International Journal of Current Research and Modern Education (IJCRME)
Impact Factor: 6.925, ISSN (Online): 2455 - 5428
(www.rdmodernresearch.com) Volume 8, Issue 1, 2023

IOT BASED REVERSE VENDING MACHINE FOR RECYCLING STATION

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Cite This Article: M. Vinoth Kumar, K. Muthu, M. Bhavani, M. R. Mohammed Riyas & P. Nandhakumar, "IOT Based Reverse Vending Machine for Recycling Station", International Journal of Current Research and Modern Education, Volume 8, Issue 1, Page Number 28-31, 2023.

Abstract:

Recycle of our daily solid waste is a sustainable and effective way to reduce the problem of landfills saturation and pollution. In urban areas and smart cities, the reverse vending machine (RVM) recycle concept has been introduced to encourage recycle habits and increase awareness among the community. In this paper, an Internet of Things (IoT)-based RVM for recycle station has been developed to resolve these issues. Evaluation of the prototype shows that it is successfully to detect inserted plastic waste and crush it then store in the storage container, and notify the users using GSM through SMS.

Introduction:

Recycling is the process of treating waste materials to produce new products. Recycling significantly will lower the amount of waste, the use of new raw materials, energy consumption, air pollution that coming from waste combustion and water pollution when leachate bringing all the contaminants from landfill. Malaysians are producing waste products fright eningrate compared to the natural degradation process [1]. There sources are being use data very high speed exceeding the rate of these materials are being reproduced. There corded recycling rate in Malaysiais only10.5 percent, which is far behind thedeveloped countries [2].

By 2020, Malaysia has targeted to not only achieve the 22% recycling rate, but also tremendous improvement in becoming a zerowaste nation. To achieve this, continuous commitment and support from the government, private sector, and public are very important [3]. This paper presents the project that combines the concept of RVM and plastic shredder machine where it can turn the original form of PET bottle into shredded plastic which had minimize done recycling process in the recycle center [4]. The objective of this project is mainly to:

- Shred the inserted PET bottles
- Reward the user in form of money in exchange to the returned PET bottles
- Help collect recyclable materials and hence, to boost recycling activities any where anytime

The scope covers the development of the RVM's prototype until the performance evaluation including functionality and reliability testing. The remainder of the paper is organized as follows. Section 2 briefs the workdone by others. Material and methods from hardware development until assembly is described in Section 3. In Section4, result from this proof of concept work is presented, followed by discussion in Section 5. This paper ends with conclusion and the proposition of future works.

Methods:

Frame Work and Product Design:

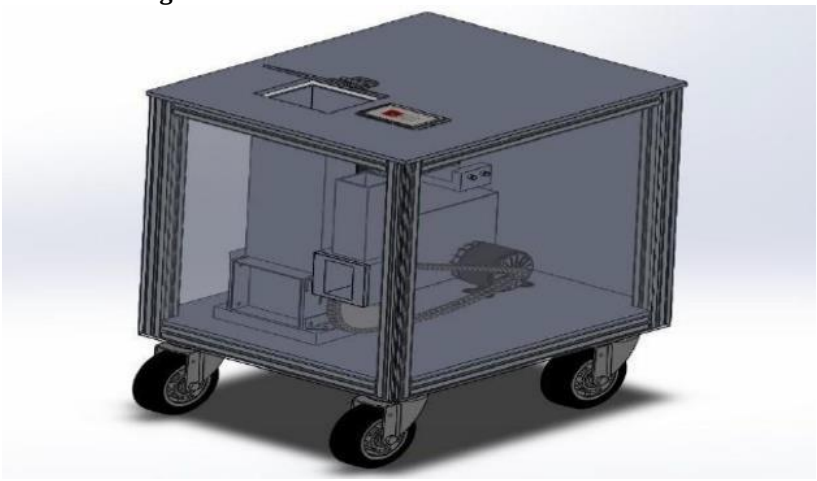

Figure 1: Main frame mechanical design of PET bottle shredder reverse vending machine

In mechanical design point of view, the RVM consist of several sub systems, material, dimension, and the related important aspects. Figure 1 shows the 3D model of PET bottle shredder RVM. It is designed insquare shaped, divided into three main sub systems; -Collecting, Shredding and Coin Dispensing. It is installed with 1-unit LCD 16x2 display, 1 shredder unit, 1-coin dispenser unit, 2unit capacitive sensors, 1unit 5V DC motor, 1unit 24V DC motor with motor driver MD10-POT, 1-unit chain drive with sprockets, 12V power supply unit, 3 LED lights and 1 Arduino Uno R3 controller. The hopper is equipped with capacitive sensor to detect and count the quantity of empty bottles. Each bottle will be shredded inside the shredder unit that is located at the bottom of the machine. Coin is dispensed out through dispensing unit. In order to run the RVM, a flow chart was design and the program was developed using Arduino IDE software. According to system flow chart in Figure 2, the system starts by inserting plastic bottles and the capacitive sensor will detect the presence of the bottles. The Arduino will make the decision to turn on the shredder motor and under go shredding process. Along the shredding process, the coin dispenser motor will turn on to push the coin out once the capacitive sensor reaches the counting number off our bottles.

