

Level and Temperature Monitoring System in Blending Process Using Zigbee Wireless Sensor Network

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ABSTRACT

The use of cable transmission media has several drawbacks related to distance problems, geographical factors, the initial cost of procurement is quite expensive, and the arrangement of the cables is not practical. Wireless based systems appear to answer these challenges, one of which is the Wireless Sensor Network (WSN). In the industrial field the use of WSN is quite extensive in the field of monitoring and measurement. This study implements WSN technology for monitoring levels and temperatures in the Zigbee Wireless Network Sensor blending process. The implementation uses the Atmega 328 Arduino Uno, Xbee Pro and LabView 2017 microcontroller as its Human Machine Interface. Using statistical analysis methods paired t test and linear regression to analyse how the error rate and correlation of the observed variables. Based on the results of the study obtained correlations of level and temperature measurements respectively 99.97% for level measurements and 99.98% for temperature measurements. The average relative error is 2.76% for level measurements and 0.65% for temperature measurements. Tests are carried out to measure the level in the range 0 -40 cm and temperatures 26°C - 70°C with ultrasonic sensors and LM35.

Keywords: *monitoring system, blending process, zigbee wireless sensor network*

1. INTRODUCTION

Oil and gas processing are one of the capital-intensive and high-risk industries, in the process of oil and gas processing there are flammable and explosive substances such as oil, diesel, gasoline, gas, and high-speed diesel (HSD) which must always be monitored to be in a safe and controlled state of standards. Instrumentation has an important role in the process of measuring and monitoring these parameters such as temperature, pressure, flow velocity, degree of acidity and levels contained in the process. Often, we encounter cables from instruments extending from the plant to the monitoring room (control room), not infrequently we often find too many cables at the connection point (junction section), which are impractical and risk causing danger. For this reason, there is the development of wireless sensor networks (Wireless Sensor Networks) or commonly called WSN, which can replace data transmission technology using cables.

Nowadays, the development of technology is so fast and fast, and there are many new inventions of sophisticated tools that are useful to facilitate human work. One of them is the development of technology in the field of measurement sensors, communication systems, and digital development itself. It aims to meet the needs of the industry in exchanging information and processing data quickly and precisely. In fact, many problems faced are related to the use of cable transmission media, including geographic factors, communication distance, high maintenance costs, and human security factors which can hamper the data

exchange process. On the other hand, WSN technology can be an answer to these challenges and has advantages including reduced cost, improved flexibility, ease scalability, and dynamics applications. Zigbee-based WSN has developed quite a lot and has internationally recognized standards. Zigbee is a telecommunications company that develops communication technology through wireless media, one of its famous products is Xbee. To ensure the advantages of wireless sensor networks in addressing the disadvantages of communication using cable media, research must be conducted to test the performance and performance of wireless communication systems compared to cable media. Testing can be done on a small scale beforehand such as creating a mini process or prototype of an industry minimum system. This study takes a sample of a mixing process that often occurs in the industrial world. The test is conducted to see whether the wireless sensor network using zigbee can send data that matches the actual conditions in the field, such as the ability of the cable media to transmit actual data from the field to the Human Machine Interface (HMI).

2. METHOD

A paired sample T test method will be conducted to determine whether there is a relationship between the two variables, as well as linear regression analysis by determining the actual difference in measurement levels to measurements displayed on the HMI will be used to obtain the same form, taking into account the distance of testing the measuring instrument is less than 100 meters and using a peer to peer Line of Sight communication topology. And for data communication, using peer to peer Line of Sight.

3. RESULTS AND DISCUSSION

The hardware consists of the ATmega 328 microcontroller as the minimum system monitor and controller of the process. Ultrasonic sensor is used for level measurement, while LM35 is used for temperature measurement. Xbee is used as a wireless communication hardware.

The software is determined based on the supporting requirements of the hardware, such as being able to operate Arduino Uno or ATmega 328, we need to first embed the

program in Arduino memory. The programming process requires Arduino Programmer v1.8.5 software to support these needs. XCTU is used as Xbee's programming software so that it can be used properly, with XCTU we will determine the functions and work procedures of each Xbee unit. Labview software is used to design HMI and to program the interface design that we expect to be able to work in accordance with the needs of the process.

