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Design, Fabrication and Analysis of Fully Automatic Solid Waste Segregation System

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Abstract:- Rapid growth in urban population coupled with economic growth, urbanization and rise in community living standards have resulted in generation of huge quantities of municipal solid waste posing serious problems: to municipalities, and corporations in terms of collection and disposal of solid waste, negative impact on the hygienic. The current project is one of a kind prototype, for the segregation of mixed household, Educational institutions and small industries waste into various components for easy processing of later stages for re-usage, recycling or disposal methods. This is achieved by three different criterions, namely a) Ferro - metallic scrap material b) Light weight waste material c) Centrifugal separation. Due to this the occupational hazard for waste disposal workers is reduced. Also, the segregated waste could be directly sent to the recycling and processing plant instead of sending it to the segregation plant.

Keywords:- *Solid waste, Separator, Centrifugal separation, Blower, Ferro metallic scrap.*

I. INTRODUCTION

It has been observed that the human labor for tasks that requires special dedication has dropped down drastically due to various reasons, it is necessary to find an automated system to help ease the task. It has been also noticeable that the municipality of growing urban regions are demanding mandatory pre-segregated waste as and when it leaves from the source point (Houses, offices, small industries, commercial places etc,) so a system to ease out the process is required using automation.

In India, rag pickers play an important role in the recycling of urban solid waste. Rag pickers and conservancy staff have higher morbidity due to infections of skin, respiratory, gastrointestinal tract and multisystem allergic disorders, in addition to a high prevalence of bites of rodents, dogs and other vermin. Dependency on the rag-pickers can be diminished if segregation takes place at the source of municipal waste generation.

Solid waste management is in crisis in many of the world's largest urban areas as populations attracted to cities continue to grow. This has led to ever increasing quantities of domestic solid waste while space for disposal decreases. Municipal managers are looking to the development of sanitary landfills around the periphery of their cities as a first solution. However, sitting and preparation of landfill requires the acquisition of large areas as well as good day to day operation in order to minimize potential negative environmental impacts. Another approach that has recently caught the attention of decision makers is mass burn incineration similar to systems found in the OECD countries. However, capital and operating requirements for these plants are generally an order of magnitude greater than required for landfills. Project developer angled with rosy financial forecasts can be found in all corners of the globe encouraging municipal officials to consider incineration.

A hygienic and efficient system for collection and disposal of solid waste is therefore fundamental for any community. Generally, the demands on the solid waste management system increase with the size of the community and its percapitaincome.

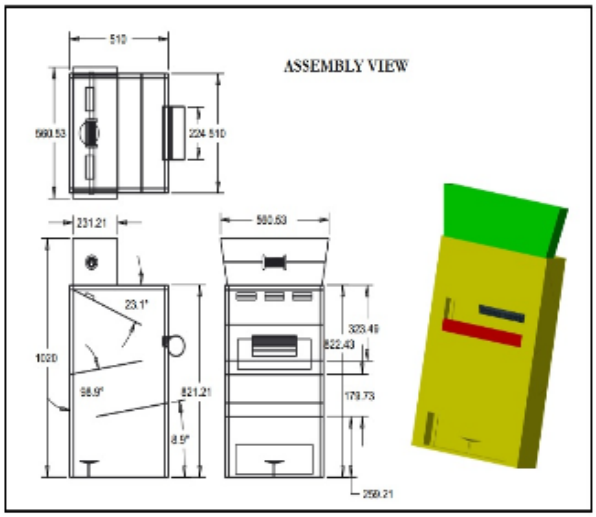

Fig 1:- Automatic waste segregator Assembly Model

II. CONCEPT GENERATION

Basic Design Idea

The basic idea before starting the project was to segregate the waste based on three different criterions, namely.

