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Chapter 8

Automation of Integrated System for Grain Beverages Processing

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Abstract

The research work focus on design and construction of automatic system for integrated plant for grain beverages processing. A grain beverage processing plant is a complex system that integrates several operations (blending of soaked grains, mixing the slurry, extracting the aqueous liquid and discharging of the paste out of the machine) together and finished in one go. Incorporating an automatic system into the integrated system simplify its mode of operation. Essential design consideration, analysis and calculations were carried out in order to determine and select materials of appropriate strength and sizes for various part of the automatic system. The major parts of the automatic system includes power supply unit, transformer, filter capacitor, voltage regulator, power indicator, pre-set buttons, time controller, eprom, display unit, controllers, limiting sensor, solenoid valve and electro-mechanical switch. The system was designed to have two controllers, one interfaced with the button network and the other organized the operational time (blending, sieving and paste expelling) in minute. Results of the testing revealed that the highest machine output of 90.24 L/h was obtained from speed of 1650 rpm using the integrated machine with automated system, low value of output of 52.64 L/h was obtained from the same speed using the integrated machine with semi-automatic system. The least machine output of 32.59 L/h was obtained from the same speed using the integrated machine without the automated system. The machine output was found to be influenced by both the automatic system and machine speed. The automatic system allows efficient work flow, reduces human labor, ensure safety and hygiene product production by eliminating human interference. Also it increased the machine output by 67%, reduce operational time by 65% and completely eliminating human interference with the product.

Keywords: automated, beverages, grain, integrated, system

1. Introduction

Automation in farm machineries and processing is a very important factor considered to reduce losses, achieve faster and better ways of food processing so as to meet the increasing demands of consumers. Food processing is an important operation that contributes immensely in economic development of the states as it is vital in ensuring food availability and security all over the globe. According to Gana [1] the production process of most agricultural food materials is multi operational process, comprises of many different unit operations requiring separate equipment.

The present trend in agricultural food manufacturing and processing is focused on automation of integrated system that combines many batch operations into single manufacturing system. The design provides on-line and continues control capacity. According to Gunasekaran [2] most of the automation systems carried out in food industries are isolated, batch-type operations targeting a specific task. Steve [3], reported that food processing and manufacturing operations in small and median enterprises (SME) are basically carried out manually unlike in larger industries where automations were achieved either with the aid of robots or combination of simpler electromechanical devices [3].

Food Processing has been defined by Gana [1] as the alteration of raw food materials into consumable state or the later into other forms. According to Rachel [4] food processing involves the use of clean raw materials either from crops or animal product to produce good-looking and profitable products and animal feed. It also helps in extending the shelf-life of these products. Food processing removes toxic materials from food, enhanced preservation, marketing, increased food concentration and availability of several foods which are beneficial to the consumers. The author stated that health standard of certain group of people with specific health problems such as diabetes and allergies can be improved through modern food processing. Also additional nutrients can be added to certain class of food that lacks such nutrients. It sometimes involves mechanical processes that employ the use of mixing and grinding equipment and machines in the production line. The author also stated that in food processing industry, the food performance parameters are vital element necessary in the design process. Some of these parameters include: hygiene, energy efficiency, labor used [4].

1.1. Importance of automation in food processing

According to Jijo and Ramesh Kumar [5] some of the advantages of automation in food processing include improved productivity in processing line by allowing efficient schedule of work flow and labor utilization. Also it ensures high quality products consistently thereby encourage customer loyalty and this result to expanding market share. In addition one of the major advantages of automation is ensuring food hygiene and safety by eliminating human interference with food product.

For successful automation of agricultural food manufacturing and processing an integration of the manufacturing process must be carried out with view of transforming the operations into single manufacturing design.

1.2. Unit operations involved in beverages production from grains

The production of beverages from grains involved series of unit operations. The major unit operations include steeping, size reduction (milling), mixing, sieving, filtration, paste discharge, sedimentation, boiling, storage and packaging [1].

1.3. The present status of grain beverages production

The available machines are made from mild steel materials and with frequent contact with water, rusting easily take place. This can easily lead to contamination of the food materials thus decreasing quality of the final food product. Also the production process involve different steps using various machine and equipments that make the production procedure tedious, time consuming and products are predisposed to contamination as results of human interaction and exposure to the environment. In additional there is possibility of contamination of beverages as result of wearing of component parts of milling plate with time of use. Furthermore, unlike milling machine the sieving machine is not easily accessible by the local processors. It is expensive and its mode of operation is complex [6]. Therefore there is need to develop an automated machine plant capable of integrating the various unit operations such as blending soaked grains, mixing of the slurry, extracting the aqueous liquid and expelling the paste out of the machine into single operation [1, 7].

Hence, the design and construction of an automatic system for grain beverages processing plant capable of blending soaked grains, mixing of the slurry, extracting the aqueous liquid and expelling the paste out of the machine in one compartment became necessary in order to improve on the functionality of the already existing grain drinks processing machine.

