Design and fabrication of fresh juice vending machine for commercial applications

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Abstract. The objective of this work is to provide a fresh juice in an effective manner to promote the people for drinking hygienic and healthy fruit juices using a single vending machine within 90 seconds. The design has three storage units which are fully refrigerated and the fruits can be placed on the top rack. Below that, a pneumatic mechanism is available to pick and place the fruits of required quantity. A mixture and crusher is made available within the machine to ease the mixing process. Mixture will convert fresh fruits into juicy state and crusher will extract juice from the fruits, milk and water ratio will be controlled by the machine. The entire process is controlled using a raspberry pi which is programmed for every movement and functions of the vending machine. A monitor is attached for the selection of the juice and helps to modify the program on the raspberry pi. A biometric setup is attached with the unit for the people who are using the machine regularly. Overall, the fabricated machine becomes alternative for the soda vending machines, and it can change the morality of the people for drinking fresh juice then and there with a hygienic preparation.

Keywords: Fruit juice, vending machine, pneumatic mechanism, raspberry pi.

1. Introduction

INDIA becomes the second highest producer of vegetables and fruits in the globe. Fruits are important components to maintain human diet because it contains vitamins like A, B, C and important minerals like Calcium and Iron and it meets the daily nutrients requirements to ensure good health for a human. If fruits are consumed regularly in sufficient amount of quantity, which could assist from causing main diseases such as certain types of cancers and Cardio Vascular Diseases (CVDs). Also, automation using sensors provides sophistication to the workers [1]. In past, Fruit juice extraction process become very crude, normally individuals those who needs juice will apply pressure using...
hand during squeezing process in order to get the fruit drink (Juice) out of the fruits (for citrus) and other conventional process like peeling (Orange, apple, pineapple and watermelon). Those methods are primal and it consumes much energy and time; the rate of production is also very low and also the juice will not be available in major public places. Also, consumption of fruits in the form of juice becomes crucial in rural and city areas which enable local farmers to produce high quality and quantity of fruits to increase their economy. Also, the process should reduce the wastage of fruits therefore, there is a need for agricultural scientists, farmers and food process engineers, to produce a low cost affordable machine which will extort juice in their raw forms from fruits at affordable cost. There are two most important methods used in juice extraction process from fruits. In first method, the juice from the fruits are crushed effectively and pressed constantly through a single operation. In the later method, fruits are sliced or carved into small-small pieces and then the slices are processed using an appropriate pressing machine. The juice extraction machines are normally available include: manual juicers, simple juicers and continuous juicers. Automation plays a major role in growth & development[1] of food product selling sectors using the modern selling method. It helps in improving the quality of selling process. Nowadays in cities, the vending machine plays a major role in food product selling and also in several processes. A vending machine is normally an automated machine which provides items such as beverages, snacks, alcohol, cool drinks and lottery tickets to the clients by paying directly as cash or through a credit/debit card, or specially designed cards which can be inserted into the machine.

2. Literature survey

Normally, hygienic problems in humans cause due to the local methods of juice preservation (which uses chemicals) and juice extraction (adding preservatives), time and also energy wastage occurs because of hand squeezing. Normally process like hand squeezing induces work related musculoskeletal disorders and become serious, causes several pain for the workers[1]. PLC as a controlling unit to actuate the fresh pulps in vending machine was proposed. They have two modes for the quantity of the outcome[2]. A fruit juice extracting machine was manufactured and carried out a performance evaluation study with a function of the machine's extraction efficiency[3]. The developed extractor consist of frame, connecting screw rod, screw jack, pressing mechanism, feeding pot, interlock, receiving pot and discharge mechanism. The process of fruit juice extractor normally involves the crushing of fruits, squeezing it with maximum force and compressing the whole fruit with a maximum pressure in order to obtain the fresh juice without or with fruit bulb/flesh which conventionally reduces the bulkiness of the fruit to liquid. Such hand extraction process is normally slow due to human work and took more time, become tedious and most of the time it’s hygienic
enough to attract peoples. The advantages of using automated machine for fruit juice extraction are: consumes less time to process, improves the performance efficiency, capacity and reduces the spoilage and waste[4]. The process of fruit juice extractor normally involves the crushing of fruits, squeezing it with maximum force and compressing the whole fruit with a maximum pressure in order to obtain the fresh juice without or with fruit bulb/flesh which conventionally reduces the bulkiness of the fruit to liquid. Such hand extraction process is normally slow due to human work and took more time, become tedious and most of the time it's hygienic enough to attract peoples. The advantages of using automated machine for fruit juice extraction are: consumes less time to process, improves the performance efficiency, capacity and reduces the spoilage and waste[4].

