Tools to Measure Oxygen Concentration and Oxygen Flow Rate in Continuous Positive Airway Pressure

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Abstract— Measuring oxygen concentration and measuring the flow of oxygen is a tool used to measure the percentage of oxygen content and oxygen flow rate in CPAP. This tool uses the OCS-03F sensor, with Arduino NANO processors then displayed on the 2X16 character LCD. Measuring the percentage of oxygen content and the oxygen flow rate is carried out on CPAP for 5 measurements. The research and manufacture of this module use the Pre-experimental method with the After Only Design design, which examines the "Oxygen Analyzer", which results in measurements compared to the traced tools to obtain high accuracy values. Based on the results of measurements on the CPAP tool at Dr. Soetomo Surabaya Hospital with oxygen level settings of 21%, 30%, 40%, 50% 60%, 70%, 80%, 90%, 100% while setting the oxygen measurement rate 1L/m, 2L /m, 3L/m, 4L/m, 5L/m, 6L/m, 7L//m, 8L/m, 9L/m 10L/m. Each measurement was carried out 5 times. For the measurement of oxygen levels, the biggest error value is 5% and the smallest -0,06% while for the measurement of oxygen flow rate the biggest error value is 4% and the smallest is 0%. Based on the results of the analysis of the manufacture of oxygen levels and oxygen flow rates, it can be concluded that the manufacture of oxygen concentration measuring instruments and oxygen flow rate can work well.

Keywords: Oxygen Concentrate, Oxygen Flow Rate, OCS-03F Sensor, CPAP

I. INTRODUCTION

Continuous Positive Airway Pressure (CPAP) is a tool to maintain positive pressure on the neonatal airway during spontaneous breathing. CPAP is a simple and effective tool for the management of respiratory distress in the neonates. [1]

In general, older CPAP devices are still often used for medical services in a hospital. Where this tool has an oxygen level setting but it is not equipped with an oxygen level and flow rate display so that the oxygen level and flow rate issued are not known according to its level settings. This can be bad for patients. In the opinion of [2], if the body lacks oxygen the cells will die so that the metabolism in the body does not go well. Likewise, if too much oxygen levels can affect the lungs. For this reason, when giving oxygen to patients it needs to be considered. According to [3] if there is a decrease in the frequency of airflow it can cause obstructive sleep apnea (OSA). Based on this problem, it is necessary to have a tool for reading oxygen levels and oxygen flow rates on CPAP or the Oxygen Analyzer with Flow to find out oxygen level and the rate of oxygen flow released by the device so that oxygen and oxygen flow to the patient is in accordance with the arrangement.

According to, [1] of the total 2.9 million neonates who die each year, nearly 1 million (35%) die from complications of preterm birth. Premature neonates are not only at high risk of death but are also at risk for developing serious morbidities such as respiratory distress syndrome, intraventricular bleeding, necrotizing enterocolitis, and infection. Despite advances in neonatal intensive care, respiratory distress syndrome remains the single most important cause of death among preterm neonates. More than 50% of neonates born before 31 weeks of pregnancy develop respiratory distress syndrome, which is caused by a deficiency in pulmonary surfactant production. [1]

In 2015 Kholikul Akram Radianto conducted a study entitled "Oxygen Analyzer" in this study using the KE-50 type gas oxygen sensor using an ATmega8 microcontroller IC processor, and the results of oxygen levels were displayed on 3 Display 7 Segments. The lack of this research is not accompanied by data storage [4].

In 2015 Zaini Latif conducted a study entitled "Designing a Measurement System on Oxygen Gas Sensor Calibration Tools (O2)" in this study using the KE-25 gas sensor using Arduino Uno processors, for calibration of Electronic Fuel Injection the weakness of this study sensors used only last 1 year for linear readings [5].

