WASTE MANAGEMENT: DRUM SIEVE SEGREGATOR

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Abstract— The growing population and their changing consumption patterns have made Solid Waste Management a serious environmental and social problem. This situation has further become complex as domestic waste, market waste, industrial waste, agricultural and hazardous waste and other types of waste including both degradable and non-degradable particles get mixed in the mainstream of the municipal solid waste. Failure to segregate waste at the source has created the need for alternate methods. Drum–Sieve segregator is one such alternative for segregation, which similar to conventional processes segregate the non-decomposable from the decomposed particles through a sieve. The Drum-Sieve segregator is an approach to provide the segregation at lower power requirements, unlike conventional processes which are bulky and require larger space and power for operation. The Drum-sieve segregator is aimed to be used in cities where space for huge plants for operation is scarce. And hence it is designed to be compact and efficient. Drum-Sieve segregator is primarily aimed for segregating plastic from Organic waste, which is the final separated product obtained that can used a natural fertilizers. Unlike traditional segregating systems, the proposed model is smaller, easy to maintain and absorbs less power. It is mobile, and eliminates the need for manual feeding and cleaning of impurities.

IndexTerms- Drum Segregator, Sieve Size Changer

I.INTRODUCTION

The rapid urbanization, constant change in consumption pattern and social behaviour have increased the generation of municipal solid waste (MSW) in Kerala beyond the assimilative of capacity of our environment and management capacity of the existing waste management systems. Therefore, there is an urgent necessity of improved planning and implementation of comprehensive MSW management systems for upgrading the environmental scenario of the State. It requires detailed information on the quantity and character of MSW generated and their physical and chemical properties. This is to evolve appropriate waste management strategy based on the principles of reduce, reuse and recycle and design appropriate collection, transportation, processing and disposal system.

1.1 PHYSICAL COMPOSITION OF MSW

Muncipal Solid Waste is a combination of degredables and non degredables, varying widely from plastic waste, kitchen waste, glass, metal, paper, etc. However in a state like Kerala, were people consider waste as wealth, the composition of waste that is pushed out for landfill usually just comprises of plastic and kitchen waste.

1.2 PROBLEMS ASSOCIATED WITH LANDFILL OF MSW

Of the various challenges associated with accumulated garbage, its smell, the area of land for dumping and the diseases spreading from them, are the ones that gather special focus and attention. Municipal Waste can be seen as a physical composition mainly composing of degradable and non-degradable matter. The Degradable matter contributes to the problems associated with stink, while the latter contributes to the bulkiness and accumulation

1.3 PROJECT OBJECTIVE

The objective of the project is therefore to create a mechanism that has the capability to separate the degradable matter from the non-degradable matter, and to thereby reduce the problems associated with accumulation of waste.

- The objective of the project is to develop a product at economic rates, which is portable and could be operated by a single man.
- To develop a product prototype, that requires least power consumptions, and that which occupies least space.
- To develop a product prototype that provides maximum efficiency in segregating waste after fulfilling the above conditions, such that the separated waste is of good quality natural fertilizer.

2. MOTIVATION

In the past, a large amount of waste material produced was almost 100% biodegradable as the 'open dumping' of waste was in practice. But with new innovations and changing consumption behaviours, the non-degradable components of waste have gradually increased with extensive use of plastics,

polythene and glass items. This situation has further become complex as domestic waste, market waste, industrial waste, agricultural and hazardous waste and other different types of waste got mixed in the mainstream of the municipal solid waste as seen in [1]. This has led to the increase in the quantity and variations in types of waste that is being generated. The situation has further aggravated as the final disposal is predominantly open dumping leading to increasing environment degradation and growing health problems.

In most parts of Kerala, all the waste collected from houses, poultries etc. are being collected and dumped in dumping yards, producing foul smell and making no use out of it as seen in [2]. At Attingal, exists a plant where these waste materials after being allowed to decompose for 40 days ,is then fed to a plant, where size wise separation of plastic is being down, and finally decomposed matter is separated out which can be used as manure (fertilizers) as seen in [3]. This plastic separated can either be recycled or even used for road tarring purposes.

This plant in Attingal was a source of inspiration to bring out this idea because, the plant in Attingal bore a lot of limitations like bulkiness, complex process, time consuming etc. Thus our thought process turned out to create a product that served the same purpose, at the same time avoiding all these limitations.

