https://doi.org/10.46335/IJIES.2023.8.4.10 e-ISSN: 2456-3463
Vol. 8 , No. 4, 2023, PP. 46-51

International Journal of Innovations in Engineering and Science, www.ijies.net

Automated Waste Segregation System

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***Received on**: 29March,2023* ***Revised on**: 21 April,2023* ***Published on**: 23 April,2023*

Abstract— *Urban regions and metropolises have faced an increase in waste segregation problems owing to the rapid population growth. The accumulation of huge quantities of waste has led to health hazards for workers. Scientific studies show that their life expectancy of them including their offspring decreases. Indian waste is not directly segregated as wet or dry waste. The total solid waste generated in the Palghar district is 613.6 MT/D. This main problem is owed to the waste consisting of all types of materials such as metals, plastic, leftovers, etc. In India, Waste segregation is done manually by workers. The above factors and the living conditions of the workers call for an Automated Waste Segregation System at least in the initial stages of separation on the landfills. The proposed system focuses on an Automated Waste Segregation System using conveyor belt, washing unit and other techniques. It emphasizes hardware in tandem with apposite sensors to reduce incompetence and redundancy. In simple words, the proposed system aims to reduce human intervention involved in waste segregation using effective automation suitable for large-scale waste.*

Keywords— **Waste Segregation, Conveyor belt, washing unit, Automation, Eddy-current separation.**

I. INTRODUCTION

In India, where urbanization, industrialization, and economic growth have led to increased municipal solid waste (MSW) generation per person, waste management is a major problem for many urban local bodies (ULBs). The littered waste lying around, dumped on open lands, becomes a major breeding ground for bacteria and viruses that cause disease. To minimize environmental and public risks, waste must be segregated, transported, handled, and disposed of appropriately. The spread of diseases in metro cities and urban areas makes waste management and segregation a necessary process. A city with high population density faces a major challenge when it comes to effective WM. Figure 1.1 illustrates how waste management is handled on a manual basis in India.

In an Indian traditional waste management system, the following steps are involved which are health hazardous, time-consuming, and inefficient for waste generated in India.[3]

Figure 1. 1: Current Situation of Landfill

The waste is collected from all households and large bins across the city and brought into the landfill.

1. Later the accumulated waste in the landfill is manually taken in small quantities for processing.

https://doi.org/10.46335/IJIES.2023.8.4.10 **e-ISSN: 2456-3463**
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2. This includes handpicking things, and separating plastics, metals, and non-biodegradable waste while it passes through a conveyor belt or spread on a huge sheet.
3. Further segregation rounds take place which finallyresults in the categorization of waste:
    a. Wet Waste: Bio-degradable waste which can be used as manure, biogas, etc.
    b. Solid Waste (Plastics): Molded into different products which can be used by people. E.g., Flowerpots, coasters, pens, etc.
    c. E-Waste: Sent for further recycling or to scrapcollector.

II. LITERATURE SURVEY

Waste generated by India each year amounts to 62 million tons. [1] The research carried out provides a system to segregate waste plastic based on its size and color before recycling. Waste recycling plants use different sensors like IR Sensors, Proximity Sensors, and Color sensors. The proximity and color sensor can be used to segregate waste based on size and color thereby reducing the intervention and also the risk of health hazards for the workers. The research also conveys the use of the Arduino UNO Board for controlling the entire functioning of the proposed model [2].

The research explored the performance of different CNN Classification models like VGG-16, RestNet-50, Mobile Net, and DenseNet-121. All four models could separate waste into four classes- general waste, hazardous waste, combustible,and recyclable. However, the research is based upon the wasteavailable in western countries which is majorly dry waste thereby making it inefficient for countries like India where the waste is majorly wet and hybrid. [3]

The District Environmental Plan by the Environmental Department Government of Maharashtra & MPCB highlights different plans for waste management, air quality control, etc. Total Solid Waste generated from Palghar District is 613.3 MT/D wherein the dry waste is 290.9 MT/D and wet waste is 321.05 MT/D segregated every day. [4]

Thus, most of the research conducted is done on an entirely different type of waste which is not according to the Indian waste which calls for surveying the Indian Waste as illustratedbelow:

Landfill Plant, Malad:

The landfill plant visits at Malad Plant led to the identification of the problem statement and current condition of landfills in India which includes manual segregation on an actual practical scale rather than just the number counts. Figure 2.1 shows the homogenous mixture of waste that is procured daily on a humongous scale which breaks down the working of any western machinery solutions for waste segregation.

