Design and Fabrication of Solar Powered Trash Compactor Bin using Scissor Mechanism with GSM

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ABSTRACT: *India is the second populated country in the world making it to produce waste about 42 million tons of municipal solid waste per year at the present per capita generating waste about 200 to 600gm per capita/day causing a potential hazard to the human health and the environment. In order to reduce the pollution and volume of the wastes that piled over the rural or urban areas of India is because of insufficient waste bin storage and equipment. This project can help in waste management in order to improve environment of the urban areas in India by compressing the wastes deposited or thrown inside the dust or container bin. The mechanism adapted for compressing the waste is a scissor mechanism which is connected to a lead screw coupled to the DC gear motor, which is actuated by solar powered battery. This project reduces the transportation cost of wastes which are carried by the garbage trucks to the landfills. Large amount of wastes can be dumped in a comparatively smaller area of landfills. By compressing the volume of refuses or wastes in the container bin can reduced from 100% to about 60%.The lead screw used for this project can lift the force of 268.335N and efficiency of the lead screw is about 38.791% , torque given by motor to lift the force is about 2.0126 Nm. The angle of inclination for the scissor mechanism is about* $35°$ *to* $50°$*to vertical axis for compressing the wastes inside the bin. This project uses one pair and two sets of scissors for the mechanism. This project also uses GSM sensor which alerts with a message to the operator stating that the bin is filled when the volume of container bin reaches 100%. And it also includes a Fire alert alarm which beeps and messages when fire catches inside the compactor. Due to lack of proper dust bin, this project can reduce about 40-50% of wastes which are piled on the public area.*

Key Words: *solar panel, ultrasonic sensor, ardino controller, 12 volts battery, 12 volts dc motor, scissor mechanism, fire alert system, GSM (Global System for Mobile) sensor*

I. INTRODUCTION

Country like India with large population is been developing via industrialization, which is very significant for increase in urbanization and per capita income causes high amount of municipal or domestic solid wastes. These wastes can be a source for air pollution, ground water contamination, releasing green house gases. This affects the human health and urban environment. [1] Consequently to decrease the conflicts caused from the solid wastes a solar powered trash compactor is used. Solar powered trash compactor is used to compact the volume of the solid waste. Waste management is a process and action required or essential to manage waste from its inception to its disposal. It also includes collection of waste, transportation, treatment and disposal. [2] The approaches of waste management practices are different among countries of (developed or developing nations), regions (urban and rural areas), and residential and industrial areas. [3] Municipal solid waste is the largest waste management practices which consist of household, commercial and industrial activity. [4] The solar- powered compactor garbage or trash bins are designed to reduce the essential for emptying the wastes frequently in public areas. The capacity of this bin is to hold four times the volume of a normal average dust bin used in the municipalities, leading to reduce at least two to three collections trips in a day. It also reduces the operating costs, labour cost, littering, garbage smells, which leads to lesser air pollution and green house gases. It also minimizes the emissions of the garbage trucks which carry wastes while collecting wastes around two trips a day [5, 6, and 7]. The solar powered compactor trash bin is accoutred with a solar photovoltaic panel of 20 watts and a battery of 12 volts with 7.5 amps. This battery can be removable and charged conventionally or it is charged by the solar panel during daylight and it is also used during night time [8]. When certain level of garbage reaches inside the bin it automatically compresses the garbage using a scissor mechanism which is mounted on to the lead- screw or screw thread shaft. This shaft is connected to a Dc motor operated from the power of the battery. The Dc motor is actuated via relay switch. This relay switch is connected to the ultra- sonic sensor. This sensor senses the level of garbage inside the bin and sends the signal to the ardino controller which controls the relay switch for actuating the DC motor to operate the lead screw shaft which holds the scissor mechanism [9]. This mechanism extends to compress the waste in the bin, at the bottom end of the scissor mechanism a metal platen is welded so that the garbage is compressed uniformly with high pressure inside the bin after compacting; the mechanism is retracted to its initial or home position. In this project it is found that in India there is no solar power trash bin with scissor mechanism to compress the waste inside a dust/container bin, and it contains a fire alert system which beeps like alarm and sends message to the operator when fire occurs inside the compactor via GSM sensor.

II. LITERATURE REVIEW

Thomas R. Tracy, Jan, 9, 1989. He developed a trash compactor which is self powered by using a rechargeable battery to power scissor mechanism which is connected to a plate for allowing the plate to minimize the force exerted on the housing and bottom floor of the compactor. This compactor is used specially for aircrafts in food servicing tray carts. [9]. and it contains a box shaped container bin which offers light- weight and high strength with re-usable properties for deposition of waste. This setup of the mechanism can be retro-fitted to other food service containers, carts and waste dust bin of higher capacity volume.

