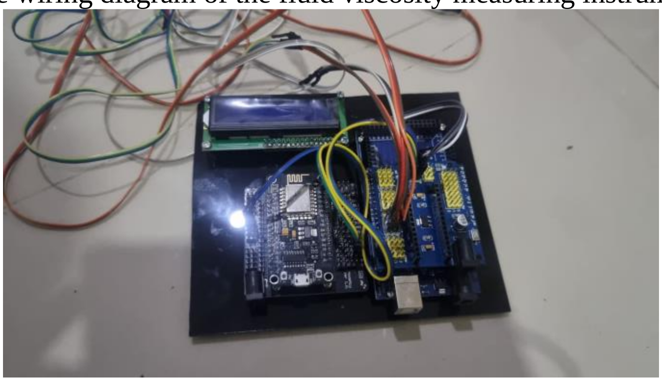

Fig 2. 8 Wiring Diagram Realization

In Figure 2.8 is the realization of making wiring for fluid viscosity measuring instruments with IoT-based capillary pipes.

3. Result And Discussion

3.1 Testing Each Component

The components that will be tested to get the desired results or not are as follows:

3.1.1 *Current and Voltage Sensor Testing*

Sensor testing is carried out for validation between the Liquid Pressure Sensor and Liquid Flow Sensor with the measured fluid viscosity value. Testing is carried out with the following steps:

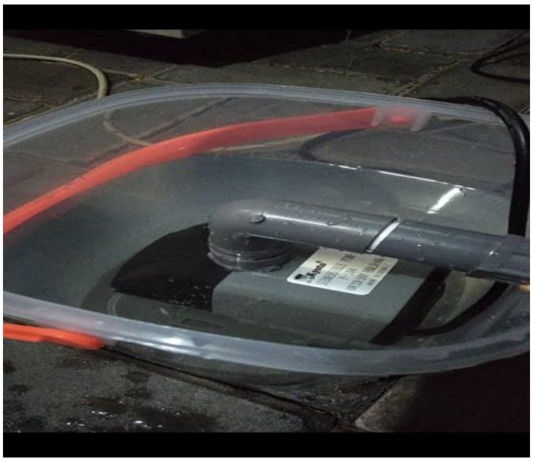

Figure 3. 1 Container filled with water

In Figure 3.1 there is a container containing ±2 liters of water to test the tool.

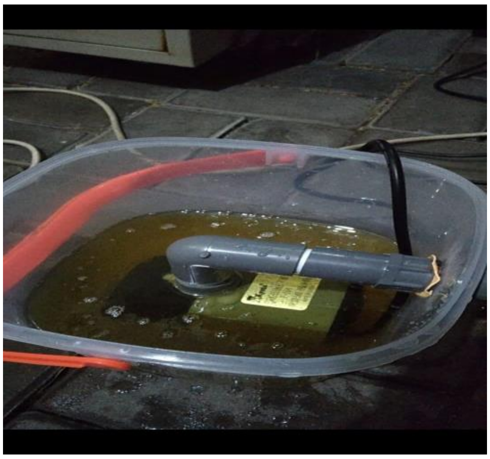

Figure 3. 2 Oil filled container

In Figure 3.2 there is a container containing ±2 liters of oil to carry out tests on the tool.

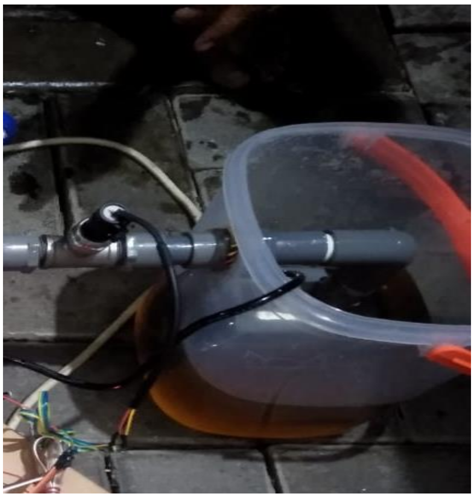

Figure 3. 3 Oil filled container

In Figure 3.3 there is a container containing ±2 liters of oil for testing the tool.

