# Chapter 10
# Solar-Assisted Smart Solid Waste Dustbin


**R. Jayagopal, T. Devapounraj and V. Mayilvelnathan**

**Abstract** In the past few decades, the rapid growth of the urbanization rate has taken place, and therefore, plans for sustainable urban planning are required. Using new technologies and a strategic approach, the concept of smart cities is approaching the whole world. A smart city is not built without a smart waste management system. In this article, our model describes the application of "solar-assisted smart solid waste dustbin" for the management of the solid waste system of the city. In our model, the volume of solid wastes has been drastically reduced compared to the conventional process. It reduces the cost of transportation and reduces the odor of waste. First of all, organic waste is ground by grinders and, at the same time, the humidity content is heated to reduce the weight of the waste. Compressors will then compress, and finally, compressed waste materials are stored in the storage unit. The control system is run by solar energy, and the systems are semi-automated. In addition, rented materials are collected by bin to be used for agricultural purposes. Today's traditional bins will be able to efficiently manage these wastes as they waste their waste on the road, and it may cause insects and mosquito breeding. Dismantling in dirty environments also causes serious illness. It controls through solar energy and is a semi-automatic system; by doing this, we can change the contaminated environment.

**Keywords** Smart city · Urbanization · Solid waste · Grain size · Waste heating · Odor removing · Waste compressing · Solar power

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## 10.1 Introduction

As the world is in the stage of upgradation, there is one stinking problem we have to deal with solid waste management. In our daily life, we see the garbage bins being overfull and all the garbage spills out. This leads to increase the number of diseases because of the large number of insects and mosquitoes breed on it [1]. In current scenario, the solid waste management in urban cities is the big challenge not only in India but for most of the countries in the world. We should eradicate this problem or at least reduce it to the minimum level. The effective solid waste management system is one of the efficient way that to stay our surroundings clean and green. The purpose of establishment of 100 smart cities in India is to create clean and green environment. Now, with the upcoming large number of smart cities, large numbers of responsibilities are also required to be fulfilled. The prime need of a smart lifestyle begins with cleanliness and cleanliness begins with a dustbin. When the dustbins are placed well and collected well, then the society will get clean environment. The main problem in the current waste management system in most of the Indian cities is the unhealthy status of dustbins [2]. In this paper, we have tried to upgrade the trivial but vital component of the urban waste management system, i.e., dustbin.

Here we implemented the bin which consists of solar cells, grinder, drier, compressor, and sensors. Three key implementation challenges are: (1) reduce the transportation cost, (2) reduce the size of waste, and (3) reduce the odor of waste [3]. Our main goal is reducing the waste transportation expenditure by increasing storage capacity of dustbin for same size [4]. Traditional dustbins are not designed to take these advantages. Such methods do not cut and compress the solid waste. Another aspect of that method is to not dry the waste to remove from odor-releasing gases. Our model is semi-automatic so not necessary to operate. It has some other features like solar energy used with sensors. And here it is possible to store waste more than traditional bins. It has three chambers: (1) temporary storage chamber, (2) grinding and heating chamber, and (3) compressing chamber.

## 10.2 Present Scenario

Normal municipal waste junk is often overwhelmed. The waste management team collects eight times more and is ready to get rid of it. The municipalities can choose the suitable rental program that offers an alternative to the purchase. Leases allow customers to realize immediate savings, instead of spending significant resources. It also works on the management of solar energy waste management, in areas not directly covered by sunlight. With new trainers, the city wants to reduce weekly collections from 17 to 5 intervals [5]. In ten years, these restrictions would have to save more than 12 million dollars and much more. Recently, the capital of Philadelphia has replaced 700 common clays with 500 solid composts and 210 single-stream recycling units. Now that one week of 17 passengers out of 700 containers (annual

