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Design and Fabrication of a Novel Low Cost Food Waste Composting System with Accelerating Process Technology

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Abstract: ***Waste disposal is one of the biggest problems faced by the most countries. Unless and otherwise a proper methodology is met to treat the domestic and industrial effluents the public health and environment will face serious problems. Our project finds its application in the safe treatment of food waste aerobically with the help of mechanical agitation to reduce the risk of contamination in our households. Composting can be defined as the biological decomposition of organic matter under controlled, aerobic conditions into a stable product that may be used to improve soil quality or as a potting medium. Composting also disinfects organic wastes so that they may be beneficially used in a safe matter. The purpose of the project was to design and fabricate a low cost food waste composting system which ultimately accelerate the composting process. Experimentally it was found that the composting of normal vegetable residues take about 60 days with the help of a bacterial composter, like any biochemical reaction time duration required for the completion of composting was contributed by many factors which includes particle size, water content, temperature, air circulation. The device fabricated was fully functional in controlling the major factors among the above stated and can accelerate the overall process by 50%.***

Keywords: ***food waste, composting system, accelerating process technology***

I. INTRODUCTION

Daily life in industrialized nations can generate several pounds of solid waste per consumer and if the biodegradable parts in such things are directly exposed to nature it will create unhygienic conditions. Composting and biogas generation are the two important remedial measures which can be used to reduce the contamination and utilise for alternative purposes. A portable system capable of composting the organic waste materials can reduce the risk of household contamination also it will reduce the adverse effects of excessive alkalinity, acidity of the soil generated by the prolonged use of chemical fertilizer.

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Being portable it can be quiet useful for a group of customers. End product of this system is beneficial to the farmers. In the present work, the entire material selection and fabrication methods were chosen in the most economical and cost effective way. The product development was done with special reference to design for 'X' , where most speculated X terms are 'Safety', 'Ergonomics', 'Manufacturing', 'Assembly'.

II. LITERATURE REVIEW

Ajinkya *et al.* [1] introduced the concept of portability as a main facility needed for a domestic composting system and Inferred that Shredding and grinding organic materials helps to speed up the composting technique. The authors mainly focussed on composting of rice husk with help of organic lechants. Tom [2] discussed the potential scope for generating compost from the Municipal Solid Waste and pointed out the main advantages of the process for the society. They also demonstrated a system for shredding the waste materials accelerating the process by a large extent of time. Delia *et al.* [3] discussed the effect of mechanical shredding in the effective time duration for composting. Graphical representations obtained from the author's experiments shows the exact time duration for composting technique with the assistance of Mechanical shredding and water removal.

Bertoldi et al. [4] found that the key factors influencing the speed of composting process are: type of food , air, moisture, temperature and particle size. Decomposer organisms need water to survive microbial activity occurs at maximum speed at relatively thin water films. Optimum water content is limited to 40-60% of the total mass of compost pile. Below 40% water content Bacterial activity slows down and makes the process dull. Above 60% water level excess water force the air out of the pile and suffocate the microbes however anaerobic reactions take over to form compost but both the product and process will release bad odour.

The aim of this work is to develop a system for composting domestic food waste. The major problems that have to be overcome are: (i) bring down the time required by the composting process to obtain a stable product, (ii) reduce the particle size and increase the surface area of the waste material so as to increase the rate of chemical reaction (iii) bring down the water content it is possible to accelerate the process of composting (iv) provide air flow through the waste materials etc.

There must be a convenient mechanism for handling the materials. The material flow and transport in the device should be planned so that the operation does not cause degradation in the surroundings.

III. METHODOLOGY

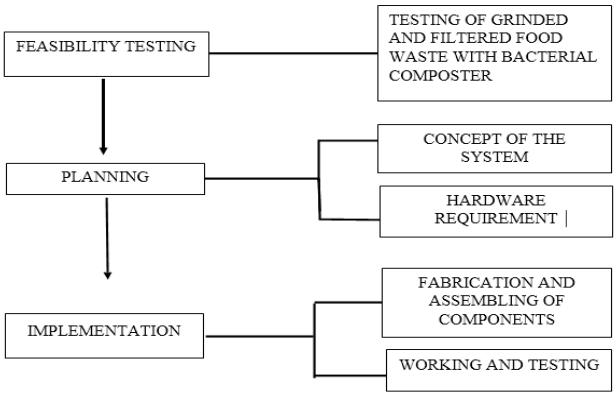

Fig.1 Methodology of the Proposed Work.