Table 3. 1 Water fluid calibration test results

No Sampling	**Viscosity**
	Sensor Reading(Pa.s)
1	21
2	21
3	21
4	21
5	21
6	21
7	21
8	21
9	21
10	21
Average	21

Table 3. 2 Oil fluid calibration test results

No Sampling	**Viscosity**
	Sensor Reading(Pa.s)
1	28
2	28
3	28
4	28
5	28
6	28
7	28
8	28
9	28
10	28
Average	28

Table 3. 3 Oil fluid calibration test results

No Sampling	**Viscosity**
	Sensor Reading(Pa.s)
1	29
2	29
3	29
4	29
5	29
6	29
7	29
8	29
9	29
10	29
Average	29

Based on Table 3.1, Table 3.2 and Table 3.3 above, the average sensor readings are obtained to be processed in order to obtain correction values or data errors of fluid viscosity measuring instruments.

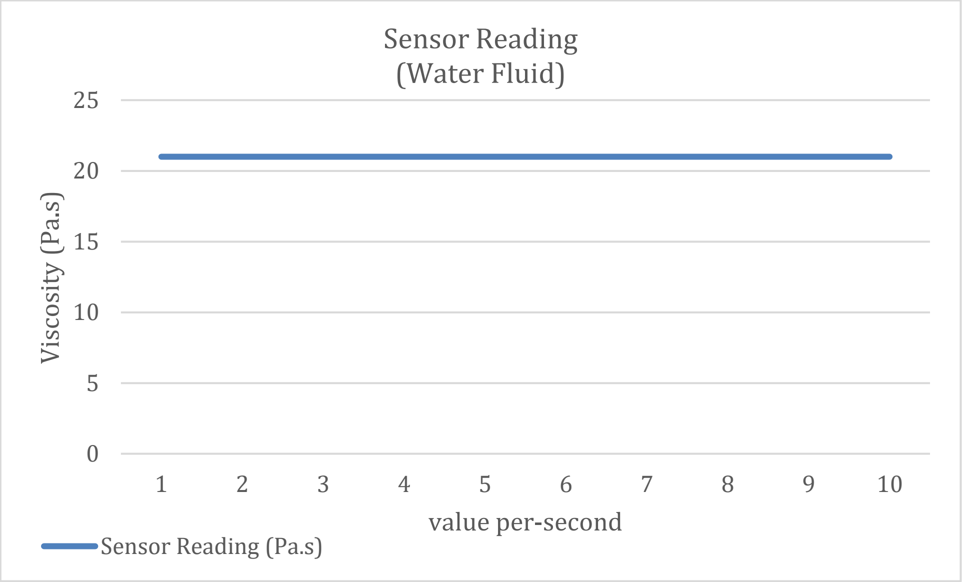

Fig 3. 4 Graph of Sensor readings and Standard readings on water

On Figure 3.4 is a graph of sensor readings on the tool when making measurements with water fluid.