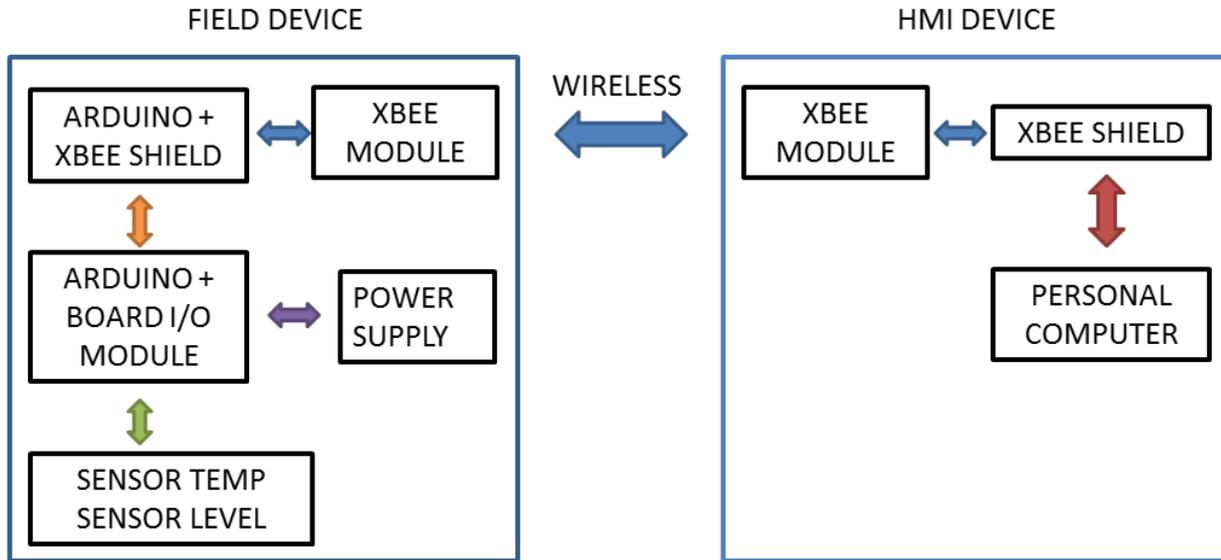


Figure 1 Hardware design block diagram

Figure 1 present a block of communication hardware design in this study. In general, the block is divided into two parts, namely the Block filed device and the HMI device block. Each block consists of different equipment units to support their respective functions. The device field block consists of sensors, power supply, arduino board, arduino shield for xbee, and xbee modules. Block HMI devices consist of a personal computer, xbee shield, and xbee module. These two blocks will communicate via the Xbee module in the outer architecture of the system, both of which have the ability to send and receive data. One block can work as a transmitter and receiver alternately to carry out the data handover process. Data transmission occurs using air media through electromagnetic waves. To be able to communicate properly the two Xbee must be on the same frequency band and have been programmed to get to know each other between devices. The frequency used by the two Xbee is at 2.4GHz. As for the communication distance generally up to a range of 100 meters based on ideal conditions.

The aim of testing to see the ability to measure levels, temperatures and data transmission from the microcontroller to the PC and from PC to microcontroller.

In addition, testing is also carried out with the conditions of the distance between the microcontroller and the HMI that has been made. As a means of analysing the test results, the data acquisition device that is connected to a PC and HMI that has been created through LabView 2017. It is used to measure the process variable size from the sensor and manipulation variable from the controller where the measurement results can be displayed in graphical form on the monitor PC.

Obtained test results and instrument implementation data with given variables range measurement level 0 cm to 40 cm, for the temperature given a working range of 26 oC - 70 oC and testing the level and temperature measurements are carried out with the distance between the receiver and transmitter ± 20 meters.

The picture below is one example of real time LabView HMI display when testing the level and temperature measurements. In the picture above it shows that the measured temperature is 29.37oC and the measured level is 31.68 cm. The blue animation on the tank shows the actual level proportion.

