Oil Well Monitoring and Control Based on Wireless Sensor Networks using Atmega 2560 Controller

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Abstract

Most of the Oil Pumping Units (OPU) are manually monitored. This existing oil-pumping systems use a high power-consuming process, is incapable of OPU’s structural health monitoring. In this paper, a sensor network based intelligent control is proposed for power economy and efficient oil well health monitoring. The condition of the oil storage tanks can be monitored using sensors like level sensor, temperature sensor and gas sensor. These sensors are fixed inside the oil storage tanks. The sensor output is given to a microcontroller located in each oil well. Based on the condition of the oil storage tanks, the oil pumping motor is controlled. The monitored information about each oil well is wirelessly transmitted to an administrator located in a remote location. By this method, multiple oil wells within the transmission range of the wireless sensor network used can be monitored and controlled.

1. Introduction

Sensor networks have drawn much attention for their broad practical applications-investigate specific sensors and sensor networks for air-craft structural health and performance monitoring. A real-time radiological area monitoring sensor network is developed in for emergency response.

In this paper, a sensor network based intelligent system is proposed for remote oil well health monitoring and automatic oil-pumping control. The motivation of developing this system is that 1) due to the special nature of oil exploration and oil drilling, the majority of oil pumping units are spread over barren hills, mountains and deserts, and 2) the existing oil-pumping systems still adopt manual control.

Existing manual control systems have three evident drawbacks: 1) The OPU administrators have to frequently go to the oilfield to check the OPU status and collect its health analysis data. For the sake of the harsh oilfield environment, especially in the winter when it is chilly and snowing overspreading the whole oilfield, it is quite difficult to effectively manage and maintain all OPU manually. 2) Power consumption for OPU is huge during the oil-pumping process. Especially in barren oil wells, power wastage is extremely high because each oil-pumping is not filled under such condition and thus oil production greatly drops even though the OPU pumping stroke remains high. And 3), since an administrator has to take charge of a number of oil wells, an OPU malfunction is difficult to locate and repair in a reasonable time, which causes an oil production drop.

To overcome these three disadvantages of the existing manual control system, a sensor network based automatic control system is proposed for OPU management and oil well health monitoring based on wireless sensor networks using Atmega 2560 Controller.

Monitoring multiple oil wells: The proposed system consists of three-level sensors:

- First level sensors (FLS) – designed with a temperature sensor, a level sensor and a gas sensor used for oil well data sensing.
- Intelligent sensors (IS) –control head (Atmega 2560 Controller) performs significant malfunction detection and indication based on the elementary processing of data, such as short circuit and over current.
- Third level sensors (TLS) -PC is used for receiving data from the control heads periodically and for monitoring the Oil Pumping Unit from a remote location using zigbee.
Proposed Methodology:

- Setup for a single oil well

2. System Descriptions

The IS consists of the following three modules: a central processing unit (CPU) module, a sensing module, a wireless communication module and a user interface module.

1) Sensing Module: It consists of temperature sensor, level sensor and gas sensor for data sensing from an Oil Pumping Unit. The unit converts all measurements into electrical signals and then transports them into its corresponding control heads.

Ultrasonic sensor

- Ultrasonic Sensor is used for Oil level measurement in Oil storage tank. The sensor is fixed at the top of the tank facing the oil stored.
2) **CPU Module:** The CPU in our system is ATmega2560 microcontroller. It is a standard ATmega core CPU made suitable for industrial control.

![ATmega2560 Microcontroller Image](image-url)

- Microcontroller ATmega2560, Operating Voltage 5V
- Input Voltage (recommended) 7-12V, Input Voltage (limits) 6-20V
- Analog Input Pins 16
- Digital I/O Pins 54 (of which 14 provide PWM output)
- DC Current per I/O Pin 40 mA
- DC Current for 3.3V Pin 50 mA
- Flash Memory 256 KB of which 8 KB used by boot loader
- SRAM 8 KB, EEPROM 4 KB
- Clock Speed 16 MHz

![Zigbee Wireless Communication Image](image-url)

3) **Wireless Communication Module:** ZIGBEE module is used for wireless transmission between third level sensor and intelligent sensor.

