IOT Based Real-Time Control and Monitoring System for Food Grain Procurement and Storage

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Abstract. Nowadays, healthy and risk free foods play an important role in our day to day life. So it is necessary to monitor the environmental conditions and parameters which are inside the grain (Barley, Brown rice, and Buckwheat) storage containers and taking care of it. In our proposed system a set of sensors which are integrated inside the grain storage containers and our prime objective is to provide an effective, secure, easily accessible storage in unpredictable weather conditions. In the process of grain storage, temperature and humidity are two factors that can affect the quality of grains. The overall structure of the proposed grain storage system consists of two components, one is the host computer located in control room for information processing and prediction of grain situation, the other is the computer terminal in the granary with grain data acquisition. The main purpose of the system is to acquire data from different sensors and transmit this data wireless connectivity through IOT(Internet of Things) to access the status of granary. If the parameters of the grains exceeds the specified threshold level then the exhaust fans are automatically ON to reduce the exceeded parameters namely temperature and humidity. The proposed system has good reliability, maintainability and cost effectiveness.

Keywords: Internet of Things, Real Time Control, Microcontroller, Food grain

1. Introduction

Grain storage is an essential component in the economy and the society. Therefore it occupies a vital place in the economies of developing countries like India. The purpose of any grain storage facility is to provide safe storage conditions for the grain in order to prevent grain loss caused by adverse weather, moisture, rodents, birds, insects and micro-organisms like fungi [1-3].

The traditional grain storage methods were suffered through several drawbacks such as wide wiring coverage, more interference lighting strike and high maintenance cost. By monitoring and controlling grain storage more relevant real time information can be obtained [4]. And after analyzing the data of rice, millet, wheat, jowar, etc. under different stress conditions, combining this result with parameters like temperature, humidity and gas, more widespread analysis about the activities of pests and mildews in the granary will be taken and submitted to the admin members [5-7].
Then, the administrators can perform different manual controlling actions like ventilation or cooling by granary operating devices according to the analysis. Due to low cost sensor and effectiveness in communication, several problems in traditional system can be solved by the proposed system [8-10].

The objective of the paper is to design and develop an IoT enabled food grain monitoring system that are stored in closed storage yards and report the humidity, temperature and the presence of gases inside the yard, there by preventive measures can be carried out in an appropriate manner.

2. Proposed System

The proposed system includes sensor networks along with actuation and communication terminals. Sensor networks used to measure the grain parameters inside the granary. And appropriate actuation modules are used to control the grain parameters in case of any abnormality due to improper weather conditions especially in summer. Communication terminals incorporated in this system in order to monitor the grain parameters from the remote place through Internet of Things (IOT).

3. System Architecture

![Figure 1. System architecture](image)

This system includes sensors for measuring Temperature, Humidity, Moisture, Gas, Flame, and Moisture inside the granary. Along with sensor networks Real Time Clock (RTC) used to display the Real time Date and clock. These parameters can be processed by the ATMEL Atmega328P controller. An actuation can be carried by Exhaust fan, Alarm and Humidifier. If the level of measured parameters goes beyond the threshold level means these control system are automatically actuated to control. Communication part includes ESP8266 Wi-Fi module to upload the data from the sensor networks part to the cloud (Thing speak Server) through Internet connectivity.

Grain humidity content and temperature are the two critical factors for maintaining grain quality during storage. Under unsafe grain temperatures and humidity content, cereal grains and oilseeds deteriorate and produce heat, water, and carbon dioxide (CO₂).

Table 1. Temperature and Relative humidity for different grains

| Grain | Temperature in deg °C | Relative humidity % (gm/cm³) |
|-------|-----------------------|-----------------------------|
| Rice  | 22-32                 | 50-75                       |
All living organisms in a grain bulk respire, including grain, insects, mites, and microorganisms. During respiration the carbohydrates, fats, or proteins in the grain or in the living organisms are oxidized. The general respiration process can be defined by the following equation.

\[
C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O + 2870 \text{kJ}
\]

Applying this formula, 15.7 KJ of heat is produced for each gram of \( C_6H_{12}O_6 \) was broken down.

