INNOVATIVE COLD STORAGE TECHNOLOGY

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Abstract –In todays world we are noticing there is tremendous increase in the supply chain systems due to various factors like online shopping, improved logistics, globalization etc. This in turn has lead to challenges of accommodating these products . One important parameter is to maintain the temperature and other ambient conditions for different temperature sensitive products. Thus there arises the need for specialized storage solutions . One such solution is to develop a cold storage. This paper explains about the challenges that are encountered in cold staorage and the means of providing smart control of it by the using the latest technology.

A cold storage warehouse is a storage facility which is usually equipped with temperature-controlled environments. The primary function of the cold storage is to store the temperature-sensitive products. The products oftenare perishable goods like fresh produce, frozen foods, pharmaceutical products, thereby maintaining their quality, and hence extending their shelf life.

Cold storage warehouses are categorized as refrigerated and frozen based on their maintained temperatures of cold storage service ;Refrigerated warehouses, are also called aschill stores, typically maintain temperatures between 2 and 8 degrees Celsius and prevent cold loss. These are typically used for for storing fresh produce, dairy products, and other perishable items that require a cool but not frozen environment.

On the other hand, frozen warehouses operate in sub-zero temperatures, commonly between -18 to -25 degrees Celsius. These facilities, started as a cold storage project, are designed to store frozen foods, such as meats, seafood, and frozen desserts, that must be kept at low temperatures to prevent bacterial growth and maintain product integrity. From the above discussion it is quite obvious that maintaining the right temperature is one major task in the cold storage.

The other challenges include

Preparation:

Inspect incoming goods for quality and damage.

Sort items based on temperature requirements.

Loading:

Load items into the cold storage unit according to a planned layout to optimize space and airflow.

Place items on designated shelves or pallets, considering weight distribution and potential cross-contamination

Storage management:

Rotate stock using the "First In, First Out" (FIFO) method to prevent spoilage.

Regularly check for potential issues like condensation, leaks, or damage to packaging.

In this paper, we discuss about how we can develop a system that can sort the goods depending on the temperature requirement and then helps to maintain , monitor and control the various parameters of the cold storage using IoT. The system monitors various parameters like temperature, humidity in the warehouse and helps in achieving the optimum function of the cold storage. The advantage of the system is that it automatically controls the parameters and reduces the interference from the human person . The system also uploads the real time data on the web server so that the parameters can be monitored and controlled from anywhere and anytime.

Temperature Fluctuations: Maintaining consistent temperatures within a cold storage facility is a critical challenge. Fluctuations can lead to spoilage or degradation of temperature-sensitive goods.

Energy Consumption: Cold storage facilities are energy-intensive. Balancing the need for low temperatures with energy efficiency poses a challenge, as excessive energy consumption can result in high operational costs and environmental impact.

Equipment Failure and Maintenance: The reliability of refrigeration equipment is paramount. Unexpected breakdowns can lead to significant financial losses due to spoiled inventory. Predictive maintenance becomes crucial to identify potential issues before they escalate.

Inventory Management: Efficient inventory management in cold storage is challenging due to the need for precise temperature control and the varying shelf life of different products. Proper tracking and monitoring are essential to prevent product wastage.

Space Utilization and Layout: Optimizing the use of space within a cold storage facility is complex. Efficient storage and retrieval systems, along with strategic layout planning, are necessary to maximize storage capacity while maintaining accessibility.

***Key Words*:**NODE MCU, Blynk App, DHT11, Gas Sensor MQ-5.

1.INTRODUCTION

A cold storage warehouse is a storage facility which is usually equipped with temperature-controlled environments. The primary function of the cold storage is to store the temperature-sensitive products. The products often are perishable goods like fresh produce, frozen foods, pharmaceutical products, thereby maintaining their quality, and hence extending their shelf life

The proposed prototype system has been designed with NodeMCUmodule along with the sensors to monitor the moisture, temperature, and detect methane gas liberated in chamber. The various parameters are maintained by using water pump, heater, fan, servo motor. The system monitors and automatically controls the parameters. Also the current status of the parameters is transmitted to the Blynk server for the purpose of monitoring and even controlling.

2. CONCEPTUAL FRAMEWORK

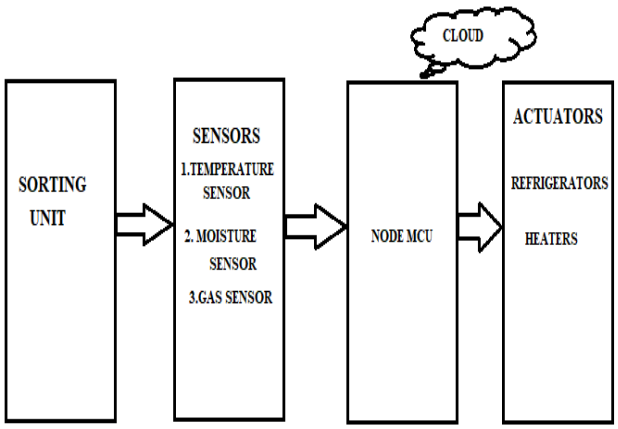

Fig 1: Block diagram of the system

The sorting unit which is usually a PLC based system sorts the commodities to be stored in the cold storage depending of the temperature requirement of the particular commodity. The sorted materials are then placed in their respective compartments. The temperature level, moisturelevel , gas level of the particular compartment is set and continuously monitored using temperature sensors,moisture sensors and gas sensors. The real time data of these parameters is also pushed on the cloud by the NodeMCU.The control of the parameters can be done automatically. In case the temperature varies then either heaters or refrigerators can be turned on/off to maintain the required temperature.