4.1. Feasibility Testing

Figure 1 shows the methodology of the proposed work. In order to check the feasibility of the project, some amount of food waste is taken and it is grinded and water is removed. Then sufficient amount of bacterial composter is added to it. It is then kept for some days to found out how much time it will take to form the compost.

4.2 Planning

Planning includes steps from the concept of the system to the design, implementation and maintenance of it. During the planning we determines the design of the project, number of components required and the working

4.3 Implementation

Implementation of the system includes fabrication of components and its assembly. It also compromises the working of the components. The components are fabricated using various machining operations.

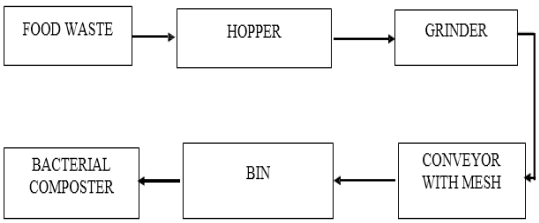

Fig. 2 Block-Diagram Indicating the Steps

Figure 2 depicts the step-by-step procedure of the proposed work. Food waste is fed into the grinder. The food waste is directed between the rollers by means of hopper. The hopper is made up of sheet metal. The grinder consists of two rollers rotate in opposite direction. The food waste will crush in between the rollers. From the rollers, the grinded food waste falls on the conveyor system. The conveyor system transports the food waste to the bin. The conveyor is made up of fine mesh, so that during transporting the flowing water from the food waste will filter out through this fine mesh. A tray made up of sheet metal is provided to collect the filtered water. From the conveyor the food waste will go into the bin. The base of the bin is made up of fine mesh in order to filter out the water during standing. The bacterial composter can be added directly to the bin. After the formation of compost it can be taken out from the bin.

4.4. Proposed system

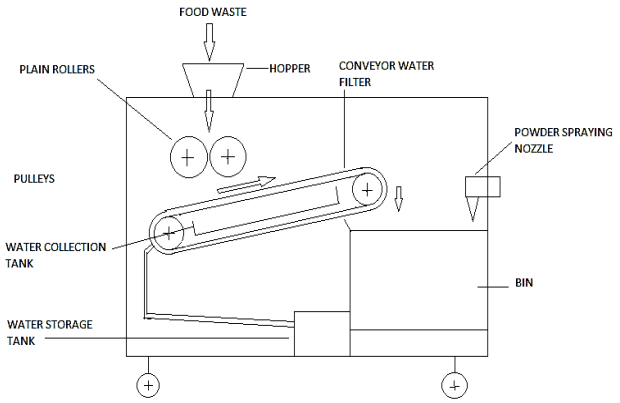

Fig. 3 Schematic Diagram of the Proposed System

The schematic diagram of the proposed system is indicated in Fig. 3. The major components of the system include: (i) Grinder (ii) Conveyor system and (iii) Bin. A grinder can be used for crushing the food materials into smaller size. The grinder consists of two or more rollers which revolves towards each other and pull particles of food materials through the space between the rollers, which is known as nip there by resulting in crushing. The feed particle size determines the type of rollers used. Rollers with teeth are able to grip large particles, making it possible to crush blocks of considerable size in rolls of moderate diameter. However, depending on what is being crushed and how fine it will be crushed, the rollers can be selected for best performance.

A conveyor system consists of two or more pulleys, with a continuous loop of material- the conveyor belt- that rotates about them. One or both of the pulleys are powered, moving the belt and material on the belt forward. The powered pulley is called the drive pulley while the unpowered pulley is called the idler. There are two main industrial classes of belt conveyors; those in general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport industrial and agricultural materials, such as grains coal etc. generally in outdoor locations.