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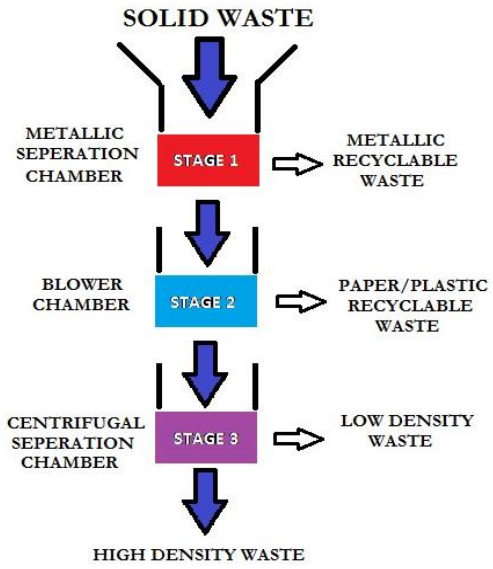

Fig 2:- Basic Design Idea Flow Chart [Ref.6]

A. Ferro - metallic scrap material
B. Light weight waste material
C. Centrifugal separation

A. In stage *1*, the plan was to eliminate the Ferro metallic waste by using electro magnets for attracting the metal particles and sending the rest of the material to the next level. As we pass electricity through a metallic bar, it gets magnetized and attracts the incoming metal waste among the mixed garbage. As soon as the current passage stops, the magnetic power of the metal is lost, henceforth, dropping the metal waste into the collection chamber. This separates out the metal waste.

B. In stage *2*, the initial plan was to eliminate the light weight particles like paper bits, plastic covers etc by using the principle of blowing air.

C. In stage *3*, the plan was to separate out the heavy waste particles from the light waste particles by using the principle of centrifugal force.

The basic design was in only a single unit in which all three stages are implemented.

III. STAGE MODULE PURPOSE AND PRINCIPLE

Stage1:Hopper

The main concept behind hopper is to ease out the flow of solid waste and house the waste into enter into magnetic chamber.

Stage2: Magnetic waste separator

The magnetic waste separator operates on the principle of magnetic attraction of Ferro-metal pieces towards permanent magnets. There are two platforms behind the metal collection door. The first platform is made up Electro-magnet and the second platform permanent magnet. Both these platforms are separated by a distance of 12cm.

Electro magnet is energized when electricity is supply to by 24V Dc current, it so magnetize and attract the Ferro-magnetic waste scraps. And for non- magnetizing action is achieved by disconnecting the power supply and makes the metal pieces to fall into the collection chamber from where the pieces can be retrieved.

Stage 3: Blower

The blower chamber consists of one blower inserted in corresponding slots. The fans rotate at speeds as high as 1200RPM driven by three separate 12 V dc motors. Blower stage uses the simple principle of blowing away the lighter particles from an incoming charge of waste material falling vertically downwards. The main aim behind using blower fans is to sort the waste in as less time as possible and without using handpicking or hand sorting or any kind of physical tangible operations. The charge of light weight waste that is blown away is collected in a chamber provided in the next stage. The vertical height of this collection chamber is lesser than that of the blower height from ground level.

Stage 4: Centrifugal Separator

The centrifugal separator works or operates on the principle of outward pseudo forces or in other words, centrifugal forces. The centrifuge is a conical device connected to a 12 V dc motor. As the centrifuge rotates the light particles stay in the centre of the cone whereas the heavy particles are thrown out of the conical surface due to centrifugal action. The movement of waste material inside the cone is always along the radius. Therefore, only a slight gap is provided along the circumference so as to prevent waste from coming out in all directions.

IV. CALCULATION FORMULATION

A. Magneto motive Force

The amount of flux available in any given magnetic circuit is directly proportional to the current flowing through it and the number of turns of wire within the coil. This relationship is called Magneto Motive Force or m.m.f. and is defined as:

Magneto motive Force,

(m.m.f) =I*N ampere turns

Magneto Motive Force is expressed as a current, I flowing through a coil of N turns. The magnetic field strength of an electromagnet is therefore determined by the ampere turns of the coil with the more turns of wire in the coil the greater will be the strength of the magnetic field.

B. Magnetic Field Strength for Electromagnets

The strength or intensity of a coils magnetic field depends on the following factors.