Anthony fox, Aug 17, 2006. He invented a trash compactor which is especially used in restaurants to compact the food wastes. The compactor was designed to give a firm supportive frame with a horizontal rectangular base and four upwardly extended sheet metal cabinet panels which he calls it as 'skins' that is fixed to the rectangular base at the four corners of the edges. This base is extended across the width of the compactor between the side walls of trash compacting container attached at the top which is called as tray member. On the tray member it houses a hydraulic ram operated via hydraulic pump which is connected to electric motor for operating a hydraulic ram to compress the wastes or receptacles. [10]

Daniel Patras, Dec, 4, 2003. He developed a compactor trash bin including a bi-planar unitary load carriage which is housed at lower edge of the trash deposition entrance, with a proximal panel which functions as lid for selective opening and closing at trash deposition entrance and it consists of system controller having a sensors to monitor the position of the ram which is connected to a piston rod coupled to the cylinder this system controller detects the motion or action of the public while throwing the waste inside the bin so that the ram does not hit or harm the people when waste is compressed in the compactor bin.[11].

Fady E.F Samann 30, august, 2017**.** The work done by him was to develop a smart waste dust bin in streets of Iraq. The smart waste dust consists of ultra-sonic sensor which measures the height of the waste complied inside the dust bin and this smart bin also has a GSM module sensor which operates through a micro-controller which sends the message to the sanitation department when it is filled this setup of sensor and microcontroller is operated by a solar power source which is collected in the form of electricity inside a removal battery and an LED notification light blinks until the waste bin is emptied. [12]

Ranjeet Kumar Jha, Durgesh Sharma 16, Nov, 2018**.** They invented a solar compactor trash bin to compress the waste about 5 to 7 times when the bin gets filled. They used a motor connected with screw thread operated ram to compress around 15kg of solid waste at a time; the capacity of the bin was about 20 litres. The motor was operated by the battery which is charged from the solar panel, the motor is connected to vertically placed screw thread shaft which moves up and down to compact the waste in the bin, at the end of the shaft a metal platen is mounted to compress the wastes. They tested this compactor in their college's hostel for performance analysis. [13]

James Poss., Jeffrey Satwicz, Bret Richmond Mikell Taylor. June 9, 2004**.** They all formed an alliance to work on a solar powered compactor invention, which operates by using photovoltaic (PV) energy. This invention uses the solar energy to convert electrical energy into mechanical energy. Here the collected solar energy during daylight is stored in a removable battery or a capacitor. The DC current supplied by the battery is changed into AC current through on inverter. This AC current is used to operate the mechanism which supplies a pressurized hydraulic fluid to compact the waste through a compaction ram that uses hydraulic pressure. Another improvement in this device was to provide a separate compartment chambers for plastic wastes which can be recycled and other for domestic wastes such as tissues papers, papers cups, and food wastes, so that it reduces the weights of the chambers making for easy lift of each individual chambers and reduces the load carrying capacity of the chambers and workers to get less injury and easy removal of the chambers from the bin. This device is made to be placed in remotes places where electric source is less so that solar energy is used for compaction and it also uses a sensor for tracking the filled bins which sends the message to the sanitation department to empty bins were it is filled.[14]

III. OBECTIVES

- To develop the waste management system.
- To develop and improve the use of electrical controls using solar as the power source.
- Working out the design and fabrication with minimum cost and efficient outcomes.
- Making the working domain to be fully automated to reduce the human efforts.

IV. METHODOLOGY

The methodology postulates methods for understanding the Literature summary, objective of work, state of problem, gap identification, design procedures, fabrication of the model using suitable equipments and to make proper testing and work process with accurate results. Scissor mechanism is the premier element of this project. It is a four bar chain linkage called the tong linkage pivoted at off- centre connection symmetrically and it is a sliding pair with the degree of freedom of one (DOF). The 3D model of the project is simulated via CATIA V5 designing tool.