3. **Hardware & Software Requirements:**

**Hardware Required**
- Microcontroller ATmega2560
- Level Sensor (Ultrasonic Sensor)
- Temperature Sensor (LM35)
- Gas Sensor
- Zigbee Series 2 Module
- PC

**Software required**
- Arduino C
- X-CTU

4. **Results & Discussion**

Microcontroller Atmega 2560 controls the oil pumping unit based on the values read by the level, temperature and gas sensor.

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The normal temperature of the oil storage tank is preset as 50°C. When the output of LM35 goes above 50°C, the oil pumping motor should be shut down. When the temperature lies below 50°C, the oil pumping motor keeps running.

In figure 8, the temperature of oil well is 53.90°C. The oil level is normal, but, the temperature is above the threshold value. So, the oil pumping motor of oil well is shut down.

Inside the oil storage tank, the normal concentration of combustible gas level is 300ppm. Under normal conditions, the oil pumping motor keeps running. When the concentration of combustible gases like natural gas, iso-butane is high, the gas sensor output is greater than 750ppm and the oil pumping motor is shut down.

Table 1. Tabulation by varying input parameters

<table>
<thead>
<tr>
<th>S.No</th>
<th>Temperature (cm)</th>
<th>Level (cm)</th>
<th>Gas (ppm)</th>
<th>Motor Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35.28</td>
<td>22</td>
<td>262</td>
<td>Running</td>
</tr>
<tr>
<td>2</td>
<td>24.99</td>
<td>23</td>
<td>807</td>
<td>Shutdown</td>
</tr>
<tr>
<td>3</td>
<td>35.28</td>
<td>36</td>
<td>802</td>
<td>Shutdown</td>
</tr>
<tr>
<td>4</td>
<td>54.39</td>
<td>37</td>
<td>235</td>
<td>Shutdown</td>
</tr>
<tr>
<td>5</td>
<td>66.64</td>
<td>37</td>
<td>241</td>
<td>Shutdown</td>
</tr>
<tr>
<td>6</td>
<td>34.79</td>
<td>5</td>
<td>274</td>
<td>Shutdown</td>
</tr>
<tr>
<td>7</td>
<td>32.34</td>
<td>4</td>
<td>254</td>
<td>Shutdown</td>
</tr>
<tr>
<td>8</td>
<td>35.77</td>
<td>15</td>
<td>255</td>
<td>Running</td>
</tr>
<tr>
<td>9</td>
<td>35.28</td>
<td>3</td>
<td>255</td>
<td>Shutdown</td>
</tr>
<tr>
<td>10</td>
<td>53.90</td>
<td>30</td>
<td>243</td>
<td>Shutdown</td>
</tr>
</tbody>
</table>
This table 1 shows the oil parameters output. These outputs are obtained from temperature, level, and gas sensors respectively.

Hardware Design Layout:

Figure 11. Top Elevation of Hardware Design

Figure 12. Bottom Elevation of Hardware Design

Figure 13. Atmega 2560 Microcontrollers

Figure 14. Control Circuit of dc Motor

Figure 15. Zigbee series 2 Module & Transmitter Sensors

In the proposed system, the following sensors are used which is shown below.

Figure 16. Level Sensor HC-SR04

Figure 17. Temperature Sensor LM35
5) CONCLUSION

A sensor network based oil well remote health monitoring and intelligent control system was developed for Oil Pumping Unit management in the oilfield. This system consists of level sensor, temperature sensor and gas sensor for sensing the condition of the oil storage tank. The control head processes the sensor output values and controls the oil pumping motor accordingly. The control head transmits the condition of each oil well using a Zigbee transmitter. An administrator located in the Zigbee receiver side can monitor the oil wells using the X-CTU software and manual monitoring in oil wells would be avoided. When the oil storage tank is almost full, the oil pumping motor is shut down and there is no wastage of power. The condition of the oil well from a remote location is received at the zigbee receiver end and can be displayed using X-CTU software in the range of the wireless sensor network. In the future, the range of the wireless sensor network can be increased by increasing the operating power of the network. When the range of the wireless sensor network is increases, more number of oil wells can be monitored from a remote location and data transfer would occur with minimum power requirement.

6) REFERENCES