costs of 2.3 million), the city only charges once a week for an operating cost of around 720,000 $ annually, saving 70%. It requires seven sets per week to run under the new 33-h program instead of a single collection once a week; only nine employees are required in one single change. Other workers have sent other production works together. This increase in the production of solid wastes is becoming a disaster due to poor Indian management practices. These are the basic services and management of the Indian government. In general, municipalities and other local entities regulate the management and disposal of solid wastes in 2000. But municipalities and local organizations generally do not assume this responsibility. The incorrect reasoning is, above all, that it does not have the proper collection, transportation and accessibility system, lack of technical skills, and lack of financial resources. For bad practices, MSWs are distributed in small areas or landfills in cities, without taking the necessary measures. Practical scientific solid waste does not endanger environment due to air, soil, and water pollution. The rapid urbanization and population growth improve the production of solid urban waste [6]. The creation and characteristics of DSM can be modified in different areas of the same country, state, and cities. According to a report from the Indian energy portal, solid waste in India remains uninterrupted from 1971 to 2015. Per capita, waste and urban waste in the city totaled 375 g/day and 14 Mt/year in 1971, 490 g/day and 48.5 MT/year in 1997 respectively. The per capita waste generation is supposed to increase and the city's waste reaches 700 g/day and 97 Mt/year in 2025. The amount of solid waste in 1997, it will be increases twice in 2025.

## 10.3 The Configuration of Our Model

We constructed our bin by the following content like solar cells, grinder, heater, compressor, AC motors, self-actuating doors (for each chamber), and sensors. The total confirmation of our model is shown in Fig. 10.1. First we discussed temporary solid waste storage chamber. The ultrasonic sensor is fixed at the head of this chamber. And the automated actuating door is located at the bottom surface of the chamber which is actuated by AC motor by accepting the command from control unit by means of sensor. This door will open when the solid wastes are reached to the fixed level. And the solar panels are located at the top surface of this chamber that is immovable. The waste is imported at the top. Here the importing door is operated by human or users. The grinding chamber is located next to the temporary storage chamber. Here cutter and heater are placed. We have designed the cutting blades that are fixed around the rotating arm. This is run by the AC motor that rotates in very slow speed. On the other hand, the heating system is attached to the cutting blades. The top and bottom surfaces of this chamber are the doors for other section. This one is also connected with the AC motor (Figs. 10.2 and 10.3).

The next section is the compression section. In this section, dried waste is compressed into a compact size. Here the reciprocating-type compressor is used which is run by AC motor.

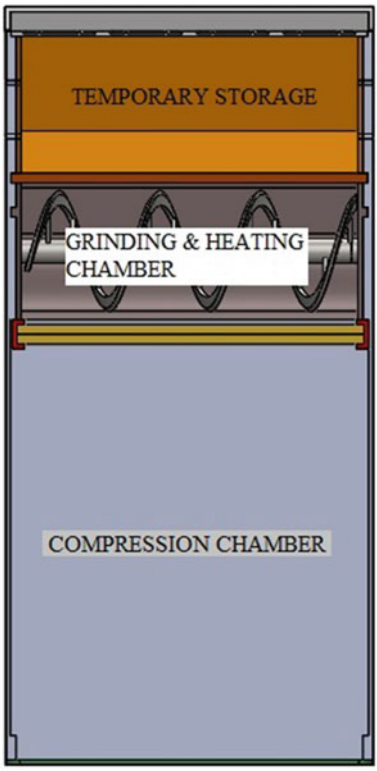



**Fig. 10.1** Various chambers of solar-assisted smart solid waste dustbin

## *10.3.1 Various Chambers*

### 10.3.1.1 Temporary Storage Chamber

Here the solid waste is dumped into the bin. Then the automatic door will open when the waste reaches the predetermined level (max. level) by means of an ultrasonic sensor.

### 10.3.1.2 Grinding and Heating Chamber

Here the grinding and heating operations were done by means of grinder and heater. The grinder is operated by the DC motor. And where explaining about drier is nothing but a simple heater consists of heating coils. So that the moisture content of waste is to be eliminated.

