Development and Fabrication of Smart Waste Segregator

R. Harshith, Y. Karthik, Pruthvishri Hegde, Sharma B. N. Tejas, D. Shivalingappa and H. S. Kumarswamy

Abstract The magnitude of waste disposal in public areas is increasing due to increase in population, change in the lifestyle of the human beings, and improper measures for reducing and recycling of waste. There is an urgent need for creating awareness among the public and spread motivation among the youth of the country. The problem can be overcome by segregation at source. The main motto of the project work is to develop a smart waste segregator to collect recyclable and reusable waste. It tries to reduce human interference by automating the system to the maximum extent possible. The model is developed and fabricated to meet the requirements for separating different kinds of wastes using various mechanisms and electronic circuits which include conveyor, Arduino board, sensors, motors, etc. It involves various mechanical operations for setting up the system and programming to make the electronic circuits work. The model can segregate wet waste, dry waste, and metal waste. The mechanical part of the system involves preparing conveyor frame and mechanisms for material transfer, whereas the electronic circuits include programming the movement of various mechanical elements to perform their jobs automatically. Waste alignment will happen with the help of resistance plates provided at both ends of the conveyor belt. Sensors with specific applications are used

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to identify wet, dry, and metal wastes. Bins are monitored using sensors to avoid overflowing of waste.

Keywords Smart waste segregator · Recyclable and reusable waste · Conveyors · Arduino board · Sensors · Motors

1 Introduction

The magnitude of waste disposal in public areas is increasing due to increase in population, change in the lifestyle of the human beings, and improper measures for reducing and recycling of waste. Dumping wastes in open sites result in deterioration of soil quality affecting vegetation adversely [1]. Rats, flies, and other insects which carry diseases such as malaria, dengue fever, etc. are attracted toward these sites which infect people around. Dumping waste in crowded areas increases the vulnerability of spreading more diseases. In general, to reduce the waste disposal in public, the government has arranged bins at several places, vehicles for collecting waste on daily basis, etc. [2]. Further development measures are undertaken by setting up segregation and waste management plants where different kinds of wastes are separated manually or using mechanical components and recycled in respective plants [2].

There is a need for a system which can segregate different types of waste at the source so that the wastes which are recyclable and reusable can be processed further and turned out into useful end products [3]. The waste segregation system has a very good scope for development in the current situation of the country in terms of waste management and awareness of people toward it. A system can be built with an application of multiple branches of engineering. Both mechanical and electronics play a vital role in building this system and proper research and survey are required to get better ideas about the requirements and specifications of the model that is concentrated on.

Samreen et al. [4] have developed a method for Automation of Waste material Segregation (AMS) in scrap industry. It was designed to sort the trash into metallic waste, plastic waste, and glass waste. The method uses inductive sensors for metallic items and capacitive sensors to distinguish between plastic and glass waste. Experimental results show that the waste segregation is successfully implemented using the Automation of material segregation (AMS) method.

Aleena et al. [5] tried to implement an automatic waste segregation system. The machine was designed to sort different categories of waste classified into metallic, organic, and plastic. Ultrasonic sensors were also used to monitor the waste collection system.

Baishya et al. [6] built a machine for segregation of waste based on the size as small-sized, bigger-sized lightweight, and heavy materials. The machine is made of declined roller conveyor which is setup with blower and hopper. Various weights

of different materials are recorded before and after segregation and waste recovery amounts are calculated and efficiency of the machine is tabulated.

Chowdhury et al. [7] discussed about the development of a waste sorter which can separate different dry wastes. The waste sorter was developed using an electromechanical system using a microcontroller and operational amplifier which can sort various materials.

Various researchers have proposed different approaches to initiate awareness among the people and to develop systems for achieving a solution to the problem. With reference to the previous work done on the waste management and segregation and its techniques, the information is available on segregating either for dry waste or wet waste. Though systems are available for the concerned problem, the systems are not considerably efficient; therefore, effective separation and segregation of waste are predominant.

