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Automatic Data Acquisition and Monitoring Device to Indicate the Freshness of Milk during Transportation

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Abstract: ***Milk is a nutrient-rich liquid food and it is the primary source of nutrition and a cheap source of protein for large vegetarian population living in India. Dairy industry in India is the world's largest milk producer and dominates about 13% of world milk production. Milk contains several groups of nutrients & considerable amount of organic substances and functional elements such as traces of vitamins, enzymes & dissolved gases, dissolved salts, calcium, water, carbohydrates, proteins, fats, complex & simple lipids, minerals, vitamins , etc.,. Milk transportation has shown to contribute to a greater extent to milk spoilage. Most of the milk which has been rejected by milk processing plants had samples which indicate milk of good quality at farm level before transportation. Milk processors request that milk must be cooled to 2°C to 4°C within 2 to 3 h of milking. The monitoring system that we have implied here is to check the temperature throughout the transportation using micro-controller and to ensure the quality of the milk. This monitoring device consist of NTC Temperature sensor to indicate the exposure to excessive temperature and controlled temperature like cold storage and a gas sensor is used to detect the spoilage of milk while transportation. The RFID tags are used to record the information of the vendor, temperature and how much litre they are giving to the society and hereby, the complete record of this is maintained separately by data acquisition system with the open source software cayenne. In this monitoring device, the temperature of the milk is continuously monitored using microcontroller and an immediate alert message is given to the driver and admin when there is raise in temperature.***

Keywords: Milk, cayenne, data acquisition, RFID, NTC

I. INTRODUCTION

Milk is a nutrient rich liquid food produced by the mammary glands of mammals. It is the primary source of nutrition for young mammals, including breast fed human infants before they are able to digest solid food [1]**.** Milk is an opaque white fluid rich in fat and protein, secreted by female mammals for the nourishment of their young. A huge variety of food products are made from cow's milk, such as cheese, cream, butter, and yogurt. India is the world's largest producer of milk, and is the leading exporter of skimmed milk powder, yet it exports few other milk products [2]. India has the highest level of milk production and consumption of all countries [3]. The annual production was 186 million tonnes as of 2018. As of 2020; approximately 4.2% of India's gross domestic product was due to dairy production [4]. In 2019, the Indian dairy sector was reported to be growing at 4.9% yearly. In 2018–19, the Government of India reported that 187.7 million tonnes of milk had been produced, and that the per capita availability of milk in India was 394 grams per day. In Maharashtra alone, there are approximately 4 million dairy farmers [5] although as of 2014, Gujarat had the highest dairy output of the states and union territories of India [6]. The livestock sector in India is characterized by large numbers but little productivity across species. As of 1992, the number of cattle, the most populous species, was 204 million [7]. Dairy production in India comes primarily from small-scale dairy farmers; most of India's 75 million rural dairy farms consist of 10 cattle or less and are family-owned and operated [8]. According to European Union legislation specification, the milk temperature should be at 8°C during milk collection. Milk processors request that milk be cooled to 2° to 4°C within 2 to 3 hrs of milking [9]. This study [10] suggests that bulk tank milk can be stored at 2°C or 4°C for up to 96 hours with minimal deterioration of quality as long as the milk entering the tank has minimal bacterial contamination but at 6°C and 8°C psychrotrophic bacterial growth remained in the lag phase for at least part of the first 48 hours period. The high bacterial index of milk consignment will be rejected by the processor. In real-world conditions, this has led to scenarios where the milk passed the temperature and senses tests after that rejection may occur. It can lead to substantial financial loss for both the farmer and the transporter. According to a survey [11], farmers (93.8%) had their milk rejected either once or twice per month by the processor. In India, lack of road connectivity and poor infrastructure is backbreaking for dairy farms to supply their raw milk to a processing facility at the proper time [12]. Therefore dairy farms should adopt new technologies that can improve productivity, operations, and profitability.

The Automatic data acquisition and monitoring device of milk during transportation is to monitor the temperature of the milk continuously with the NTC temperature sensor and the gas level in the milk tanker is monitored simultaneously using MQ-2 gas sensor which is recorded in the cloud storage.