In 2016 Nova Marta Anggarianto conducted a research entitled "Oxygen Analyzer Equipped with Microcontroller Based Data Storage" which has a function to measure oxygen levels in medical devices. Weaknesses in this tool are still using the ATmega16 microcontroller system and storing as much as 10 data with LCD display [6].

In 2017 Moch. Andrean Nur Faiz S conducted a study entitled "Levels of Concentration Measuring 02 on a Ventilator" which displays the oxygen levels received by patients on the

Ventilator. The weakness of this tool is not equipped with the reading flow rate [3].

Based on the identification of the above problems, the author intends to conduct research on "Measuring the Oxygen Concentration and Oxygen Flow Rate in Cpap". This tool can measure oxygen and flow levels, and the percentage of oxygen and flow readings results, with a character LCD interface.

II. MATERIALS AND METHODS

A. Experimental Setup

Data taken is oxygen level and oxygen flow rate that comes out of CPAP. Measurements are made 5 times. After that, measurements were made using a comparison device, namely Ultramax O2 Oxygen Analyzer.

1) Materials and Tool

This study uses the OCS-03F sensor was using one sensor can read the output oxygen concentration and oxygen flow rate on CPAP. The component used uses the Arduino Nano as a Microcontroller and OCS-03F as a sensor to read output from CPAP and then display on the 2x16 character LCD

2) Experiment

In this study, researchers compiled a module that will be used for the data collection on CPAP

a. Test to make sure the sensor can work

b. Test the tool with CPAP which is connected to the oxygen and air channels

c. Do data collection of oxygen concentration from setting 21% to 95% and continue taking data of airflow rate from setting 0 L / m to 10 L / m

B. Diagram Blok and Flowchart

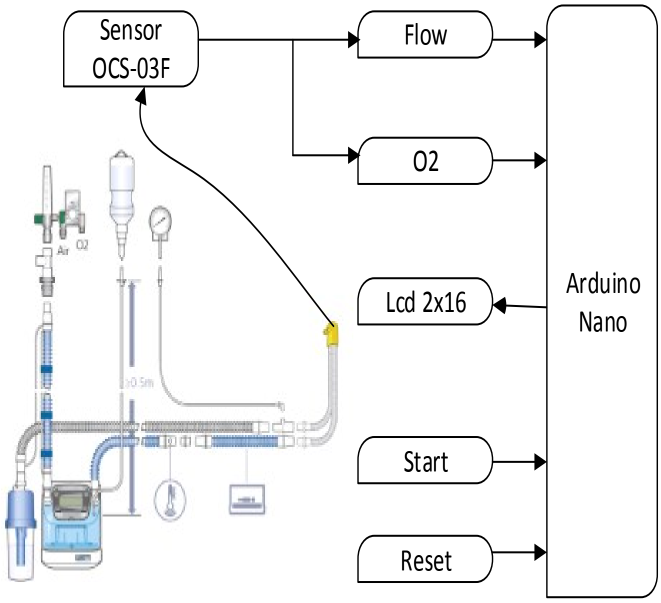

Fig 1. The Diagram Block of tools to measure oxygen concentration and oxygen flow rate in CPAP

Ways of working:

When the "ON" button is pressed, the sensor detects oxygen and the oxygen flow rate from the CPAP output, the output of the sensor is divided into 2 namely the oxygen flow rate and oxygen level, oxygen output and the flow rate and then input to Arduino ADC pin. The START button is used to give a command to start the measurement process, then inside Arduino