Hardware Components:

- Capacitive Proximity Sensor: This capacitive proximity sensor is used to detect plastic bottles that go through the reverse vending machine. It uses the variation of Capacitance value between object and sensor. Capacitive proximity sensor output is typically transmitted as a contact closure or a pulse that is activated when an object reaches a specific distance threshold.
- Shredder Unit: The purpose of the shredding mechanism is to shred up to four plastic bottles at a time. The size of the shredder is 210mm x 149mm x 135mm. It has 5 curve edge cams shaped cutting knives that are arranged in a design as shown in Figure 3. The shaft is hexagon shaped and made of stainless steel. The knives are assembled to the single shaft with spacer in between them. The material of the cutting knives is made from mild steel while the body of the shredder case is made from steel.
- Chain Drive: The chain drive is a way of transmitting mechanical power form one place to another. Power conveys by a roller chain known as drive chain or transmission chain. The drive gear pulls the chain with mechanical force into system and transfer to another with same or different output power. In this project, chain drives isused to transfer energy motion from DC motor to shredder.
- Sprocket: Sprocket is a profiled wheel with teeth that mesh to chain, track, and other indented material. Sprocket transmits rotary motion between a motor and a shredder. In this project, 12 teeth with 15mm diameter use to transfer motion to 48 teeth with 75mm diameter. This motion transfer is use for the motor to drive the shredder unit.

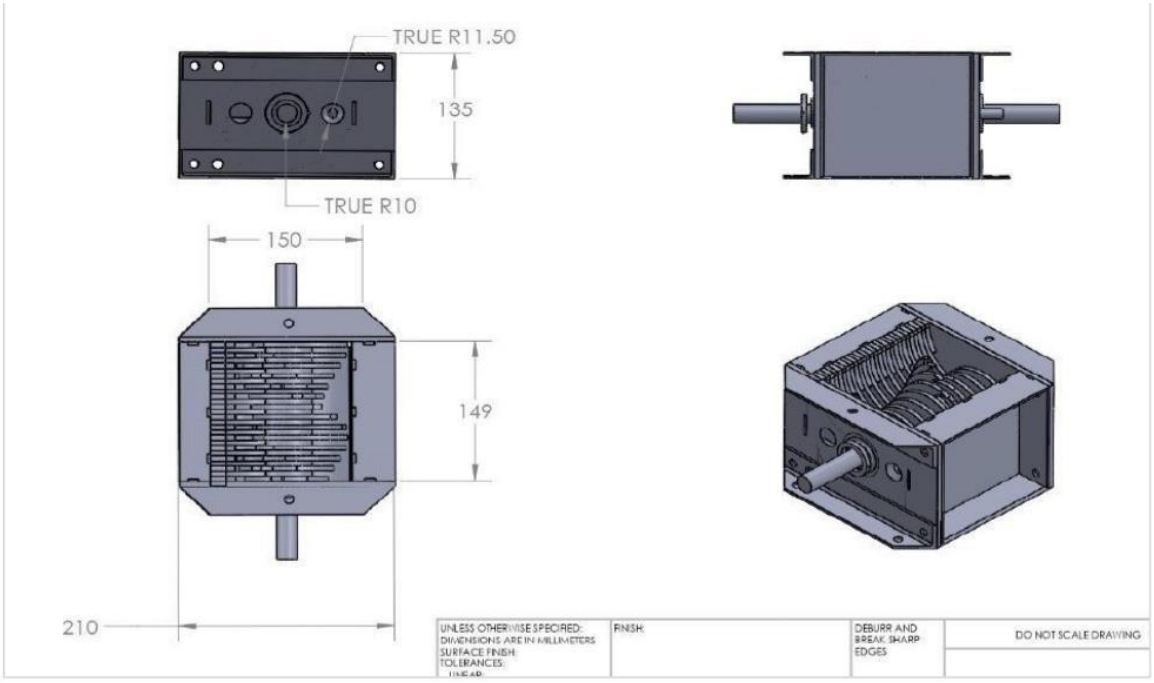

Figure 3: The design of shredder unit

- Arduino uno R3: Arduino Uno R3 is a widely used microcontroller board that is designed based on ATmega 328P. It offers it is a microcontroller board based on ATmega 328P. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button; it provides enough input and output to support the PET bottle shredder Reverse Vending Machine system development.

- Coin Dispenser Unit: The coin dispenser unit is developed to dispense RM0. 20 coins for every 4 bottles counted. It uses a 12V DC motor with 30 rpm that rotates the spring to dispense coin. The size of the coin dispenser is 70mmx 160mm x 62mm. The coins are stored in a spring inside a covered box with thickness of 2mm.