Figure 2.1: Landfill Visit in Malad Plant

Figure 2.2: Unusable Machine at Malad Plant

The workers are observed to be working in conditions as shown in Figure 2.2 which calls for health hazards. It also portrays the drawbacks of traditional methods and failing methods including western hardware systems. Thus, the visit widened the scope and horizon of the practical implication of the proposed model.

Thakur Ramnarayan College, Dahisar:

Figure 2.3: Shredder Demonstration in Thakur College

The visit to Thakur Ramnarayan College was aimed to know about the applications of the project in real-life post- waste segregation. The recycling of different types of plastics such as PET, HDPE, and PVC was observed

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which is obtained after dry waste segregation. The process of production of eco-friendly flower pots, coasters, barn floors, benches, etc. was observed closely. The working of the shredder and injection molding process was demonstrated as shown in Figure 2.3.

Components Designing & Manufacturing, Sativali, Vasai:

The main aim of the visit to the manufacturing house was to survey the actual implementation process of the proposed model. The designing process behind the production of the Shredder, Conveyor, and other assembly components was studied as shown in Figure 2.4.

Figure 2.4: Blade Design of Component

The Pricing, dimensions, and capacity of the components were discussed which gave a clear insight and idea into the industrial manufacturing process tailored to the proposal.

Techno Shell Automations Pvt. Ltd., Nashik:

Figure. 2.5: Conveyor Belt

Figure. 2.5: TechnoShell Automations

Figure 2.4: Blade Design of Component

The main aim of visiting TechnoShell Automations Pvt. Ltd. was to understand conveyor belts and looking at different types of belts. Additionally, the specification of motor and hardware feasibility calculations were studied on discussion with the industry expert.

Green Sutra, GoShoonya:

The main objective of visiting Green Sutra was to understand the concept of BOM and Material needed to use.

Later, more inputs were taken from college faculty for Inventor Design of Washing Unit.

III. METHODOLOGY

On performing the necessary literature survey, the problem statement was identified. The proposed solution includes is based on the aim to make hardware work in tandem with appropriate sensors. This proposed model ultimately reduces inefficiency and redundancy. They are decided upon the basis of components, sizing, pricing, and amount of automationrequired for proper execution.

A. Proposed System Model

4.1 Proposed Model:

The proposed model first begins with an intake which includes an electromagnetic conveyor for separating ferrous substances. At this point, the waste is already shredded.

As shown in Figure 4.1, this shredded waste will be washedinside the washing unit. The washing unit washes them with high rpm tumble revolutions and dries it with drying action as analogous to a washing unit but with high capacity

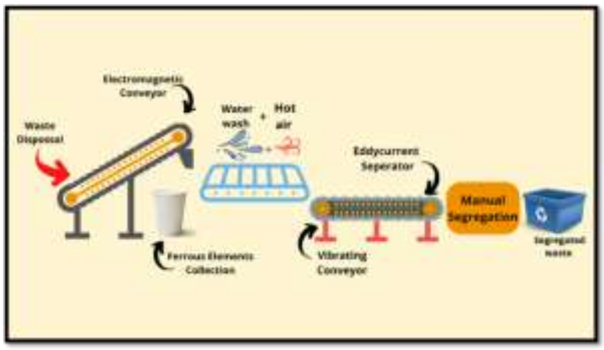

Figure 4.1: Block Diagram of Proposed Model

The washed and dried waste further passed through a vibrating conveyor to loosen the waste that in turn would

https://doi.org/10.46335/IJIES.2023.8.4.10 e-ISSN: 2456-3463
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be coupled with an eddy-current separator as shown in Figure 4.3. At the last stage, human intervention would be required where the workers manually pick up the plastic waste for segregation thereby completing the segregation process.

This proposed model paper focuses more on the aspect of Washing Unit as shown below.

4.2 Washing Unit:

The washing unit as discussed in proposed model is responsible for proper, effective cleansing of waste followed by drying.

