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Automated Filling Machine

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Abstract – *India: a country with population of over a billion, the demand for food and other daily necessities in people's everyday life keeps on rising sharply. The world is modernizing at a rapid rate and the current COVID-19 pandemic situation has resulted in entrepreneurs becoming more technology oriented over labour force. This brings up the need for more automation in every sector where there is involvement of human work force be it small scale or an industry. This research project focuses on reducing the customer to vendor gap by eliminating the involvement of labour at small grocery or other enterprises.*

Key Words: **COVID-19, Automation, PLC, Filling Machine, Packaging, Labour, Microcontroller, Wheatstone Bridge.**

1.INTRODUCTION

The world in the 21st century is on a constant rise. The population is increasing sharply and so is the demand for fulfilling its requirements. This demand has resulted in a jittery situation among the vendors of small businesses as well as large scale industries. Local vendors with private businesses such as grocery shops, supermarkets and others, hence find a need to increase their labour so they can meet up with the upcoming daily demand.

The year 2019 where the global economy was already upsetting, the sudden outbreak of a respiratory disease called COVID-19 hit China followed by spread all over the globe lead to a huge disaster. This dreadful situation affected the supply chain of these small and local vendors, which in turn, created an altercation in the public for acquiring goods from the vendors. In addition to this the vendors were facing lockdown and social distancing standards to appoint labours and keep up with the demand. This led the shop owners to do all the filling and packaging all by themselves and meet the daily demand.

In large scall manufacturing industries, a large workforce of labours was being appointed for completing the manufacturing as well as the manual measuring, filling and packaging of bags for different commodities. As the technology has modernized with time, these industries have started inculcating smart techniques, smart machines and automations which totally eliminates the previously required large workforce for each and every operation. Automation hence helps the industries to increase the manufacturing and production in less overall cost and hence allows them to gain maximum profits.

Coming to small scale industries or businesses and enterprises, the owners know the fact that their sales cannot be increased to a larger extent due to limited coverage of region. So, for gaining maximum profits, vendors need to perform the packing, filling and attending the customers all by themselves or appoint less labour. This will surely help in gaining maximum available profits but will also cause fatigue and will pressurize the seller.

This research project aims to fill this gap between the customers and the vendors in a view to increasing the profits, without any expense of hefty efforts. Vendors will be able to easily keep up with their inventory of most demanded stock and on the other hand, will also be able to fulfil the demand with just-in-time supply to the customers.

The research project will be a small machine implementing the combination of Electronic and Mechanical components which will help in packing the bags of commodities for example sugar, rice, cereals, screws, nuts, etc. precisely in the bag and provide sealing to the bag consequently.

2. PROBLEM STATEMENT

2.1 Quantity

There is a problem for the vendors to fill extremely small weights such as 20-100 grams and it becomes complicated and cumbersome to also fill big quantity such as 4-5 kilograms.

2.2 Price of Industrial Packaging

Industrial packaging is done on a large scale and they demand hefty amount for lot wise packaging and delivering.

2.3 Labour Time Required

While packing manually it takes a lot of time and efforts for the workers to each time measure and fill the bag and then pack it which becomes tedious.

2.4 Inaccuracy in Manual Packing

When workers are packing the bags of solid materials there is a good chance that every bag will not be precisely and accurately filled which may result in loss to the vendor.

3. OBJECTIVES

3.1 To reduce the time required for packaging
3.2 To reduce labour efforts
3.3 To eliminate wastages
3.4 Sealing the bag consequently after filling

4. LITERATURE

There has been a lot of progress in the research work in manufacturing industry to make it more automated and reduce the human efforts and its involvement as machine work is more accurate and very fast. A lot of development has also been made in the filling and packaging sector as well. Here are two of the research projects that we referred and are similar in some way to this project, the Automated Filling Machine.