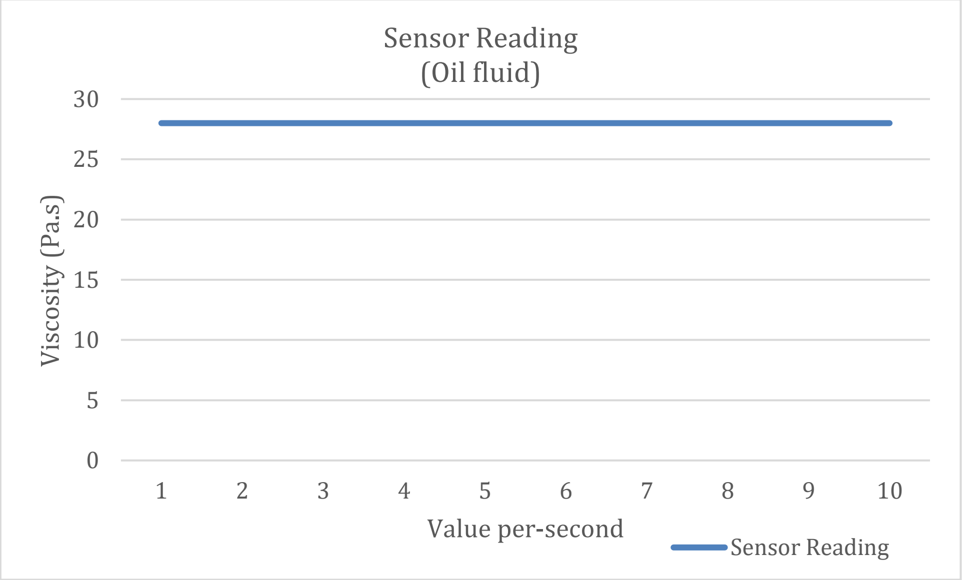

Fig 3. 5 Graph of Sensor readings and Standard readings on oil

On Figure 3.5 is a graph of sensor readings on the tool when taking measurements with oil fluids.

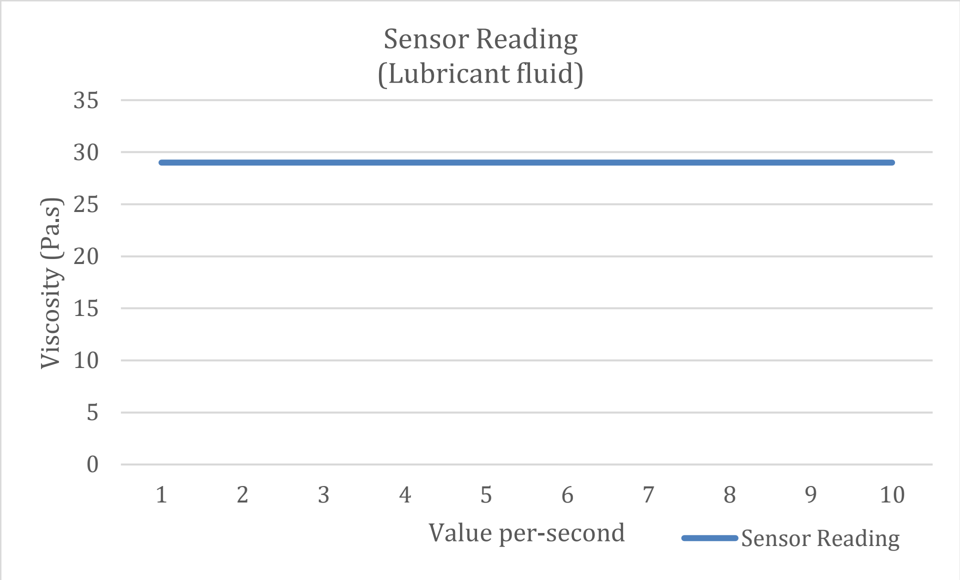

Fig 3. 6 Graph of Sensor readings and Standard readings on lubricant

Figure 3.6 is a graph of sensor readings on the tool when taking measurements with lubricant fluid.

Table 3. 4 Comparison of calculation values using the formula

No	Water	Oil	Lubricant
1	22 Pa.s	30 Pa.s	31 Pa.s

Based on the data above, the viscosity value is obtained by calculating the formula, us at 2.14. Below is the validation data from the Liquid Pressure Sensor and Liquid Flow Sensor as follows:

Table 3. 5 Data Validation of Liquid Pressure Sensor and Liquid Flow Sensor on water fluid