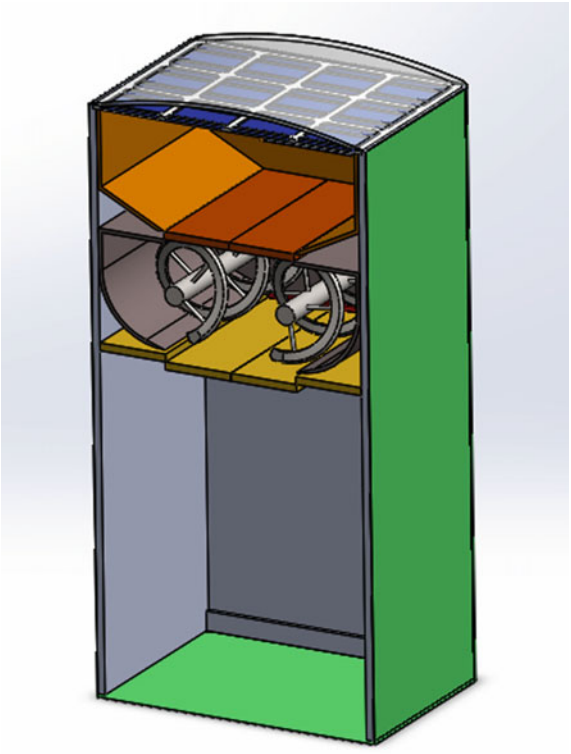


**Fig. 10.2** Various chambers of solar-assisted smart solid waste dustbin

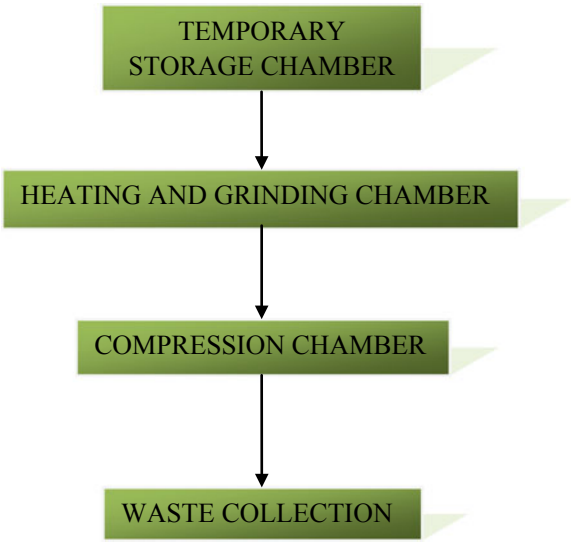



**Fig. 10.3** Flowchart

#### 10.3.1.3 Compressing Chamber

After grinding operation is done, the dried waste is introduced to this chamber. Here the total volume of the solid waste is to be reduced by means of compression of waste.

### *10.3.2 Stepper Motor*

DC polished wheels rotate continuously when the DC voltage is applied to its terminals. The stepper engine is known for its properties in the input pulse (usually the square wave poles) for the increase in the position of the shaft to be converted to the train. Each pulse moves the axes through a fixed angle. Stepper engines have many "multiple" electro-windings that are arranged around an iron element. The electrodes are fed through an external controller or a microcontroller. To activate the motor shaft, first of all, an electromagnetism is given strength, which magnetically attracts the gear teeth. When the gear is aligned with the first electromagnetic teeth, they break a bit from the next electromagnet. This means that when the next electromagnetism is switched on and when the first one is deactivated, it turns the gear slightly to align it with the next one. From there the process is repeated. Each of these rotations is called a "step," with complete steps making a complete step. In this way, the engine can become an exact angle. Here it is used to control this engine, which controls the automatic doors that open and close the doors, separating the chambers. This engine runs in AC power source under the control of microprocessors, clockwise and counterclockwise.

### *10.3.3 Solar Cell*

The solar cell or photovoltaic cell is an electrical device that turns electric energy into a direct photovoltaic effect because it is a physical and chemical phenomenon. The photoclip is defined as a device, whose electrical properties, such as electric current, voltage, or resistance, change light. Individual solar cells can be combined into modules, otherwise solar panels. A basic condition is that the maximum voltage of the solar cell in the electric circuit of the solar cell is approximately 0.5–0.6. Here is a photovoltaic installation that uses 12 factors. The control systems and sensors used in our system are solar systems. The live stream generated is stored in the battery for effective use. The curved solar panel is used after a driver and battery connection.