2. Materials and methods

2.1. Materials selection

A Grain beverages processing plant developed by Gana et al. [7] was used in this study. Grain processing plant is complex machines that can blend soaked grains, mixed the slurry with water, sieved, extract the aqueous liquid and expelled the paste out of the machine. The machine is shown in **Figure 1**.

2.2. Integrated system description

The system is made up of the following components; outer casing made up of stainless sheet and a liquid out let valve was fitted to its bottom side in order to allow out flow of extracted aqueous liquid from the tank. A paste outlet chute was also fitted at the bottom of the casing for discharging of expelled paste as shown in **Figure 2**. Conical centrifugal basket with lower impervious part that allowed thorough washing of the milk from the paste and upper part which is smooth with perforated openings in order to allow fluid drainage and also to prevent paste losses as shown in **Figure 2**. A conical screen was also fitted inside the conical

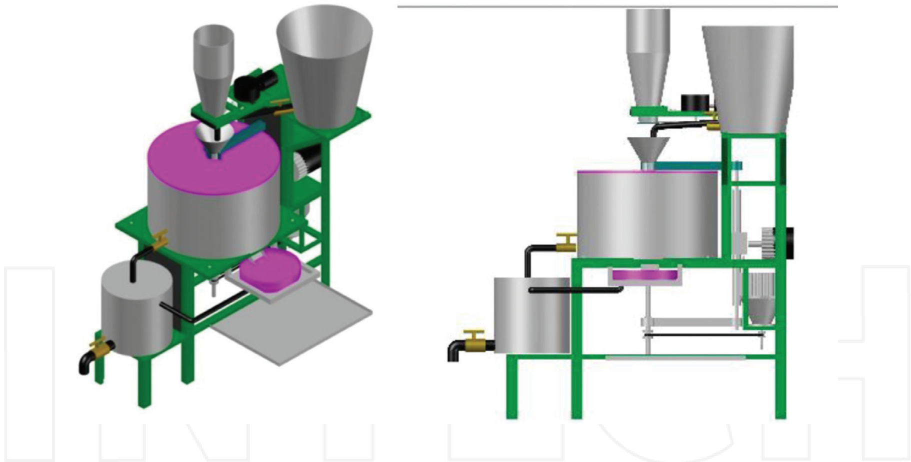

Figure 1. AutoCAD drawing of the machine.

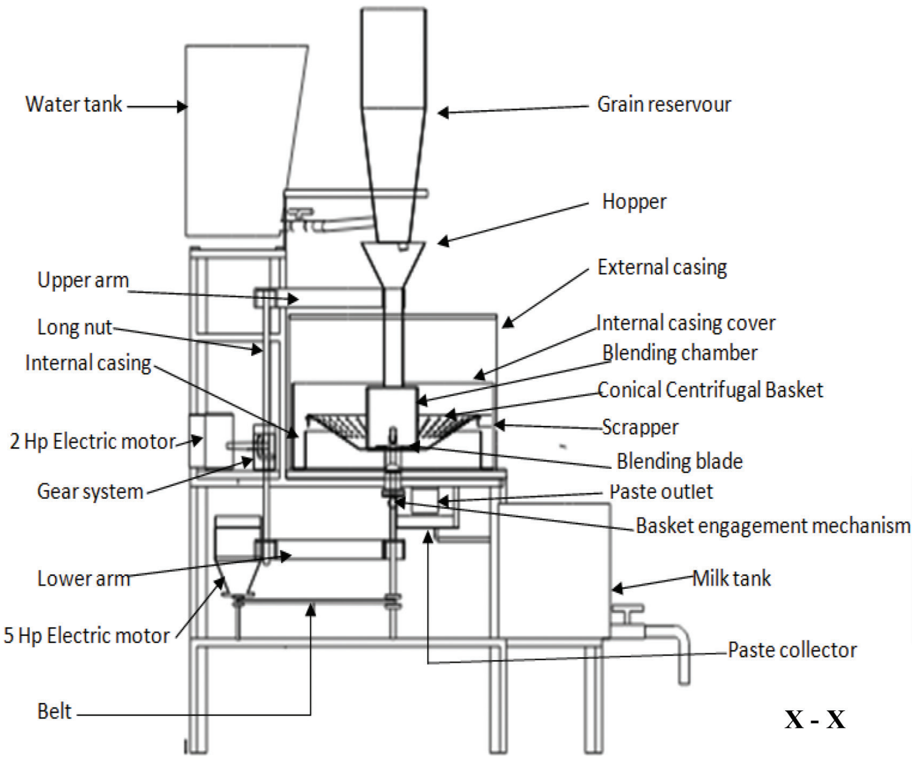

Figure 2. Cross section of the integrated system for grain beverages processing.