4.1 Existing Work

A. Domenico Speranza: Olive Oil Filling Machine

For the design, a traditional French pattern was followed, identifying the needs of operators in the oil sector and analyzing the problems, in order to define the specifications of the machine. Then, using CAD/CAE tools, evaluation was done for the different solutions in terms of efficiency, in order to obtain the best possible result. Furthermore, during the initial stage of conceptual design, the use of the deductive technique resulted to be fundamental: by using analogy with similar problems, solutions that were innovative or improving compared to the traditional ones were sought.

Highlights of this research project are:

1. Weight Based Machine

2. Use of CAD/ CAE to develop the design

3. Indexing Mechanism or Bottle changing

B. Ameer L. Saleh, Mohammed J.: Liquid Filling Machine

This design is a water filling machine system for different sized bottles by using PLC. Where the water filling machine system includes design and implementation of a prototype of a flat belt conveyor with dimensions (120*70*30) cm and automatic process for water filling machine using the solenoid valve and sensors which gives the appropriate information to control unit then design the controller using PLC.

The PLC plays important role to implement automatic filling process by using PLC programming software and ladder diagram language. It was found that the water filling machine using PLC is less operational cost and less power consumption than the traditional control systems, in addition more flexible and time saving.

The highlights of this research project are:

1. PLC based Conveyer Machine

2. Use of Timer to perform functions

3. Timer function changes when bottle size changes

C. Bhavani Engineering Works: Ointment Filling Machine

At Bhavani Engineering Works, high quality manufacturing machines for filling viscous liquids like ointment cream, lotion and other viscous products are fabricated and used. The Ointment Filling Machines that are manufactured are available with various filling speed, filling range and are suitable for high viscosity products.

This filling machine is appreciated among customers due to its less maintenance & easy installation. The filling machine is developed by utilizing high quality of material & modern techniques. As well, this filling machine is available on numerous specifications so as to meet the demand of customers.

Highlights of this research project are:

1. Power Consumption of 3KW

2. Contacting parts of the machine are made with 316L grade of stainless steel

3. Filling head uses anti leakage and a lifting filling device

4.2 Conclusion

1. It was observed from the literature reviews that majority of filling projects are made for liquid filling purposes on large scale and small scale and use PLCs and Electronic Controllers. These machines are energy efficient as they operate on low voltage DC supply.

2. Ladder Programming is used in these projects which is simple and is widely used already for different operations in industries.

3. There are already existing projects and researches from a long time that contributed in making prototypes for filling liquids such as water, oil, sanitizers and also other edible drinks and viscous fluids.

4. Use of timers for filling operations hampers the versatility of machine as this leads to filling only fixed amount of material in the packages.

5. Not much prototypes are available for solid granule filling and the ones that exist are highly automated special purpose machines that are placed in manufacturing industries.

5. RESEARCH METHODOLOGY

5.1 Block Diagram

A basic block diagram which shows the basic setup and gives a rough idea about the working of the automated filling machine is proposed.

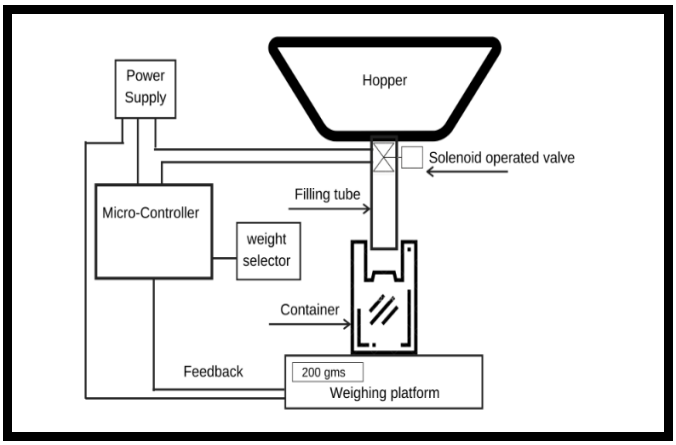

Figure 1: Basic Block Diagram

5.2 Components

5.2.1 Load Cell with Weighing Platform

Load cell of rated load 3kg is used for weighing the quantity being filled in the bags and works on the principle of Wheatstone Bridge. The safe load and ultimate load that these load cells can bear is 120% and 150% of the rated load respectively. Input resistance and output resistance are 400 ± 10 ohms and 350 ± 5 ohms respectively.