2 Methodology

Generally, wastes are classified into various types based on different parameters. We can classify wastes as dry wastes and wet wastes. Separation of waste is a major concern in the society. The machine developed can be of prime use to separate the wet waste from dry waste. Further, metals are separated from dry waste. The development of the machine involves various equipment such as conveyor, DC motors, high torque low-speed-geared DC motor, conveyor rollers, bearings, hopper, sensing table, sheet metal, MS tubes, and sensors. Figure 1 shows the work flow of the smart waste segregator.

- The hopper is a conical passage where the waste is dropped initially and stored during the operation of the mechanism.
- A controlled flow of waste from the hopper onto the conveyor is achieved using an additional mechanism.

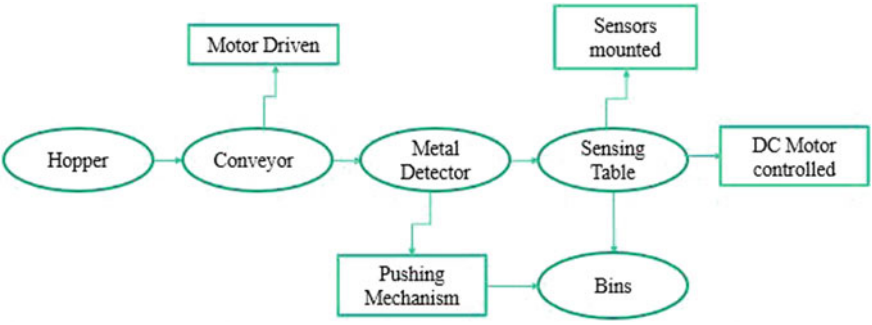

Fig. 1 Work flow of the smart waste segregator

- The conveyor is driven by the rollers specifically designed for the conveyor and the velocity required for carrying out the operation. The rollers are driven by a geared DC motor which can help to step down the speed and provide high torque required to drive the belt conveyor.
- The motor is connected to the conveyor by means of sprockets. Both ends are coupled with sprockets of different teeth and are made to rotate by means of a chain drive.
- The conveyor carries all the waste throughout the length and drops it on the sensing table.
- The sensing table consists of the sensors to detect the wet waste and dry waste. If the moisture sensor and IR sensors are activated, then the waste is pushed into the wet waste bin. If only IR sensor is activated, the waste is considered to be dry waste.
- At the end of the conveyor, a metal detector is used to identify metals. A mechanical arm is used to push the metals out of the belt. The arm is actuated by the motor and is programmed to traversing the arm forward and reverses to the desired span.
- The waste is made to fall into the bins, which are manually fabricated as per the ratios of the amounts of classified wastes.
- A pushing ring is used to push the wastes into respective bins by moving the ring to either side of the sensing table.
- The whole process is controlled by an Arduino board which has analogue and digital input ports in which sensors and motors can be mounted and programmed to achieve required movements and operations.

Figure 2 shows the initial conceptual design of the smart waste segregator. As research was carried on sensor specifications and dimension constraints, the concept design was found to have little technical and practical infeasibilities. Thus, modifications were incorporated in the fabricated model to improve the effectiveness of the system.

3 Development and Fabrication

3.1 Materials and Equipment

The machine is supported completely on the frame. It is made of mild steel pipes which are welded or fastened together to form a rigid structure which supports the complete setup and bear the loads acting on the system. The conveyor belt is the key component of the machine which carries the waste onto the sensing table placed at the end of the conveyor. The conveyor is powered by a high torque low-speed-geared DC motor which drives the rollers coupled to the gearbox of the DC motor and in turn connected on to the conveyor belt.

Low-capacity DC motors are used for the functioning of the mechanical arm, pushing ring of the sensing table, and to control the waste flow at the hopper. Bearings are used to support the rollers and reduce the load on the motor. The HTLS DC motor