centrifugal basket in order to allow fluid drainage and prevent paste losses. Scrapper was attached to the conical basket at the top from outside. It scraped, conveyed and discharged the expelled paste from the basket through the discharge outlet as shown in **Figure 2**. The Internal

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casing was attached to the internal wall of the outer casing. It is cylindrical in shape with its upper side opened in order to allow collection of expelled pastes. The hopper serves as the reservoir where the grains are fed to the machine. It was made up of stainless sheet, and of conical shape as shown in **Figure 2**. The delivery pipe is cylindrical in shape and conveyed the grains directly to the blending chamber; it is shown in **Figure 2**. Blending Chamber is where the blending operation takes placed. It was designed to prevent the materials from spilling and moving out of the blending chamber until after the blending operation is completed, it is shown in **Figure 2**. Blending Blade this is attached to the shaft inside the conical basket. The gear box this controlled the movement of the upper and lower arms. Therefore is responsible for opening and closing of the blending chamber, engagement and disengagement of the basket from rotation [1, 7].

2.3. Design plan of the automation

To automate the system, there is need to have blending and sieving time as both operations cannot occur at the same time. To ensure flexibility, the timing system designed must be programmable so as to ensure the best blending by adjusting the blending time. During blending, the blending chamber has to be closed in order to ensure efficient blending and also the centrifugal basket has to be disengaged from rotation with the central shaft. The flow of the process is shown in **Figure 3** while the block diagram that illustrates the hardware design unit by unit and their interconnection is shown in **Figure 4**.

2.4. Components of automatic system

The Automatic system is a combination of electronic, electrical and mechanical parts. Some of the parts include the following;

Power unit; this unit was made up of the following components: transformer, rectifier, filtering capacitor, voltage regulator and power indicator [8].

Transformer; the transformer used for this purpose was a 15 V 3 A transformer due to its availability in the local store. It steps down the current from 220 to 15 V A.C. A circuit representation of this component is shown in **Figure 5**. A bridge rectifier was employed for this design in order to ensure a smother conversion of the current from A.C. to D.C. However it is important to note that despite the conversion, some element of A.C was still observed with the D.C. power supply [9, 10].

Capacitor; the filter capacitor helps to ensure the complete conversion of A.C. power supply to D.C. power supply. The electrolytic component has to be carefully selected based on filter capacity and dielectric voltage. Usually, the dielectric voltage which is often written on the body of the capacitor must be greater than the voltage supply to the component when connected to avoid damage, it is shown in **Figure 5** [11].

Voltage regulator; this help to achieved steady voltage supply to drive the whole control system. This parameter is often times influenced by the demand of the circuit. In this design, 5 V is demanded by the controllers which by manufacturer's instruction can be powered with 3 to 5 V for effective workability. For this reason 7805 voltage regulator was used to power the system as shown in **Figure 5** [12].

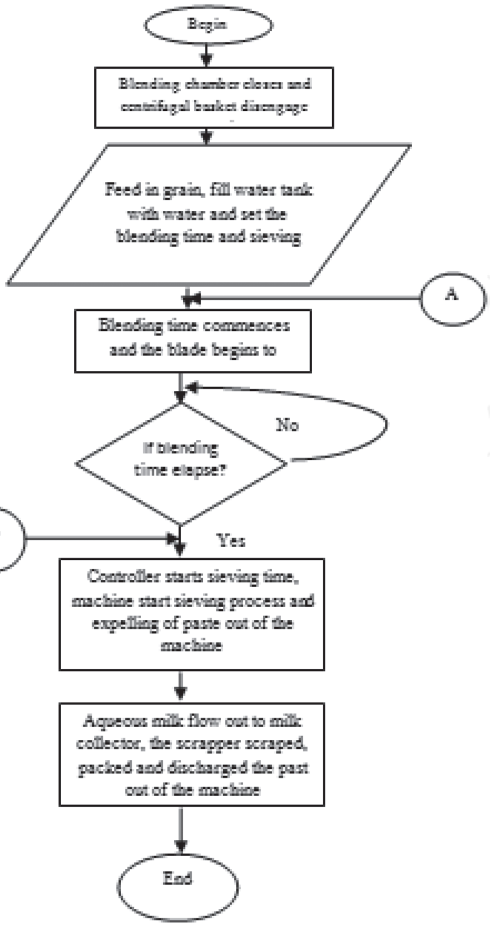

Figure 3. The flow process of the system.

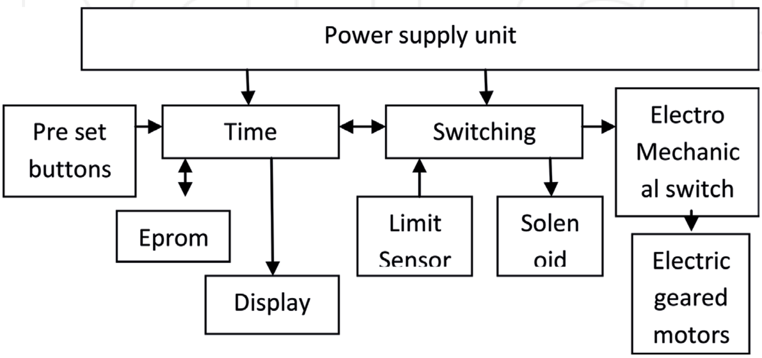

Figure 4. Block diagram of the system.