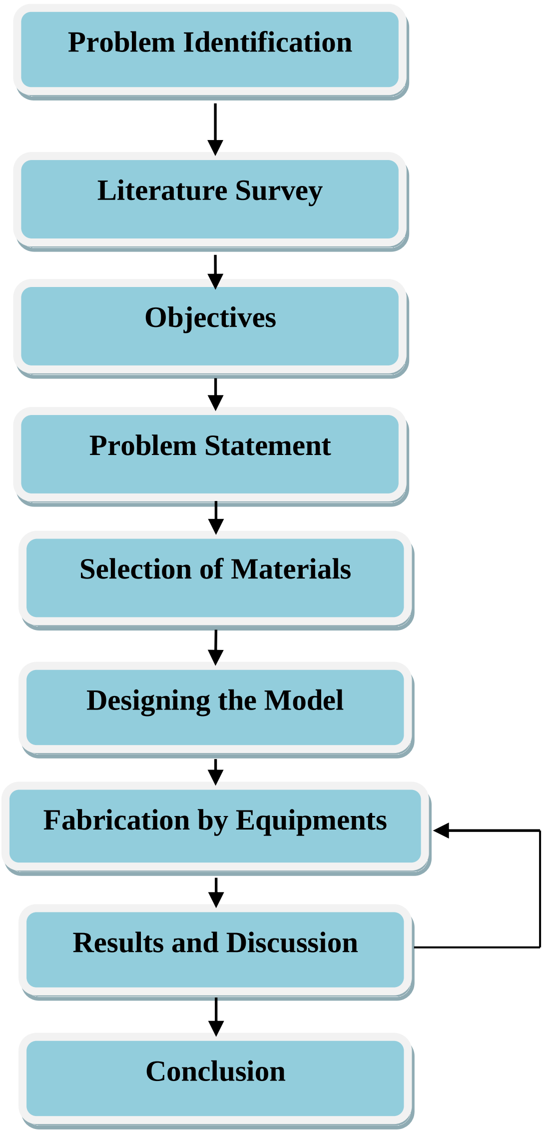


Figure 1: Flow Chart

V. Design Procedure

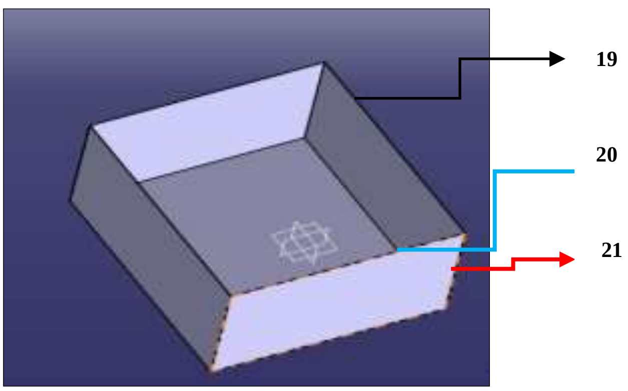


Figure (a): Container/dust bin

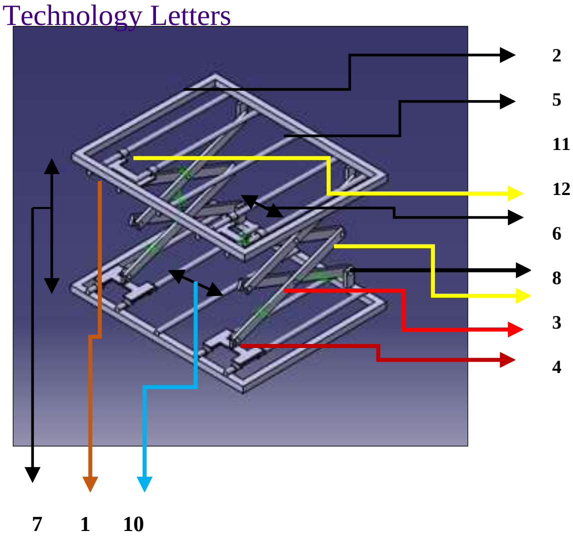


Figure (b): Inner rectangular frame with scissor mechanism

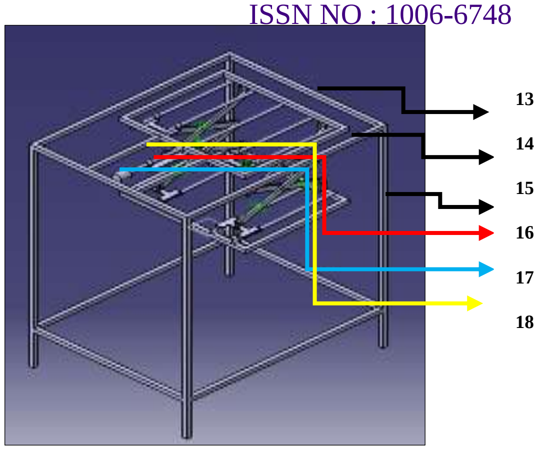


Figure (c): Outer rectangular frame welded with whole scissor mechanism

Figure (a) shows the waste or container bin which accumulates the waste thrown inside it. (19) It shows the length of receptacle or container bin measuring 686mm. (20) it is width of the container in 508mm. (21) shows the height of container bin in 279.4mm. Area of container bin is $3483.86cm^2$ and volume of $97339.16cm^3$.

