APPLICATION OF PLC & SCADA IN HIGH QUALITY MEDIUM SCALE JAGGERY PRODUCTION

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Abstract- **Jaggery (Gur or Panela) is a natural sweetener, made by evaporating water from cane juice, thereby making it highly concentrated as a thick semisolid paste. Jaggery being the purest form as it is free from chemicals is known as a substitute for sugar which is manufactured chemically. Conventionally, jaggery manufacturing is a tedious and unhygienic process, involving risky working conditions. This paper elaborates a whole new process for jaggery manufacturing, providing a hygienic and fully automated manufacturing environment, hence reducing the manpower involved. The main controlling and consoling unit is a PLC (Programmable Logic Controller). PLC interfaces all the inputs and the outputs. The Switches, and the Sensors are the Inputs while the Valves, Machines, LED's, Conveyers, etc. are the Outputs. Jaggery production essentially involves following steps viz. harvesting of raw Sugarcane, Precleaning, Crushing, Filtration, Boiling, Concentration, evaporation and finally filling them into moulds. All the machines are controlled by the PLC and proper working of the whole plant is monitored through SCADA (Supervisory Control and Data Acquisition). Various additives are added for enhancing the quality and clarification of Sugarcane juice at the time of boiling. Proper automated filling in moulds is done to give it a proper shape. The process for jaggery manufacturing will therefore result in both, enhancing the rate of production and the quality of jaggery and thus jaggery production will be more profitable for the Sugarcane growers. Thus, by using automated technologies, many commercial availabilities become needs of the hour to sustain future profitability in jaggery production, thereby having a direct effect on health and wealth of people.**
Keywords: jaggery, PLC, sensors, valves, SCADA, value addition.

1. INTRODUCTION

Jaggery is the natural sweetener obtained on concentrating the sweet juices of sugarcane or date with or without prior purification of juice and without use of any chemical/synthetic additives or preservatives, into a solid or semisolid state[1]. Jaggery is known by different names across the globe. It is known as Gur in India, Desi in Pakistan, Panela in Mexico and South America, Jaggery in Burma and African countries, Hakuru in Sri Lanka and Naam Taan Oi in Thailand. Jaggery is also termed as "Gur" in North India and "vellum" or "bellam" in South India [1]. Jaggery is the one of the main agricultural products which is widely used in individual households, eateries, restaurants, hotels and clubs and Industrial Applications [2].24.5% of the sugarcane produced in India is utilized for Jaggery production, by the world's production more than 70% of the Jaggery is produced in India[3]. Jaggery has enormous health benefits. It contains proteins, vitamins and prescribed as a medicinal sugar which cures health problems like dry cough, cough with sputum, indigestion, constipation, etc. by Ayurveda [1]. Jaggery is very rich in iron and prevents Anaemia.

The process of producing Jaggery is carried out in five stages i.e. crushing of sugar cane, storage of sugar cane juice, heating of the juice, cooling and filling in moulds[4]. The conventional method for Jaggery production is a very tedious and unhygienic process which involves lot of health risks for both the workers and consumers. In this paper we are discussing a whole new hygienic process for Jaggery production and its proper packing which increases its shelf life. The main controlling and consoling unit of the whole plant is a PLC and the whole plant can be monitored through a SCADA system.

1.1 PLC

PLC or programmable controller is an industrial digital computer which has been ruggedized and adapted for the control of the manufacturing process. PLC is a digital computer or industrial computer used for automation of various processes [5] such as assembly lines, or robotic devices, or motors or any activity that requires high reliability, control and ease of programming and process monitoring. The main difference from other computers is that PLC's can adopt harsh conditions (such as dust, moisture, heat, cold) and have the facility for extensive input/output (I/O) arrangements [6][7]. All the inputs and outputs such as sensors and actuators are connected to these I/O arrangements. PLC's read limit switches, analog process variables (such as temperature and pressure), and the positions of complex positioning systems. On the actuator side, PLC's operate electric motors, pneumatic or hydraulic cylinders, genetic relays, solenoids, or analog outputs. The input/output arrangements may be built into a simple PLC, or the PLC may have external I/O modules attached to a computer network that plugs into the PLC.