It is made up of aluminium alloy which is colourless and anodized. It works on the principal of Wheatstone Bridge by taking up load in the form of resistance and gives an output voltage difference of —2.0 ± 0.1 mV/V (milli Volt per Volt).

Figure 2: Load Cell Assembly

5.2.2 HX 711 IC (ADC) with LCD Setup

HX711 is a precision 24-bit analog-to-digital converter (ADC) designed for weigh scales and industrial control applications to interface directly with a bridge sensor. Basically, HX 711 is a Load Cell Amplifier and an integrated circuit that converts the analog signals to digital binary signals in the form of 1 and 0 output forms. This IC works on an input power supply of 2.7V – 5.5V and gives an output of 5V. HX711 is mounted on a board having buttons '+, -, OK' for adjustment of weight on the LCD Display.

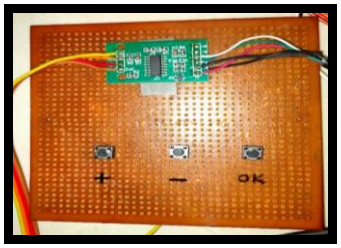

Figure 3: Load Cell Amplifier with LCD Buttons Setup

5.2.3 IR Module

IR Sensor is a commonly used device in remote controlling devices as a sensor transmitting signals. This sensor has two heads or bulbs — transparent and black. The transparent one emits infrared signals to certain distance to fetch an obstacle in its path. If these rays hit any obstacle on their way, they get reflected back and are gathered by the black bulb. It operated on 5V DC supply and has a range of 20 cm.

Figure 4: IR Sensor

5.2.4 Arduino UNO

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery. It works on an operating voltage of 5V. The flash memory it uses is 32 KB (ATmega328) of which 0.5 KB is used by Bootloader, SROM is 2 kb and EEPROM is 1 kb. It has a clock speed of 16 MHz All the inputs and outputs of the circuit are attached to the Arduino board and a specific program that implements the operation intended is fed into the Arduino.

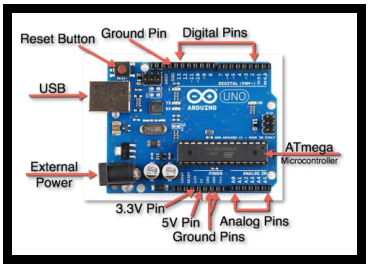

Figure 5: Arduino UNO

5.2.5 LCD Display

The term LCD stands for liquid crystal display. It includes two rows where each row can produce 16-characters. A 16×2 LCD has two registers like data register and command register. The RS (register select) is mainly used to change from one register to another. When the register set is '0', then it is known as command register. Similarly, when the register set is '1', then it is known as data register.

Figure 6: LCD Display

5.2.6 Relay

Relay is a simple device used in the circuit connected on one side to the Arduino UNO and to the solenoid and power supply from the other side. It is used as a device driver for operating the solenoid properly. Relay receives the power supply from an external source and is used to step up the voltage of 5 V to 12 V which is required to operate the solenoid. When the solenoid gets actuated and retracts, the relay gives information of this actuation to us in the form a light signal by glowing a small bulb on it as seen in the figures.