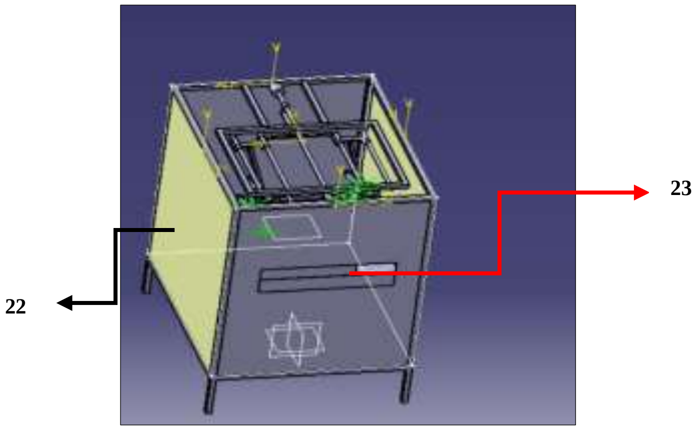


Figure (d): Outer rectangular frame isolated with sheet metal covering

Figure (b) shows the whole complete scissor mechanism with two sets or stages of scissor arms. Abbreviation (1) shows the width of inner rectangular frame measuring 431.8mm and (2) shows the length of 558.8mm. (3) it shows the moving arm of scissor mechanism and (4) being the fixed arms, (5) supporting five metal rods of diameter 12.5mm and length of 431.8 mm, it provides a sliding motion to the moving scissor arm in other words it acts as the guide-ways for the moving scissor arm. (6) It is the supporting metal hinge for fixed scissor arm measuring the length of 76.2mm and width of 25.4mm. Abbreviation (7) provides the length of the retraction and extraction of the scissor mechanism, when retracted it measures the length of 584.2mm and at extracted for compression of waste its length is 863.6mm. (8) It shows the pivoted joint between the moving arms and fixed arms to provide extension and retraction of the mechanism, it is pivoted via small metal rod of diameter 8mm and length of 317.5mm. Pivoting angle of inclination is approximately about $45° - 50°$to the vertical axis at retraction position and $30°$ to $35°$ at extended position of the mechanism. (9) It shows the I-section supportive joint which consist of two flanges width of 76.2mm and height of 25.4mm and web connecting the flanges with height of 50.8mm and width of 25.4mm. This I-section is pivoted to the moving arm of the mechanism and it also slides on the metal rod which is welded on the inner rectangular frame. (10) Shows the distance between the centre supportive metal guide way rod and guide ways metal rod measuring 88.9mm. (11) The distance between two guide-way metal rods is 63.5mm. (12) It shows four metal bushes which provide sliding motion to the moving scissor arms on the guide-way metal rods which placed at both left and right sides of the inner rectangular frame. The length of the bush is 20.34mm and diameter of 18mm and on these metal bushes the I-section joint is welded at four corners on to the flanges.

Figure (c) shows the whole scissor mechanism welded to the outer rectangular frame (the outer structure of invention or model). (13) It shows the length of the outer frame measuring 740mm and (14) width of the outer frame in 915mm. (15) height of the outer rectangular frame measuring 1120mm. (16) shows the connecting rod which is connected between lead screw and the moving arm of the scissor mechanism, this connecting rod is firmly fastened to the lead screw and moving arm. The lead screw rotates in anti-clock wise direction when the mechanism extends and it rotates in clock wise direction at retraction. The length of connecting rod from fastens point on lead screw and the moving arm is 381mm. (17) It shows the ball bearing's outer diameter 40mm and inner diameter 15mm, the lead screw is attached to the ball bearing firmly to provide rotary motion. This lead screw is also connected or fastens to a Dc gear motor which converts rotary motion of lead screw to liner motion of the scissor mechanism. (18) Shows the supportive metal flat for supporting the scissor mechanism at the top of outer rectangular frame with length of 355.6mm. **Figure (d)** shows the finished model of the invention is covered with sheet metal of thickness 0.18mm at all four corners of the outer rectangular structure. Orderly to reduce the over flow of wastes and disease spread to the environment, and (22) it is a door which can be opened and closed manually for removal of wastes after the container bin is filled. (23) It shows the passage opening for depositing waste inside the container bin.

❖ Calculations for lead screw

Figure (e): lead screw

Diameter of lead screw (D) = 15 mm
Co-efficient of friction for mild steel (μ) = 0.3
Mass exerted on the lead screw (M) = 50 kg
Pitch of the lead screw (P) = 10 mm
DC motor speed (N) = 30rpm

1. Velocity ratio = $\dfrac{\text{one revolution of the lead screw}}{\text{Lead distance}}$

Velocity ratio = $\frac{\pi D}{P} = \frac{\pi \times 15}{10} = \underline{\mathbf{4.712}}$

2. Efficiency of lead screw (η) = $\frac{\tan\alpha}{\tan(\alpha+\beta)}$

Where α → angle of slope of each outer threads

β → friction angle

$$\therefore\ \boldsymbol{\alpha} = \frac{\tan^{-1}P}{\pi D} = \frac{\tan^{-1}(10)}{\pi\times 15} = \mathbf{11.980°}$$

$$\beta = \tan^{-1}(\mu) = \tan^{-1}(0.3)$$

$$\therefore \boldsymbol{\beta} = \mathbf{16.699°}$$

$$\therefore \boldsymbol{\eta} = \frac{\tan(11.980°)}{\tan(11.980° + 16.699°)}$$

$$\boldsymbol{\eta} = 0.3879 = \mathbf{38.791}\%$$

3. Mechanical advantage (MA) = velocity ratio × **η**

MA = 4.712 * 0.3879 = **<u>1.82784</u>**

$$\therefore \text{MA} = \frac{\text{force of the load}}{\text{force of effect}}$$

4. Force of effect $= \frac{\text{mass of exerted on lead screw}\times\text{specfic gravity}}{\text{mechanical advantage}}$

Force of effect on lead screw = $\frac{50\times 9.81}{1.8278}$ = **<u>268.355N.</u>**

5. The torque of motor for lifting the load (T) = Force * distance

T= force * radius of the lead screw =$268.355 \times [7.5 \times 10^{-3}]$

∴ **Torque** = **2.0126 Nm.**

6. Power required to operate the DC motor

$$P = \frac{2\times\pi\times N\times T}{60} = \underline{6.322\text{watts}}.$$

❖ **Calculation for scissor mechanism** [15]