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The buzzer in the device rings when the temperature of milk is above 4˚ c and when the co_2 gas is released due to spoilage of the milk. The RFID tag is to maintain the record of the milk given by the vendor to the society, it also contains the name of the vendor with the contact details in it.

The main objectives are as follows;

1) To design and develop Automatic Data Acquisition and Monitoring Device to indicate the freshness of milk during transportation.
2) To conduct trials during transportation of milk and collecting real – time data.
3) To calculate the cost of the monitoring device.

II. MATERIALS

A. Arduino UNO

Arduino is an open source gadgets stage dependent on simple to utilize equipment and programming. Arduino boards can be able to understand inputs. There are numerous other miniature regulators and microcontroller stages accessible for actual processing. Arduino ATMEGA-328 microcontroller has been programmed for various applications. By using the power jack cable, the Arduino microcontroller has been programmed so that the execution of the program may take place. Arduino software is installed on the computer and so that we can edit and upload the program according to the applications. Mainly this Arduino software supports c and c++ programming languages [13].

B. NTC Temperature Sensor

An NTC (Negative Temperature Coefficient) thermistor is a temperature sensor that uses the resistance properties of ceramic/metal composites to measure the temperature. Thermistors are temperature-sensing elements made of semiconductor material that has been sintered in order to display large changes in resistance in proportion to small changes in temperature [14]. NTC Thermistors are non-linear resistors, which alter their resistance characteristics with temperature. The resistance of NTC will decrease as the temperature increases. The manner in which the resistance decreases is related to a constant known in the electronics industry as beta, or ß. Beta is measured in °K [15].

C. Gas Sensor (MQ-2)

A **gas sensor** is a device which detects the presence or concentration of gases in the atmosphere. Based on the concentration of the gas the sensor produces a corresponding potential difference by changing the resistance of the material inside the sensor, which can be measured as output voltage. Based on this voltage value the type and concentration of the gas can be estimated. The type of gas the sensor could detect depends on the **sensing material** present inside the sensor. When the concentration of the gas exceeds this threshold the digital pin goes high. The analog pin can be used to measure the concentration of the gas [16].

D. RFID Tag and Reader

Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. An RFID tag consists of a tiny radio transponder; a radio receiver and transmitter. Most RFID tags contain at least two parts. One is an integrated circuit for storing and processing information, modulating and demodulating a radio-frequency (RF) signal, and other specialized functions.

The second is an antenna for receiving and transmitting the signal. RFID tag includes microchip with radio antenna mounted on substrate which carries 12 Byte unique Identification number [17]. RFID reader reads its unique ID and transmits it serially to the microcontroller or PC. RFID reader has transceiver and an antenna mounted on it. It is mostly fixed in stationary position. **EM18** is a RFID reader which is used to read RFID tags of frequency 125 kHz. After reading tags, it transmits unique ID serially to the PC or microcontroller using UART communication or Wiegand format on respective pins. EM18 RFID reader reads the data from RFID tags which contains stored ID which is of 12 bytes.

E. Wi-Fi Module

The NodeMCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. NodeMCU can be powered using Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface[18].

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F. Cayenne

Cayenne is the world's first drag and drop IoT project builder that empowers developers, designers and engineers to quickly prototype and share their connected device projects. Cayenne is designed to work on popular browsers Progressive Web Application (PWA) for iOS[19]. http://cayenne.apache.org

G. MQTT Protocol

MQTT (Message Queuing Telemetry Transport) protocol is a protocol specifically designed for "machine to machine" communication. MQTT protocol runs over TCP / IP and has a data packet size with a low overhead minimum (> 2 bytes) so that consumption of the power supply is also small enough. This protocol is a data-agnostic protocol that can transmit data in various forms such as binary data, text, XML, or JSON and this protocol uses a publish/subscribe model rather than a client-server model [20].

III. METHODOLOGY

The monitoring device that is implied here has a temperature sensor, gas sensor, RFID reader, micro controller, WIFI module in it. The temperature sensor (NTC) and the gas sensor (MQ-2) is interfaced with the arduino UNO where the temperature sensor detects the temperature of the milk during transportation which runs in a loop. The gas sensor senses the gas in the milk tankers and if there is a spoilage of milk during transportation it will give an alert to the driver as well as admin. RFID tags are used to collect the details of the vendor at the initial stage of collecting milk from the vendors. The overall information is collected separately with the Wi-Fi module and it is linked with the open source MQTT protocol where the information can be retrieved when needed.