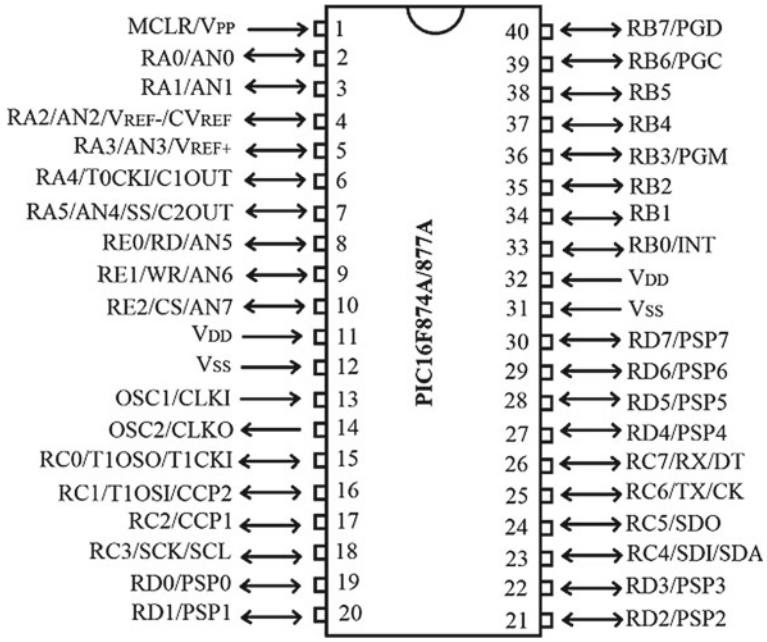



**Fig. 10.4** Pin diagram of PIC16F877A

### *10.3.4 Control System (PIC16F877A Microcontroller)*

The control system, PIC16F877A Microcontroller having 200 ns of powerful instruction executions and simple programs (only 35 single word instructions). CMOS Flash based on an 8-bit microcontroller is a powerful Microchip PIC® architecture compatible with 40 packages and the PIC16C5X, PIC12CXXX, and PIC16C7X versions (Figs. 10.4 and 10.5).

The PIC16F877A contains 256 bytes of EEPROM data memory with self programming, ICD, two comparators, 8 channels of 10-bit Analog-to-Digital convertor, two capture/comparison/PWM interface functions, or two-wire integrated circuit $I^2C$ ™ bus and universal asynchronous transceiver (USART). Here, this microcontroller offers a complete control system. It controls the door, compressor, and sensor and heating stages. This system is not included in the figure. The regulator is provided for this power supply in order to make the DC 5 V a suitable power supply.

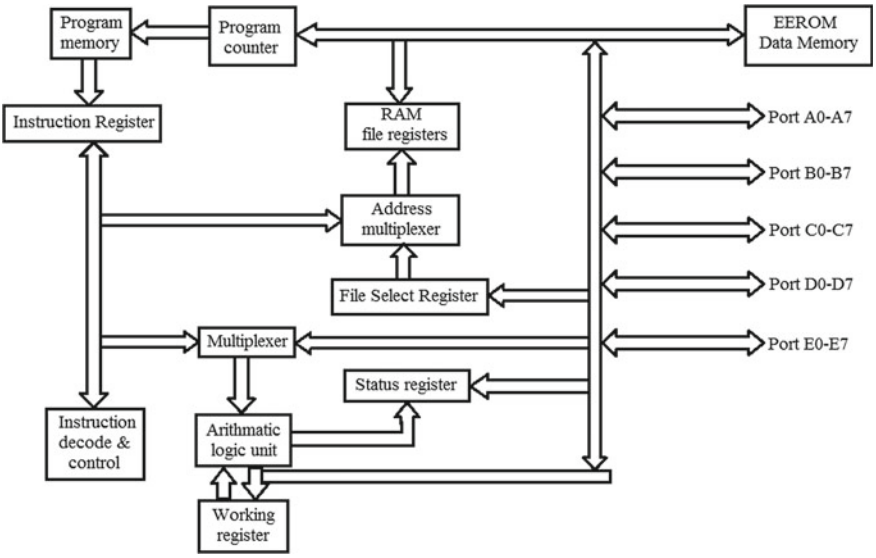



**Fig. 10.5** Architecture of PIC16F877A

## *10.3.5 Sensor*

The sensor is a device which is used to detect events or changes in its environment and send the information to the processor. The sensor is still used in other electronic devices, with the exception of the simplest computer or computer.