Power indicator; the purpose of this part of the circuit is to give a visual evidence of the state of live of the power supply. This is achieved via the use a resistor connected in series with a light emitting diode (**Figure 5**) as reported by Thakur and Sharma [13].

Pre-set buttons; this unit helps to preset the blending time and paste expelling time. To achieve this, the switch is connected in series with a resistor so as to achieve difference in logic at different state of the switch. When the switch was opened it is logic HIGH (4.3 V) and when close is logic LOW (0 V), it is shown in **Figure 5** [14].

Time Controller; the time controller (Atmel 89C52) used is compactable with MCS-51. The 8 K byte controller in terms of in-system reprogrammable flash memory can be reprogrammed 1000 times, when the clocking frequency is between 0 Hz and 24 MHz. The device which has 32 bits input-output pins, three 16 bit counter/timer, eight interrupt sources, programmable serial channel is embedded with 252 × 8 bit internal RAM. It is however connected as seen in **Figure 5** according to manufacturers' instruction and programmed using Kiel version IDE for effective functioning. Pin 31 is connected to the V_{CC} (5 V) so as to ensure that the controller fetches instructions from its internal program memory. The reset pin (pin 9) is connected to the mid-point of a resistor capacitor series network. This ensures delay while booting so that the controller fully booths up before performing the instructions. Pins 18 and pin 19 is connected to crystal oscillator of 12 MHz. It is shown in **Figure 5**.

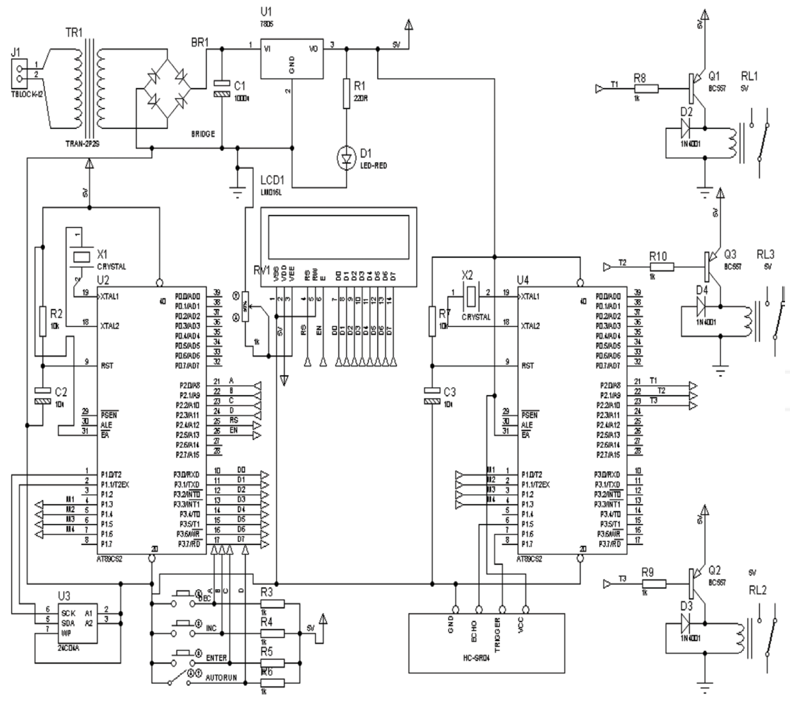

Figure 5. Complete circuit diagram of the system.

Eprom; the Eprom (24C08) used in this project stored the preset data such as the blending time, and paste expelling time. The device is connected to the controller in such a way that it communicates using I^2C. The essence of using the Eprom is to prevent loss of data due to power failure.

Display unit; the display unit used in this work is an alpha numeric 16 by 2 LCD display, it serves as medium of interaction with the operator. The 16 pin device (**Figure 5**) could be interfaced with the controller using 1 byte (using DB0 to DB7) or 1 nibble (4 bits using DB4 to DB7). However to aid a fast display, the 1 byte medium of communication is used. Pin 1 and pin 2 is the power pin of the display connected to ground and V_{CC} respectively. The contrast of the display is adjustable via the use of a variable resistor connected between pin 3 and the ground. According to the data sheet, the logic on pin 4 which is the register select pin and determines if the LCD will display the data sent to it or use it as instructions. When this pin is connected to a pin on the controller and it becomes logic zero (0 V), the LCD takes the data sent to it as an instruction. But if it is logic 1, it takes the data as information to be displayed. Pin 5 which is the read or write pin is connected to ground since the intention is to write not read [13].