3. METHODOLOGY ADOPTED

Our initial approach to the situation was to develop a system that separates all waste from each other. This included organic, plastic, glass, metal, aluminium, etc. We analysed both wet and dry separation methods. The wet processes included waste to flow with water throughout the process. The plant consists of machines for each segregation. Later we were introduced to the **Municipal Solid Waste recycling system in Sunnyvale**. The plant did a similar process with a number of conveyor belts, huge power requirements, large space requirements etc..

However based on the situation as we saw in the **Vadavthur plant**, we understood that such a huge process of segregating all kinds of waste from each other was not necessary in our state. The waste at Vadavthur plant had piled up. This accumulated waste was in the form of just plastic and organic. Presence of metal, glass and aluminium in waste was rare. This is because of the people making a living out of waste, Hence our target was shifted to just segregating plastic from organic.

Size separation was one of the methods we decided to move our approach to. However it faced problems as the waste in India is not uniform and remains heterogeneous in size and shape.

A visit to the **Attingal plant,** and understanding their process helped us in narrowing down to our product. The Attingal plant follows a process of decomposing the solid waste for a period of 30 to 40 days and then separating the waste using a screening process.

3.1 PROCESS INVOLVED
Process consists of two stages:

1. A biological process for decomposition of organic matter and

2. A mechanical process for screening the decomposed organic matter.

3.1.1 Biological process

A mixture of mesophillic and thermophillic micro-organisms identified to be more effective in speedy decomposition of organic waste will be used as an innoculum. The innoculum will be prepared using the mixture of bacteria, cow-dung and water. Solid wastes collected by Municipal Corporation will be delivered at project site regularly. Soon on arrival, innoculum will be sprayed on the garbage and the treated garbage will be stacked in the form of windrows. Separate windrows will be formed for each day's collection. These windrows will be turned once a week for proper aeration, so that aerobic process continues uninterrupted. Progress of composting will be monitored by measuring the inside temperature of the heap and the level of moisture. For optimum results, the temperature has to be between 65-70 degree centigrade and the moisture should be 25%. Composting will be completed in 25-30 days.

3.1.2   Mechanical process

Mechanical process is essential for screening out the digested organic matter in the form of powder from all impurities. The digested compost is highly heterogeneous having impurities of various shapes, sizes and texture. Hence, the screening has to be done in different stages. Suitable machines based on different screening principles will be employed at different stages.

4. IDEA DEVELOPMENT

The design process involved understanding the problem and the growing need of developing a product that satisfies the users requirement of segregating waste to separate the various components. The design development process through rough sketches on paper and CAD was targeted to develop a product that provided:

- **Utility:** The product's human interfaces should be safe, easy to use, and intuitive. Each feature should be shaped so that it communicates its function to the user.
- **Appearance:** Form, line and proportion are used to integrate the product into a pleasing whole.
- **Ease of Maintenance:** Product must also be designed to communicate how they are to be maintained and repaired.
- **Low Costs:** Product must be developed at minimum overall cost, so that they are easily available to all.

The design development involved studying the conventional processes and to develop methods to work on its limitations.

4.1 CONVENTIONAL PROCESS

The conventional process of size wise segregation involved sieving through multiple drums arranged along a line, and connected by conveyor belts. The system in Aatingal as shown in figure, involved 3 sieves rotating independently and connected to each other via conveyor belts.
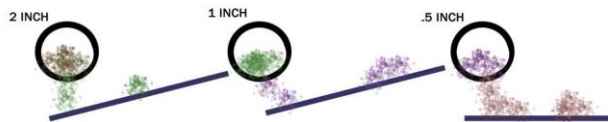

FIG. 4.1 THREE DRUM SIEVING PROCESS

4.2 LIMITATIONS OF PLANT IN ATTINGAL

1	Size	Multiple drums, for multiple segregation, connected by conveyor belts. Require greater floor space.
2	Power consumption	To drive 3 drums, and the connecting conveyor belts
3	Cost	Material cost, technology cost, land cost
4	Overall time	Time for waste to travel from one drum to the other
5	Labour	Operator, plant engineer, security persons, etc.