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- The number of turns of wire within the coil.
- The amount of current flowing in the coil.
- The type of core material.

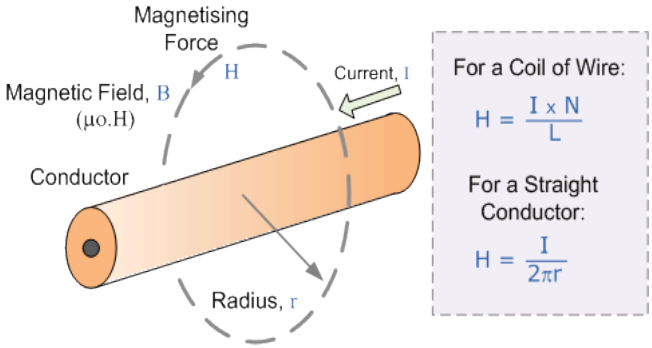

Fig 3:- Magnetic Field Strength for Electromagnets

Where,

- H – is the strength of the magnetic field in ampere-turns/metre, At/m
- N – is the number of turns of the coil
- I – is the current flowing through the coil in amps, A
- L – is the length of the coil in metres, m

C. Magneto motive force (M.M .F)

Magneto motive force (M.M. F)= I × N ampere turns

= 6.25 × 600

MMF = 3750 At.

D. Magnetic field strength

i For a coil of wire

$$H = \frac{I \times N}{L} \text{ ampere turns/metre} = \frac{6.25 \times 600}{9.9}$$

H = 378.78 At/m

ii For a Straight conductor

$$H = \frac{I}{2 \times \pi \times r} \text{ampere turns/meter}$$

$$378.78 = \frac{6.25}{2 \times \pi \times r}$$

r = 0.1026 m = 10.26 cm

iii Electro-Magnetic force

$$F = \frac{(N \times I)^2 \times K \times A}{2 \times G^2} \text{Newton}$$

$$F = \frac{(600 \times 6.25)^2 \times 4 \times \pi \times 10^{-7} \times 6 \times 1.77 \times 10^{-4}}{2 \times (0.1026)^2}$$

F = 0.89139 Newton

= 90.754 Gram Force/0.09075 Kilogram Force

V. RESULTS AND DISCUSSION

The experiment has been conducted for large volume of the dry waste objects to consider at worst condition. Ceramic waste is very rarely generated at home and other objects like glass and wood have detected as heavy weight waste.Plate1 represents the primary plate which is positioned at the entrance of the structure. Plate2 represents the intermediate plate. Paper, dry cloth and plastic bags are objects that belong to light weight waste. As the size increases, thus bigger metallic objects can be detected easily.

Based on the tests conducted the following following results were obtained:

Test1:

From analyzing the results obtained from first test we can conclude the following points: -

After careful examination and observation, the problems were identified for the above values. They are as follows

In stage 1 some of the metallic waste escape because of two reasons, first is that the power requirement for powerful electromagnet was not sufficient due to use of 12v battery and the second, reason is that the garbage fall with very high velocity on the sheet, because of this velocity they escape to next stage.

In stage 2, efficiency is less because of improper positioning of blower. The position of blower was located at starting of 2nd stage and air was circulating inside which made the light particles to circulate along with it.

In stage 3, efficiency is almost zero this is because the RPM of the centrifuge was verylow. This made all the particles which fall on it flyaway.

After making necessary changes after first test, second test was conducted.

From analyzing the results obtained from second test we can conclude the following points

1. After making necessary changes the efficiency of stage 1 increased from 65% to 90% which is acceptable.

2. After positioning of the blower at the correct position, II stage efficiency was increased from 60 to 80%.
3. After increasing the RPM of the centrifuge efficiency was found to be 30%.

VI. CONCLUSION

Automated Waste Segregator has been successfully implemented for the segregation of waste into metallic, dry and heavy weight waste at domestic level. However, the system can segregate only one type of waste at a time with an assigned priority for metal, light and heavy weight waste.

Thus, improvements can be made to segregate mixed type of waste by the use of buffer spaces.

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