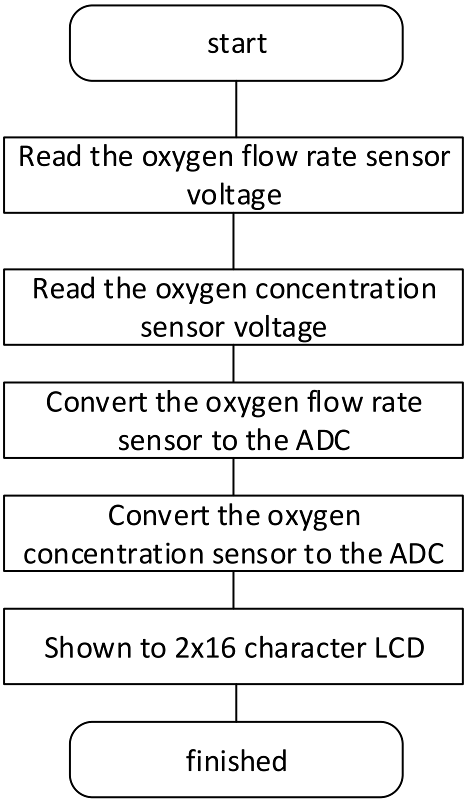

Fig 2. Flowchart tools to measure oxygen concentration and oxygen flow rate in CPAP

Ways of working :

The sensor reads the oxygen level and the oxygen flow rate then the sensor emits a voltage and then converts it into an ADC and then displays it to the LCD

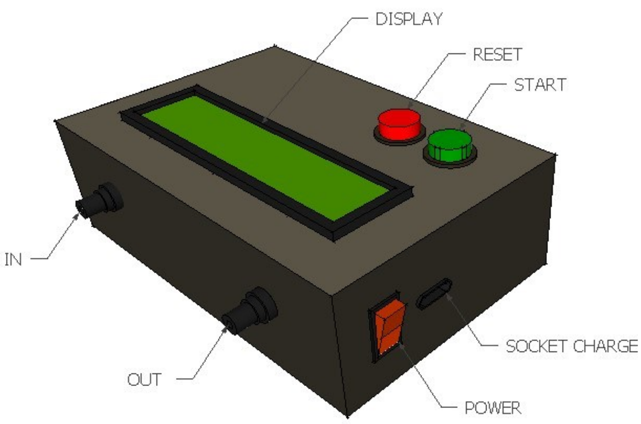

Fig 3. Mechanical diagram

III. Results and Analysis

In this study, the comparison of the results of the data with predetermined comparison tools and data calculations and analysis was carried out.

1) calculation of oxygen concentration and oxygen flow rate

```
kal = analogRead(A0);
  kal = ((0.0195 * average ) + 0.4825);
   if(kal<=0){
    kal=0;
  }
  if(kal>=10){
    kal=10;
  }
```

kal = analogRead (A0); read the ADC value on pin A0

kal = ((0.0195 * average) + 0.4825); calculation formula from excel that uses a liner system serves to display the value of the oxygen flow rate

if (kal <= 0) {kal = 0;} lower limit of results

if (kal> = 10) {kal = 10;} upper limit of results

```
adc = analogRead(A2);
volt = (adc/1023)*5 ;
nilai_o2 = (volt/0.02764932);
if(nilai_o2<=21){
  nilai_o2 = 21;
}
if(nilai_o2 >= 95){
  nilai_o2 = 95;
 }
```

adc = analogRead (A2); read the ADC value on pin A2
volt = (adc / 1023) * 5; calculation formula to get the ADC value
o_2 = (volts / 0.02764932); forestry formula to get oxygen level values
if (value_o2 <= 21) {value_2 = 21;} lower limit of results
if (value_o2> = 95) {value_o2 = 95;} upper limit of results

2) Test Point Measurement Results

The results of measurements carried out at each test point conducted by the author by measuring the oxygen concentration of the Ultrasonic OCS-3F Sensor. The results are shown below

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TABLE I. MEASUREMENT OF OXYGEN CONCENTRATION

Oxygen Concentrate (%)	Reading (%)	Output voltage sensor (V)
21	21	0,54
30	30	0,92
40	40	1,18
50	50	1,45
60	60	1,71
70	70	1,92
80	80	2,19
90	90	2,36
100	95	2,50

Based on the measurement of the sensor output voltage to changes in oxygen concentration in the table above the graph is obtained as below

