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Smart Storage Bin with Real-Time Monitoring and Control of Stored Grains

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Abstract: India is an agricultural country where 70% of the population depends on farming, the storage of grains plays a vital role in the national economy. Grains are one of the major sources of food. The storage of grain is the primary task for restoring and reusing. In the process of grain storage, moisture content, temperature, and humidity are major environmental factors that can influence directly on the quality of the grains. To reduce the quality issues, the sensor-based bin has been designed and developed. This new design is used to monitor the parameters, control the moisture content of grain that present in the bin, and delivers real-time results. The results will be displayed automatically on the LCD. With this model, we have tried to decrease the human interface and manipulation available in the current system.
Keywords: Storage bin, IoT, control, grains, sensors, drying, moisture.

I. INTRODUCTION

As India being the second largest country with the highest population, therefore it is very important to ensure food security. Food preservation is very important to fulfill the food supply chain needed by developing countries like India. There is a huge need for preservation, protection, storage, distribution, and consumption of food at a later stage. The main objective of this project is to preserve the food grains from rodents invading at warehouses and also threat to the destruction of stored crops, due to variation in temperature, humidity, fire, theft, rain, flood, etc. So the stored food grains can be delivered as and when required. In this paper, we are integrating the Internet of Things with smart sensors to improve the efficiency of food preservation in the warehouse. (Ms. Manisha gaur, 2016) Environmental factors like temperature, moisture content, humidity, and light influence the storage of food grains. Also, factors like time and purpose of storage, type of storage, preventive insecticide treatments, and storage practices account for the food storage losses. During storage, both qualitative and quantitative losses occur due to insect pests, mold growth, rodents, rats, fungi, micro-organisms, and subsequent production of mycotoxins in storage. (Ms. Esther Magdelene 2014).

The storage problems can be prevented with the help of bins for the storage of grains. Bins can be used to store solids in small capacities. Bins mainly operates in the post-harvest sector where it offers a solution for bulk grain, animal feed storage, and pelletized products. There are different types of bins and they are metal bins, flat bottom bins, hopper bins, truck train load bins, etc. (Silos Cordoba 2019) Certain types of sensors are also used to detect various parameters. A sensor is a device that converts signals from one energy region to the electrical domain. Sensors are of two types: Active and Passive. Active Sensors are which require an external activating signal or a power signal. Passive Sensors, on the other hand, do not require any external force and directly generates an output response. (Aleman-Meza, 2005). The other classification of sensors is based on the means of detection used in the sensor.

II. REVIEW OF LITERATURE

In India, food grains are stored by traditional methods in ancient days but it leads to many issues like deterioration, discoloration, rodent attacks, damage due to moisture, and negligence. At present days, the advanced technology ranges from mud structure to modern silos and bins. The silo is fabricated with different materials differing in shape, size, design, and functions. The raw materials for silos are food grains, milk, oilseeds, etc. Storage makes an essential link between the entire procurement and distribution system of food grains. According to FCI (2018), the grain storage capacity in the country is about 877.37lakh tonnes. Depending on requirements in specific areas and for modernization of storage facilities, the government has been implementing several schemes for the construction of godowns and commonly used material because they are easily controllable and more resistant. According to the FAO statistics (2018), cereals which include rice, wheat, and barley make up the heavier part in food crop production. They play a vital role in food sources for human consumption. The storage capacity of cereals and pulses are very huge when compare to millets and oilseeds. Storing food material in a stainless metal silo is the most preferred technique in the food processing industry because of its quick dispatch and hygienic conditions. They are different types of silos material are available in the market such as wood, food-grade steel, metal, galvanized, and stainless steel/metal,. The food-grade steel and galvanized silos are the most commonly used material because they are easily controllable and more resistant. The term sensor is defined as a system or device that include process and control electronics, software and interconnection network that respond to a physical and chemical quantity to produce an output that is a measure of that quantity (S. Neethirajan, 2007). The recent technology allows the development of the system which can monitor the food grains in good quality and hygiene conditions. By using advanced modern technique, the lifespan of grains can be expected. It makes the system to access and control easily.