4.3 APPROACHES

1. To eliminate time factor :

Total time for process can be reduced by replacing conveyor belts with a suitable replacement that functions to transport waste from one drum to another. Several options were studied for finding the perfect alternative.

a. Option 1 : Connecting 3 drums

But the system still remains bulky

b. Option 2 : Concentric drums

This increase the overall diameter of the 3 drum system. It also creates a chance for waste to fall back into primary drum, which leads to improper segregation.
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2. To eliminate size factor

Conveyor belts connecting the 3 drums for automation of the system made it bulky. The best possible alternative involved adding a drum around the sieve for providing feed, between successive segregations.
Hence the design for drum sieve model was developed.
The main objective was to use the plant in cities where space for huge plants would not be available. Hence the product was designed developing minimum space and using least power.
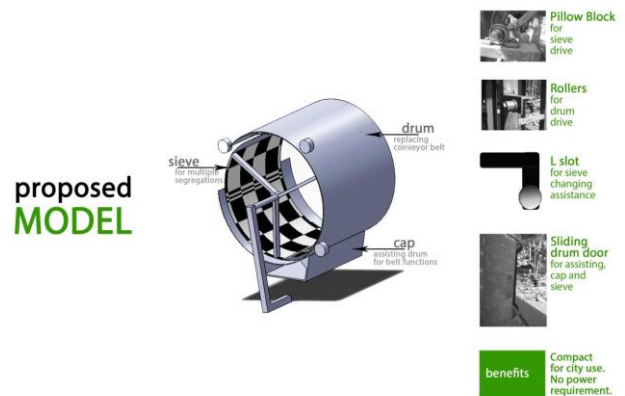
5. DRUM SIEVE SEGREGATOR

To overcome the limitations, and to achieve the benefits, a product was developed, which has a drum concentrically surrounding the sieve. Arrangements for changing the sieve size in the same sieve were provided and the whole system was made compact.
The developed product follows the given process

1. Waste **fed** into the system

2. Drum brought to basic position (organic cap at bottom)

3. **Sieve rotated**, waste segregated (smaller part moves through the mesh, larger plastic remains inside the sieve)

4. Smaller part containing the organic matter falls into the organic cap

5. The **drum is rotated** through an angle of 90 degrees , so that waste removal opening is at the bottom

6. The sieve is rotated, the **sieve flap opens** throwing the plastic waste away from the system.

7. The drum is rotated bringing the **organic cap vertically above**, this feeds the waste containing organic matter back into the system for further segregation

8. The **sieve size is adjusted,** using the sieve size changer. And the process continues

The components include

1. Sieve

2. Sieve size changer

3. Sieve flap

4. Drum

5. Organic cap

6. Sliding drum door

7. Drive components-pillow block

8. Frame for support

1 SIEVE

The purpose of the sieve is to provide a surface for segregation. The sieve is fabricated by welding areas of mesh into the sieve frame. This provides the sieve improved strength, and gives an added advantage of cheaper maintenance (if one area of mesh has a problem, only that area needs to be replaced and weld. The design has been provided to include maximum curved surface area with mesh, to provide maximum segregation. The segregator rotates manually with minimum effort, proving its portability.
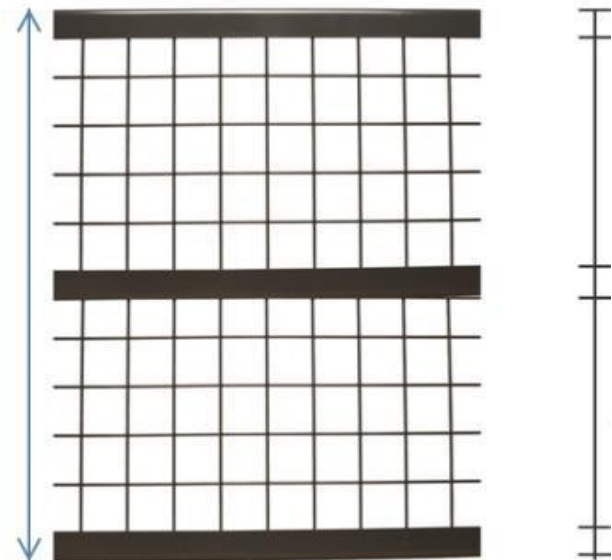

