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Brix and Alcohol Content Monitoring using Wireless Sensor Network

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ABSTRACT

Fermentation process plays an important role in the production of wine and beer, as these ferments convert Brix (sugar) into alcohol. Thus fermentation plays a key role in beer production hence monitoring entire activities is essential to breweries. As such, this project aimed to monitor the by-products of fermentation processes which are Brix (Sugar concentration) and Alcohol in order to improve the Quality of alcohol. Different stages of fermentation produce different Brix and alcohol percentages by volume. A system using wireless communication protocol is proposed where sensor node readings are transferred to a centralized station for monitoring and visualization. The sampling technique used was Non-probability purposive due to the fact that information gathered was important to contribute to better understand the problem by gathering information from the right personnel in the field of study. Through this approach, it is a perfect application of IoT and Wireless Sensor Network solution which has been achieved and provides advantages to the brewery industry. Moreover, the transfer of real-world processes to a digital world has been made possible which allows optimizing these processes. Through the project study, a simple and automated method with good accuracy was developed for estimating Brix and alcohol content during the fermentation process.

Key Words: *Brix, Fermentation, IoT, Wireless Sensor Network, Specific Gravity.*

1. INTRODUCTION

Fermentation is a common process in alcohol production. The banana juice possesses a certain percentage of varieties including sugar, vitamin C, brix [1]. The beverage industries regularly monitor alcohol and sugar concentration periodically in order to meet standards of the resulting wine. Thus the fermentation process must be monitored frequently to ensure that the end product meets quality and specified standards. Fermentation can also be regarded as a biochemical process where the sugars in solutions are converted to alcohol and carbon dioxide by yeast. It's a key process in the production of wine and beer. Due to these fermentation plays a central role in beer production hence monitoring entire activities are essential to breweries. The term "Brix" technically is referred to as the percentage by weight of sugar solids in a liquid. Brix is used to express how much sugar is in a solution. Brix values indicate the estimate of sugar content in fruits and vegetables hence it is an indicator of consumer rating as it influences sweetness [2]. Brix is also expressed as the percent by weight of all soluble solids in solutions that are generally not pure sucrose. The instruments widely used for Brix measurement are the Brix hydrometer and the refractometer. Brix and alcohol can be measured and calculated through refractive index and liquid density through refraction. As light bends when passing through a liquid, the respective refractive index is calculated on the Brix scale. The resulting reading from a handheld refractometer is assigned a certain value on the Brix scale making it easy to find concentrations in different solutions. Pure water has a Brix value of zero while contaminated water with sugars, minerals or other solids in solution produce a higher Brix value. IOT based application & WSN architecture are adapted to improve the monitoring to improve these processes during fermentation of wine to increase accuracy, reliability and traceability[3] Typically, a Wireless sensor network could be used which possess several sensor nodes. These sensor nodes have the ability to communicate among themselves through generated signals. The individual nodes in a wireless sensor network (WSN) are resource constrained, Once the sensor nodes are installed, they are responsible for their organization and using their respective network infrastructure. Sensor devices have also ability to respond to requests sent from a monitoring tool to perform certain instructions or provide information. WSN possesses a network of devices referred to as nodes through which information is gathered and can be monitored through wireless communication [4]. A single node WSN as performed in this research suffers from scalability.

2. LITERATURE REVIEW

2.1 IOT architecture for wine monitoring

Wine production is directly linked with monitoring of its key critical parameters. IOT has been spread in many different applications from automotive, agriculture, health. IOT is expected to grow 36 billion device by 2020[5].IOT architecture has found applications in wine sector and some works have shown possibility of implementing sensors network to measure the key by-product of Fermentation in production of wine [6].In this study the authors introduced the IOT architecture for Wine monitoring, the authors in this study designed to measure and monitor parameters such as Wine PH, Wine temperature, Wine level. Although this proves to have weakness since wine critical parameters in fermentation are Alcohol percentage by volume, Brix concentration and Carbon dioxide emission. This paper uses a standalone buoy which has a source of power and its low consumption makes it suitable for fermentation process, this has been achieved in many areas such as oceanography [7] the plastic material in which the material is made is waterproof and has floating properties. Through this research a low cost buoy that can be used in tanks battery was placed in the bottom. The electronic component possessed power. This System innovative device is an innovative IOT architecture capable of increasing monitoring and efficiency and effectiveness in production. The system uses connectionless communication in harsh environments. This approach allows remote monitoring and can be applied on different Wine companies while keeping the cost low.