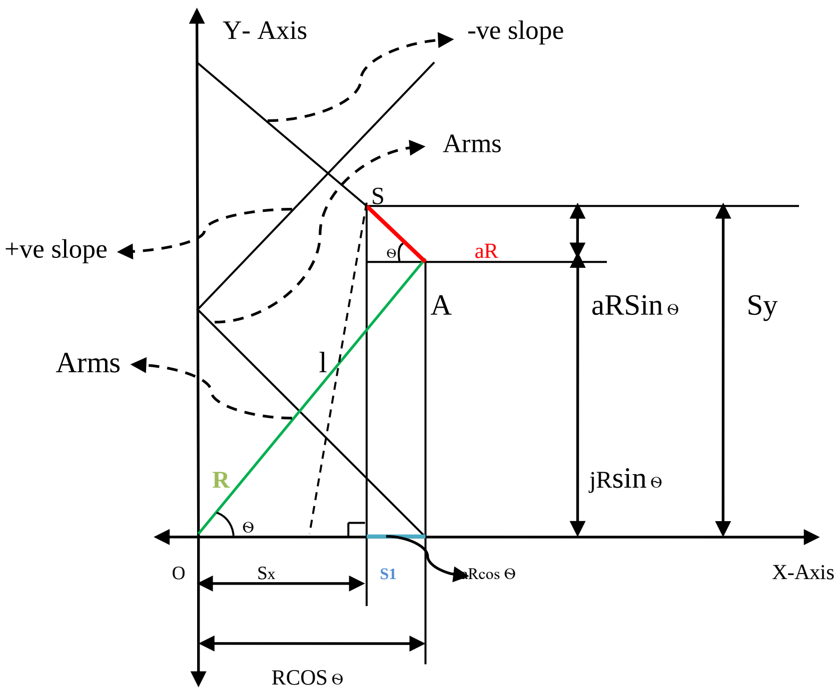


Figure (F)

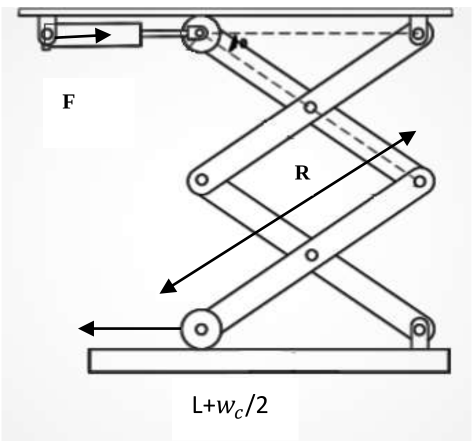


Figure (g)

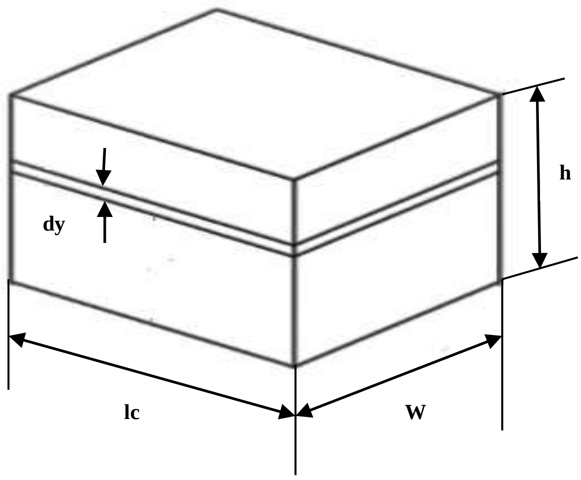


Figure (h)

The scissor mechanism contains a insignificant mass, it can be extended or retracted at any given height (h) with momentous amount of work done by the actuator (lead screw).We can consider an arbitrary cubical mass (m) shown in the figure (h) in terms for the mass of scissor mechanism.

Let weight of cubical mass (m) is $[w_c] = m*g$, where g is the specific gravity.

The volume of the cubical mass is given as $[V] = l_c*w*h$

- Where length of cubical mass is l_c , width is w, and height is h.

As the height increases, the mass will remain unchanged, therefore we know that density $(\delta) = \frac{\text{mass}}{\text{volume}}$

$$\therefore \text{mass (m)} = \delta \times \text{volume}$$

The cubical mass $[w_c] = w * l_c * h * \delta$

Considering a small amount of area on the cubical mass with thickness (dy) and height (y) from the base of the solid mass. From the figure (h)

$$\therefore P.E = \frac{W_c * h}{2} \quad \rightarrow \text{eqn (1)}$$

Note: The weight is unchanged with the change of height but the work done will change.

Δ P.E = $P.E_2 - P.E_1$

$\Delta P.E = \frac{W_c}{2}\ h_2 - h_1$ → eqn (2)

In the above equation, Work done is given as

Force ×displacemrnt

Here, the force is equal to $\frac{W_c}{2}$ and displacement is

$(h_2 - h_1)$

The work is done at the half of its weight to height (h_2) that is the work done at keeping the weight of this arbitrary mass at height (h_2).

Therefore, the weight of the scissor mechanism can be designed by keeping half of its weight at the bottom, i.e. the scissor mechanism's half of its weight is added to the load.