Switching Controller; this unit interfaced with the relays and responsible for the relay (mechanical switches) actions which are used to control the electric motors. Atmel 89C52 used in this unit is also interfaced with the time controller unit so as to know what operation or motor to control at a particular time. The basic connection of this unit is like that of the time controller unit. It is shown in **Figure 6**.

Limiting sensor; the limiting sensor (ultrasonic module HC-SR04) helps to determine the maximum distance the arms will be move upward in order to open the blending chamber and to engage the basket in rotation with the shaft and also the distance the arms will move downward in order to close the blending chamber and to disengage the basket in rotation with the shaft. This is interfaced with the switching controller so that whenever the command is given to move the arms either upward or downward, it will stop motion when the exact distance is

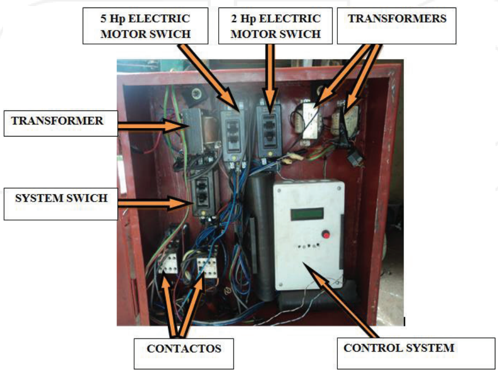

Figure 6. Component part of the automated system.

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Figure 7. Block diagram of the electromagnetic switch unit.

moved. The four pin device receives a trigger pulse of 10 μs from the controller to transmit a burst of 40 KHz. If an obstacle is seen in line of sight, the ultrasonic burst is reflected at the echo pin giving a pulse width which ranges from 120 μs to 25 ms. However if no obstacle is detected, the echo pulse width remains at 38 ms. This echo pulse width is then read by the controller and the actual distance determined [15, 16].

Electro-Mechanical switch; this unit is called the actuator, it consist of driving relays interfaced to the switching controller via a transistor as shown in **Figure 7**. The reason for driving the contactors with a relay is because they (contactors) are A.C. driven so cannot be driven directly with the controller. For this project tow contactors were used to change the direction of AC motor that aids the opening and closing of the blending chamber and to control the spinning of the blade to blend and stop blending [14].

Electric motor; the two electric motors used in this design are A.C powered motors. The 2 Hp electric motor was used to close and open the blending chamber as while as for engagement and disengagement of conical basket in rotation with the central shaft. While the 5 Hp electric motor was used to operates the central shaft, blending blade and conical centrifugal basket.

2.5. System design analysis

2.5.1. The power supply circuit

A step-down transformer with turn's ratio of 16:1 was selected to transform the 240 V mains supply voltage to 15 V for the power supply. The 15 V ac was converted to dc voltage using a full wave rectifier circuit. The circuit was designed as reported by Agbetuyi and Orovwode [17], and is given as follows;

$$\gamma = \sqrt{V_{dc}^2 - V_{ac}^2}/V_{dc} \tag{1}$$

$$V_{dc} = V_m/1.414 \tag{2}$$

$$V_{ac} = (2/\pi) \times V_m \tag{3}$$

$$V_m = V_{sp} - V_b \tag{4}$$

$$V_{sp} = 1.414 \times V_s \tag{5}$$

$$V_b = 2 \times V_{dd} \tag{6}$$

Where, γ is ripple factor for a full wave rectification process using a diode bridge (V), V_{dc} is rms value of output dc voltage of the diode bridge (V), V_{ac} is average value of the diode bridge output voltage (V), V_m is peak output dc voltage from the diode bridge (V), π is constant (3.142), V_{sp} is peak value of transformer secondary voltage (V), V_s is transformer secondary voltage (V), V_b is voltage drop across the diode bridge at any instant (V), V_{dd} is diode forward conduction voltage drop (V).

The ripple in the output voltage is directly proportional to the output current and is related to the filtering capacitance by the following equations as reported by Agbetuyi and Orovwode [17],

$$C = I/(2 \times f \times V_r) \quad (7)$$

$$V_r = \gamma \times V_{sp} \quad (8)$$

But $dV_{sp} = V_r$

$$f = t/2 \quad (9)$$

$$q = I \times t = C \times dV_{sp} \quad (10)$$

Where, C is capacitance value (μF), I is required output current from power supply circuit (A), t is time taken for filtering capacitor to discharge in compensation for the ripple in the dc output (s), f is frequency of the ac mains supply voltage (Hz), q is charge on filtering capacitor (A), dV_{sp} is peak value of transformer secondary voltage (V).

2.5.2. The sensing circuit

The sensor designed was made up of two conducting metal plate of 7 cm length and 5 mm width each placed on the machine frame above and below the upper arm of the engagement mechanism. The distance of separation of each of the plate from the arm was 6 cm. The plates were connected to the circuit.