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1.2 SCADA

The long form of SCADA is Supervisory Control and Data Acquisition, It is more frequently known as SCADA. As the name implies SCADA system supervises, acquires and control data received from a distant data source from the control center. SCADA system is located in the control center and is operated in the scanning mode, communicating between the CONTROL CENTER and the REMOTE STATION by means of two-way communication channels [13]. Through SCADA system we can find smallest of the faults in the ongoing process or plant. On the basis of information received, the operator makes necessary decisions via the control system; he can then perform different control operations in power station and make necessary changes in the plant [13].

2. LITERATURE REVIEW

The conventional jaggery making process takes a large amount of time and the process too is not at all hygienic since all the pits and pans from the juice storage to the drying of hot semisolid paste remains unclosed, thus the juice gets contaminated by insects most of the times. Figure 1.shows a brief view of conventional jaggery making process. In a paper by Hosamani, R. and Desai, R.S. (2014), they automated the Jaggery manufacturing process using microcontroller. But the whole process was not automated properly and it was for small scale Jaggery production. Recently Sinde et al (2016) worked on Automation of Jaggery plant using PLC, but the level of automation was not up to the mark and they didn't focused on the plant safety. Singh (1998) and Banerji (2008) showed that the juice collected from storage tank is clarified during the boiling stage. It is mostly done by using lime. Calcium acts as complexing agent and form scum. Addition of lime also improves the consistency of jaggery by increased crystallization of sucrose, but at the same time it darkens the colour if added in excess. Vegetative clarificants like mucilage's of bhendi, chikani, kateshevari, deola (Hibiscus ficulneus) are used .Out of these vegetative clarificants Deola (Hibiscus ficulneus) was found to be most effective.

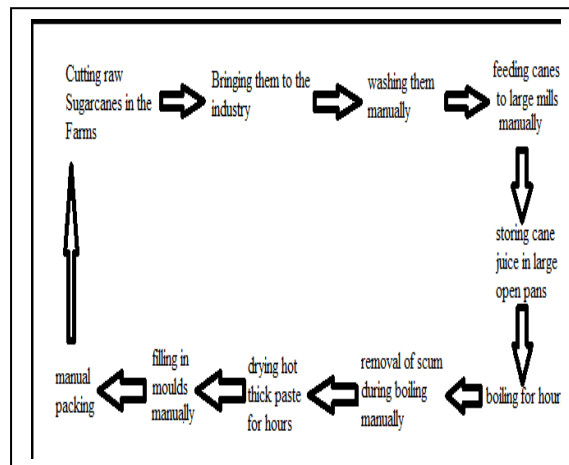This paper shows a fully automated process for hygienic production of Jaggery.