Fig. Sieve frame

Fig. Frame dimensions

2. SIEVE SIZE CHANGER

The function of the sieve size changer is to adjust the size of the sieve automatically. The sieve size changer is simply a second sieve concentrically around the first one, at minimum distance. It works on the concept of relative position between the meshes in the respective sieves

Fig. Sieve size changer

The automatic sieve size changing has been accomplished by the relative position between 2 adjacent sieves placed at a distance 1mm apart. The relative position of the 2 sieves provide 3 sieve sizes
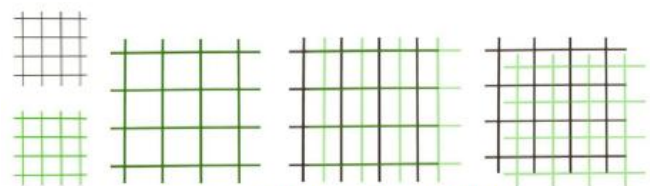

Fig. 5.5 Relative position between sieves

Initially the sieves are kept together so that they overlap each other, this provides a 2x2 inch square hole for segregation. On the next stage one sieve is moved along the length by a

distance of 1 inch which creates a hole size of 2x1 inch. For the final segregation the sieve is rotated along the circumference, by a distance of inch, which creates the smallest opening of 1x1 inch.
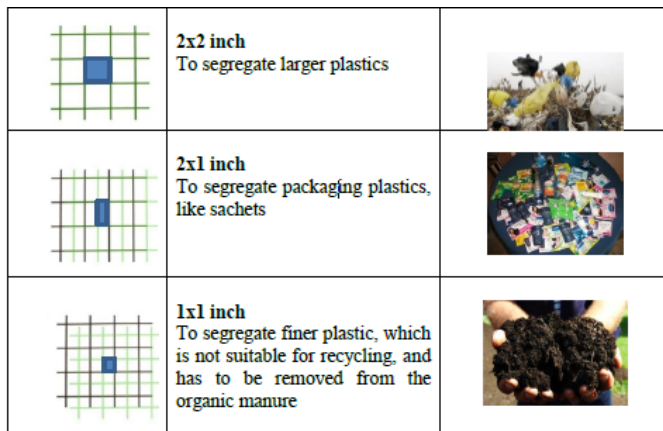

Fig. 5.6 The need for various sieve sizes

Automatic size changing technique

A simple slot of 1 inch dimensions was created for efficient relative motion between the sieves. The sieves were made to slide over each other with a bolt in the slot as a constraint. Here the bolt was attached to the inner sieve and the slot to the outter sieve.

Fig. 5.8 L-Slot

3. SIEVE FLAP

The sieve flap is a mesh hinged to the inner sieve. The purpose of sieve flap is to throw the waste away from the system during rotation, after segregation. It also performs the operation of assisting the feeding function, for transferring the matter collected in the organic cap. The opening and closing of sieve flap have been constraint with locking mechanisms to provide proper flow of work process
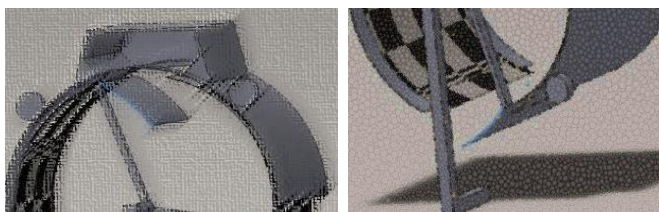

Fig. Flap open for feed and removal

4. DRUM

The purpose of the drum is to provide a casing for the sieve to rotate. The waste segregated from the sieve falls to the curved

surface area of the drum , from where it collects to the organic cup. The matter collected in the organic cap rotates with the drum, before it is automatically fed back into the system for further segregation.

Fig. 5.12 Drum

Table. 5.2 Drum dimensions

Outer diameter	611 mm
Cylinder sheet thickness	2 mm
Frame ring thickness	6 mm
Length	750 mm

Fig. 5.13 Drum dimensions

Design significance

The design significance in the construction of the drums is the position of the openings along the circumference. There are two openings in the drum
1. opening for collecting waste into organic cap

2. opening for removing waste from the system

The positions of the openings have to be designed so that operation of one does not affect the other. So as to achieve such a need, 2 concepts have been studied, before deciding on the best concept.

