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Development of Automatic Smart Waste Sorter Machine

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Abstract

Modern world meets lots of challenges that includes Smart waste management system. It is become matter of big concern if proper disposal system is not managed. Managing waste effectively and recycling efficiently, a nation can ahead one step forward. In this work, an automatic sorter machine is developed which can sort out the wastes in various categories to make waste management easier and efficient. It can be possible to sort out metal, paper, plastics and glass by developing an electromechanical system using microcontroller and operational amplifier. For sorting metal and glass conventional sensors are used and for sorting paper and plastics a sensor using LASER and LDR is developed. A weight sensor and counter is used to find out the amount of sorted materials. By using the proper recycling system, the curse of waste will turn into blessings for the civilization. The sorting procedure will make recycling more efficient. By means of this waste sorter, the conventional waste management system will be transformed into SMART system. This SMART system will help to make our environment more suitable for living, reducing global warming and making the world healthier.

Keywords: *Automatic Sorter Machine; Smart waste management; Microcontroller; Operational amplifier, Microcontroller, Sensor implementation.*

1. Introduction

From the beginning of the human civilization, people used various methods of waste disposal to get rid of unwanted material. Sometimes it was buried in the land, thrown in the sea, fed to the animal or burnt. Getting rid of unwanted material is always a major concern for the modern society. Trash has played a tremendous role in history. The Bubonic Plague, cholera and typhoid fever, to mention a few, were diseases that altered the populations of Europe and influenced monarchies. They were perpetuated by filth that harboured rats, and contaminated water supply [1]. When wastes are not properly managed then it may cause serious hazard, as seen in 1350. "Black plague" erupted and more than 25 million people from all over Europe fall victim to it in just five years [2]. There is an increasing rate of waste generation in Bangladesh and it is projected to reach 47,064 tonnes per day by 2025. The Waste Generation Rate (kg/cap/day) is expected to increase to 0.6 in 2025. A significant percentage of the population has zero access to proper waste disposal services, which will in effect lead to the problem of waste mismanagement [3]. The total waste collection rate in major cities of Bangladesh such as Dhaka is only 37%. When waste is not properly collected, it will be illegally disposed of and this will pose serious environmental and health hazards to the people of Bangladesh [4]. This is not the only problem of Dhaka city but also for other big cities around the world [5]. With so much concern recently about being greener and economically friendly, waste management has become a very important topic. People and companies are starting to realize that the things they use and the way they dispose of them can make a big impact on our world. Proper management of waste plays a vital role in global environment. That is why a waste sorting system is designed which can be used in houses, offices, industries as a part of smart waste management system.

2. Present Status of Solid Waste Generation

Present condition of the solid waste generation can be described in different point of views. The generation and management of solid wastes are described in World and Bangladesh perspective.

7.1 *World Scenario*

Confederation of European Waste to Energy Plants (CEWEP) [6] and European Environment Agency (EEA) [7] provides sound, independent information on the environment.

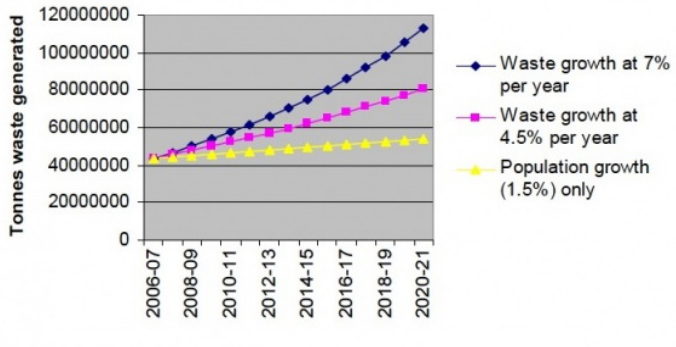

Fig. 1 Comparative waste generation 2006-07 to 2020-21.

Fig. 1 has been generated from the corresponding data from CEWEP and EEA [6], [7]. Considering present condition, waste growth at 7% per year is plotted. Considering future waste reduction, waste growth at 4.5% per year is plotted. Fig. 1 illustrates the fact about the total generation of wastes around the word. The total amount is increasing day by day and hence the waste management is becoming a challenge for both the developed and developing countries. Hence, recycling is becoming very important [5]. Recycling is a resource recovery practice that refers to the collection and reuse of waste materials such as empty beverage containers. The materials from which the items are made can be reprocessed into new products. For recycling the waste is required to separate into various different bins. As it enables us to convert waste into a valuable resource, gradually this practise is gaining popularity.