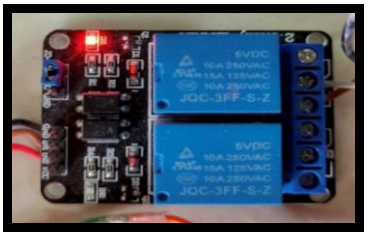

Figure 7: Relay ON

5.2.7 Solenoid

Solenoid is an electronic device that works as ana actuator in different applications as per the input given to it. In this case a small solenoid of 5 mm travel when it translates in one direction is used. It is connected to an external power supply and runs on 12 V. It has the following characteristics:

1. 12 VDC operation (please note lower voltage results in weaker/slower operation) - 250mA current draw

2. Push or pull type with 5.5 mm throw

3. DC coil resistance: 40 ohms

4. 5 Newton starting force (12VDC)

5. 1.4 oz / 39 grams

Figure 8: Solenoid

5.2.8 Frame

A trapezoidal structure is made with one side open with the help of 4 plywood pieces and finished with plain white Sunmica (laminate) and glued together with a strong adhesive. A sliding plate is installed at the smaller opening of the trapezoidal hopper.

A mechanical metal frame is created so as to give support to the hopper and to accommodate the electronic circuit connected to the weighing scale.

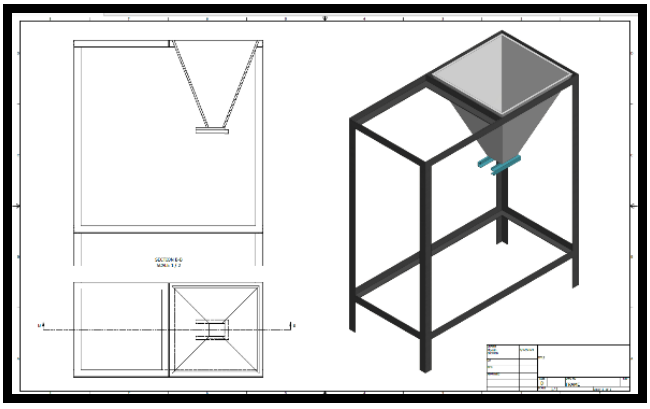

Figure 9: 3D Model of Frame

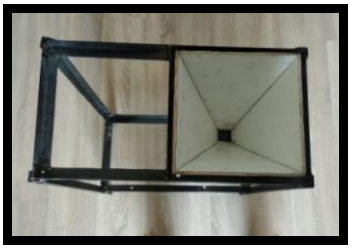

Figure 10: Actual Frame

5.3 Electronic Circuit

A theoretical Circuit Diagram is prepared just before the components are finalized and this circuit is simulated and their flow is checked on an electrical software. The theoretical circuit shows the proper connection of the components with block diagram of each device used so as to make clear the flow of process from the start to end.

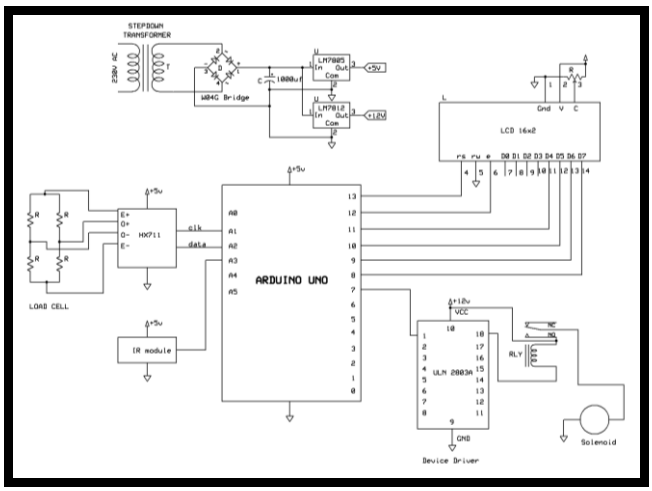

Figure 11: Circuit Diagram

Referring to the circuit, we have two inputs viz. IR Sensor and Load Cell and two outputs viz. Solenoid and LCD Display. To control and to decide what action is to be take when there is input received from these both input devices, an Arduino UNO is used which is a Microcontroller which is fed with a suitable program.