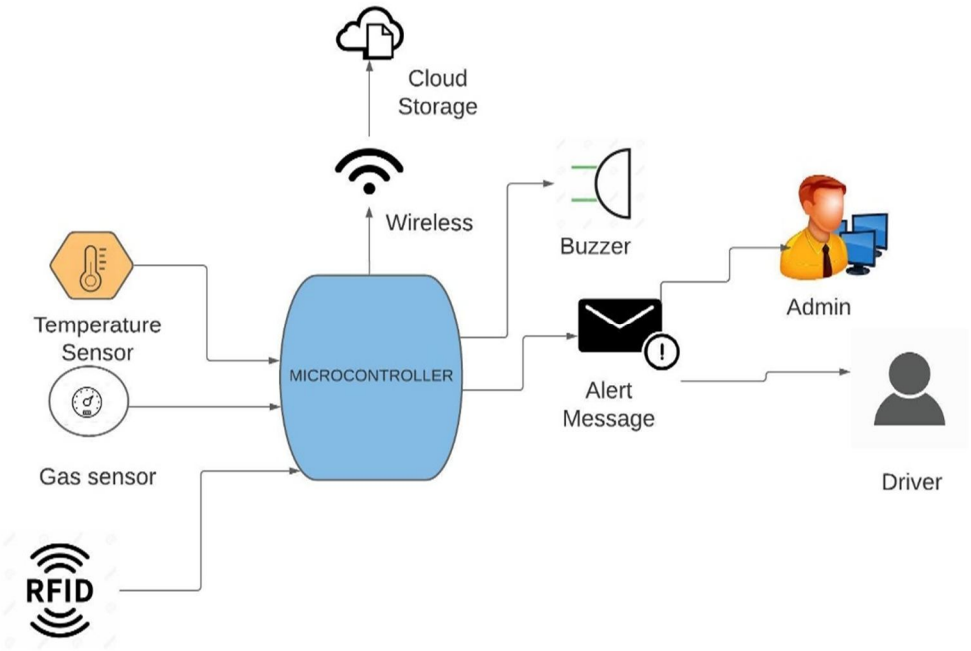


Fig 1. Block Diagram of the Monitoring Device

The block diagram represents the device which consist of temperature sensor, gas sensor, RFID tags, buzzer, wifi module and Arduino UNO. The Arduino Uno is the central controller of the system. The Arduino Uno is embedded with the temperature sensor, gas sensor and the RFID tag. The monitoring system implied here is to check the temperature throughout the transportation using micro-controller and to ensure the quality of the milk. This monitoring device consist of temperature sensor to indicate exposure to excessive temperature and controlled temperature like cold storage and a gas sensor to detect the spoilage of milk. The RFID tags are used to record the information of the vendor, temperature and how much litre there are giving to the society. The complete record of this is maintained separately by data acquisition. The pictorial representation of the monitoring system is given below Fig. 2.

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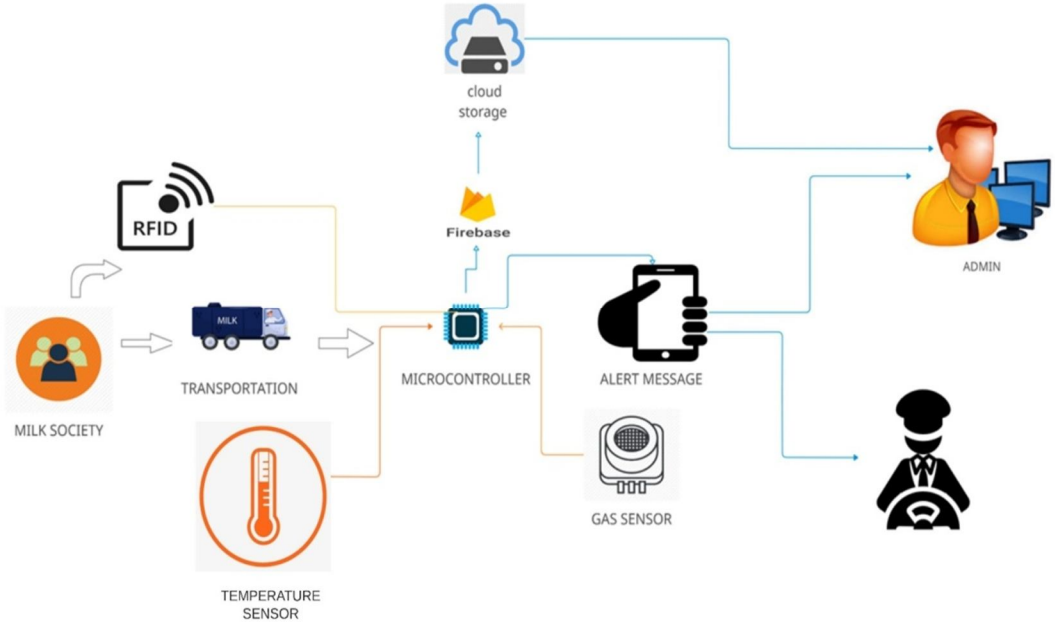