Figure 1: Conventional jaggery making process

3. BLOCK DIAGRAM

Block diagram shows (Figure 1.)the I/O arrangements on the PLC. All the inputs are obtained across the input side of the PLC by HLS (High Level Sensor), MLS (Medium Level Sensor), LLS (Low Level Sensor) and Temperature Sensor, etc. On receiving the inputs, the output movement of various motors, valves, heating of the rods in the tank, etc. are obtained.
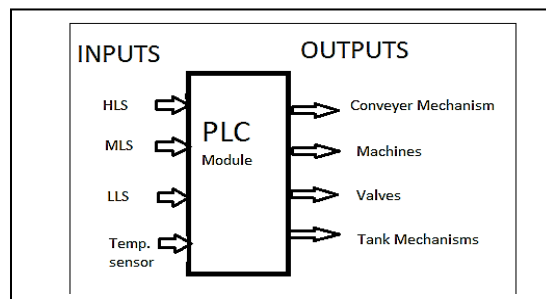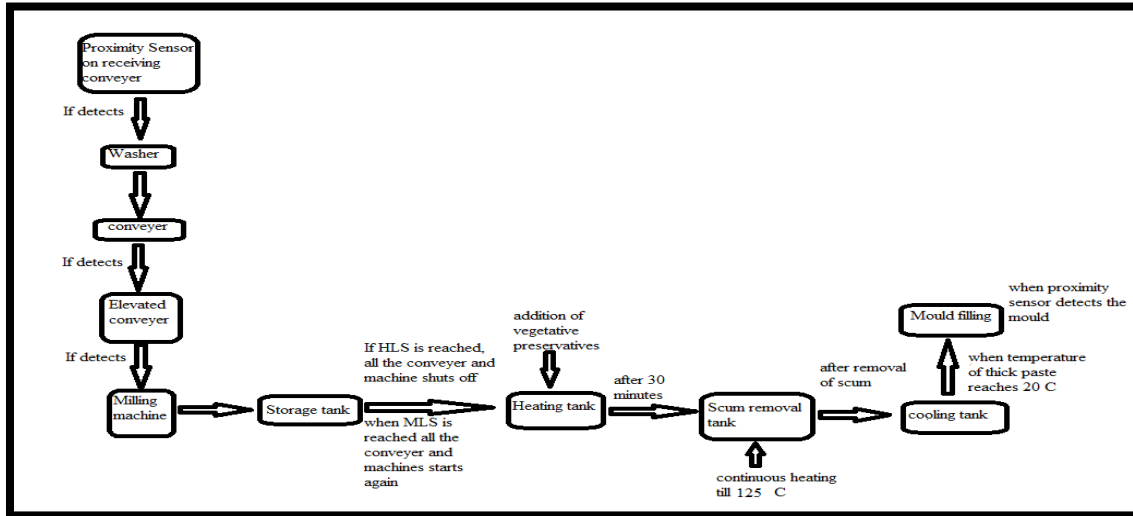

Figure 2: PLC Block Diagram

Figure 3: Flow chart with network of sensor

4. METHODOLOGY

The entire plant is connected through a network of sensors (Figure 2.) shows the flow chart of the plant with the network of sensors. Fresh Sugarcane harvested are cut down into homogeneous pieces by sophisticated machinery in the farms and brought to the industry. Sugarcanes are loaded on to a receiving conveyer, which takes the cane to a cane washing machine. In this machine the pieces of canes are washed under high pressure of water, thus cleaning the outer surface of the sugarcanes thoroughly. Then the washed sugarcanes are transported to the large milling machines by an elevated conveyer. The milling machines are located just next to this conveyer, so the conveyer forces the sugarcanes into the large milling machines. This results in extracting the sugarcane juice to the full extant. The extracted juice flows through pipes to a large storage tank. The tank is fitted with a screen to filter the large impurities present in the juice coming through pipes. When the juice reaches the HLS, all the machines and the conveyers shut down. The process starts again when the level of juice reaches the MLS. After this the juice is transferred to the heating tank, here the juice is heated with the help of heating rods for 30 minutes. During this time some vegetative preservatives are added to the juice, about which we will discuss in the next paragraph. After 30 minutes of heating in the heating tank the juice is transferred to a scum removal tank. Heating is continuously carried out in this tank till the temperature of the juice reaches 125° C. This tank is fitted with an arrangement of a horizontal scumremover, which skims off all the scum which forms during heating in this tank.This scum remover skims all the scum from the surface of the juice.Because of heating all the dense particlecome to the top most layer of the juice and hence can be skimmed off by the skimmer.