Hence, the total weight of the mechanism will be carried for by taking the effective load L_E for a particular load (L)

$$\therefore\ L_E = L + \frac{W_c}{2} \rightarrow \text{eqn (3)}$$

Considering the load of the two stages of scissors to be (L) and weight of the compression platen to be arbitrary mass weight that is $\frac{W_c}{2}$.

Deriving an equation for force required compress the waste accumulated in container bin:

Let the force excreted from the actuator with respective to time is given as (F) and length of actuator be (l)

Applying law of conversation of energy, we get

Work done from actuator = work done of mechanism at height (h)

$$\int_{l_1}^{l_2} Fdl = \int_{h_1}^{h_2} L_E\, dh$$

$$\int_{l_1}^{l_2} Fdl = \int_{h_1}^{h_2} (L + \frac{W_c}{2})\ dh\ \rightarrow\ \text{from eqn (3)}$$

Differentiating both the sides with respect to (l) and h

$$\therefore F = \left(L + \frac{W_c}{2}\right)\frac{dh}{dl} \rightarrow \text{eqn (4)}$$

The above equation will give the theoretical force required to raise a particular load L, for a particular actuator placements.

$$\frac{F}{L_E} = \frac{dh}{dl} \rightarrow \text{mechanical advantage}$$

Let us consider the mechanism is embedded in a Cartesian plane, with the origin (o) at the lower most hinge of the fixed end of the scissor mechanism. It is the point where the mechanism does not translate when it is extended, making it the origin. Shown in the figure (f)

To derive an equation for the type of actuator used to operate the mechanism:

From the figure (f), considering the force is applied on the negatively sloping arm (-ve slope arm) [AB]

Let (j) be the number of scissor arm stages or levels below point 'S'

Let 'S' be the point where the force is acting, 'T' be the point where the actuator is fixed. Line 'ST' is the outline of the actuator. The length of line 'ST' is the length of actuator.

Let S^1 be the projection of the point 'S' on the x-axis, 'O' is the origin, 'θ' is the angle between any of the positive (+ve) sloping arms and the X-axis.

'h' is the height of extension of scissor arms mechanism with load.

From the figure (f) (j = 1) where there is only one complete scissor arm stage below point (S) but this derivation can be done for any value of 'j', 'l ' is the length of actuator $\overline{ST}$, 'R' is the length of the scissor arms. $\overline{AS} = aR, |0 < a < 1$

Let the distance between point 'S' and pivoted joint of the negatively sloping arm on same arm as 'S' be 'aR' where $0< a <1$, that is 'a' is fraction of 'AS' in the full length of 'AB' arm.

Similarly, let $\overline{OT} = bR$

Let 'n' be the number of stages of scissor mechanism arms.

First note that,

$$h = nR\sin\theta \rightarrow \text{eqn (5)}$$

Because the length of scissor arm (R) is inclined at angle 'θ' which has vertical height of $R\sin\theta$ and the total height 'h' depends on the number stages or levels of scissor arms (n).

The co-ordinates of point 'S' with respect to origin (o) is $[S_x, S_y]$.

From the figure (f) we have,

$$S_x = R\cos\theta - aR\cos\theta$$

$$\therefore S_x = (1\text{-}a)\, R\cos\theta \rightarrow \text{eqn (6)}$$

$$S_y = aR\sin\theta + jR\sin\theta$$

$$\therefore S_y = (j\text{+}a)\, R\sin\theta \rightarrow \text{eqn (7)}$$

Consider the right angled triangle at which the actuator forms a hypotenuse in ΔTSS^1

In ΔTSS^1

$$\overline{ST} = l \rightarrow \text{eqn (8)}$$

$\overline{SS^1} = S_y$ → eqn (9)

$\overline{TS^1} = S_x - bR$ → eqn (10)

Substituting eqn (6) into eqn (10) and eqn (7) into eqn (9)

$\therefore \overline{SS^1} = (j + a)\, R\sin\theta$ → eqn(11)

$\therefore \overline{TS^1} = (1-a)\, R\cos\theta - bR$ → eqn (12)

Applying the Pythagoras theorem to $\Delta\, TSS^1$

$\overline{TS^2} = \overline{SS^1}^2 + \overline{TS^1}^2$ → eqn (13)

Substituting eqns (8), (11) and (12) in eqn (13), we have

$l^2 = (j + a)^2 R^2 \sin^2\theta + R^2 [(1 - a)\cos\theta - b]^2$ → eqn (14)

$l^2 = (j + a)^2 + R^2 \sin^2\theta + [\,(1 - a)\cos\theta\, R^2 - bR^2]^2$

$(a - b)^2 = a^2 + b^2 - 2ab$

$\therefore l^2 = (j + a)^2 R^2 \sin^2\theta + R^2 [(1 - a)^2 \cos^2\theta - 2b \times (1 - a)\cos\theta + b^2]$ → eqn (15)

$\frac{l^2}{R^2} = [(1 - a)^2 - (j + a)^2]\cos^2\theta - 2b\,(1 - a)\cos\theta + b^2 + (j + a)^2$ → eqn (16)