When moisture is high, it is difficult to separate the respiration between grain and mold. Actually, mold is the more important contributor of the heat produced in damp or wet grain (about 85 to 95%). For example, wheat stored at 24% moisture content can rapidly deplete oxygen to 0% in two to three days, while CO2 continually increases. At 17% moisture content, it takes 70 days for the oxygen to drop to near 0%. At 14% moisture and 15°C there is less than 2% reduction of oxygen in 18 months.

The table given below provides the moisture content thresholds to be maintained for the different food products.

### Table 2. Moisture content levels for different foods

| S.No | Food product | % of moisture content in food product |
|------|--------------|--------------------------------------|
| 1.   | Rice         | 12.2-13.8                             |
| 2.   | Wheat        | 12.2-13.9                             |
| 3.   | Rava         | 11.1-13                               |
| 4.   | Maida        | 10.5-13                               |

The moisture content to be maintained also varies depending on the time of storage. The values specified above have been mentioned with respect to long storage periods. DHT11 is a sensor which is used to measure the environment temperature and humidity. Here it will used to measure temperature and humidity inside the grain storage container. If suppose the humidity goes beyond the threshold level means the humidifier will be automatically actuated to increase the humidity level. And if temperature level increase means exhaust fan will automatically turn ON to reduce the heat inside the container.

3.1 Gas Sensor

Gas sensor used to measure concentration of toxic gas level (i.e. CO\(_2\)) and the degradability and early spoilage of grain can be detected inside grain bin using CO\(_2\) sensors Instruments capable of sensing CO\(_2\) concentrations of 0.1% will detect spoilage during stored grain in 80% of deteriorating bulks in farm granaries. Employed commercial CO\(_2\) sensors near the vents and exhaust air stream of fans in the grain bin for measuring CO\(_2\). Micro-sensors can be fabricated
and deployed inside grain bulk which will measure the intergranular air composition. Carbon dioxide is also used as a fumigant for insect control during grain storage. During fumigation, there is a need to measure the CO$_2$ concentration throughout the grain mass to ensure uniform distribution and maintenance of CO$_2$ concentration. These sensors should be able to replace the traditional plastic syringes of gas sampling and infrared gas analyzers in grain storage.

3.2 Light level

Here LDR (Light Dependent Resistor) acts as a photo sensor and used to sense the Light level inside the container.

The lighting conditions are also playing a role in increasing the infestation levels of food. The reproduction of various insects depends on the lighting levels inside the bin. An optimum illumination level between 50 lux and 90 lux is maintained to prevent increase in infestation. Hence, by having the environmental conditions within the allowable limits, the food grains are controlled & prevented from damage.

3.3 Real time clock (RTC)

This tiny RTC module includes the clock chip DS3231 which supports the I2C protocol. It uses a Lithium cell battery to hold the data even the system in OFF condition. This module provides seconds, minutes, hours, day, date, month, and year information.

4. Internet Of Things

Internet of Things is an ecosystem of connected physical objects like sensors and hardware modules that are accessible and monitor through the internet. Here the sensor data are aggregated, processed and uploaded to the cloud through internet. And the person at remote end can able to view the data in the real time.

5. Results and Discussion

The system developed consists of two separate grain storage bins with appropriate sensors like temperature, Humidity, Moisture and CO2 sensor to monitor the parameters of the grains. The captured sensor data were uploaded periodically to the server through internet.

**Figure. 3.** Snapshot of the system designed

*Result analysis of Bin I*

Bin I incorporates sensors to measure the container or Bin temperature, Bin humidity, Grain Moisture and CO2 level inside the bin. And actuation part includes Humidifier and Exhaust fan to maintain the optimum temperature and Humidity inside the Bin.
Figure 4. Bin temperature Vs time

The above Figure 4 represents temperature variation inside the bin. The optimum temperature to be maintained inside the bin is set as 30 deg C. When the bin temperature reaches beyond this level, immediately the exhaust fan was actuated and the set temperature was maintained.