2.5.3. The control circuit

A 555 controller was used as the brain of the control circuit due to its operational characteristics in the monostable mode. The timer was used to produce 11.01 V to energize the relay coil, consequently activating the 2 Hp motor circuit for 7 s, which is the time needed for the blending chamber cover to open for 25 mm when the upper arm is moving upward (expelling of paste from blending chamber) and also to close that space when the upper arm is moving downward (for blending operation to take place)

$$R_t = T_{EB}/1.1 \times C_t \quad (11)$$

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R_t is resistance tying the discharge and threshold pins to V_{cc} (V), T_{EB} is the time needed for opening and closing of the blending chamber cover during expelling and blending operation respectively (s), C_t is capacitance tying the discharge and threshold pins to ground (μF).

2.6. Working procedure of integrated system

The integrated system was designed to be operated in three forms with; the developed automatic system, semi-automatic system and without the automatic system.

2.6.1. Operating the integrated system with automatic system

The controller U2 interfaced with the button network (enter, INC and DEC), Eprom (U3), LCD (LCD1) and the other controller U4 is used to organize the time for blending, sieving and paste expelling time in minute. Firstly, when the system is powered, it will give a welcome message before asking for the operational (blending and paste expelling) time setting. When all these settings are done, the autorun switch is closed to save the parameters into the Eprom and enable the system into normal operation (**Figure 8**). During the operation, after the grains have been fed into the machine, and the water tank filled, the controller U2 through P1.3 which is connected to P1.0 of U4 sends a control signal (Logic HIGH) to U4 for the period

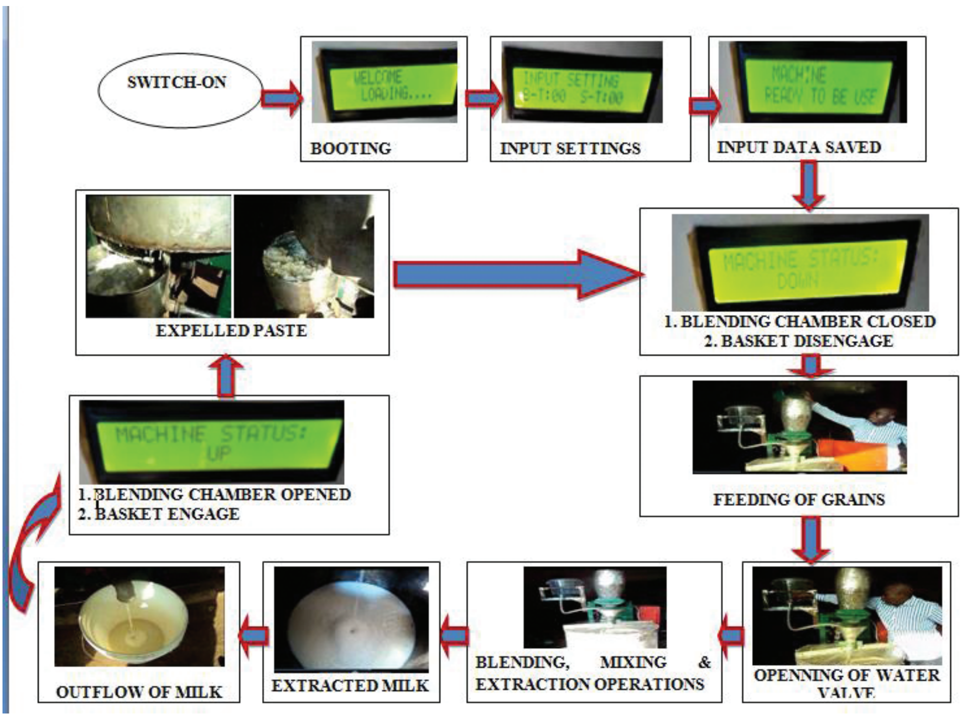

Figure 8. Mode of operation of the automated system.

of the blending time. This aids the energizing of relay (RL1) which links the contactor to AC power supply, powering the motor for the shaft to close the blending chamber. Three seconds later the line M2 which connects P1.4 of U2 to P1.1 of U4 becomes HIGH to start the blending. When the blending time is exhausted, M1 and M2 goes LOW and then the controller U2 makes M3 goes HIGH to start sieving and paste expelling.

2.6.2. Operating the integrated system with semi-automatic system

The system can also be operated in semi-automatic mode using the two contactors without the control system. This was achieved by switching on the first contactor which in turn activates the gear system to rotate in cloanti close wise direction, thereby moving the arms downward to close the blending chamber and to disengage the basket from rotation with the central shaft, for blending operation. After the blending operation is completed the first contactor is switched off and the second is switched on to activates the gear system this time to rotate in anti-clockwise direction. Thereby moving the arms upward to open the blending chamber and to engage the basket in rotation with the central shaft for sieving and paste expelling operations. The shortcomings of operating the machine in semi-automatic mode is that the operator has to monitor the upward and downward movement of the arms to ensure proper closing and opening of the blending chamber, as while as the engagement and disengagement of the basket. Also the blending and paste expelling time has to monitor. Unlike when the system is operated with the automatic system here the engagement and disengagement of the basket required that the machine most be stooped.