7.2 *Bangladesh Scenario*

The waste generation amount by Zone at Dhaka metropolitan city, Bangladesh is shown in Fig. 2 [8].

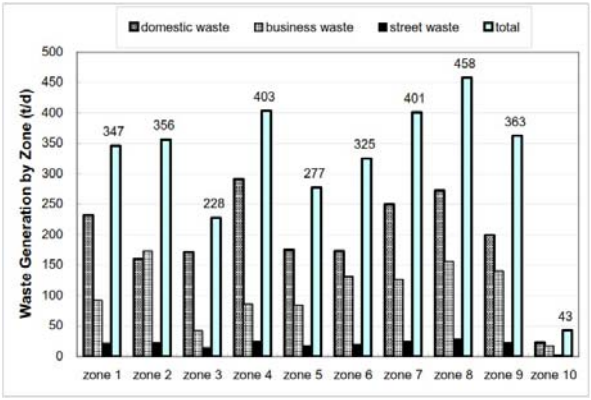

Fig. 2 Waste generation amount by zone at Dhaka metropolitan city, Bangladesh

The zonal average of waste generation is estimated at 320 t/d (tonnes per day) with the maximum at approximately 460 t/d in Zone 8 and the minimum at 43 t/d in Zone 10. The zonal waste generation reflects the population size and business activities in each zone [8]. Estimated Volume of paper, glass, metal and plastic waste generation in Dhaka City is shown in Table 1 [8].

TABLE I

ESTIMATED GENERATION OF PAPER, GLASS, METAL AND PLASTIC WASTES IN DHAKA CITY

Materials	Estimated Generation (t\d)
Plastic	124
Paper	260
Glass	46
Metal	27
Total	**457**

3. Methodology

The system activates when the IR detects some sorts of material is being put on the system tray. Then at first the weight sensor activates and find out the weight of the trash, then the metal sensor and glass sensor starts their actions. If metal sensor detects the material as metal, then a servo motor will put that trash in the bin 3 (which is dedicated for metals). If the glass sensor detects glass then it will perform same action and put the trash in bin 4. If both sensors fail to detect then the LASER and LDR activates. If the LASER passes through the trash then it is decided as a transparent and moves to bin 2. If the LASER fails to pass then the material is decided as Paper and move to bin 1.

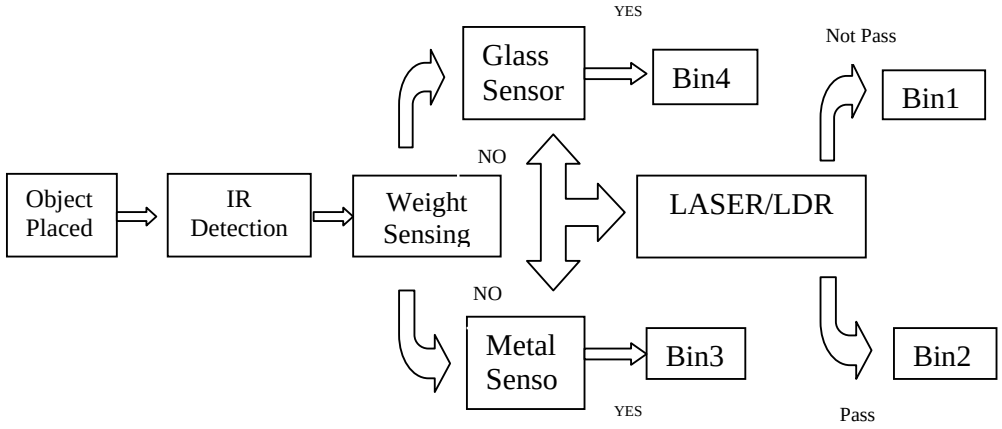

Fig. 3 Sequential Logic Flow Chart.

4. Sorting System Details

The sorting system consists of Light Dependent Resister (LDR), LASER, Infrared (IR) transmitter and receiver, Metal Sensor (Capacitive proximity sensor *E2K-C*) [9], glass sensor (Omron E3SCR67C), Weight Sensor (MLC900 micro weight sensor) [10] and a Liquid Crystal Display (Alpha-numeric 16*4 LCD). The whole program is run by a microcontroller (PIC 16f877A) [11].