The sensors used in our model are (1) IR sensor, (2) ultrasonic sensor, and (3) limit sensor.

### 10.3.5.1 Infrared Sensor

Infrared sensor is an electronic device that sensitively detects some of the environments. An infrared sensor can measure the heat of an object and detect motion. These types of sensors measure only infrared radiation, rather than those called passive infrared. In our model, the sensor type is automatically stabilized next to the import gate and for closing purposes for the use of import waste.

### 10.3.5.2 Ultrasonic Sensor

As the name implies, ultrasonic sensors measure distance using ultrasound. The sensor head transmits an ultrasonic wave, and the lens reflect the reception of the wave. Ultrasonic sensors measure the target distance to measure the transmit and

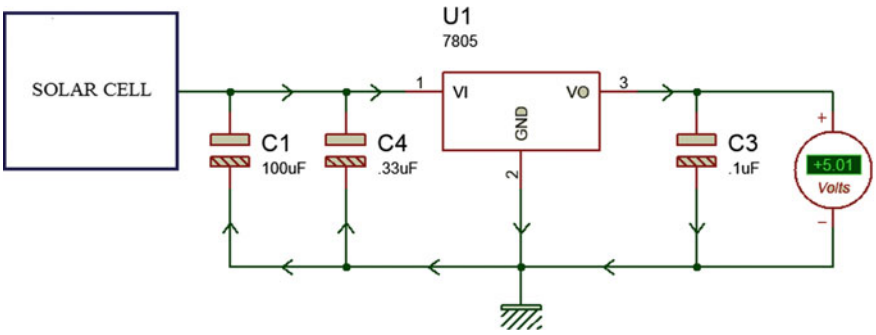



**Fig. 10.6** Voltage regulator

receive time. Here it is used to determine the amount of waste import. It is attached to the sides of the first chamber.

#### 10.3.5.3 Temperature Sensor

These temperature sensors can be switched between simple and thermostatic devices that control the heating system. For this reason, it is used in the heating section of our model to maintain the temperature of the particles.

#### 10.3.5.4 Limit the Sensor (Proximity Sensor)

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared for instance) and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. In our model, it is fixed in the compression chamber to indicate the current status of stored waste.

### *10.3.6 Voltage Regulator*

The voltage regulator is a device that reduces the voltage with any device. Here is a microcontroller of power 5 V. The 7805 voltage regulator of 5 V can be easily designed. The 7805 voltage regulator is used to obtain a regulated output of 5 V. A 5-V socket for the PIC16f877A power source microcontroller can be used (Fig. 10.6).

### *10.3.7 Battery*

The solar panels collect energy from the sun and turn it into electricity, which is supplied to run the microcontroller. But it requires only 5 V, so the excess of power can be stored in the battery to use when off-peak period (i.e., when the solar energy not avail).

### *10.3.8 Control System*

The total operation of the bin is semi-automatic (i.e., without human interference), so it is necessary to control the total action of all parts with in feasible time.

## 10.4 Methodology

Due to population growth in our country, the energy consumption should be necessary. In our model, the control system and sensors are run by solar energy and other systems are run by normal ordinary electric current.

As shown in Fig. 10.3, when the IR sensor senses the person in front of the dustbin the feeding door will be open at the time solid waste is imported from outside. Then the ultrasonic-level sensor senses the garbage level continuously, and when the waste is reached to the predetermined level, then the door will automatically activated by control unit as per program (Figs. 10.7 and 10.8).