To start with the first input, the IR Sensor detects whether there is a bag placed on the weighing platform which acts as an obstruction to the IR frequency of 38 kHz. IR Sensor works on logic units and hence gives the input to the program of Microcontroller or Arduino UNO in the form of 0 and 1 binary logic units. If there is no bag placed on the weighing platform, it keeps on giving the 0 input to the microcontroller. Once a bag is placed in front of the sensor, it obstructs the path of IR frequency and hence the input of logic 1 is immediately sent to the microcontroller to take suitable actions.

The second input, the load cell, is a strain gauge which has 4 resistors connected together to form a Wheatstone Bridge. This Wheatstone bridge works on the principle of an imbalance in the bridge generating differential voltage. One half part of the bridge gives V1 voltage and the other half gives V2 voltage and the difference between these two voltages i.e., V1 – V2 becomes the differential voltage given by this bridge. Hence the load cell gives the input differential voltage in the form of analog signals. Since, this differential voltage is very small in the order of millivolts and is analogous, HX711 Analog to Digital Converter IC is used to change this analog input to digital one and also to step up the voltage to 5V (Arduino operational voltage) This ADC is calibrated such that specific millivolt differential voltage input converts into a specific 12-bit digital data and this data is transmitted to the microcontroller in A1 and A2 pins i.e., clock and data pins. Clock pin connection ensures that there is continuous communication between the ADC and the microcontroller and data pin is for receiving the 12-bit data to the microcontroller from ADC.

The first output will be the LCD Display which will continuously display the weight of the bag that is being filled with the material. The second output is the solenoid that gets actuated once the relay receives the green signal from the microcontroller to initiate the process and stop it. Likewise, the lever of solenoid gets pushed back and forth to work as it is desired.

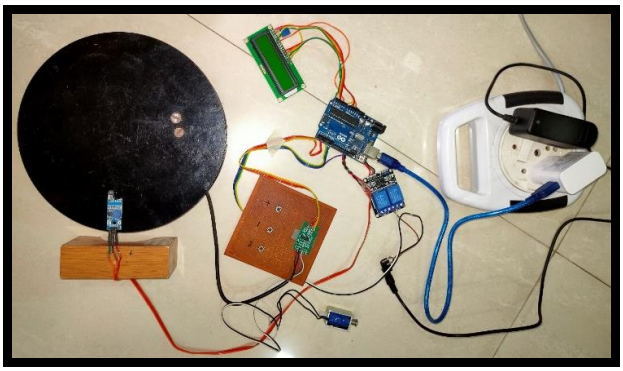

Figure 12: Actual Integrated Circuit

6. WORKING AND OUTPUT

6.1 Power Supply ON

The power supply through the extension board is turned ON and is given to the Arduino board and to the solenoid through the USB port and 1 pin socket respectively. As soon as the power is received in the Arduino, the LCD displays a message 'Packaging System' as seen in the figure, for 3

seconds and then the complete system initiates and is ready to operate.

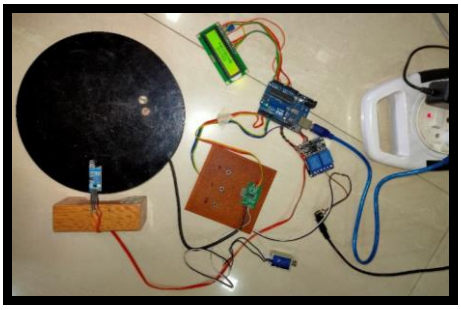

Figure 13: Power Supplied to the system

6.2 Adjusting the Weight on LCD through buttons

Once the system boots up a message is shown on the LCD Display which says 'Set Weight 250 Grams'. We can change this value by using the '+, -' buttons on the board which contains the ADC Unit. We can set any value which is a multiple of 50 i.e., 50, 100, 50, 200, 250 grams because the program is made to work on steps of 50-gram difference only. After finalizing the weight of 200 grams of the material to be filled in the bag we press the 'OK' button on the board and hence the display shows 'Current Weight 0 Grams' as in figure 14.