Concept 1: 180 degree model
The following processes take place
1. Primary position : organic cap at bottom

2. Matter collected into organic cap

3. Secondary position : organic cap vertically above

4. Matter fall back into system

5. Tertiary position : waste removal hole at bottom

6. Plastic Waste removed from system

Concept 2 : 90 degree model
The following processes take place
1. Primary position : organic cap at bottom

2. Matter collected into organic cap

3. Secondary position : waste removal hole at bottom

4. Plastic Waste removed from system

5. Tertiary position : organic cap vertically above

6. Matter fall back into system

5. ORGANIC CAP

As the name suggests, organic cap, is to provide a temporary storage to house the segregated organic portions after segregation. The cap has a hinged door at the bottom to withdraw the rich organic manure in the final stage.

6. PRODUCT ANALYSIS

6.1. ESTIMATING THE WORKING VOLUME

Volume of sieve = $r^2 h$
= 3.14 x 0.2972 x 0.750
= 0.207m^3
= 207 litres

Loading fraction = 0.25

Maximum volume of waste that can be loaded in the sieve = 207 x 0.25
= 51.75 litres
= 52 litres (approx.)

6.2. DIMENSIONS OF THE ORGANIC CAP

Volume of cap = 0.3 x 0.3 x 0.65
= 0.058 m^3

6.3. CAD ANALYSIS

Maximum Weight of waste = 55 kg
Weight of drum sieve apparatus = 400 kg
Total weight acting on the shaft =500kg (approx.)

The following tests were performed:
1. Static displacement test

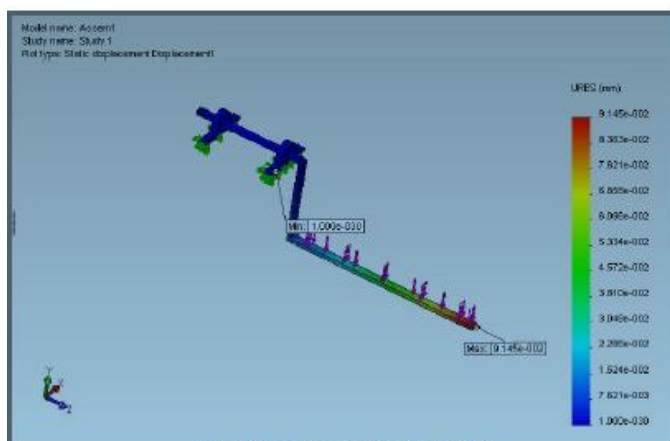2. Estimation of Factor of safety

6.3.1 Static Displacement Test

Fig. 6.1 Static displacement test
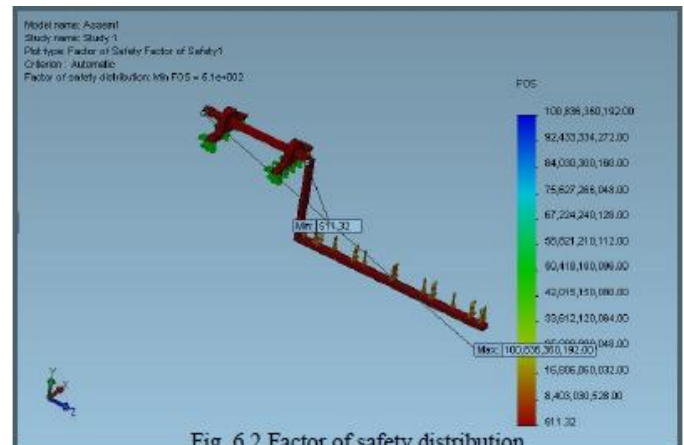
6.3.2 Factor Of Safety distribution

Fig. 6.2 Factor of safety distribution

7. CONCLUSION

The drum sieve segregator provides a solution to the growing concern of waste accumulation and associated problems. It serves to separate plastic from other waste, and helps to recycle it. The end product, the organic manure is equally useful for agriculture and horticulture crops. Hence, marketability of the end product is very good and the project is economically viable. Here plastic is separated from the waste in 3 stages, because only a particular segment of plastic (according to size) can be shredded. Shredded plastic is a great additive for tar roads. The Separated out organic matter , which is already decomposed is a good natural fertilizer

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