At the time of opening the door, the cutter blade and heater have been activated. The grinding blade grinds the solid waste into small grain size. At this time, the moisture content in the waste is eliminated by providing heat using heaters and also eliminates the gases and odor formed by the wet solid waste. In this chamber, the temperature is maintained for certain level by the control system with help of temperature sensor. When the above operation is done, the bottom of heating and grinding chamber door will be open. And the compression chamber will be activated. The all above doors are activated by means of AC stepper motors. Then the compressor compressed the dry solid waste to reduce the volume of waste. And finally, the compressed solid wastes are stored in this chamber or normal dustbin insert to chamber. Here the limit sensor is fixed to indicate the current level of this stored waste. The total volume of waste stored in our proposed bin is to store more quantity of waste than conventional dustbins storage capacity (Fig. 10.9).

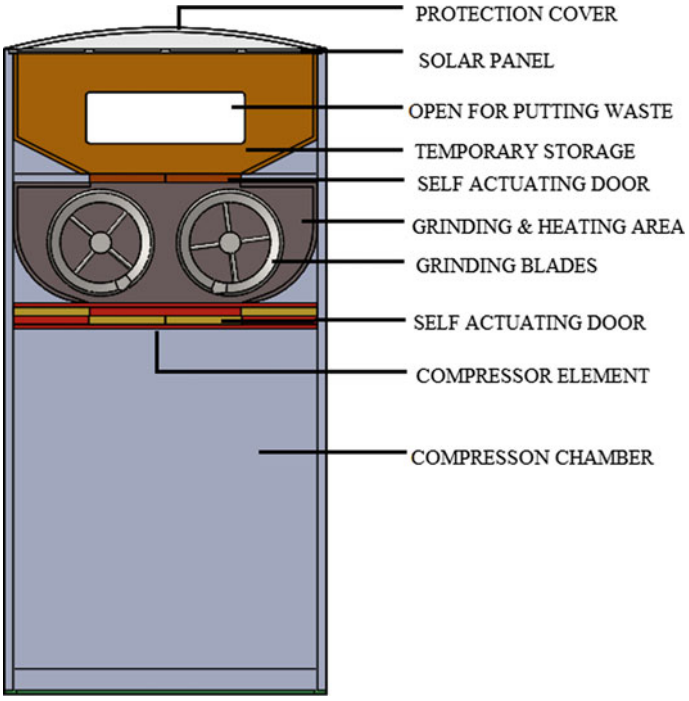



**Fig. 10.7** Parts of solar-assisted smart solid waste dustbin

## 10.5 Benefits

The solar-assisted dustbin supports to reduce cost [7]. It is suitable for all urban cities. It runs with help of solar energy and is renewable one. By using this smart bin, we can store large amount of solid waste and can be eliminate the odor of the solid waste. By using heater, we can also eliminate the water content of the solid waste. This system will occupy the small space (i.e., compact in size). By using this system to Eliminate overflowing of rubbish bins and also Eliminate birds/vermin scattering rubbish across streets, parks, beaches etc. it is also used for advertisement purpose. There is no windblown litter (or) access for critters. Reduce fuel consumption during collection of waste. Reduce the spread of diseases. Cost reduction and resource optimization.

## 10.6 Limitations

It is difficult to use this system at night, and the compressible waste only can be employed in this system. It is not well suitable for cold areas.

## 10.7 Application

### *10.7.1 For Urban Area*

In urban areas, there are many more shops and population compared to rural areas, so high amount of solid waste is formed. In traditional method, it is difficult to store, transport, and handle that waste [8] (Fig. 10.10).

So that our model is best suitable for handling that area. In urban area, the traffic is also high but in our model, we can reduce the transportation cost [9]. And in some cases, odor is produced from the traditional dustbins because there is possible leakage. In order to prevent that, the improved dustbin is best suited because here no leakage and no odor (because heater will eliminate the moisture content of the waste), and it reduces the volume of waste, so that we can store more volume of solid waste [10].