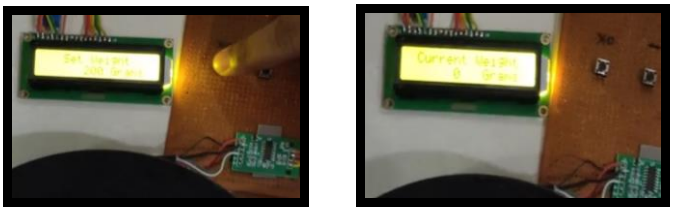

Figure 14: System asking to set desired weight and press OK

6.3 Placing Bag on Platform

When the display shows current weight 0 grams, the bag is to be placed on the weighing platform. As soon as a bag is placed, the IR Sensor senses the bag and gives the signal to Arduino which in turn gives the command to relay. A bulb glows in the relay and the solenoid opens quickly. This process takes place very quickly in around 10 milliseconds. Then, the material is to be slowly dropped and filled into it. When the weight is 188 grams referring to figure 15, the solenoid is still open and waiting for the weight on the display to turn 200 grams.

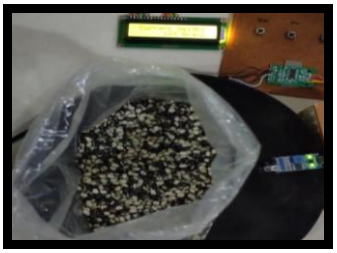

Figure 15: Working of Circuit

As soon as the weight is displayed as 200 grams i.e., the quantity of material filled in the bag reaches 200 grams as in figure 16, the solenoid quickly actuates and shuts off. This shuts off the shutter provided at the bottom opening of the hopper and stops the material which is being filled from felling down onto the weighing platform and hence the vendor can remove the bag from the platform. The bag is removed and then the IR Sensor gives 0 input and again a new cycle begins when a new bag is placed on the platform.

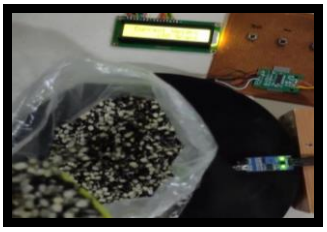

Figure 16: Working of Circuit Continued

6.4 Solenoid Cut OFF

The solenoid the is connected to the shutter of the hopper gets actuated at the exact moment when the display shows 200 grams is filled in the bag. This in turn makes the solenoid close the shutter of the hopper hole and the material is stopped from felling down on the weighing platform and hence one cycle gets completed.

6.5 Removing Bag and Resetting Cycle

For a new cycle to begin, the previous bag which is filled is to be taken off and a new bag is to be placed in position. If different quantity of material is to be filled, the reset button is pressed and the LCD display again asks to input the desired weight and the IR sensor again starts a new cycle and this cycle can go on until desired number of bags are filled by the vendor.

7. CONCLUSION

7.1 Work Completion

1. The aim of the project 'Automated Filling Machine' was successfully achieved without any obstacle in the technical part of the project.

2. The circuit components were bought from the electronic stores and were integrated manually by testing continuously.

3. The design of model of hopper and the frame was done in Autodesk Inventor software and was successfully fabricated in a very similar design and aesthetic sense with the exact dimensions.

4. The electronic circuit's working was tested with varying weights and giving different inputs and conditions successfully for different materials.

7.2 Scope for Future Work

1. The project can further be extended and transformed into a packaging machine with the incorporation of a sealing technique for the bags in machine itself.

2. A change in hopper design and material can be inculcated to make use of the machine for filling of solids as well as liquid materials.

3. A larger load cell can be used so as to increase the capacity of the machine and hence made use of in mid-scale enterprises.

4. A battery of medium size can be incorporated which will make the machine 100% portable without the need of external power supply.

5. A solar panel can be placed at the top of the enterprise using this machine and the power generated can be supplied to the machine which will make it run free of cost.

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