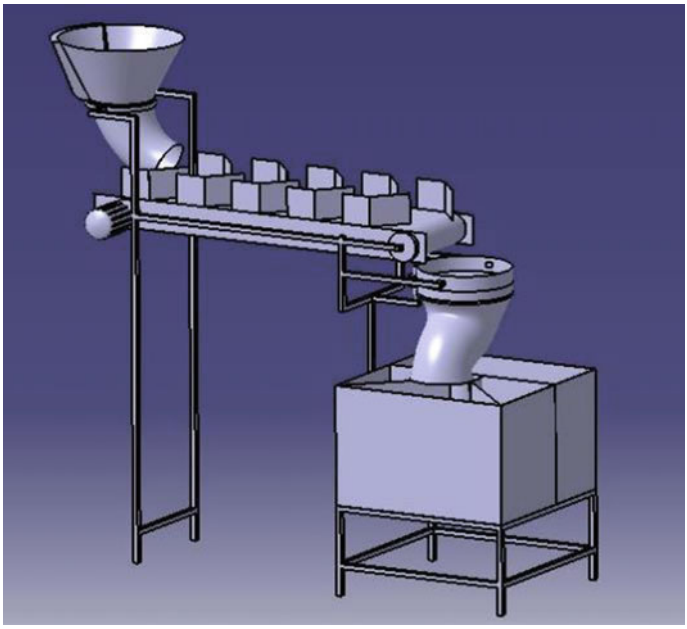

Fig. 2 Conceptual design of the smart waste segregator

used in the setup has to transmit torque and provide movement to the conveyor, which is done by the chain sprockets. A less toothed sprocket is coupled to a motor and a sprocket with more teeth is fixed to the conveyor roller shaft to step down the speed.

A metal detector, IR sensors, and moisture sensors are used in the setup to monitor the segregation process. A metal detector is placed under the conveyor to identify metals. The mechanical arm pushes the metals out of the conveyor. The sensing table consists of a grid of moisture sensors to detect wet waste and IR sensors to detect the presence of materials on the table. A pushing ring is used to push the waste on either side depending on whether the material present is wet or dry.

Some major electronic components include the Arduino board and motor driver. Arduino board is the brain of the system which automates the whole system. All the sensors and motors are integrated with the Arduino and are programmed to the requirements. The motor driver is used for the forward and reverse rotation of the DC motors which is again integrated with the Arduino.

3.2 Specifications

Various materials are selected on the basis of certain requirements. Specifications of major components are mentioned below:

- The HTLS-geared DC motor: It is a high-speed motor stepped down to 10 rpm with the help of worm gears.
- Low-capacity DC motors: Two 10 rpm motors are used. One for the mechanical arm movement and the other for the pushing ring at the sensing table. A 500 rpm motor is used to lift the hopper plate.
- The top end diameter of the hopper is 15 in. and the bottom end diameter is 9 in. Two bins of 1 sq. ft. and one bin of 2 sq. ft. each with 24 in. height are used to collect the waste.
- The diameter of the pushing ring inside which waste falls is of 9 in. diameter. It is considered to be equal to the bottom end diameter of the hopper.
- The conveyor roller is of 3.5 in. diameter. On the basis of the required conveyor speed, the suitable roller diameter is considered.
- The Arduino board used to control all the circuits is "Arduino UNO." The motor driver used in the electronics setup is "L298n."
- The metal detector used is MD-300 and the moisture sensor used is a grid type raindrop sensor module.

3.3 Mechanisms

Waste Flow Control Mechanism The waste which is thrown into the hopper moves on to the belt conveyor. To control the amount of waste flow, a mechanism is used. The bottom end of the hopper is grooved and a plate is placed which can traverse in the direction parallel to the cross section of it. The plate movement is provided using a DC motor which is mounted directly to the hopper bottom end. The motor shaft is coupled with a screw rod rigidly, which makes the screw rod to rotate at the speed of the motor. The mechanism of the waste flow control is shown in Fig. 2. The plate creates buffer storage inside the hopper when it is in a closed position. Once the motor starts rotating, the plate widens the path for waste by moving above.

Mechanical Arm A mechanical arm shown in Fig. 3 is mounted near the sensing table end of the belt conveyor which is used to push the metals out of the belt region to the dustbin. The metal detector is placed below the belt and arm right above the detector area. When the sensor detects the metal, the motor will run, which simultaneously rotates the mechanical arm fixed to the motor shaft.

Separating Mechanism A pushing ring is used over the sensing table to separate wet waste from dry waste. The pushing ring is fixed through a slider to move to either side of the table. A slider is a fixture for the pushing ring which acts as horizontal support and driver, while the motor spindle is vertical. The slider is rigidly mounted between the motor shaft and the pushing ring end enabling it to slide left and right of the sensing table. The Separating mechanism is as shown in Fig. 4.