Figure 5. Bin humidity vs time

The above Figure 5 represents humidity variation inside the bin. Initially the humidity inside the bin is 68 %. In this system a threshold level of 65 has been set to actuate the humidifier. Here when the humidity inside the bin decreased to 64 at that time the humidifier was automatically actuated to maintain 65% relative humidity.

Figure 6. Co2 gas level vs time

The above Figure 6 represents the Co2 gas concentration inside the bin. Here the Co2 level can be measured in PPM. Initially the concentration is nearly 500 PPM. For the testing purpose we had introduced the smoke inside the bin during that the concentration inside the bin get increased and reached to 600 PPM.

Figure 7. Grain moisture vs time
The above Figure 7. represents the moisture content of grain with respect to date and time. Moisture content represents as the amount of water vapors contain by the grain. Initially it was in zero level, after pouring some sprinkle of water the moisture value increased.

5.1 Result Analysis of Bin II

BIN II incorporates sensors to measure the container or Bin temperature, Bin humidity, Grain temperature and CO2 level inside the bin. And actuation part includes Exhaust fan to maintain the temperature inside the Bin.

*Bin temperature and Humidity*

The Figures 8, 9,10,11 represent the temperature and humidity variations of container with respect to time and date.

![Figure 8. Bin temperature vs time](image)

![Figure 9. Bin Humidity vs time](image)

![Figure 10. CO2 gas level vs time](image)

A figure below represents the temperature of the grain which we are accommodated in the bins. These kinds of sensor can contact with the grains to measure the grain temperature. **Note:** Bin temperature and grain temperature both are different.
6. Future Enhancement

The system has a very vast scope in future and it will create a big impact in the agriculture field especially in post-harvesting stage. In future, the quality of the grains can be measured based on physical, sanitary, and intrinsic traits. Physical traits relate to the physical appearance or characteristic of the grain. Examples of physical traits include weight, grain size, moisture content, damaged grains, and other properties of the grain that can be determined by automatic inspection and separate by using conveyors. Sanitary traits relate to the cleanliness of the grain.

7. Conclusion

The system designed and developed accurately senses the grain parameters and the actuation is automatically taking place in case of any abnormalities in the sensed parameters. Similarly it will update the sensor data to the cloud through internet. Thus eliminate the fact of any manual intervention and manual switching.

References

[1] Abdul Salam Mubashar, M. Saleem Khan, Khalil Ahmad 2011 *International Journal of Scientific & Engineering Research* 6.

[2] J Delin, S., 2004. *Within-field variations in grain protein content - relationships to yield and soil nitrogen and consistency in maps between years*. Precision Agriculture 5 565-577.

[3] L K Hema 2015, *International Journal Applied Engg. Research* 10 25870-25890.

[4] Dr. Subhi R. M. Zeebaree, Hajar M. Yasin, 2014 *Arduino Based Remote Controlling for Home : Power Saving, Security and Protection*. International Journal of Scientific & Engineering Research 5.

[5] L.K. Hema 2014 *Wireless sensor network based conservation of illegal logging of forest trees*. IEEE National Conference on Emerging Trends In New & Renewable Energy Sources And Energy Management pp. 130-134.

[6] Jayas, D.S. and N.D.G. White. 2003 *Storage and drying of grain in Canada: low cost approaches*. Food Control 14(4) : 255-261.

[7] Taylor, J., Whelan, B., Thylen, L., Gilbertsson, M., Hassall, J., 2005. *Monitoring wheat protein content on-harvester - Australian experiences*. 5th European Conference on Precision Agriculture pp. 369-375.

[8] L K Hema 2016 *International Journal of Chemical Sciences* 14(83) 829-834.

[9] C.M., McBratney, A.B., Skerritt, J.H., 2002. *Site-specific durum wheat quality and its relationship to soil properties in a single field in Northern New South Wales*. Precision Agriculture 3 155-168.

[10] L K Hema 2019 *Inteln. Jour. of Recent Tech Engg* 8 507.