No Sampling	**Viscosity**		**Correction**	***Error***
	Calculation (Pa.s)	**Sensor Reading (Pa.s)**		
1	22	21	1	0.04
2	22	21	1	0.04
3	22	21	1	0.04
4	22	21	1	0.04
5	22	21	1	0.04
6	22	21	1	0.04
7	22	21	1	0.04
8	22	21	1	0.04
9	22	21	1	0.04
10	22	21	1	0.04
Average			1.0	0.4

Table 3. 6 Data Validation of Liquid Pressure Sensor and Liquid Flow Sensor on oil fluid

No Sampling	**Viscosity**		**Correction**	***Error***
	Calculation (Pa.s)	**Sensor Reading (Pa.s)**		
1	30	28	2	0.07
2	30	28	2	0.07
3	30	28	2	0.07
4	30	28	2	0.07
5	30	28	2	0.07
6	30	28	2	0.07
7	30	28	2	0.07
8	30	28	2	0.07
9	30	28	2	0.07
10	30	28	2	0.07
Average			2.0	0.7

Table 3. 7 Data Validation of Liquid Pressure Sensor and Liquid Flow Sensor on fluid lubricant

No Sampling	**Viscosity**		**Correction**	***%Error***
	Calculation (Pa.s)	**Sensor Reading (Pa.s)**		
1	30	29	1	0.03
2	30	29	1	0.03
3	30	29	1	0.03
4	30	29	1	0.03
5	30	29	1	0.03
6	30	29	1	0.03
7	30	29	1	0.03
8	30	29	1	0.03
9	30	29	1	0.03
10	30	29	1	0.03
Average			1.0	0.3

Based on Tables 3.5, 3.6, and 3.7 validation data of the Liquid Pressure Sensor and Liquid Flow Sensor, a graph of the comparison of sensor readings and calculations on water, oil, and lubricant fluids is obtained. The following is a graph of the comparison between the reading by the sensor and the calculation.

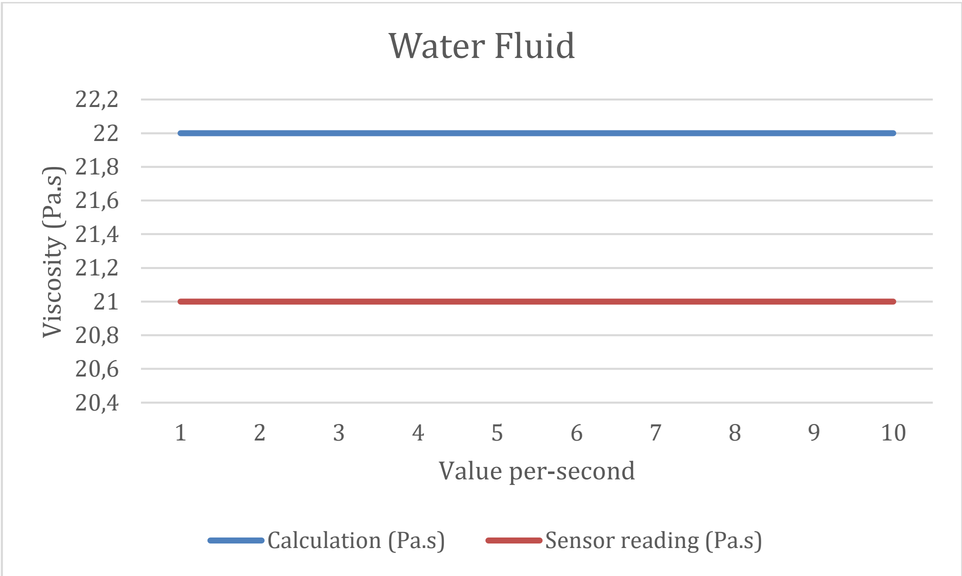

Fig 3. 7 Water fluid validation chart

Figure 3.7 is a graphic image of the validation between the viscosity calculation and the readings on the water fluid sensor. There are still differences in the graph due to inaccurate sensor readings.