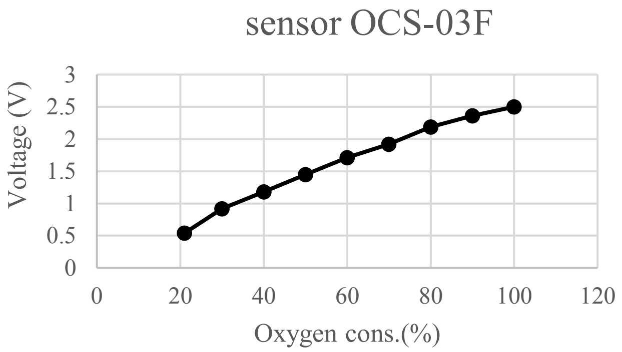

Fig 4. graph of oxygen concentration

The measurement results carried out on each test point by the author by measuring the output of the oxygen flow rate from the OCS-3F Ultrasonic Sensor. The results are shown below

TABLE II. OXYGEN FLOW RATE MEASUREMENT

Flow (L/m)	Reading (L/m)	Output sensor (V)
1	1	0,26
2	2	0,54
3	3	0,80
4	4	1,08
5	5	1,34
6	6	1,63
7	7	1,85
8	8	2,11
9	9	2,24
10	10	2,45

Based on the measurement of the sensor output voltage to changes in the oxygen flow rate in the table above, the graph is obtained as below

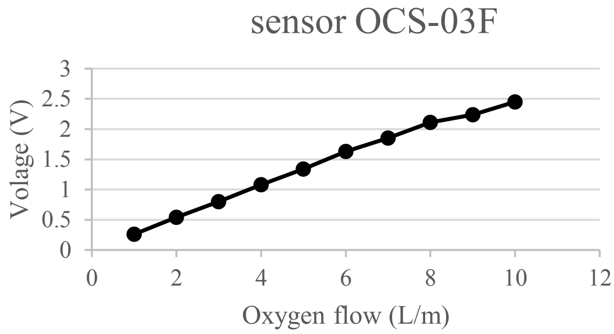

Fig 5. Graph of oxygen flow rate

3) Measurement Results for Calibrators

TABLE III. COMPARISON OF MEASUREMENTS OF OXYGEN CONCENTRATION

Calibrator (%)	%Error
21	0,14
30	-0,8
40	-0,27
50	-0,36
60	-0,12
70	-0,06
80	-0,15
90	-0,27
100	5

Oxygen content retrieval data is carried out 5 times with settings of 21%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100% with a comparison tool in the form of a CPech brand Sechrist produces an average of 59, 66. From these data, there is the largest error value of 5% at the setting point of 100% and the smallest error value -0.06% at the setting point of 70%

TABLE IV. COMPARISON OF THE MEASUREMENT OF OXYGEN FLOW RATE

Calibrator (L/m)	%Error
1	4
2	3
3	2
4	-1
5	0,8
6	-1
7	0,85
8	-0,5
9	0,67
10	0

Collecting Oxygen Flow Rate data is carried out 5 times with settings of 1L / m, 2L / m, 3L / m, 4L / m, 5L / m, 6L / m, 7L / m, 8L / m, 9L / m, 10L / m , 10L / m, with a comparator consisting of a CPAP the Sechrist brand produces an average of 6.01. From these data, the biggest error value is 4.00% at the point setting of 1L / m and the error value is 0.00% at the point setting of 10L / m.