Because $\frac{l}{R}$ is always positive, therefore take square root on both RHS and LHS

We have,

$$\frac{l}{R} = \sqrt{[\,(1 - a)^2 - (j + a)^2]\cos^2\theta - 2b(1 - a)\cos\theta + b^2 + (j + a)^2}$$ → eqn (17)

Differentiating with respect to ‘h’

$$\frac{1}{R}\frac{dl}{dh} = \frac{1}{2}\,\frac{2b(1-a)\sin\theta\frac{d\theta}{dh} - [(1-a)^2-(j+a)^2]*2\cos\theta\sin\theta\frac{d\theta}{dh}}{\sqrt{[(1-a)^2-(j+a)^2]\cos^2\theta-2b(1-a)\cos\theta+b^2+(j+a)^2}}$$ → eqn (18)

To find an expression for $\frac{d\theta}{dh}$

From eqn (5), we have

$h = nR\sin\theta$

Differentiating eqn (5) with respect to θ we have,

$\frac{dh}{d\theta} = nR\cos\theta$ → eqn(19)

$\therefore \frac{d\theta}{dh} = \frac{1}{nR\cos\theta}$ → eqn (20)

Substituting eqn (20) in eqn (18), we get

$$\frac{dl}{dh} \Rightarrow \frac{1}{n} * \frac{b(1 - a)\tan\theta - [(1 - a)^2 - (j + a)^2]\sin\theta}{\sqrt{[(1 - a)^2 - (j + a)^2]\cos^2\theta - 2b\,(1 - a)\cos\theta + b^2 + (j + a)^2}}$$ → eqn (21)

$$\frac{dh}{dl} \Rightarrow n\frac{\sqrt{[(1-a)^2-(j+a)^2]\cos^2\theta-2b(1-a)\cos\theta+b^2+(j+a)^2}}{b(1-a)\tan\theta-[(1-a)^2-(j+a)^2]\sin\theta}$$ → eqn(22)

Substitute the above eqn (22) in mechanical advantage eqn, we have

$$\frac{F}{L_E} = n*\frac{\sqrt{[(1-a)^2-(j+a)^2]\cos^2\theta-2b(1-a)\cos\theta+b^2+(j+a)^2}}{b(1-a)\tan\theta-[(1-a)^2-(j+a)^2]\sin\theta}$$

$$F = n\left(L + \frac{W_c}{2}\right)\frac{\sqrt{[(1-a)^2-(j+a)^2\cos^2\theta-2b(1-a)\cos\theta+b^2+(j+a)^2}}{b(1-a)\tan\theta-[(1-a)^2-(j+a)^2]\sin\theta}$$ → eqn(23)

To simplify the expression, constants are defined for any actuator position:

Let K = 1- a → eqn(24)

Let M = j + a → eqn(25)

Substituting the above constants in eqn (23), we have

$$F = n\left(L + \frac{W_c}{2}\right)\frac{\sqrt{[(K)^2-(M)^2\cos^2\theta-2b(K)\cos\theta+b^2+M^2}}{bK\tan\theta-(K^2-M^2)\sin\theta}$$ → eqn(26)

Further we can simplify the expression by using constants,

Let $N = b^2 + (j + a)^2$ → eqn(27)

We have,

$$F = \pm\, n\left(L + \frac{W_c}{2}\right)\frac{\cos\theta - b}{b\frac{\sin\theta}{\cos\theta} - \sin\theta}$$ → eqn(28)

$$F = \pm\, n\left(L + \frac{W_c}{2}\right)\frac{\cos\theta(\cos\theta - b)}{\sin\theta(b - \cos\theta)}$$ → eqn(29)

$$F = \pm\, n\left(L + \frac{W_c}{2}\right)\frac{\cos\theta(\cos\theta - b)}{\sin\theta(\cos\theta - b)}$$ → eqn(30)

$$\therefore F = \pm\, n\left(L + \frac{W_c}{2}\right)\frac{\cos\theta}{\sin\theta}$$ → eqn(31)

$F = \pm\left(L + \frac{W_c}{2}\right)\frac{n}{\tan\theta}$ → eqn(32)

From figure (g), the force is acting at the pivoted part of the moving scissor arm, to extend and retract the mechanism therefore the distance between the pivoted point and the actuator is less below that point is zero. Hence, $a = 0$.The number of scissor stages or levels at the actuator level or height is nil [zero], ∴ □ = 0
From figure (g) the distance between the origin (where the actuator is connected to the moving arm of scissor mechanism) and the fixed or static end is depended on the length of the actuator which would be any arbitrary length, as it could take any value of length. Therefore the force expression becomes independent of 'b'. ∴ b = b
Substituting the values of *'a'*, 'j', 'b' in the constants (K, M, N), we have
$\therefore\ K = (1-0)^2 - (0+0)^2 \Rightarrow 1,\ M = b\,(1-0) \Rightarrow b,\ N = b^2 + (0+0)^2 \Rightarrow b^2$
Therefore for expression of 'force' associated to the position and type of actuator that is lead screw actuator.