2.2 IOT architecture for monitoring wine fermentation process of Debina variety semi sparkling wine

Generally, the evolution of the internet has brought the network of internet connected devices through IOT. For transfer of real time and sensor data different object can be used to exchange data. This literature review examines the IOT based integrated system for monitoring and measuring wine parameters in which possess a number of interconnected sensors and actuators which will create more dimensions to the real time monitoring of wine parameters while fermentation is considered a key process to harvest wine, monitoring is also vital. In this paper, the author presents an IOT based integrated system for monitoring Poor Quality Wine which may be caused by stuck fermentation that can be reduced through monitoring [8].Recent advancement in monitoring systems has led to various designs of wine sensors. In this paper the author uses a low cost microcontroller which uses Bluetooth to communicate however Bluetooth offers disadvantages as its short range communication and less secure. The methodology used is smart barrel architecture of the Wine Smart Barrel System which consists of wine from vessels; this methodology is costly to adapt. Due to the increase in the fermentation monitoring system, it has been demonstrated for previous research that the requirement of daily monitoring of wine is essential before harvest. Through the system also a central station was developed for analysing and monitoring of information.

2.3 Alcohol refractometer

Figure 1: Determination of %Brix in alcohol refractometer

Figure 1 represents the inside view of alcohol refractometer which represents 1.012 SG and 3% alcohol by volume. This is obtained by refractive index through refractometer.The most preferable method of measuring these parameters is by specific gravity or refractive index[9]

3. METHODS

3.1 Study area, data collection

The project was conducted at Raha Beverage Company located at Arusha region Northern part of Tanzania. The company's main activity is to produce alcohol made from local content of banana which is grown largely in this part of Tanzania. The Company's

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main products are Raha Gold, Raha Poa which are all alcoholic products which are famous and popular to local people and markets. The sample size was chosen for this project in order to recognize the difficulties associated with acquiring Brix and Alcohol control at Raha Beverage Company

3.2 SYSTEM DESIGN

The block diagram architecture of the Brix and Alcohol monitoring using Wireless Sensor network is adopted from the Internet of things (IOT) architecture from collection to analysis[10]. It consists of standalone microcontroller ESP32, the microcontroller units which is capable of translating the motion by measuring the density of liquids, hence translating into measuring of brix and alcohol content at the solution. It also consists of application software for visualizing real time parameters of alcohol and brix to generate reports.

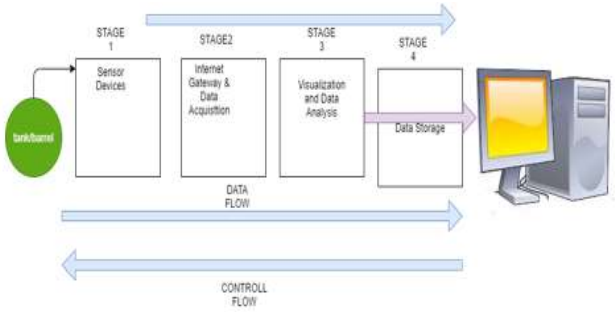

Figure 2: Flow of information from sensor node to central station

3.2.2 USE CASE DIAGRAM

A use case diagram is a visual representation of how a system works from the user's perspective. It's a diagrammatic representation of how actors communicate with the system to meet functionally requirements. As a result, the decision was taken to use the Use Case diagram as a design tool in this study. It also aids in capturing the system's functional specifications correctly and accurately.