2.6.3. Operating the integrated system manually (without the automatic system)

In the mode of operation all the settings are carried out manually. Firstly, the upper arm that holds the hopper assembly is lower down until the blending chamber cover rested on the base of the basket. At the same time the lower arm is lower down until the basket is disengage from the shaft. The same setting is also required in opposite direction for sieving and paste expelling operations. The shortcomings of operating the machine manually is that all the settings were carried out manually which is tedious, time consuming and required expertise.

2.7. The constructed automatic system

The automatic system was designed, constructed and embedded to the integrated system as shown in **Figure 9**, while the automatic system and its accessories are shown in **Figure 6**.

2.8. Testing of the automatic system

The performance of the automatic system was evaluated in accordance with procedure reported by Gana et al. [7]. The soya bean (TGX 1954-IFXTGX 1835-10E) was purchased from Bida central market and the samples were cleaned and sorted to remove unwanted materials before soaking at room temperature of 27°C for the recommended time of 12 h [18] before processing using the automated integrated system. Three sets of experiments were carried out to investigate

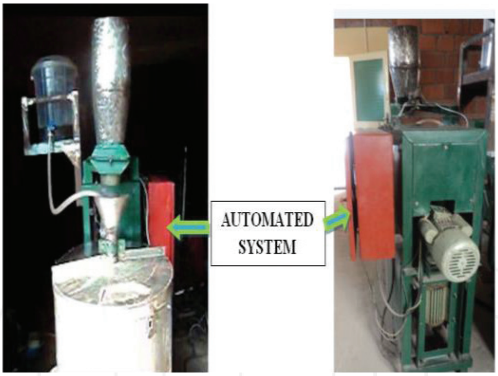

Figure 9. Front and back view of the machine showing the automated system.

the system performance. In the first experiment the integrated system was operated without automation. In this case the opening and closing of the blending chamber covers as while as the engagement and disengagement of the conical centrifugal baskets in rotation with the central shaft were carried out manually. In the second experiment the integrated system was operated with semi-automatic system with aid of two contactors that control the opening and closing of the blending chamber covers as while as the engagement and disengagement of the conical centrifugal baskets in rotation with the central shaft. In the third experiment the integrated system was operated with the automatic system. In each of the experiment the effect of machine operational speeds (850, 1050, 1250, 1450 and 1650 rpm) on the machine output per hour was investigated. The experiments were carried out at the Agricultural and Bioenvironmental Engineering Department of Federal Polytechnic Bida, Nigeria.

2.9. Determination of performance parameters

The machine performance was determined based on machine output per hour.

2.9.1. Machine output

This is the quantity of aqueous liquid obtained after processing the grains. Procedure described in AOAC [19] and reported by Adebayo et al. [20] was used to evaporate water content of the aqueous milk in order to obtain soya milk with total solid content of 7% as recommended by SFAA [21]. It was measured in liters per hour (L/h) as reported by Gbabo et al. [22].

$$M_{OP} = N_{BH} \times \left(\mathrm{W}_{\mathrm{Ac}}/\mathrm{W}_{\mathrm{g}} + \mathrm{W}_{\mathrm{w}}\right) \tag{12}$$

where, M_{OP} is the machine output (L/h), N_{BH} is number of batches in 1 h, W_{Ac} is weight of the aqueous milk with 7% total solid content (Lts), W_{g} is weight of soaked soya beans processed (kg), W_{w} is weight of water used (kg).

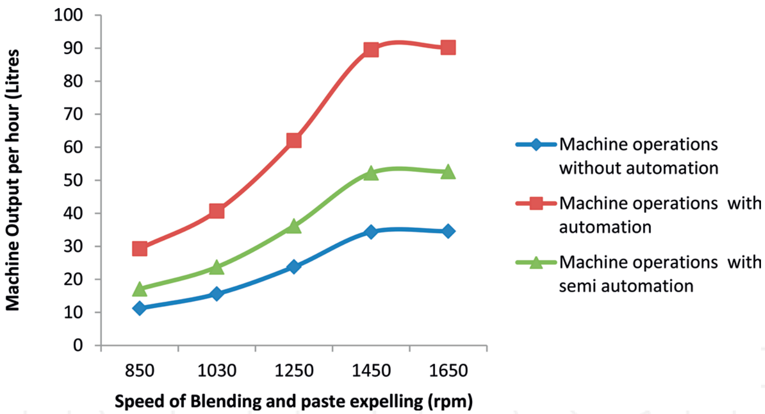

Figure 10. Results of effect of speed and automation system on machine output.