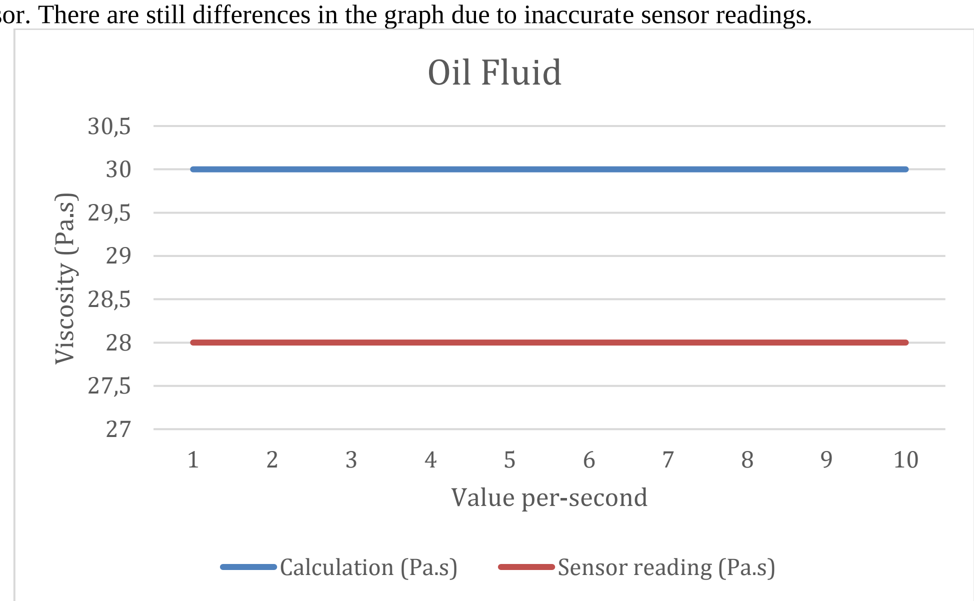

Fig 3. 8 Oil fluid validation chart

Figure 3.8 is a graphic image of the validation between the viscosity calculation and the readings on the oil fluid sensor. There are still differences in the graph due to inaccurate sensor readings.

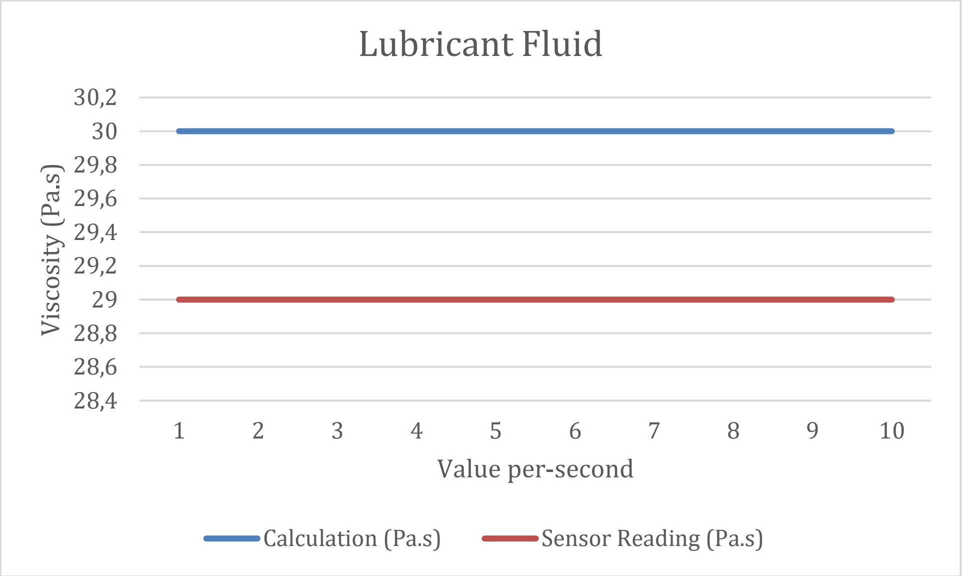

Fig 3. 9 lubricant fluid validation

Figure 3.9 is a graphic image of the validation between the viscosity calculation and the reading on the oil fluid sensor. There are still differences in the graph due to inaccurate sensor readings.