A small scale motorized automatic orange juice extracting machine was developed using commercially available construction materials[5]. In past, several juice extractors were designed to automate the process. The key component parts of the extractor is which made of stainless steel and are mostly mechanically driven using an electric motor. A multi fruit juice extracting machine using a screwed shaft which is made of iron was fabricated [6]. The extractor normally works with the principle of compression using pressure and mostly squeezing process. The use of various units to process the fruits into juices was proposed[7]. Screw shaft is mainly used to compress the fruit pulps and they show the efficiencies for various fruits. The final aim of fabricating a machine is to extract juice from fruit as much as possible, to achieve more profit for the farmers. It is still better, if the developed presser can extract, almost all moisture content present in fruit and also can lower its dumping costs as well[8]. The fruit variety, ripening stage, agro-climate conditions, texture, fruit processing, and extraction technique, sanitary and waste disposal normally influences the worth of juice products and also could be controlled cautiously to maintain the adequate quality of fruit drink the materials used for components are elaborately explained in [9, 10]. V belt and 4 hp electric motor has been used for their mechanism. They also mentioned the cost of their product. Considering, all above works, the objective of this work is framed such that to design and fabricate a low cost affordable vending machine to extract juice from fruits which can be placed at crowd places for public access.

3. Methodology and advantages

In this proposed work, the fruits are loaded at top and various sensors have been provided to check the status of the entire machine and update its status to the server which is fitted to the machine. Under any faulty condition of any components, the machine will sent an error message to the owner as well as the machine location through GPS module connected via. Raspberry pi model B. The entire system
has been automated and various feedback networks have been provided to check the status. In order to obtain elevated efficiency, and dependability, the machine was designed considering the following aspects:

- The machine should be comparatively inexpensive and be within the buying ability of normal persons.
- The machine should have the capability to handle several range of fresh fruits.
- The machine must be manufactured with approved food grade materials.
- The fabricated machine should reduce the labor force as like in traditional methods of handling, processing & preservation of fruits.

Figure 1 show the block diagram of the proposed machine and step by step procedure of the process which will be carried out in the machine.

Figure 1. Block diagram of fresh juice vending machine

4. Materials used

The machine/extractor is broadly consist to three key parts; first belongs to the mechanical setup involving the frame, Shafts and Bearings. Second important part is the electrical circuit which involve limit switch, relays, microcontroller, linear Encoder, SMPS and Transformer and the third part is Pneumatic system involving Pneumatic Cylinders, DCV, Hoses. All the three units work with synergy
to perform the Automatic fresh juice vending process. Once the inputs from the Limit Switches and linear encoders are obtained and on checking the condition with microcontroller, if any uncertainty found, then emergency shutdown will occurs. Table 1 lists the various components which are used to fabricate the machine with its details and specifications.

**Table 1. Components used for fabrication**

| S.NO | Components          | Description                                 |
|------|---------------------|---------------------------------------------|
| 1    | AC Induction Motor  | 230V, 50 NM, 1000rpm                        |
| 2    | Micro Controller    | Raspberry pi 3 model B                      |
| 3    | Linear Encoder      | Direction of rotation of rear axis          |
| 4    | Limit Switch        | Monitor Pressure of fruits in storage tray  |
| 5    | Transformer         | 220V AC to 12V DC, 5A                       |
| 6    | Relay               | 5V DC                                       |
| 7    | Resistors           | 220 ohm, 1k ohm, 10k ohm                   |
| 8    | Transistors         | BC 547                                      |
| 9    | Solenoid Actuated DCV | 5/2, 12V DC                     |
| 10   | Pneumatic Cylinders | Double acting cylinders                    |
| 11   | Pneumatic Hoses     | Connects compressor and pneumatic cylinders |
| 12   | Bolt and Nuts       | Low or medium carbon steel                  |

5. Working principle

Figure 2 represents the block diagram of the entire process arrangement. The entire process has been commencing with the payment GATEWAY (through Paytm) and a signal has been generated from the raspberry pi to the 5V relay module through a transistor (BC547) in order to amplify the current because the current available at the output of the controller is few amps (around 3 mA). The relay output has been used to actuate an actuator (namely Squeezer or Mixer motor depending upon the nature of need). Through the motor of required torque, the crushing load has been applied to the fruits, the timing sequence program has been employed to run the motor for a particular timing and water is added to reduce the concentration of the juices. After the dilution process, the motor is said to run for a particular timing and the motor stops. The prepared juice have been transferred to the cups by providing the solenoid valve at the outlet of the mixer unit and the wastes from the squeezer are collected at the time of the process ends. On the collection of juices, the entire setup is subjected to water wash and draining for about 20 seconds.
6. System model

6.1. CAD modelling

This machine is designed using a modelling software i.e. solid works. The part drawings are initially drawn as per the dimension calculated from the manual methods, the parts are then assembled and the assembled machine is shown in Figure 2. The reason for using solid works is the fact that the ease of drawing 3D diagram using dimensions. Figure 2 depicts clearly the motors actuation step by step and the entire setup.