Fig 2. Pictorial Representation of the Monitoring Device

When the monitoring system is ON the temperature sensor senses the temperature of the milk, the gas sensor senses the gas released in the milk and RFID tags collects the information of the vendor. This data is collected in the Arduino UNO micro controller. The Wi-Fi module used in it collects these data and is sent to the cloud storage. When there is a raise in temperature of above 4^0C or the gas sensor senses the CO_2 gas, the buzzer activates and an alert message is sent to the driver as well as the admin. Then these data reports can be obtained in the open source software named cayenne.

IV. RESULT AND DISCUSSION

In dairy supply chain management, traceability and transparency play a prominent character in quality supervision; it is important to store the record of the data. The automatic monitoring device has collected data on temperature, freshness, and quantity of milk during transportation. Those results are stored in the cloud for future reference. Here the result is discussed with the help of a graph and datasheet. Automatic data acquisition and monitoring device is shown in the (Fig.3).

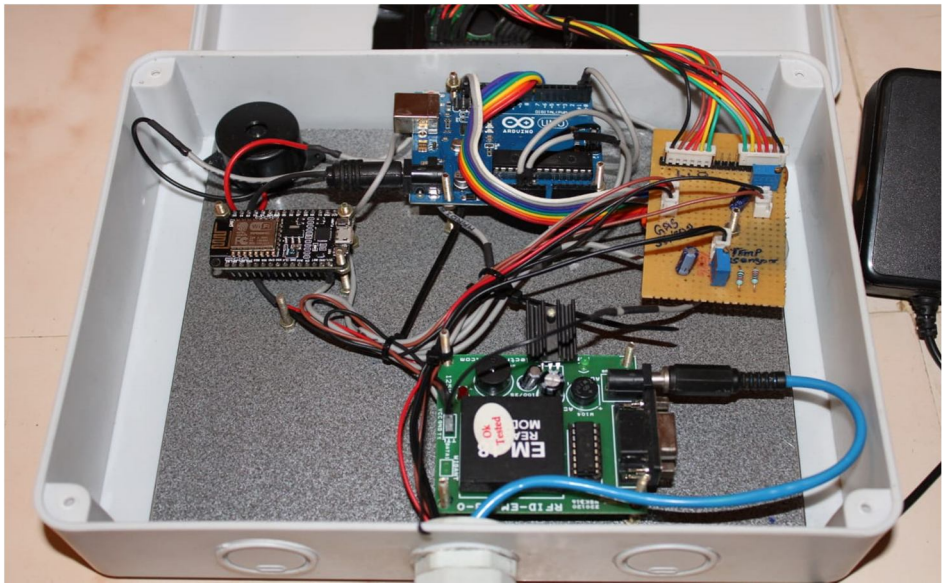


Fig.3 Automatic data acquisition and monitoring device

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The level of temperature maintained during one hour of transportation is shown in the temperature graph (Fig 4). By using an NTC temperature sensor it is proved that the temperature is sustained below -4˚C and those values are collected in a datasheet.