4.2.1 Design

The washing unit design consists of a main-frame structure over which the entire unit rests to provide stability while the washing action is in process. The bottom is supported by 3 legs joining in unison. Extra support is also added to each beam in the form of reinforcement. The design of washing unit is as shown in Figures 4.2.1, 4.2.2, 4.2.3, 4.2.4.

Figure 4.2.1: Main Frame (Isometric View)

Figure 4.2.2: Main Frame (Top View)

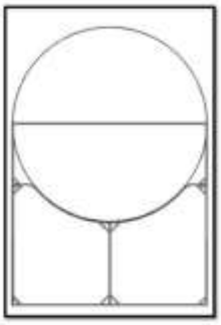

Figure 4.2.4: Main Frame (Front View)

Figure 4.2.4: Main Frame (Right View)

A water tank rests on the top of the main frame. This water tank houses a motor shaft on the circular side face which is used for washing along with water. This shaft exactly passes through the centre of tank and perforated tub as shown in Figure 4.2.5. It further has 2 inlets for faster filling and 1 outlet for draining which can be placed as per the manufacturer. Inside the water tank, there is perforated sheet drum where the actual waste is given as input. The perforation allows the water to cleanse it along with detergent and also helps during the draining process thereby leaving behind clean plastic waste as shown in Figure 4.2.6, 4.2.7, 4.2.8.

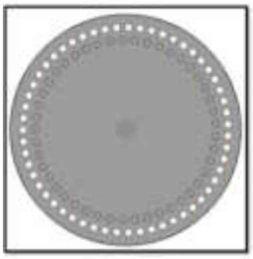

Figure 4.2.5: Inner Tub (Front View)

Figure 4.2.6: Inner Tub (Isometric View)

Figure 4.2.7: Inner Tub (Front View)

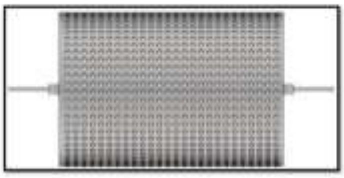

Figure 4.2.8: Inner Tub (Front View)

The face as shown in Figure 4.2.9, 4.2.10 covers the top cylindrical part from Figure 4.2.11. The tank has rubberized window opening which can be used for loading the washing unit with plastic waste to be cleaned. Additionally, for safety, the drum can also be tied along the cylindrical body with the frame Pillow Block base mounting points against the Main- frame as shown in Figure 4.2.12.

4.1.1 Specifications of Washing Unit

Figure 4.2.9: Sheave Rope 10mm Wheel 300mm

Figure 4.2.10: Face of Drum

Figure 4.2.11: Outer Drum

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4.1.2 The following are the specifications of Washing Unit as mentioned in Table No.1. The BOM structure for each item is normal for each unit quantity along with Pillow Block diagram as shown in Figure 4.2.12

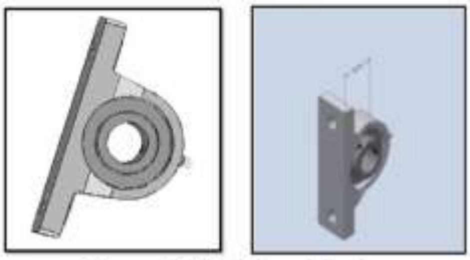

Figure 4.2.12: Pillow block

Item	Des.	QTY	Description	Dimension (mm)	Material
1	FM frame	1	Main Frame housing,	L x 50 x 8 where L is the variable length	Mild Steel 304 Grade
2	HPC – UCP 206/ PBT/W	2	UCP / PBT- Pillow block - Polymer and stainless steel - Base with 2 mounting points	163 x 46 x 91	Metal depending on the purchase
3	Inner tub	1	Preforated Metal Sheet Inner tub	1340 x 920 x 920 - Tub, 300 x 30 x 30 - shaft	Stainless steel Tub, Mild Steel Shaft
4	Sheave Rope 10mm Wheel 300mm	1	STEP AP214 Pulley	300 x 300 x 10	Metal
5	Face	2	Outer Drum Circular faces	1000 x 1000 x 2	Plastic
6	Outer Drum	1	Outer Drum	1500 x 1000 x 5	Plastic

4.1.2 Bill of Materials (BOM)

A bill of materials an extensive list of raw materials, components, and instructions required to construct and manufacture a product. The following and table no. 1 is an estimated material list for washing unit:

Metal perforated sheet for inner drum, motor and shaft, bearings, rotary sealings, axials, hinges, latches, Stainless Steel screws, nut bolts, rivets, rods, square pipe, valve, etc.