III. MATERIALS & METHODS

1) *DHT11 Temperature And Humidity Sensor:* This DHT11 Temperature and humidity sensor give out digital signal output and are a peripheral integrated with a high-performance 8-bit microcontroller. It also exhibits high reliability and long-term stability. It showcases excellent quality, fast response, anti-interference ability, and high performance. It is extremely accurate with high calibration features.
2) *Moisture Probe:* Moisture is defined as the measure of water content in the material. It uses capacitance to measure dielectric permittivity. Dielectric permittivity is the function of water. The probe sends a voltage proportional to the dielectric permittivity and hence the moisture content is measured.
3) *Particle Photon IOT Hardware:* Particle photon IoT hardware is a complete solution to development with powered ARM Cortex M3 microcontroller.
4) *DC Boost Converter:* It is the simplest type of switch-mode converter. It takes an input voltage to boost and increase it further.
5) *Cortex M0+ Processor:* It is the entry-level 32-bit ARM cortex processor crafted for a broad range of embedded applications.
6) *Ultrasonic HC-SR04 Sensor:* This sensor is featured with an ultrasonic transmitter and receiver. It works on the principle of

Distance=Speed x Time.

It transmits an ultrasonic wave, eventually transmitted and when it gets objected by any material it reflects with which the distance is known and hence the capacity is calculated.

7) *Relay Switches:* These switches are used to control both AC and DC appliances. Primarily used in the case of high voltage currents of the AC/DC power supply.
8) *LCD:* 16 x 2 LCD screen is used which is an alphanumeric display that can show up to 32 characters on a single screen.

A. Procedure

1) *Step 1:* When the device is ON, the control unit initially enables the entire system.
2) *Step 2:* After the system is enabled, the SoC initializes the sensors, electromechanical devices, and handshakes with the cloud for a secure connection.
3) *Step 3:* In the whole process, the readings from the sensors are first taken and send to the cloud remote access.
4) *Step 4:* Additionally, for controlling the ambiance inside the bin, the temperature, humidity, and moisture values are compared with the predefined sets. If the ambiance requires the heater to be ON, the SoC turns on the coil heater

Fig 1: Image of Smart Storage Bin

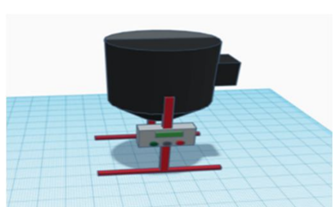

Fig 2: 3D Image of Smart Bin

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IV. RESULTS & DISCUSSIONS

Minimizing storage losses is a very effective way of reducing the area needed for production and thereby increasing food production efficiency. By preventing storage losses, the smart storage bin also becomes an important technology for enhancing food security, particularly for small-scale farmers in developing countries. The smart storage bin will create a positive impact on the stakeholders directly or indirectly associated with grain production and storage.

The trails were done using rice and wheat for a month from February to March for a capacity of (2kgs to 2.5kgs). The initial moisture content of the grains when stored in the smart bin was ranging from 16%-18%. The grains were stored at proper atmospheric conditions, and the moisture content reduced to 12%-14% (which is the proper moisture content). The stored grains do not show any kind of deterioration or damage. The grains were also stored in a normal bin for the same period, which is from February to March and the grains showed some discoloration and insect infestation was also merely there. Based on the results, it can be concluded that the smart storage bins are an effective alternative to traditional storage practices for maintaining the quality of grains and to overcome huge storage losses. The need of the hour is to strengthen traditional means of storage with modern inputs and also to provide cheaper storage options to farmers to prevent enormous storage losses.

Table 1: Analysis on Moisture Content Of The Stored Grain (Rice) Capacity: 3kgs

DAY	SAMPLE	INITIAL MOISTURE CONTENT (%)	FINAL MOISTURE CONTENT (%)
1	RICE	18	14.11
2		17	12.33
3		16	13.4
4		18	12.74
5		16	14.0
6		17	12.22
7		17	13.0

1) *Inference:* When the grains were stored in the smart bin for seven days, the initial moisture content was between 16-18%, which is higher than the desired moisture level. After storing at proper temperatures in the smart bin, the moisture content reduced to a range of 12-14%, thereby the chances of the fungal and discoloration of grains can be controlled.

Table 2: Analysis On Temperature, Relative Humidity and Heat Index Of The Stored Grain (RICE)

DAY	TEMPERATURE	RELATIVE HUMIDITY	HEAT INDEX
1	84.2	54	29.42
2	84.2	54	29.42
3	87.8	52	30.17
4	84.2	54	29.78
5	87.8	52	29.78
6	87.8	52	29.78
7	87.8	54	29.78

2) *Inference:* In the smart storage bin, when the grains were stored for a week and if the moisture content is higher than the desired limit, the temperature has increased and the relative humidity and heat index are reduced. Hence the grains are stored at proper atmospheric conditions.