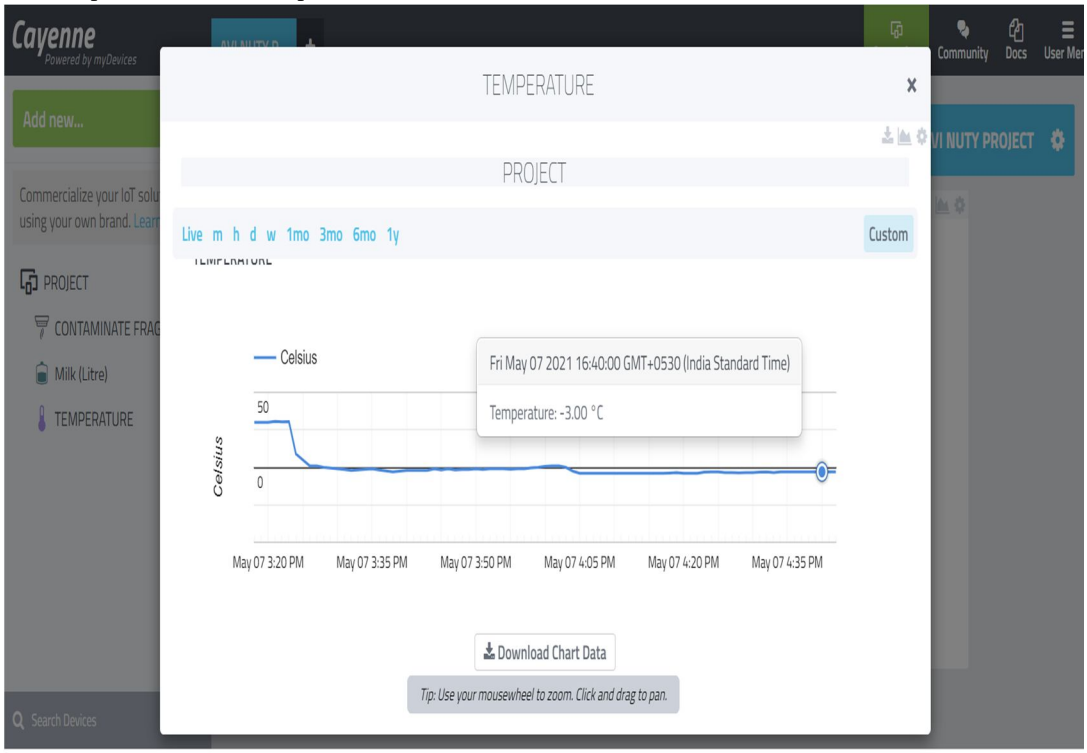


Fig.4 Temperature Graph

The gas emission graph (Fig.5) shows the gas level of the milk during transportation; this indicates that in our test the gas level is maintained at 1.0 where the milk is safe during transportation. If the value exceeds 3.0, there will be spoilage of milk. An alert message will be sent to the driver and industry authorities. The gas emission level values of milk during transportation is in the time interval of 1/10 per sec.