3.1.2 *Simulation Results*

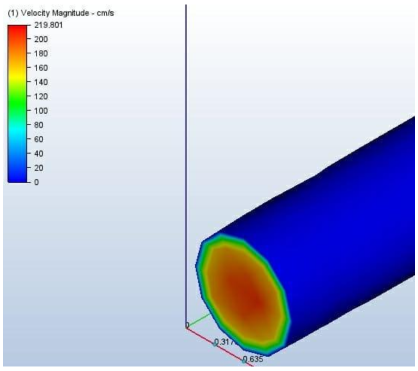

Fig 3. 10 fluid velocity input in CFD applications

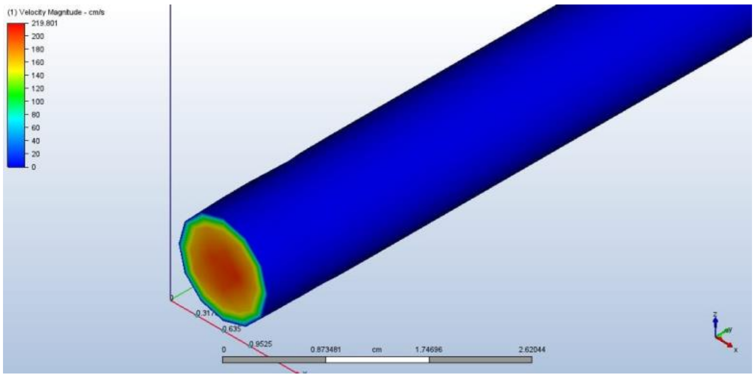

Fig 3. 11 fluid velocity output in CFD applications

Figure 3.10 and figure 3.11 is the result of fluid velocity in the pipe using the CFD application, for fast or not the fluid flowing is indicated by the presence of color in the application. For the blue color is a low flow velocity if the red color of the flowing fluid is fast.

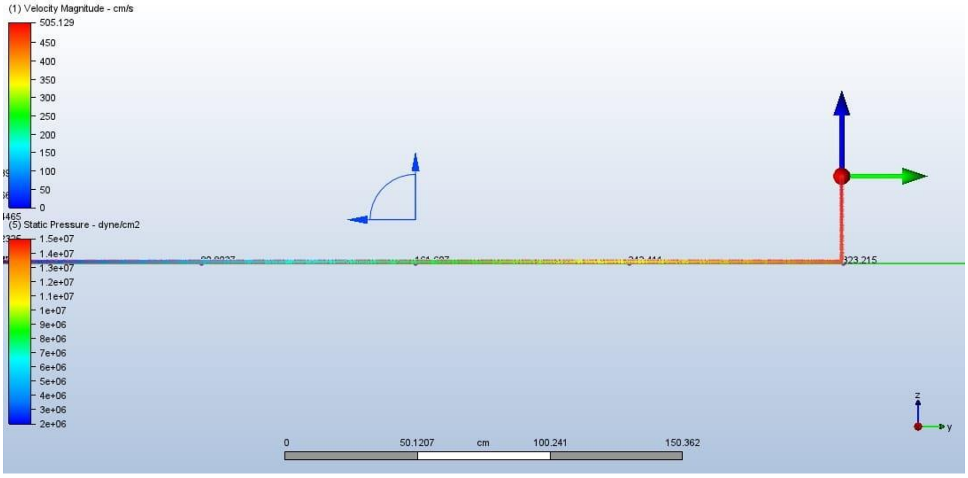

Fig 3. 12 Fluid velocity and pressure

Figure 3.12 is an image on the CFD application by showing the value of the fluid velocity and fluid pressure from the fluid input in the pipe to the output on the pipe.