The belt consists of one or more layer of materials. They can be made out of rubber. Many belts in general material handling have two layers. An under layer of material to provide linear strength and shape called carcass and an over layer called the cover. The carcass is often a cotton or plastic web or mesh. The cover is often various rubber or plastic compounds specified by use of the belt. Covers can be made from more exotic materials for unusual applications such as silicone for heat or gum rubber when traction is essential. Material flowing over the belt may be weighed in transit using a belt weigher.

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Belts with regularly spaced partitions known as elevator belts, are used for transporting loose materials up steep inclines. Belt conveyors are used in self-unloading bulk freighters and in live bottom trucks. Conveyor technology is also used in conveyor transport such as moving sidewalk or escalators, as well as on many manufacturing assembly lines. Stores often have conveyor belts at the check-out counter to move shopping items.

A wide variety of related conveying machines are available, different as regards principle of operation, means and direction of conveyance, including screw conveyors, vibrating conveyors, the moving floor system, which uses reciprocating slats to move cargo, and roller conveyor system, which uses a series of powered rollers to convey boxes or pallets.

Basically the purpose of a bin is to collect matter. According to the nature of matter to be collected bin can be made up of different materials and convenient shape. Here, bin is the final place where the food waste is accumulated and transformation to compost takes place. The capacity of bin determines the final capacity of the whole machine. All the chemical reactions on the food waste will take place at the bin. Final compost is collected from the bin. design of the system is carried out with the standard procedure available in the reference books.

IV. FABRICATION

Fabrication involves two stages (i) Fabrication of components (ii) Assembling of components. The components of the systems are fabricated using the different machines such as lathe, shaper, drilling machine etc. The components are the assembled in the main frame made up of angular section.

5.1. Fabrication of components

5.1.1. Turning

Turning in a lathe is to remove excess material from the work piece to produce a cone shaped or a cylindrical surface. The various types of turning are described below.

Straight turning: The work is turned straight when it is made to rotate about the lathe axis, and the tool is fed parallel to the lathe axis. The straight turning produces a cylindrical surface by removing excess metal from the work piece.

After facing the ends and drilling the centre, the job is carefully mounted between the centres using a lathe dog attached to the work piece, the bent tail of the dog fitting into the slot provided on the catch plate. If the work piece is mounted on a chuck or a face plate, care should take to centre it accurately with the lathe axis. The trueness of the work piece held on a chuck is tested by holding a chalk or a scriber or a dial indicator against the rotating work piece.

5.1.2. Drilling

Drilling is the operation of producing a cylindrical hole in a work piece by the rotating cutting edge of a cutter known as the drill. Drilling in a lathe is performed by any one of the following methods. (i) The work piece is revolved in a chuck or a face plate and the drill is held in the tail stock or in a drill chuck. Feeding is effected by the movement of the tail stock spindle. This method is adopted for drilling regular shaped work pieces. (ii) The drill is held and driven by a drill chuck attached to the head stock spindle, and the work is held against a pad or crotch supported by the tail stock spindle. Feeding is effected by the movement of the tail stock spindle. Work pieces of very irregular shape which cannot be accommodated on a chuck or face plate are drilled by this method.

Taper shank drills are mounted on sockets or drill holders and the straight shank drills are fitted to the drill chucks. Speeds and feeds for drilling in a lathe are 25% lower than the corresponding figures for drilling in a drilling machine.

5.1.3 Boring

The cutter is held in a boring bar which has a taper shank to fit into the spindle socket. For perfect finishing a hole, the job is drilled slightly undersize. In precision machines, the accuracy is as high as ±0.00125 mm. it is a slow process than reaming and requires several passes of the tool.

5.1.4 Tapping

It is the operation of cutting internal threads by means of a cutting tool called a tap. A tap may be considered as a bolt with accurate threads cut on it. The thread act as cutting edges which are hardened and ground. When the tap is screwed into the hole it removes metal and cuts internal threads which will fit into external threads of the same size.

5.1.5 Facing

Facing is the operation of machining the ends of a piece of work to produce a flat surface square with the axis. This is also used to cut the work to the required length. The operation involves feeding the tool perpendicular to the axis of rotation of the work piece. A properly ground facing tool is mounted in a tool holder in the tool post. A regular turning tool may also be used for facing a large work piece. The cutting edge should be sat at the same height as the centre of the work piece.