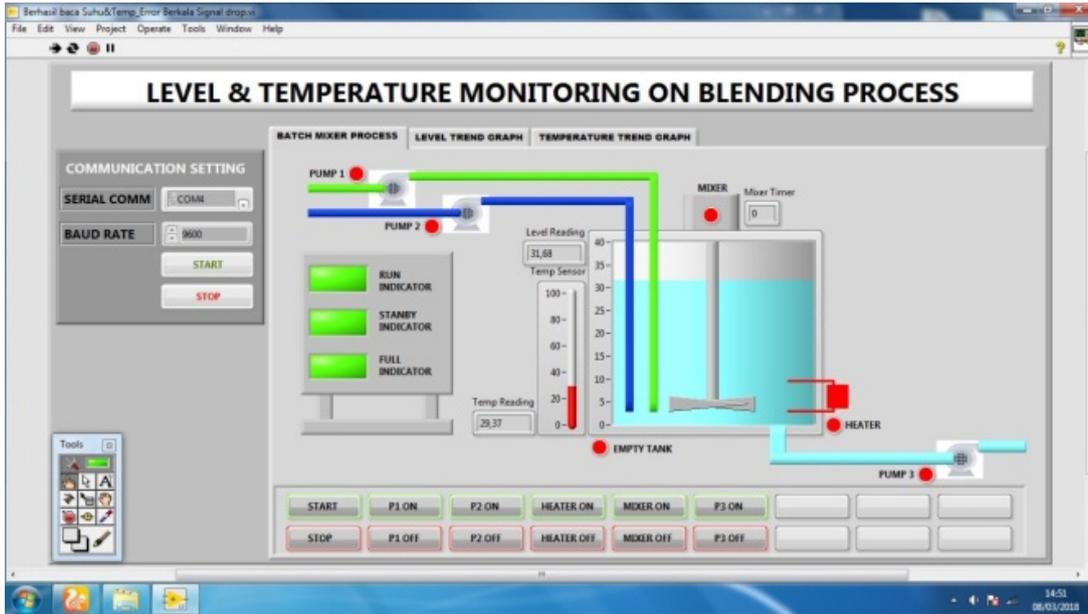


Figure 2 Testing process of telemetry measurement simulation tool

In testing the instrument measurements and taking of data levels and temperatures in a simulation tank that has a volume of ± 12.56 litres sent to HMI (PC) via wireless communication, and data collection is done randomly. Variable data is done randomly without calculating the propagation that occurs in the test. The following results of measurements and control of the level and temperature of the mixing tank against direct comparison of measurements using a measuring instrument altitude (ruler) and mercury thermometer are shown in Table 1.

Table 1 Level and temperature measurement test data (test distance of 20 meters)

No	Level (cm)		Temperature °C	
	Riil	HMI	Riil	HMI
1	0.00	0.41	26	26.21
2	1.00	1.57	28	28.31
3	2.00	2.43	30	29.62
4	3.00	3.05	32	31.87
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.
.
.
37	36.00	35.22	62	61.5
38	37.00	36.32	64	63.18
39	38.00	37.18	66	65.62
40	39.00	38.21	68	67.43
41	40.00	39.03	70	69.43

Based on the sample measurements that have been carried out, paired T Test is used to analyse the relationship between the measurement variables displayed on the HMI with the measurement variables that are in the field. The results of the level measurement analysis are analysed with a confidence level of 95% or alpha of 5%. From these

results it can be seen that the average level of measurement is actually 20 with a variance of 143.5 and measurements on the HMI have an average of 19.56 with a variance of 133.56. Correlation shows a value of 0.999 which means that almost all measurements between actual and HMI have a very close attachment between samples.

4. CONCLUSION

Making a calibrated measurement system can be carried out by comparing measurement tools made with other verified instruments. Determination of the level of accuracy, precision, measurement error and tool resolution can be analysed by statistical methods. Analysis of paired t-test shows that hypothesis 0 is accepted, meaning that it has been proven that there is a close relationship between actual measurements and measurements displayed on the HMI with a 95% confidence level. Analysis of linear regression in props, range level 0 cm - 40 cm and temperature range 26oC - 70oC distance between the microcontroller system and PC (HMI) ± 20 meters. Obtained data analysis of total linearity of direct measurements to indirect measurements of level and temperature, respectively 99.97% for level measurements and 99.98% for temperature measurements with an average relative error of measurement from this level simulation of 2.76% and The average relative error of measurement from this temperature simulation is 0.65%. Based on the results of the study obtained correlations of level and temperature measurements respectively 99.97% for level measurements and 99.98% for temperature measurements. The average relative error is 2.76% for level measurements and 0.65% for temperature measurements. Tests are carried out to measure the level in the range 0 -40 cm and temperatures 26oC - 70oC with ultrasonic sensors and LM35.

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