After the removal of all the scum, the hot juice is transferred to a cooling tank, where the thick paste is cooled down to a temperature of 20C. After all these the thepaste is filled in the moulds with the help of pneumatic filling system and the conveyer system.If the Proximity sensor connected to thereceiving conveyer doesn't detect the sugarcanes, neither the motors of the receiving conveyer gets started nor the cane washer machine. The samepaste is filled in the moulds with the help of pneumatic filling system and the conveyer system. If the Proximity sensor connected to the receiving conveyer doesn't detect the sugarcanes, neither the motors of the receiving conveyer gets started nor the cane washing machine. The same applies to all the proximity sensors connected to the conveyers. In case of filling system, when the proximity sensor on the filling conveyer detects the moulds, the conveyer stops and filling operation is performed.

5. VALUE ADDITION

During Heating in the boiling tank an aqueous extract of Deola (Hibiscus ficulneus) is added to the juice for clarifying the juice. Because of the addition of Deola the small impurities present in the juice forms scum and on heating the scum comes upwards and can be removed by a horizontal skimmer as discussed before. When all the scum formed is removed, the juice becomes transparent and yellowish brown in color [8] [9] [10]. Phyllanthus emblica(Amla), the Indiangooseberry. It is mostly used as a rejuvenator in Ayurveda. Amla ha high nutritional value with a great medicinal use and the richest source of vitamin C, the pulp of fresh fruit contains 200-900 mg of vitamin C. In living organisms, ascorbate acts as an antioxidant by protecting the body against oxidative stress. Due to its strong, cooling and laxative properties it has been widely used in hemorrhage, diarrhea and dysentery. It also prevents infection due to the antibacterial and astringent attributes present in it. It is widely used for treatment of leucorrhea and atherosclerosis. Gooseberry juice has great strength to replenish your lost energy source. Value-added jaggery may fetch better market prices and will have great export potential. Amla is added in jaggery to improve its taste, nutritional value and ultimately to make value added product [11].

The process for making jaggery with amla as a natural source of vitamin C includes processing of amla in suitable form, quantity to be added and the suitable stage for addition in jaggery. Analysis of samples indicated incorporation of 75.4mg of vitamin C/100 g of jaggery sample[1]. Jaggery may be value added with different natural flavour (ginger, black pepper, cardamom,

lemon etc.), nutrition (protein, vitamins), texture (additives) and taste (additives like nuts, spices, cereal and pulses) [12]. The value addition of jaggery has tremendous scope as there was lack of past work on value addition. The value addition improves the nutritional value of the jaggery by adding various vitamins, minerals which are not present or in fewer amounts.

6. HARDWARE & SOFTWARE USED

The hardware used is a 16I/O Allen Bradley Micrologix1000 PLC. It is an economical PLC and easily available. It requires 24VDC to operate. If high voltage needs to be operated across the PLC output than SMPS (Switch Mode Power Supply) can be used. On the input end the sensors and switches are connected and on the output end the valves and motors, etc. Are interfaced as shown below in the block diagram (Figure 2.). The software used is RS Logix Micro Starter lite and the PLC is programmed using Ladder Logic language (Figure 5). The software used for SCADA is U Can Code SCADA Software.

Figure 4: A 16I/O Allen-Bradley PLC

7. PLANT DESIGN IN SCADA

Figure 6 Shows the typical design of the plant in the SCADA software and the names of the various parts are discussed below.