V. SUMMARY & CONCLUSION

The grain production has been increasing with better facilities in terms of seeds, technology, fertilizers, pesticides, and irrigation. Around Rs 50,000 crores every year are damaged due to improper storage of food grains. Natural contamination of the food grains is greatly influenced by environmental factors such as type of storage structure, temperature, pH, moisture, etc. However indigenous storage structures are not suitable for storing grains for a very long period. Here lies the significance of improved storage structures and scientific storage of grains in the form of smart storage bins.

Minimizing storage losses is a very effective way of reducing the area needed for production and thereby increasing food production efficiency. By preventing storage losses, the smart storage bin also becomes an important technology for enhancing food security, particularly for small-scale farmers in developing countries. The smart storage bin will create a positive impact on the stakeholders directly or indirectly associated with grain production and storage.

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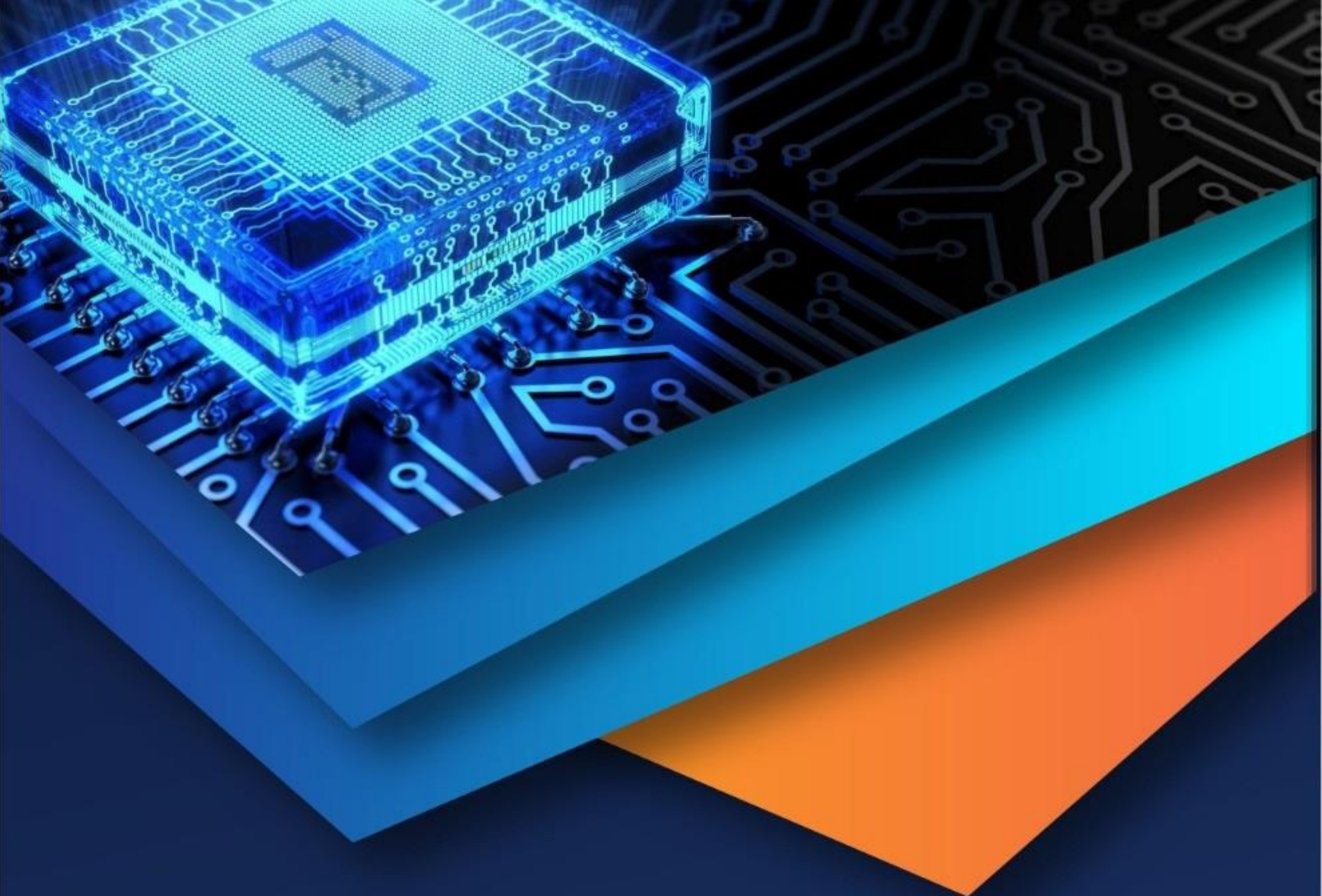

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