Circuit and Component Construction:

This system uses one controller that is Arduino UnoR3. There is one LCD 16x2 module, three LED light, one 5V Dc motor with motor driver (L293D) and one capacitive sensor used for this system. All the wire connection from the controller to each component is shown in the Figure 4 below. For the component's placement, all the electronic components are solderedon a donut board. Power supply unit 24V 10 amp is being used to supply power to the Arduino Uno R3 and motor driver to drive 24V Dc electrical scooter motor. The power supply unit is stored inside an electrical box as well. The box is then placed at the base behind the shredder unit. For the shredder unit, it is placed at the base and tightens with 4 bolts and nuts to keep the shredder from moving. There is a hopper that is made from plywood and attached on top of the shredder. The shaft of the shredder is attached with a 48 teeth sprocket. The shredder is driven by a chain attached to the 24V Dc motor. The motor is attached to an L bracket mounting and the distance between the shredder and the motor is 350mm.

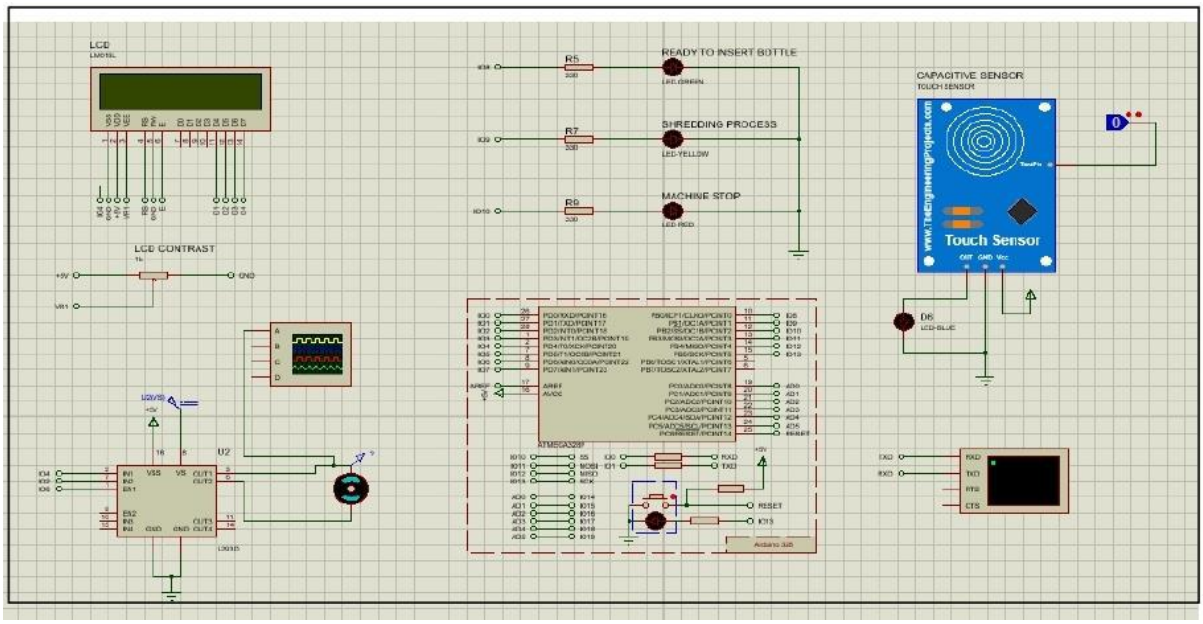

Figure 4: Schematic Electrical Diagram

Product Assembly:

The full assembly of shredder unit, coin dispensing unit and final product of PET bottle shredder RVM are shown in Figure 5, 6 and 7. Shredder and motor are connected by using chaindrive. Hopper for plastic bottle storage is attached on top of shredder. The receiving of the plastic bottle will be in vertical flow. Besides the receiving the top side, there is an LCD to indicate the machine status. The coin dispensing unit is designed at the front side. Electrical control box is designed for the circuit and power supply placement. The reverse vending machine is equipped with 4 caster wheels so that it can b e portable.

Results:

A prototype containing all material and component described above has been developed and tested. Several experiments and tests including system interfacing and data analysis were carried out during the development stage to verify the function and well-integrated of each component.

Limitations:

There are some limitations in operating this prototype RVM; - The label of the PET bottle must be removed before inserting to the hopper as the label sometime will cause the shredder to stick. Another limitation is the coin storage inside the coin dispenser unit of this prototype is designed to store maximum of 5 coinsonly. This is due to the main focus of this project which to observe the capability of the dispenser unit to response to the different quantity of inserted bottles before implementing in mass operation.

Conclusion and Future Work:

Now a day, the world is at risk by plastic pollutions which is one of the world's biggest environmental threats. A dustbin are over flowed due to these used bottles and mostly goes to landfill to be buried. Plastic is non-biodegradable and takes time to decompose. In this research work, the PET bottle shredder RVM has been proposed, which employed the combination of two concepts; RVM and shredder machine. Indirectly, it can motivate the public to recycle a small quantity of PET bottle at the nearest and reachable area while gaining the

rewards. At the same time, by having the shredding mechanism, this proposed project has reduced one necessary process in the recycle center. The testing results proved that this system is able to receive the bottles, shred and dispense coins accordingly. Future work will focus on the implementation of image processing system to sort out from any other type of material and determine that the inserted bottles are from empty bottle only. Besides, the material of the shredder needs to be further studied so that it can shred variety type of PET bottles.

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