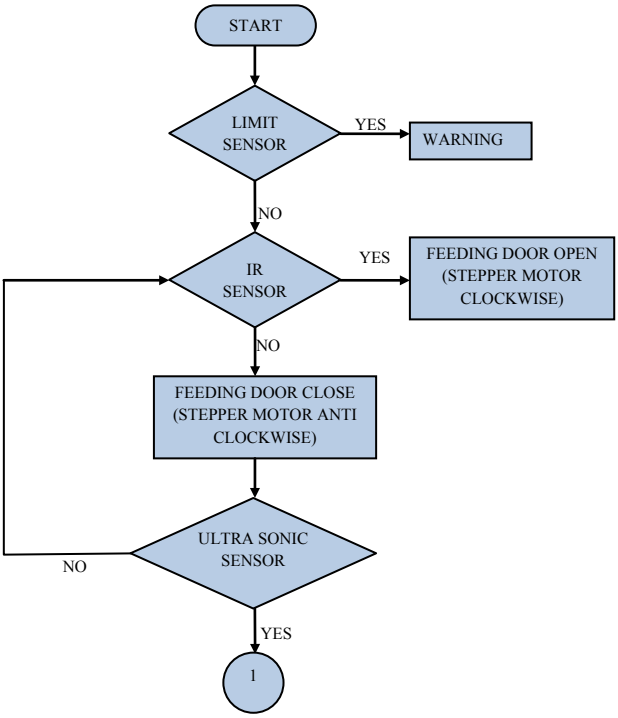



**Fig. 10.8** Process flow diagram

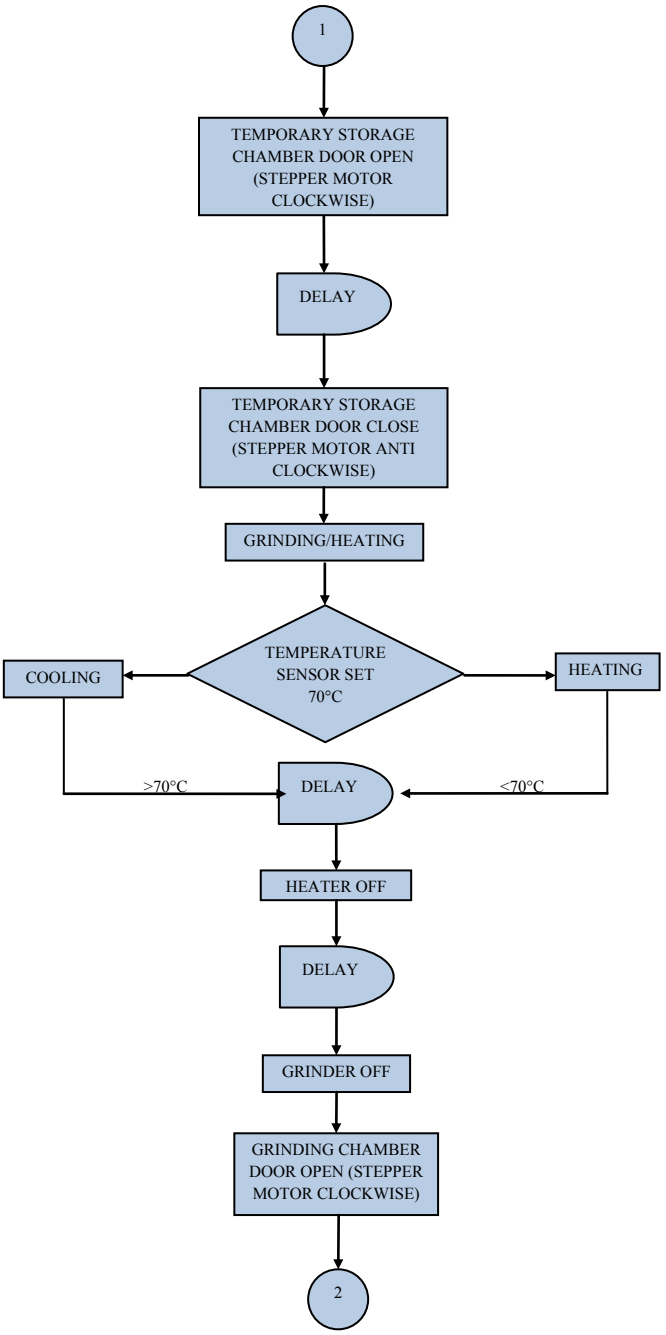
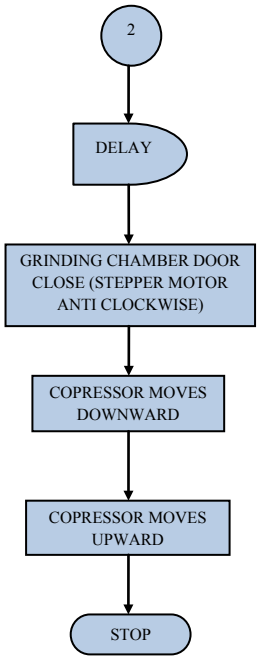