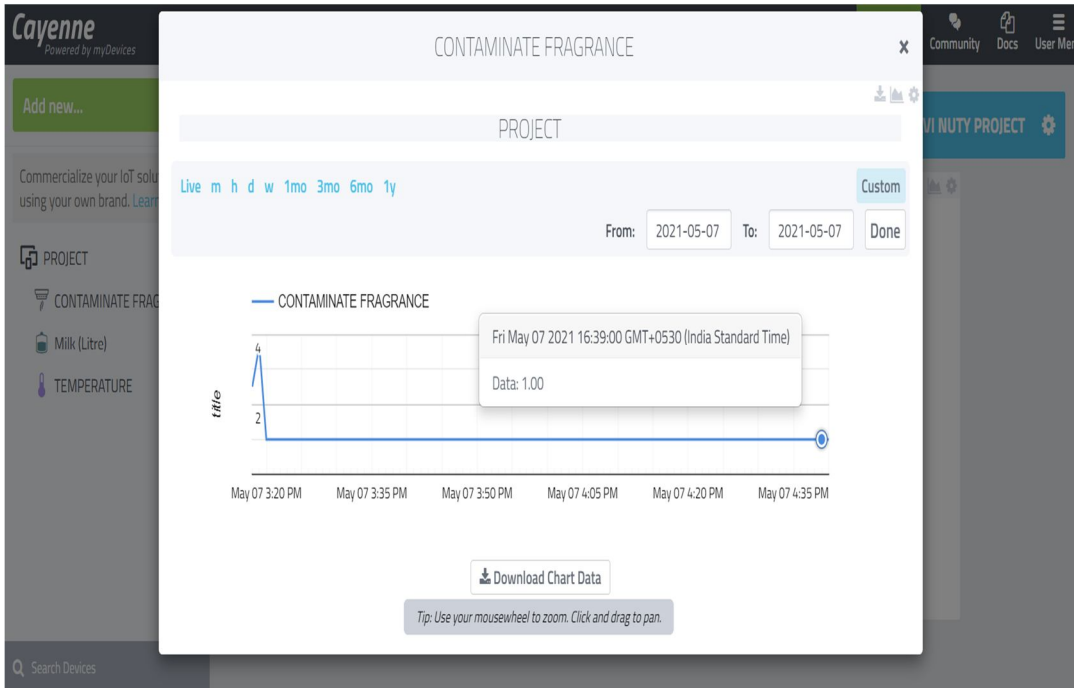


Fig.5 Gas Emission Graph

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The quantity of milk graph (Fig. 6) shows the quantity of milk given by the society members to the milk union. The graph indicates the milk provided by the society members with the time interval of one hour. The quantity of milk is collected in the time interval of 1/10 per sec.

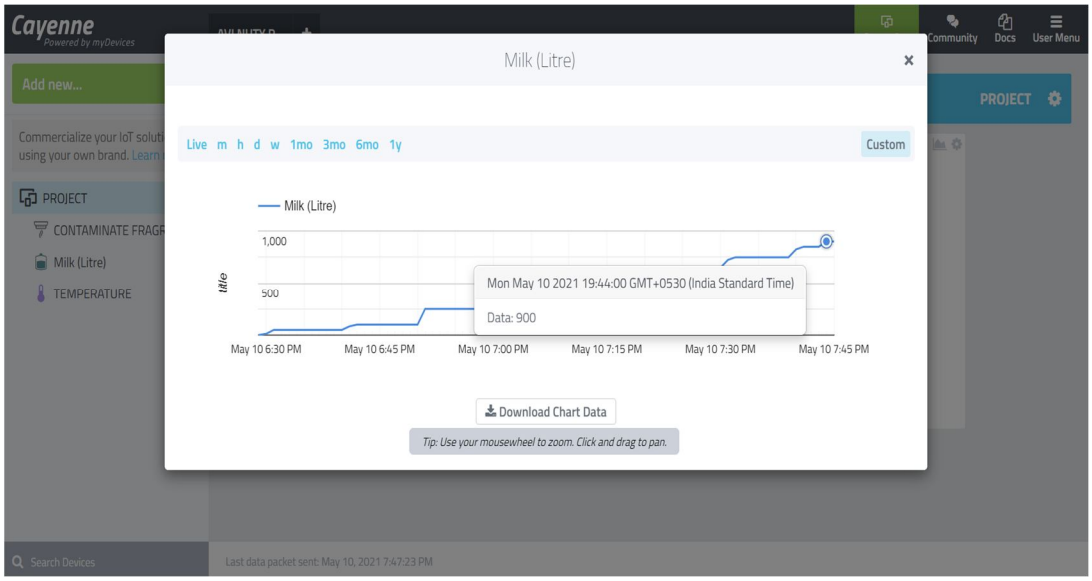


Fig.6 Quantity of Milk Graph

V. SUMMARY AND CONCLUSION

As milk is a highly perishable product, its quality may degrade while moving downstream in an imperfect cold dairy supply chain. The monitoring of temperature during the transportation is not sufficient due to the state of the vehicles for both bulk and own delivery. If the milk transportation takes a long time to reach milk processing plants, it may cause deterioration of milk. The cold milk chain needs to be maintained from the farm until the milk is transferred to processing plants. Raw milk temperature increases during transportation. When the milk arrives at the processor intake bay, milk temperature will be higher than the temperature recorded at the farm level. An automatic data acquisition monitoring device has a prominent role in determining the temperature, spoilage, and quantity of milk in a tanker during milk transportation. The efficiency of our monitoring device is higher when compared to other monitoring devices [21][22][23]. This device is supported with a cayenne cloud firebase so the recorded data can be transferred effectively. The recorded data can be manifested in graphs and further in an excel sheet which can be beneficial for future analysis. This device helps to ensure the safety and traceability of milk transportation at a low cost.