4) Calibration Calculation

TABLE V. CALCULATION OF OXYGEN CONCENTRATION CALIBRATION

SETTING (%)	KOREKSI
21	-0,03
30	-0,24
40	0,11
50	0,18
60	0,07
70	0,04
80	0,12
90	0,24
100	5

From these data, there is the largest standard deviation value of 0.33 at the setting point of 30% and the smallest standard deviation value of 0 at the 100% setting point. The biggest uncertainty value A is 0.19 at the setting point of 21% and the smallest uncertainty value A is 0 at the 100% setting point. The biggest correction value is -5.00 at the setting point of 100% and the smallest correction value is 0.03 at the setting point of 21%

TABLE VI. CALIBRATION CALCULATION OF OXYGEN FLOW RATE

SETTING (L/m)	KOREKSI
1	-0.04
2	-0,06
3	-0,06
4	0,04
5	-0,04
6	0,06
7	0,06
8	0,04
9	0,06
10	0

From these data, there is the largest standard deviation value of 0.52 at the setting point of 7L / m and the smallest standard deviation value is 0 at the setting point of 10L / m. The biggest uncertainty value A is 0.23 at the setting point 7L / m and the smallest uncertainty value A is 0 at the setting point of 10L / m. The largest correction value is ± 0.06 at the setting points of 2L / m, 3L / m, 6L / m, 7L / m, 9L / m and the smallest correction value 0 at the setting point of 10L / m.

5) Design Results

Fig 6. Photo and CPAP tools

The photo above was taken at the time of data collection at Dr. Sutomo Hospital, data collection was done on the CPAP device in the neonatal room

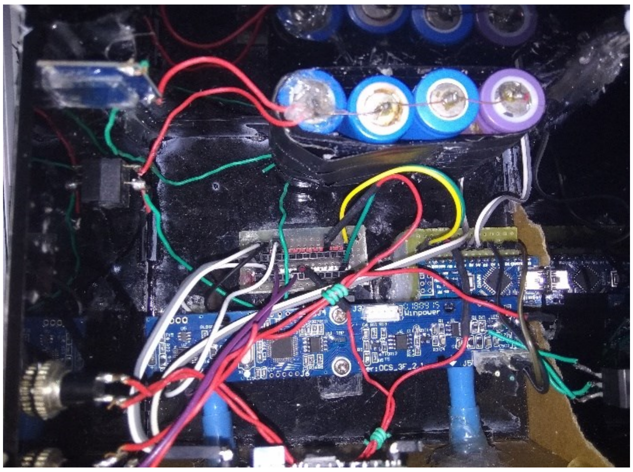

Fig 7. Photo circuit

The photo above is a series, the circuit used is the OCS-03F sensor module, Arduino nano, charger module, 5V step up module

IV. Discussion

Based on the testing and measurement system of the module with a CPAP comparison tool at the Dr. Hospital. Soetomo Surabaya which is contained in oxygen levels 21%, 30%, 40% 50%, 60%, 70%, 80%, 90%, 100% and at the oxygen flow rate of 1L / m, 2L / m, 3L / m, 4L / m, 5L / m, 7L / m, 8L / m, 9L / m, 10L / m where each measurement is carried out 5 times. For oxygen content, the reading value of the module is obtained with the biggest error value of 5% for measurement measurements. 100%, the smallest error value -0.06% for measurement at 70%, for oxygen flow rate the biggest error value is 4% for measurements at 1L / m and the smallest error value is 0% for measurements of 10L / m. The amount of error in setting 100% oxygen level is caused by the limitation of reading from the sensor used, the OCS-03F sensor can only measure maximum oxygen content of 95% while the setting on CPAP exceeds the maximum reading of the sensor. With the making of modules to measure oxygen levels and the flow rate of oxygen, this will facilitate the measurement of oxygen levels and the flow of oxygen so that patients can avoid oxygen poisoning due to excess or lack of oxygen.

V. Conclusion

The minimum system circuit can run the program, so it can display the results of oxygen levels and the oxygen flow rate on the 2x16 LCD. After testing and retrieving oxygen level measurement data 5 times using CPAP as a comparison, get the biggest error value of 5% at 100% measurement and the smallest error value -0.06% at 70% measurement. After testing and retrieving data on the measurement of oxygen flow rate 5 times using CPAP as a comparison, get the largest error value of 4% in the measurement of 1L / m and the smallest error value of 0% in the measurement of 10L / m.

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