5.1.6 Filing

Filing is the finishing operation performed after turning. This is done in a lathe to remove burrs, sharp corners and feed marks on a work piece and also bring it to the size by removing very small amount of metal. The operation consists of passing a flat single cut file over the work piece which revolves at high speed. The speed is usually twice that of turning. The file should be slowly moved forward so that the work may pass 2 to 3 revolutions during the cutting stroke. During the return stroke the pressure is relieved but an end wise feeding movement is given, overlapping the previous cut. The file handle is gripped by the left hand and the tip of the file by the right hand to avoid accidents. Over filing in a lathe damages the trueness of the work piece.

5.1.7 Shaping

Shaping is the operation of producing flat surfaces using shaper. The shaper is a reciprocating type of machine tool intended primarily to produce flat surfaces. These surfaces may be horizontal, vertical or inclined. After the work is properly held on the table, a planning tool is set in the tool post with minimum over hang.

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The table is raised till there is a clearance of 25 to 30 mm between the tool and the work piece. The length and position of stroke are then adjusted. The length of stroke should be nearly 20 mm longer than the work and the position of stroke is so adjusted that the tool begins to move from a distance of 12to15 mm before the beginning of the cut and continues to move 5 to 8 mm after the end of cut. Proper cutting speed and feed is then adjusted. Short strokes should be given with high speed while long stroke with slow speed. Both roughing and finishing cuts are performed to complete the job. For roughing cut speed is decreased but feed and depth of cut is increased. Depth of cut is adjusted by rotating the down feed screw of the tool head. The amount of depth of cut is adjusted by a micro meter dial. The depth of cut for roughing work usually ranges from 0.075 to 0.2 mm. Feed is adjusted about one half the width of the cutting edge of the tool so that each cut will overlap the last cut giving a smooth finish.

5.1.8 Bending

Bending is a manufacturing process that produces a V shape, U shape or channel shape along a straight axis in ductile materials, most commonly sheet metal. Bending operations are generally planned in order to orient the work piece so that the bends are made across the grains produced in rolling. Bending is different forming in the sense that axis about which the bending is done is the straight axis, where as in the forming axis about which the bending is done is a curved axis. When bending is done, the residual stresses cause the material to spring back towards its original position, so the sheet must be over bent to achieve the proper bend angle. The amount of spring back is dependent on the material and the type of forming. There are three basic types of bending such as Air bending, Bottoming and Coining.

5.2 Assembly

The components fabricated are assembled using welding, bolting and riveting.

V. FINAL FABRICATION

Figure 4 shows the final assembly of the composting machine. The basic skeleton for the machine is made from L-section of 1.5 inch size. The L-sections were cut for the required dimensions. It is then joined by electric arc welding. On the base skeleton the components are mounted using bolt and nuts and Electric arc welding. The power from the motor is given to the reduction gear box. The two units are coupled using a star coupling. From the gear box the power is taken to the grinder using pulleys and a belt. The pulleys are mounted on the corresponding shafts and locked using bolts. The rollers are supported on bearings. The bearing seats are welded on the frame with necessary gap between them in order to facilitate the movement of food waste between the rollers. The bearing seats supporting the conveyor shafts are bolted on the L-sections in slots in order to tighten the two conveyor shafts. The mesh on the conveyor system is fitted over it using rivets. Silicone jell paste is also used in this. Bin is placed below the conveyor, so that the food waste will directly fall into the bin. Tray for collecting the waste water is bolted below the conveyor system. Another tray is also used below the bin. The water from the upper tray is made to flow to the lower one using PVC pipe. A door is provided on the front side of the machine to take out the bin and also to add the bacterial composter.

Fig. 4 Final Assembly- Composting Machine

VI. CONCLUSIONS

1. Fabrication of the entire system was completed with special regards to the design for safety, design for assembly and design for ergonomics and portability.
2. Manufactured with indigenously developed component parts with low cost materials which are available in the local market, which makes the product more affordable to farmers.
3. Product more optimized for household applications also the floor space consumed by it is minimum. Power requirement of the system is compatible with household power supply.
4. Here the successful attempt to fabricate a food waste composting system becomes an encouraging experiment when the whole Nation yet has not developed a proper facility to compost the organic waste which is cost effective to the farmers of this country.

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