1. Pieces of Sugarcanes are carried to the Plant by truck. 2. Sugarcanes are loaded on to the receiving conveyer. 3. Proximity sensor on receiving conveyer. 4. Sugarcane washer. 5. Conveyer. 6. Proximity sensor on receiving conveyer. 7. Elevated conveyer. 8. Proximity Sensor. 9. Conveyer. 10. Led Screen. 11. Large sugarcane crushing mill. 12. Smaller sugarcane crushing mill. 13. Pipes. 14. Storage tank. 15. Level sensors. 16. Boiling tank. 17. Stirrer. 18. Temperature measurer. 19. MLS. 20. Pump. 21. Molasses tank. 22. Pump. 23. Cooling tank. 24. Pump. 25. Pneumatic filling system. 26. Proximity sensor. 27. Conveyer.
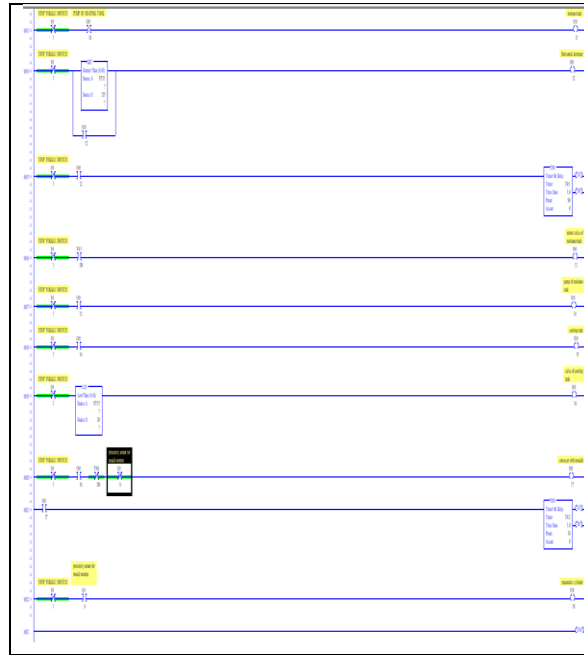
8. LADDER LOGIC

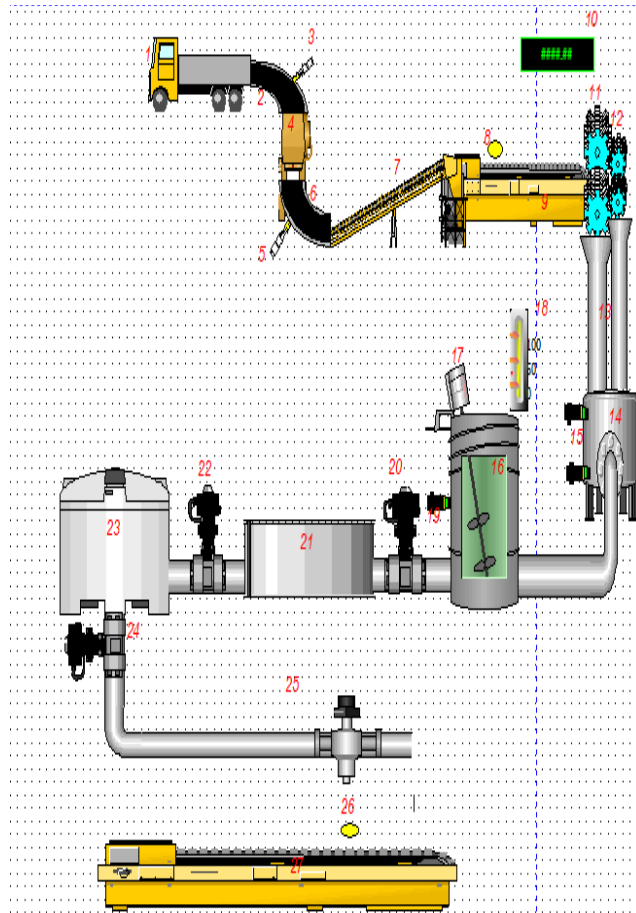Figure 5: Ladder Logic for the Plant

Figure 6: Plant design in SCADA Software

9. RESULTS

Ladder logic is created efficiently and the whole plant can be monitored in a smooth way through SCADA. High quality jaggery can be obtained if this plant is set up.

10. CONCLUSION

The ultimate aim behind this paper was to promote automation because of the benefits, which can be derived from it and to enhance the efficiency of the jaggery plants. Sugarcane being one of the major grown crops in India needs to be utilized to its full extent and automation can be the best way which can lead to its full-fledged utilization.

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