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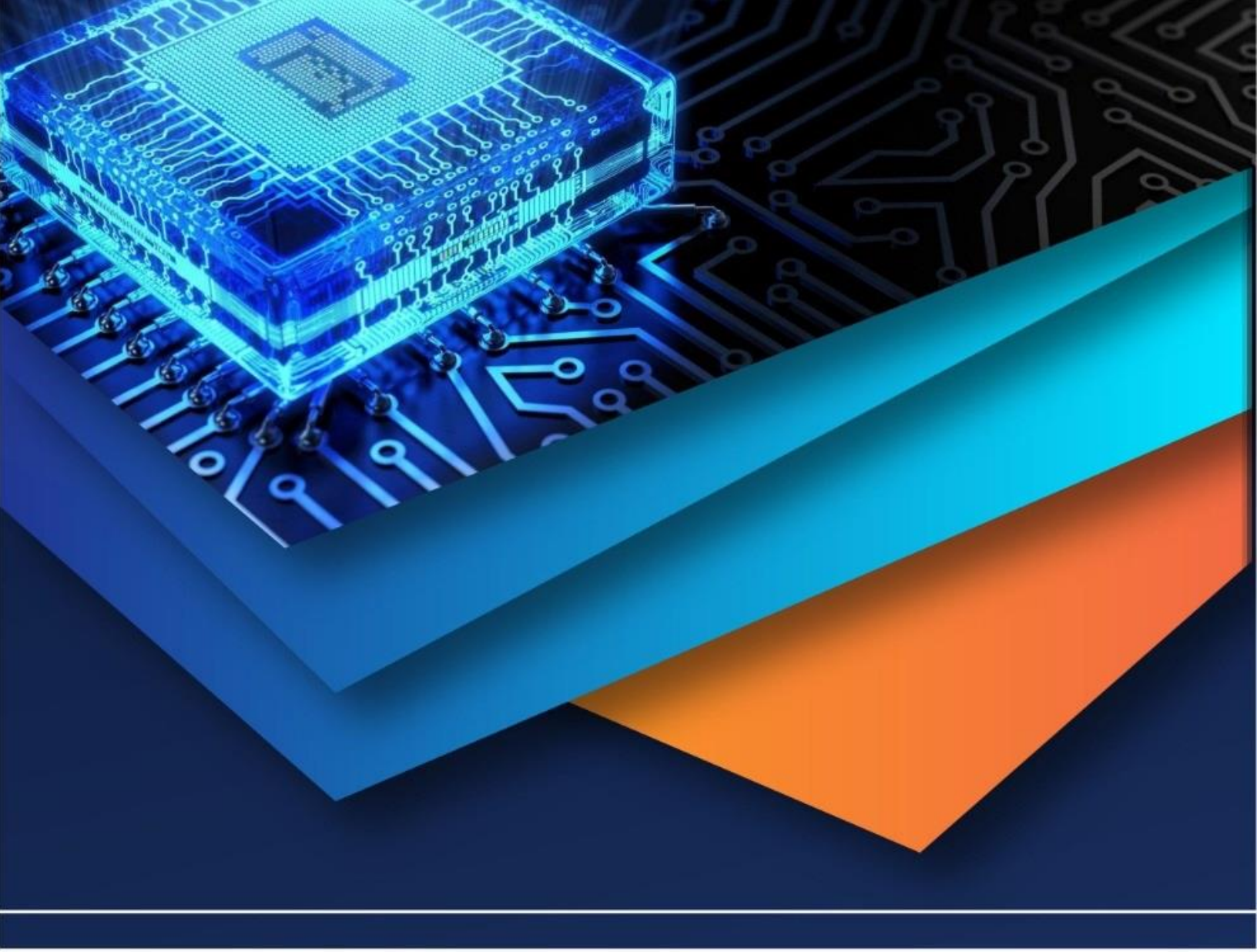
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