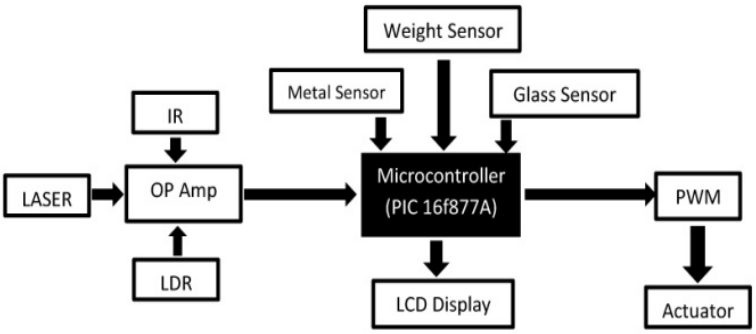

Fig. 4 Block diagram of the sorting system**.**

A servomotor (HS-65MG, Mighty Metal Gear Feather Servo) [12] based electro-mechanical system works as an actuator which puts trash in the desired bin. The microcontroller will count the trash sequence number and also the total weight of definite type of wastes.

5. Electromechanical Setup

An Automatic Sorter Machine setup consists four Bins. Each Bin is used to conatain unlike materials. Bin 1 is for Paper, Bin 2 is for Metallic elements, Bin 3 is for Plastic elements and Bin 4 is for Glass particles. At first, the object is placed at the **Detection zone**. The sensor applies its sensing activity to detect the material. Sensing signal is moved to microcontroller and final output signal comes out from microcontroller [11] that run the servo motor to a definite direction depending on the material that is being sensed.

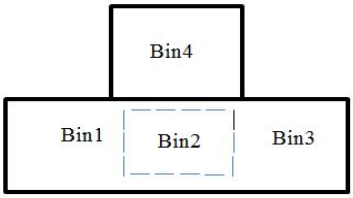

Fig.5 Top view of the Sorter

A servo motor is a motor which forms part of a servomechanism. The servo motor is paired with some type of encoder to provide position/speed feedback. This feedback loop is used to provide precise control of the mechanical degree of freedom driven by the motor. A servomechanism may or may not use a servomotor. For example, a household furnace controlled by a thermostat is a servomechanism, because of the feedback and resulting error signal, yet there is no motor being controlled directly by the servomechanism. Servo motors have a range of 0°-180° [13].

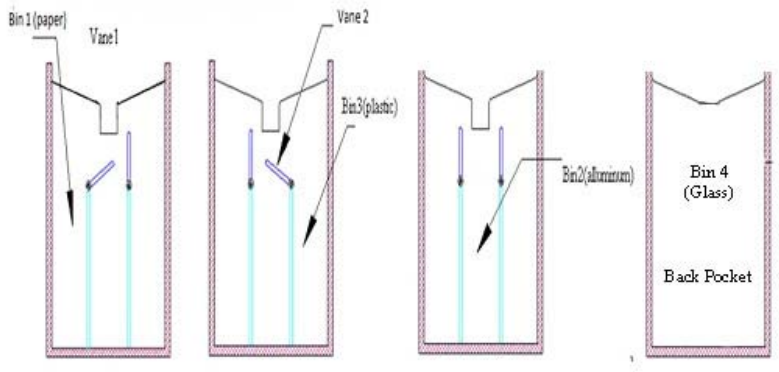

Fig.6 Sorting mechanism

The Servo motor is controlled by sending a pulse of variable width by the microcontroller. The control wire is used to send this pulse. The parameters for this pulse are that it has a minimum pulse, a maximum pulse, and a repetition rate. Given the rotation constraints of the servo, neutral is defined to be the position where the servo has exactly the same amount of potential rotation in the clockwise direction as it does in the counter clockwise direction. It is important to note that different servos will have different constraints on their rotation but they all have a neutral position, and that position is always around 1.5 milliseconds (ms). The angle is determined by the duration of a pulse that is applied to the control wire. This is called Pulse width Modulation [13].The servo expects to see a pulse every 20 ms. The length of the pulse will determine how far the motor turns. For example, a 1.5 ms pulse will make the motor turn to the 90 degree position (neutral position). When these servos are commanded to move they will move to the position and hold that position. If an external force pushes against the servo while the servo is holding a position, the servo will resist from moving out of that position. The maximum amount of force the servo can exert is the torque rating of the servo. Servos will not hold their position forever though; the position pulse must be repeated to instruct the servo to stay in position [14].

6. Comparative Studies

Comparison between the existing waste sorting bin and Automatic Sorter Machine for Smart Waste Management System is discussed below.