6.2. Mechanical and pneumatic section

The mechanical section as a whole consists of both mechanical components and pneumatic components integrated. The mechanical section of this work which consists of frame that forms the base of this developed prototype on which the pneumatic and electronics system can be located. The mechanical section also consists of a mixer and squeezer unit attached to a motor with the bearings at motor shaft. An AC induction motor is placed parallel to the mixer shaft with the gear available on the setup which acts as a drive system. Three pneumatic cylinders are actuated using compressed air which reaches the cylinders through Solenoid Actuated Directional control valves. The complete fabricated setup is shown in Figure 3.
6.3. Electrical section
The electrical section of this developed machine mainly contains microcontroller circuit, relay circuit and rectifier circuit. Most of the circuits are assembled on a dot board not including the microcontroller circuit because it is developed using a microcontroller development board. Relay board contain relays that actually indent to convert the signals received from the microcontroller to all the actuating components present in the machine. The real time electrical circuit developed for this work is provided in the Figure 4. Normally a rectifier circuit is used to convert AC voltage to DC voltage. The AC voltage is also stepped down using a step down transformer which is provided and the outcome are fed to the indented rectifier. The function of the rectifier is to convert 230V AC into 12V DC that reduced voltage is provided as input to the DC motor.

Grinding is a process that usually followed after all metal cutting action which is done to get a smoother surface finish to the manufactured components. Corrosion resistance paint is an important
part for fruit juice equipment maintenance. Industrial paint coatings are a special type of coatings which used as a protective layer which prevents damage as well as corrosion from weakening or worn-out metals. In this work, all the internal parts of mechanical elements are coated with special paints to eliminate corrosion process.

7. Conclusion and future enhancement
An affordable machine for making fresh fruit juice extraction, disposing the waste has been developed and reported in this work. The fabricated equipment can be used as an affordable machine to all small-scale industrialists. Normally, the proposed system provided a sustainable method for processing of fruits of major types and hygienically free for consuming fresh-fruit juice for all developing countries in affordable cost. It is proposed that the implementation of this product would improve healthy living conditions among the rural poor peoples, offer employment as well as promote industrialization and emphasis a food security. The initial cost of the machine to fabricate was estimated at INR. 50,000/-. This machine can be further improved by including with a refrigeration unit in order to preserve fruits for a long term and quantity of sugar syrup can be directly incorporated in the juice during the process instead of having stirrer setup which makes the machine full autonomous system. A DAQ card can be incorporated in order to obtain the series of values for future accuracy manipulation of the machine.

8. REFERENCES

[1] Shankar S, Maheswari C, Gowtham R, Kiruba P and Mohansrinivas K 2019 Design and fabrication of portable sugarcane harvesting machine International Journal of Scientific and Technology Research 8 2059-62
[2] Warankar M S V, Patil M J B and Shete O M 2018 Implementation of PLC Controlled Juice Machine International Journal of Engineering Technology Science and Research 5(3) 2394 – 3386
[3] Ishiwu C and Oluka S 2004 Development and performance evaluation of a juice extractor. In: Proc 5th Int Conf and 26th Annual General Meeting of the Nigerian Institution of Agricultural Engineers, 391-5
[4] Tressler D K a J M A 1990 Fruit and Vegetable Juice Technology West Port Connecticut: AVI Publishing Company Inc 155-158
[5] Olaniyan A 2010 Development of a small scale orange juice extractor Journal of food science and technology 47 105-8
[6] Aviara N A, Lawa A, Nyam D S and Bamisaye J 2013 Development and performance evaluation of a multi-fruit juice extractor Global Journal of Engineering, Design and Technology 2 16-21
[7] Adekanye T A and Adelakun O 2017 Evaluation of a portable watermelon juice extracting machine Agricultural Engineering International: CIGR Journal 19 219-23
[8] Yang B, Jiang Y, Shi J, Chen F and Ashraf M 2011 Extraction and pharmacological properties of bioactive compounds from longan (Dimocarpus longan Lour.) fruit—A review Food Research International 44 1837-42

[9] Álvarez R, Carvalho C P, Sierra J, Lara O, Cardona D and Londoño-Londoño J 2012 Citrus juice extraction systems: effect on chemical composition and antioxidant activity of clementine juice Journal of agricultural and food chemistry 60 774-81

[10] OO Martins B and OH Adeyemi O 2018 Design and Construction of a Motorized Citrus Juice Extractor FUOYE Journal of Engineering and Technology 3.