Fig. 3 Waste flow control mechanism

Fig. 4 Mechanical arm

4 Results and Discussion

The working model of smart waste segregator shown in Fig. 5 has been developed and fabricated. It is a compact and efficient system to segregate metal, wet and dry wastes. The machine was tested to check its effectiveness in segregating the wastes of three kinds.

The sliding mechanism of hopper plate is used to allow materials of different sizes onto the conveyor. The baffle plates on the conveyor frame are used to align the wastes as it passes on the conveyor belt. The metal detector detects metals of various sizes if the field produced is above the threshold magnetic field strength of the detector. It is found that the mechanical arm setup used to push metals detected by a metal detector kept below the belt is capable of pushing approximately 150–200 g.

The ring slides over the sensing table after the moisture sensor, mounted on the table, and the IR sensor gives an output to the Arduino which rotates the motor to the predefined angle to segregate wet and dry waste. Sensors with specific applications are used to identify wet, dry, and metal wastes. IR Sensors have maximum range of 6 in. within which the materials are detected. Bins are monitored using sensors to avoid overflowing of waste. The system requires lesser power for its operation (Fig. 6).

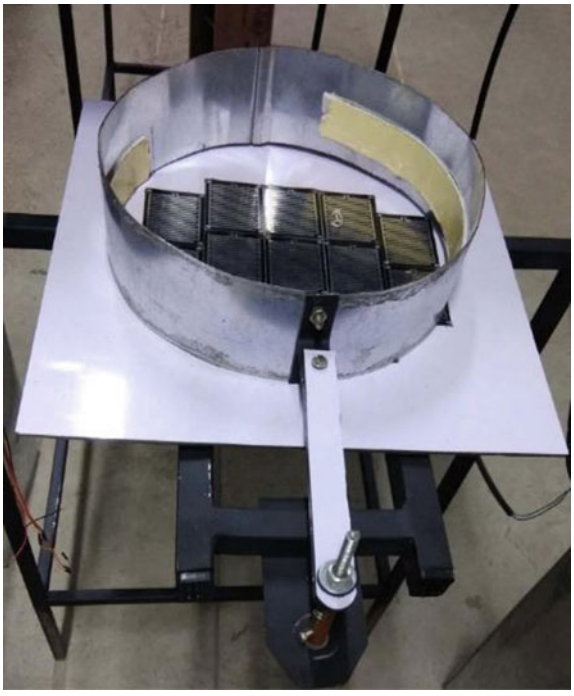

Fig. 5 Separating mechanism

Fig. 6 Working model of the smart waste segregator

The advantages of the smart waste segregator over other existing systems are:

1. The system is developed to be compact, user-friendly, and flexible. It is easy to transport the machine and relocate based on the space constraints.
2. The machine is completely customizable. The user can operate and control the machine as he/she wants it to, by modifying the program code fed into the Arduino board.
3. The sensors mounted on the sensing table can separate wet and dry wastes, while existing segregators can only categorize dry wastes.
4. The model is a small-scale development explaining the concept for a larger scale model. The performance of the machine is competitive with already existing machines, advantage being the lower cost.

5 Conclusions

The fabricated working model of smart waste segregator will be useful to the society to overcome the problem of waste segregation by segregating wastes at the source. It reduces the human interference as much as possible since the system is automated to the maximum possible extent. This project creates awareness among people about the need to segregate wastes and avoid pollution by dumping wastes in the open. Certain wastes which are segregated can be recycled. Instead of burning garbage, separation would reduce this problem which causes pollution. Since waste generation cannot be avoided, one can only try to find cost-effective solutions to this problem.

The waste segregator will be a good solution for waste segregation as it segregates the waste at the source level itself. Almost all the metallic wastes can be segregated

and, in turn, can be recycled into consumer goods. By streamlining and simplifying the waste segregation process through one central system in offices, apartments, and similar such places, one can effectively implement the waste segregation process through this type of waste segregator. We have made an attempt to reach "Zero Waste to Land Fill" targets that are part of the sustainable initiative and also this working model is an eco-friendly system as it uses electrical power.

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