2.1 Automation

Most of the waste sorters available presently are manual, which are less user friendly. Automatic Sorter Machine for Smart Waste Management System is fully automated, which have made the whole sorting procedure very easy and effective.

Fig. 7 Manual Waste Sorting Bin

2.2 Cost Comparison

Many local and international companies manufacture trash can. Among them Carron Phoenix Disposal Products are worldwide famous. But at present the price of the trash cans, by Carron Phoenix, ranges from $120 to $250 [15]. The Automatic Sorter Machine for Smart Waste Management System will cost around $90. It is cheaper

than other because a unique algorithm to sort paper and plastic is developed and the mechanical structure is very simple.

2.3 Bin Number

Presently available trash bins can sort out only two or three types of trash materials [16]. But Automatic Sorter Machine for Smart Waste Management System can automatically sort out minimum four types of trash materials very easily and efficiently.

2.4 Unique Sensor Designing

Special type of sensor by using LDR and LASER is used in Automatic Sorter Machine for Smart Waste Management System. These have replaced the conventional sensors available in the market for sorting out paper and plastic.

2.5 Power Consumption

The power supply of Automatic Sorter Machine for Smart Waste Management System is driven by 9 V (DC). It can be driven by 220 V (AC) like the other available automatic trash bins.

7. Future Scope

Automatic Sorter Machine for Smart Waste Management System can be deployed to solve our existing problem as well as can bring about a change in our daily life meeting our own demand.

7.1 Sorting More Types of Materials

The developed Automatic Sorter Machine for Smart Waste Management System can sort only four types of waste materials. If more sensors are used then it will be possible to sort more types of materials (Such as: Transparent and nontransparent plastics, Thick and thin papers, Semi-conductor and Conductors, Rubber materials, Organic etc.).

7.2 Reduction of Cost

Companies those are manufacturing and distributing trash bin throughout the world, currently producing manual trash bins. If a large scale production of Automatic Sorter Machine for Smart Waste Management System is possible then the price of this product will be cheaper than present manufacturing cost. It will be cheaper because the mechanical structure is very simple and the sensors will be industrial grade.

7.3 Increasing Response Time

The response time of electromechanical system is relatively fast. But it can be made faster by using industrial grade servo motor. The microcontroller and servo motor used in presently developed Automatic Sorter Machine for Smart Waste Management System are properly synchronized. When the industrial grade servo motor will be used, then the system should be synchronized to perform smoothly and more faster.

7.4 Health Service

Special type of sensor could be used to sort out the organic parts of the wastes. When the organic parts of the wastes are sorted out then they may be tested automatically to find out the food habit of the user and analyze it for the improvement of the user's diet. Another application of sorting out the organic parts of the wastes is, the organic parts may help to diagnosis several disease of the user. Thus the health issues of the user of Automatic Sorter Machine for Smart Waste Management System will be insured at some extent.

7.5 Primary Recycling and Reusing Unit

A primary recycling and reusing plant may be installed with the automatic sorter machine. This will ensure that a home user will practice recycling and reusing. The primary plant may consist of only paper or plastic recycling unit. This will ensure a healthier life style and guarantee cost minimization for the home or industrial users.

8. Conclusions

In communities where appropriate sites are available, sanitary landfills usually provide the most economical option for disposal of solid waste. However, it is becoming increasingly difficult to find sites that offer adequate capacity, accessibility and environmental conditions. The amount of waste, which is been recycled or reused, stands for the reduction of waste to be managed by the authority. Proper management of waste plays a vital role to control global warming [1]. Automatic Sorter Machine for Smart Waste Management System is an excellent example of proper waste management. It will also ensure effective recycling system. Hence, the improvement of waste sorter will ensure economic and ecological development.

10. Acknowledgement

The first generation of the sorter was partially automatic. The ability of total sorted waste type was three. That was plastics, metal (Aluminum) and paper (non transparent) items. This time we have upgraded our sorter is full autonomous system. Also increase the number of bins. We add the glass sensor for sorting of glasses which is one of the burning burden around the world. Our previous work was published among the two international conference named International Conference on Mechanical Engineering and Renewable Energy 2011 (ICMERE2011) 22- 24 December 2011, Chittagong, Bangladesh, ICMERE2011-PI-128 [18] and 1st International Conference on Advances in Civil Engineering 2012 (ICACE 2012) 12 –14 December 2012 CUET, Chittagong, Bangladesh, ID: AEE 069.[17]

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