Also the gas sensors employed will detect the gas liberated due to rottening of persishable goods and gives the indication as in which compartment there is issue.

3. COMPONENTS

NODEMCU ESP8266

The entire system is build around the NodeMCU. The NodeMCU ;Open source firmware is used for IoT based applications .The NodeMCU operating voltage is 3.3V. It has 1 analog input pin and 12 digital pins which be used as GPIO. It also has built in Wi-Fi, making it ideal for IoT applications.

SENSORS

TEMPERATURE SENSOR

In this project the most popular temperature sensor DHT11 - Temperature and Humidity sensor is employed for measuring the temperature of particular compartment. It measures the temperature of the surrounding air by using a thermistor. The temperature of the particular compartment is observed continuously and information regarding the current temperature is given to the NodeMCU.

MOISTURE SENSOR

In this project the most popular soil moisture sensor FC-28 is employed for measuring moisture percentage . It records the moisture percentage of the compartment continuously and information regarding the current moisture level is given to the NodeMCU.

GAS SENSOR

In this project the most popular gas sensor MCQ-05 is used to monitor the level of methane gas produced in the compartment. The sensor measures level of methane gas produced in the compartment and information regarding the current level of gas is given to the NodeMCU.

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ACTUATORS

The data collected by the sensors is processed by NODE MCU and necessary control action is taken so as to keep the essential parameters

temperature, moisture and gas level under by actuating the devices likerefrigerator, heater, fan and servo motor.

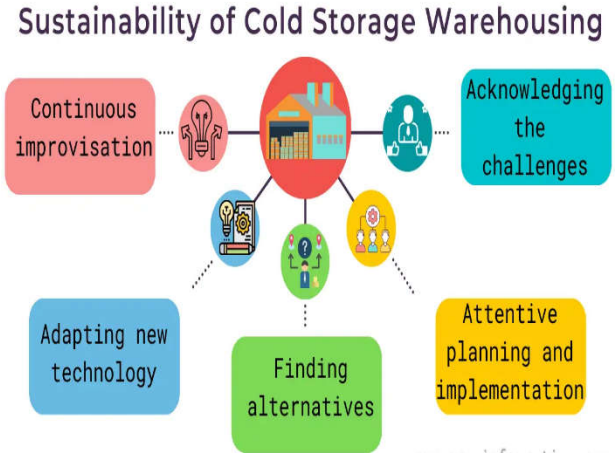
WEB SERVER

For any IoT enabled application, the ability of monitoring or/and controlling the data over internet is very crucial. In the proposed the controlling action is done automatically; different actuators enable or disable the required output device accordingly. The current values of the process parameters are also updated to the cloud server using different application in Thinkspeak, Blynk,etc., The present system makes use of Blynk platform; one such IoT analytics platform , to monitor and as well as control the parameters.

4. RESULTS

The Fig2. shows a snapshot of the temperature data displayed on the Blynk App webserver.

Fig 2. Sample Output on Blynk App Webserver



5. CONCLUSION & FUTURE SCOPE

In the proposes system we are monitoring three parameters temperature, moisture and gas level in the storage warehouse and thereby controlling and thus maintain the required parameters and preserving the commodities.The system can be made more sophisticated by using image processing techniques for sorting the commodities and made fully automated by using PLC..

IoT Elegance in Cold Storage :

- **Real-timeTemperature Monitoring:** Continuous monitoring of temperature conditions in cold storage ensures goods are stored within the optimal range, minimizing spoilage risks.
- **Predictive Maintenance:** IoT-driven predictive analytics forecast equipment issues, allowing for proactive maintenance, reducing downtime, and extending equipment lifespan.
- **Remote Management and Control:** Remote access to real-time data enables managers to monitor and adjust cold storage environments from anywhere, improving operational efficiency.
- **Inventory Tracking and Management:** Precise inventory tracking with IoT sensors and RFID tags prevents wastage and ensures efficient stock rotation.

- **Energy Efficiency:** Smart sensors optimize energy consumption, contributing to cost savings and environmental sustainability in cold storage facilities.
- **Security and Access Control:** IoT-based security systems enhance facility safety through access control measures, surveillance, and real-time alerts, ensuring the integrity of stored goods.

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