4.1.3 Working of Washing Unit

- Initially tank is filled with water and waste simultaneously.
- The inner drum is designed in such a way that the waste collides with the rod or the beam having brush/bristle like structure to wash/clean the plastic waste.
- Some chemicals/liquids too can be used to remove the oil or stains.
- After washing the water is drained from the drum and it is rotated again to remove or reduce the water inside.
- Thus, the waste is washed as well as dried so that it can used for further recycling process

IV. ANALYSIS & DISCUSSION

The implementation of the proposed model works on below generic principles below irrespective of the deployment of the proposed model one goes for. The proposed model dimensions and time of operations are calculated (approx.) foran input payload of 5kg (1 batch) as mentioned below:

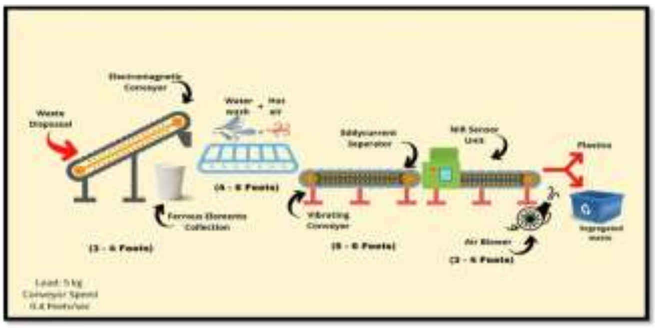

Figure 5.1: Dimensions of Proposed Model

- The proposed system includes different segregation stages, beginning with an electromagnetic conveyor that separates ferrous substances. This takes about 15-20 seconds at slow-moderate speed. (approx.)
- Further, it passes onto a vibrating conveyor where it loosens out and spreads evenly. This step is expected totake 5-8 seconds. (approx.)
- The eddy-current separator at this stage separates the non-ferrous metals. After this stage, most of the ferrousand non-ferrous metals are removed. This step takes around 15 seconds. (approx.)
- Lastly, the concluding stage of segregation requires human intervention to reduce the cost required for additional sensors as shown in Figure 4.1.

- **Optional:** NIR sensor detects the plastic materials based on spectroscopy, on which the material at that corresponding position is blown out using precision high-pressure blowers as shown in Figure 5.1. Or it can be replaced with robotic arms or manual segregation which is expected to take around 20 seconds. (approx.)

V. APPLICATIONS & RELEVANCE TO THE SOCIETY

The above proposed model reduces the time required for traditional waste segregation by significant margin. Also, the efficiency and quality of life for workers improves because of added automation. Other practical applications can be derived from the proposed system model as below:

- Reducing human intervention.
- Using Manure to generate Electricity.
- Manure to make Fertilizers
- Building eco-friendly products or for building roads.
- Improving Hygiene of Surrounding area
- Reducing Dumping Yards to Make lands for cultivation.

VI. CONCLUSION

Thus, the development of the project has started with a thorough literature survey including several industrial visits wherever necessary. In conducting the same, 3 potential proposed models are proposed for designing considering Indian Waste. The model is designed considering the initial payload waste input of 5kg including the necessary dimensions. The designed prototype also takes into consideration the health of the workers involved in the process thereby reducing human intervention. The modular units of the proposed model make it more reliable for future upgrades and repairs and extra add-ons for automation. Thereby the segregated waste is obtained as wet compost or manure and dry waste separately. The manure can be used to make compost or bio-gas energy whereas the plastic waste can be recycled and reused in different applications such as producing eco-friendly products or for building roads.

ACKNOWLEDGMENT

We would like to express gratitude to the Respected Principal Dr. Harish Vankudre, Head of the epartment, Dr. Amrita Ruperee. The progress of this project could not have been possible without the assistance of our Guide Dr. Amrita Ruperee. The contributions of the faculty are sincerely appreciated and gratefully acknowledged. We also would like to thank Gopal Sir (GoShunya) and the staff members of the Department of Electronics and Telecommunication, Vidyavardhini's College of Engineering & Technology fortheir cordial support and faith in us.

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