**Fig. 10.8** (continued)

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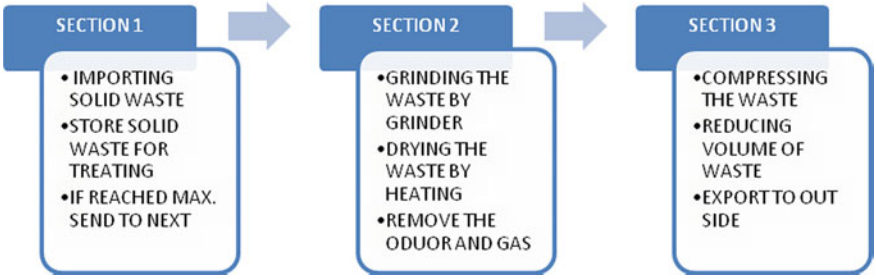


**Fig. 10.9** Various sections

## 10.8 Conclusion

Due to growth in urbanization, the waste is ever-increasing very fast. Therefore, waste management is the essential need to save the environment from harm. The technological augmentation and innovation can contribute to this essential feature to achieve environmental steadiness. To manage waste and scrutinize at the bottom level are the convincing factors for choosing these approaches. The system is a proficient step toward hygiene. As it is being said that the technology which goes equivalent with environment is the need of the hour. Our project is a stride toward

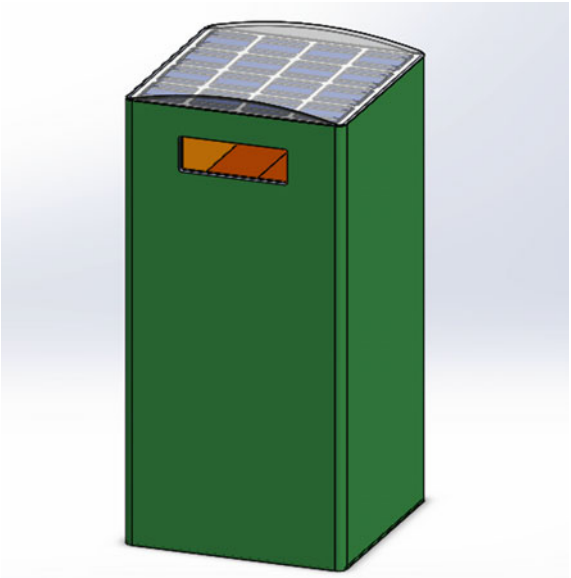

**Fig. 10.10** Solar-assisted smart solid waste dustbin

such green technology. This project monitors the fullness of bins from beginning to end by use of sensors; it is feasible to achieve a more well-organized system than the recent existing. Our idea of "solar-assisted smart solid waste management system" primarily concentrates on reducing the volume of solid waste, providing a smart technology for waste system, avoiding human intercession, minimizing human time and effort, which results in healthy and waste-ridden environment. The anticipated idea can be implemented for smart cities where the populace would be busy enough with their frantic schedule and would not have enough time for supervision waste. The bins can be implemented in a city if preferred where there would be a large bin that can have the capacity to collect the waste of solid type for a single public housing.

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