We have,

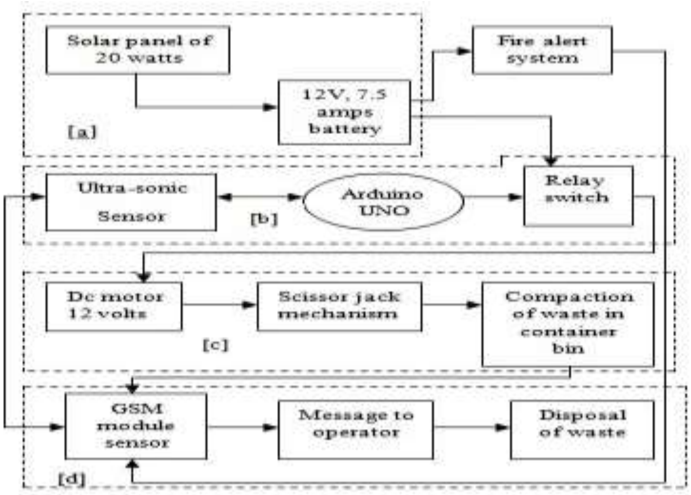
From figure (g), the load (L) is the weight of the scissor arms with two levels of scissor that n=2, L= 73.55Newton.

The weight $(\frac{W_c}{2})$ is the platen weight welded at the bottom of the scissor arm extensions that is $(\frac{W_c}{2})$ = 39.32 Newton and 'θ' = 35° it is the angle of inclination with respect to vertical axis, when the scissor arms extend for compressing the waste in the container bin.

$\therefore F = (73.55 + 39.23) \times [\frac{2}{\tan(35°)}] \Rightarrow$ **322.133** Newton.

The **322.133 N** of force is produced from the scissor mechanism to compress the waste in the container bin.

VI. Block Diagram



The above block diagram consists of following four units

a) Input unit
b) Controlling unit
c) Processing or working unit
d) Output unit

a) Input unit: The solar panel collects power from the sun's rays. It is a monocrystallic panel, containing solar photovoltaic cells which convert the sun rays into electricity. The Dc power from the solar panel is then stored in the 12 volts battery used to operate all the electronic components in the controlling unit and processing unit.

b) Controlling unit: It consists of relay switch [5V dual channel], ardino UNO [ATmega328 8-bit], and ultra- sonic sensor [HC-SR04]. These components are used to control the complete processing unit. The ultra- sonic sensor senses the wastes accumulated in the container bin at the constrained level (say about 5cm from the top of the container bin) and sends signal to the ardino UNO. The ardino UNO is programmed to actuate the GSM module which sends a message to the operator or the user when the constrained level waste is accumulated in the container bin and it also sends the message when fire is occurred inside the compactor. It also controls the relay switch to actuate the DC motor.

c) Processing unit: The Dc motor is connected to relay switch which actuates the scissor mechanism to compact the wastes in the container bin at constrained level. The relay switch with a H-bridge arrangement is used to control the Dc motor. This relay switch as two switch s1 and s2. When s1 is ON's, the motor terminals with a positive polarity, thus the direction of rotation of the lead screw connected to the motor is in clockwise direction to extend the mechanism, similarly when s1 is off and s2 is actuated the lead screw will rotate in counter-clockwise direction to retract the mechanism.

d) Output- It consists of a GSM module, when the ultra-sonic sensor senses the level of waste in the container bin (from the top of the container bin about 5cm), therefore actuating the scissor mechanism for compaction of waste and when the waste reaches about 3cm at top of the container bin, the ultra sonic sensor sends signal to the GSM module via arduino UNO, thereby it sends the message stating that the bin is going to be filled and need to dispose the wastes and the fire alert system is also connected to the GSM module, if fire occurs inside the compactor the GSM module sends message to the user stating fire is occurred

VII. RESULT TABLE

Sl no	Type of Waste	Before Compression CM^3	After Compression CM^3	Compression Rate in %
1	Cardbo-ards paper	56938.72	41508.894	27.09
2	Dry Leaves	66367.609	36953.58	44.27
3	Papers	34412.834	18025.72	48.02
4	Cut vegeta-bles	28477.87	19828.34	30.37

The result table shows the before compression volume rate and after compression volume rate of the wastes accumulated in the container bin. The wastes such as cardboard papers, dry leaves, papers, and cut vegetables are used for testing. These wastes are extensively deposited in commercial and residential areas. The results are effective and efficient for the overhead and fabrication expenditures wise of this project compared to other types of mechanisms and equipments.

VIII.CONCLUSION

The main intent of this project is to save the environmental time and money. It also stops the garbage container bins from overflowing, reducing unauthorized deposition of the wastes in commercial and public areas. Therefore reducing the diseases spread, air pollution, carbon monoxide emissions and keeping the nature environment clean and hygiene. The components used in this project are inexpensive and efficient with high build quality and durability. This project co-ordinate with both electrical and mechanical components to perpetrate the functions. But the electrical components are complicated; hence they require great isolation for protection. The battery used can withstand for longer time about a day or so, which is charged via solar panel and during winter and rainy seasons the battery can be charged using conventional battery chargers. For the time being this project requisites meticulous testing to effectively implement in populated and developing countries.

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