2.10. Experiment results

In all the three testing five levels of speeds of 850, 1050, 1250, 1450 and 1650 rpm were used based on an earlier findings by Gbabo et al. [22] and Gana et al. [7] to determine the effects of speed of machine operation as while as the effects of the automation on the machine output per hour. Each of the experiment was replicated three times using Eq. (12) and the results obtained are presented in **Figure 10**.

3. Results and discussion

3.1. Results

The automated system was designed, constructed and the result of the performance testing is presented in **Figure 10**. The highest machine output of 90.24 L/h was obtained from speed of 1650 rpm using the integrated machine with automated system, low value machine output of 52.64 L/h was obtained from speed of 1650 rpm using the integrated machine with semi-automatic system. The least machine output of 32.59 L/h was obtained from the same speed of 1650 rpm using the integrated machine without the automated system.

3.2. Discussion

3.2.1. Effects of automation on the integrated system (machine) output

The machine output was influenced by its operational speed and as well as by the automatic system. From **Figure 10**, high values of machine output of 29.28 L/h from speed of 850 rpm, 40.68 L/h from speed of 1050 rpm, 62.04 L/h from speed of 1250 rpm, 89.52 L/h from 1450 rpm and 90.24 L/h were obtained when the machine was operated with the automatic system. These values were greater more than values of 17.08, 23.73, 36.19, 52.22, and 52.64 L/h obtained from corresponding speed when the machine was operated with semi-automatic system. Least values of machine out of 11.22, 15.59, 23.78, 34.32, and 34.57 L/h were obtained from corresponding speed when the machine was operated without the control system. The higher values obtained from the former could be as result of elimination of manual settings of the upper and lower arms, closing and opening of the blending chamber cover for blending and paste expelling operations after the milk extraction respectively [1]. The time required for disengaging and engaging the centrifugal basket in rotation with the central shaft for blending and paste expelling operations respectively were eliminated. This indicated that the automatic system therefore reduce operational time by allowing efficient work flow and reduce human labor required. This is in line with the report of Jijo and Ramesh Kumar [5] were automation in food processing was found to improved productivity in processing line by allowing efficient schedule of work flow and labor utilization. The automation of the integrated system also ensure safety and hygiene by eliminating human interaction with the product thereby reduce possibility of contamination of product by human interaction and other factors such as dust, insects among others. This agreed with the report of Nayik et al. [23], where hygiene and cleanness of produced product are among the benefits of automation of food processing plant.

The machine output in both cases was observed to increase with increase in speed of operation. The total time required to process one batch was found to be 5 and 13 min when the machine was automated and non-automated respectively. The machine carried out 12 batches of operation in 1 h when automated and 4 batches in 1 h without automation. Therefore, it increased the machine output by 67%, reduce operational time by 65% and completely eliminating human interference with the product.

3.2.2. Effects of integrated system (machine) operational speed on machine output

From **Figure 10**, in all the three experiments the machine output increased significantly with increase in the machine operational speed. This could be owing to increase in impact force, cutting and shearing actions of the blade with increased in machine speed. Jayesh [24] and Gana [1] had reported that machine operational speed was found to be a key factor to segregation of solid materials. Where higher machine operational speed resulted to higher segregation of materials, while lower machine operational speed resulted to low segregation of materials. It was observed that there is significant ($p \leq 0.05$) differences between the machine output obtained from speed of 850 and 1650 rpm. But no significant ($p \leq 0.05$) differences were observed from machine output obtained from speed of 1450 and 1650 rpm. This could be as results of finer particle produced by speed of 1650 rpm, which clumped together and formed larger particles that clogged the sieve holes. As result of this some aqueous liquid were discharged out together with the paste. This agreed with the result of an earlier study by Douglas [25] where high speed of blending was found to produce finer particles in slurry. This particles clogged together and blocked the sieve holes, thus prevent materials from passing through the holes.

4. Conclusions

A control system for automation of an integrated system for grain beverages processing has been developed and tested. The controller U2 of the system was designed to interfaced with the button network (enter, INC and DEC), Eprom (U3), LCD (LCD1). The second controller U4 was designed to organize the time for blending, sieving and water dispensing time in minute. Test results of the automatic system on the machine revealed that the highest machine output of 90.24 L/h was obtained from speed of 1650 rpm using the integrated machine with automatic system, value of 52.64 L/h was obtained from the same speed when the integrated machine was used with semi-automatic system and low value of machine output of 34.59 L/h was obtained from the same speed when the integrated machine was used without the automatic system. With the automatic system the manual settings and time required for the settings of the machine parts were eliminated. The automated system allows efficient work flow, reduces human labor, it ensures safety and hygiene product. It increased the machine output by 67%, reduce operational time by 65% and completely eliminating human interference with the product. Also the machine output was found to increase with increase in machine operational speed.

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