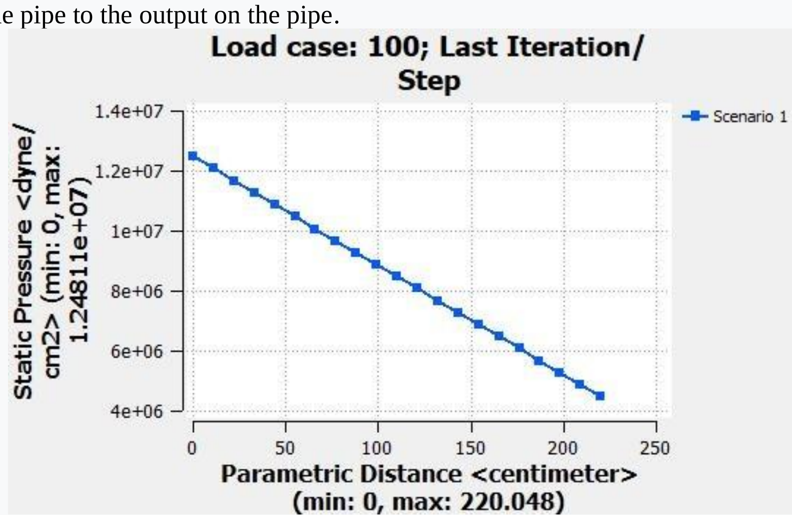

Fig 3. 13 fluid pressure graph

Figure 3.13 is a graphic image on a CFD for simulating pressure on fluid flow in a pipe which shows the lower the pressure from the input to the output, it can be shown the decreasing graph shown in the figure

4. Conclusion

The design of a fluid viscosity measuring instrument with an IoT-based capillary tube is by paying attention that the plant can be controlled and monitored remotely. So a Web Server is needed so that it can be controlled via the Web. The results of the simulation in the CFD application, namely the value of fluid velocity and fluid pressure, obtained a value of 505,129 cm/s at the maximum speed and 0 cm/s for the minimum speed, while for the fluid pressure, the value was 1.5e+07 dyne/cm² for maximum pressure and 2e+0d dyne/cm² for minimum speed. In the experiment, the fluid viscosity values were obtained, namely 21 Pa.s for the viscosity of the water fluid, 28 Pa.s for the viscosity of the oil fluid, and 29 Pa.s for the viscosity of the oil fluid.

References

[1] A., M. A., Ihsan, M., Syahputra, A., Ghani, I. R., Ramadhani, S. R., Sitompul, D. D., & Eng, M. (2017).Sensor.

[2] Aji, M. P. (2020). RANCANG BANGUN SISTEM PERINGATAN PENGGANTIAN.

[3] Andayani, L., Indrasari, W., & Umiatin. (2019). pengembangan alat ukur viskositas air sungai tercemar limbah cair berbasis sensor optik tipe through beam. *Prosiding Seminar Nasional Fisika (E-Journal) SNF2019*.

[4] Boimau, I., Mellu, R. N., & Manuain, M. R. (2020). Rancang Bangun Alat Praktikum Viskometer Berbasis Arduino. *Wahana Fisika*.

[5] R. Mulyana, "PENGUKURAN VISKOSITAS AIR MEMAKAI PIPA KAPILER DENGAN METODE POISEUILLE," 2009.

[6] Eka Jati, B. M., & Rizkiana, A. p. (2015). Studi Penentuan Viskositas Darah Ayam dengan Metode. *Jurnal Fisika Indonesia*.

[7] Lia Adini, d. O. (2017). Penggunaan Hukum Hagen-Poiseuille dalam Penentuan Koefisien.

[8] Samdara, R., Bahri, S., & Muqorobin, A. (2008). Rancang Bangun Viskometer Dengan Metode Rotasi Berbasis Komputer. *Jurnal Gradien*.