Figure 3:Use Case diagram

3.2.3 DATA ACQUISITION

The Web API retrieves its information from the hardware device. ESP32 can act as a webserver where connecting software and hardware is responsible for serving and maintaining data to webclients. The webclient in this project was a desktop PC. This type of communication is a client server communication model. Figure 5 shows the WebAPI as the central station of the system.

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Figure4:WebAPI Login Page

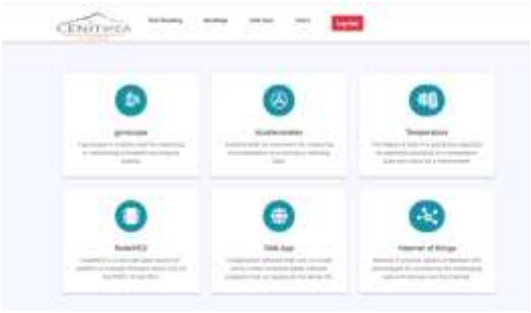

Figure 5: Central station

The Figure 5 shows the central station where Tool parameters are displayed in tool readings.

3.3 SENSOR NODE

The sensor node consists of a microcontroller with integrated WiFI which does not require any additional chipset. It's a perfect connection for IOT. It's a rich Microcontroller Unit with integrated Wi-Fi and has bluetooth connectivity for a variety of applications. Esp32 uses the communicational standards which are built in the chip of the development board without the need to communicate with external modules [11].The MPU6050 gyroscope calculates change of rotational of the object. This changes the angular position over time along the XY Z plane. The orientation of the object determines the position and changes of the object.To make the electric circuit compact and small and to give a professional look PCB was designed. A PCB involves a combination of electronics chips, capacitors, semiconductors which are mounted to give electrical connectivity between components[12].

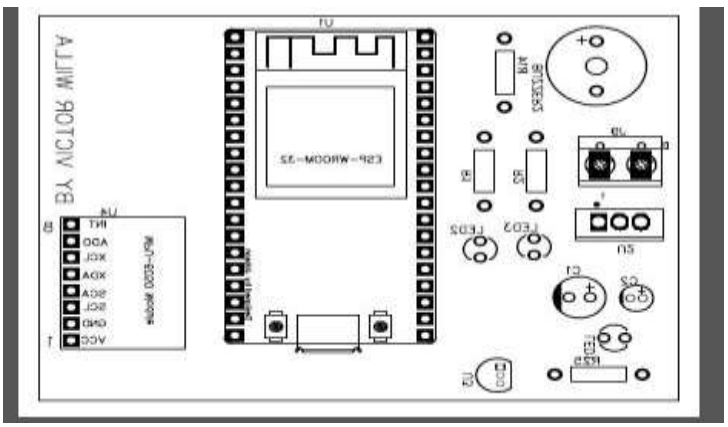

Figure 6: Sensor Node

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4.0 RESULTS AND DISCUSSION

Brix and alcohol content are key and crucial quality factors in the wine making process. It is essential to maintain these parameters in the entire fermentation process. The result readings indicate the measurement of alcoholic content by Specific gravity.

Figure 7: Display of the readings at station

5.0 DISCUSSION OF RESULTS

The Specific Gravity SG is the scale used to determine the potential alcohol by volume and Brix [13]. It's a dimensionless quantity which indicates the relative gravity of different stages of fermentation. It indicates the amount of fermentable sugar or possible alcohol percentage of alcohol by volume.Different stages of process yields different results. The Figure 7 represents brix % potential alcohol 5% and SG 1.065

6.0 CONCLUSION AND FUTURE WORK

Monitoring from handheld alcohol refractometers consumes time and it is expensive in terms of human and financial resources needed to perform the monitoring process. Furthermore, the observations and outcomes showed that the Brix and Alcohol readings were subjective to human readings. As a result, based on existing literature and sensor technology, this study aimed to design an improved monitoring system that could eliminate the existing challenges in Fermentation. The study focused on the use of wireless sensor technology to improve information flow from the Sensor node to the central station. The developed system consists of a sensor node and web API monitoring tool.This study has been limited by development of single node

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