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Design and Fabrication of Litter Cleaner for Poultry Farm

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Abstract: Poultry litter is one among the promising source of biomass, which may be used as natural fertilizer or may be used as fuel for biogas generation as it has low environmental impact and potential as green alternative fuel for fossil fuels. Litter may be cleaned by human labor or by using motor power. The objective of this paper is to investigate the performance characteristics of the motor driven litter cleaner. The objective is achieved through design and fabrication of litter cleaner for poultry farm. Investigations have been carried out to compare cleaning process by human labor and by machines along with experimental investigations to examine the performance characteristics of the cleaner variables.

KEYWORDS: poultry litter, biomass, fossil fuels, and human labor.

I. INTRODUCTION

In agriculture, poultry litter is a mixture of poultry excreta, spilled feed, feathers, and material used as bedding in poultry operations. Poultry litter is used in confinement buildings used for raising broilers, turkeys and other birds. There are specific practices that must be followed to properly maintain the litter and maximize the health and productivity of the flocks raised on it. Many factors must be considered in successful litter management including time of the year, depth of the litter, floor space per bird, feeding practices, disease, the kind of floor, ventilation, watering devices, litter amendments, and even the potential fertilizer value of the litter after it is removed from the house [1].

Broilers have on average a 47-day grow out period, during which the typical broiler chicken will generate about two pounds of litter. This means that a single broiler house, which can contain well over 20,000 birds, can generate over 40,000 lbs of litter per flock [2].

Poultry litter's traditional use is as fertilizer. As with other manures, the fertilizing value of poultry litter is excellent, this can economically utilize by nearby agricultural land. But it is now also used as a livestock feed as a cost-saving measure compared with other feedstock materials, particularly for beef animals in the U.S [3].

Conventional energy sources such as oil, coal and natural gas have limited resources that are expected not to lose for an extended period. World primary demand is projected to increase by 1.5% per year 2007 to 2030, from just 12,000 million tons of oil equivalent to 16800 million tons as over increase of 40%. As world reserves of fossil fuel and raw material are limited, it has stimulated active research interest in non petroleum and non polluting fuels [4]. There are currently several electrical generating plants in the UK, and recently in the US that are utilizing poultry and turkey litter as their primary fuel. The world's first three plants were: Thetford (38.5 MWe), Eye (12.7 MWe) and Glanford (13.5 MWe), which were developed by Fibrowatt Ltd in the UK [5].

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Poultry industry is one of the fastest growing sectors in the country. During the past 3 decades the poultry scenario in the country has changes dramatically. Today the poultry farm has transformed itself into an organized industry. In spite of this high growth rate there is lack of advancement in litter management for poultry farm. There is an urgent need for the development because of various problems faced by this like bird flu.

II. METHODOLOGY

Methodology is a system methods and principles used in concept development process. The project work is carried out in a certain methodology. Figure1 shows the following steps will be followed in Methodology.

A. Realization of need

The problem is said to exist whenever there is a difference between the situation desired and the situation exists. The realization of need for a design solution is the beginning of the design process.

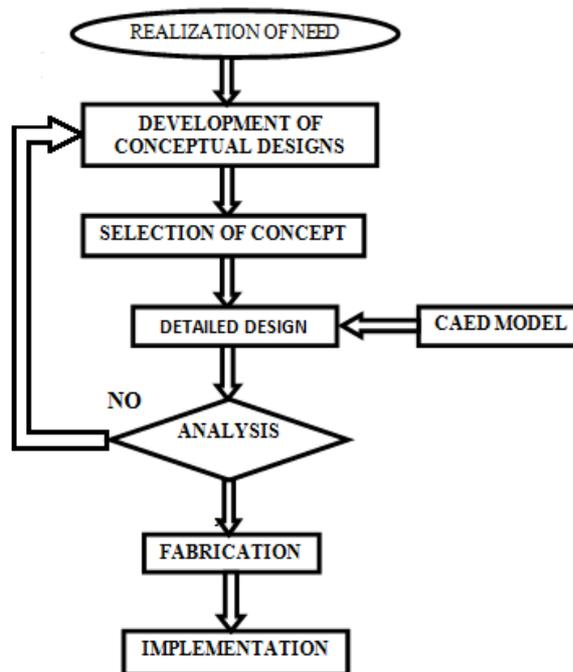


Fig.1: Steps involved in methodology

B. Development of conceptual designs

In this phase many designs will be developed as per the requirements.

C. Selection of concept.

In this phase the different conceptual design will be considered and best among the conceptual designs will be selected and finalized.

D. Detailed design

In this phase the detail design for the selected concept will be furnished.

E. Analysis

In this phase the detail design of selected concept will be considered and calculations are compared with analysis for loading points and safety.

F. Fabrication

In this phase the required materials are selected as per the design and fabrication is done.

G. Implementation

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After completion of fabrication, machine will be installed in Poultry farm.

Realizing the customer needs various concepts were developed. Based on Pugh matrix the best among the various was selected, detailed design according to the actual scale is done by using CAED modeling. Analysis is carried for the final concept for a stable system. Fabrication is done and finally installed.

III. CONCEPT DESIGN

Basically litter can be cleaned by manual labor or by using cleaning devices run by motor which use different mechanisms. Some among them are rope driven mechanism, water jet mechanism, motor driven mechanism, lead screw mechanism.

A. Manual labor

This is a tiring and lengthy process. Litter is to be cleaned by manual labor only after the batch is cleared. Availability of labor is fast depleting, so an alternative methodology is desired.

B. Rope driven mechanism

Scoop is driven to and fro in order to clean the litter by means of Motor which is placed on either ends, rope is used to drive the scoop. This method is suitable for very short distance cleaning. Additional equipments are required for retraction.

C. Lead screw mechanism

In this mechanism a Motor is connected to a Shaft. Two Lead Screw placed on either side of the floor pit is connected to the Shaft in the perpendicular direction through Bevel Gears. A cleaning unit is attached between the Lead Screws. This method may seem faceable but fabrication and implementation is difficult.

D. Water jet mechanism

A slant surface is provided throughout the floor pit and it will be arranged in such a manner that the droppings will be made to fall on that slant metal sheet. Water of high pressure is then made to pass over the slant surface which carries away the droppings along with water.

E. Motor driven mechanism

In this mechanism, cleaner attached with four wheels will be placed over two horizontal guide ways. These guide ways will be placed on the either side of the floor pit. A shaft assembly connected to gear box coupled to motor will be used to drive this cleaner. As the shaft rotates, the cleaner moves forward thus scrapping the poultry manure.

IV. SELECTION PROCESS

Pugh Matrix method is a decision making model where several concepts are evaluated according to their strengths and weaknesses against a reference concept, this method helps us selecting the best concept among the group.

The below scoring matrix used for concept selection. The selection is made based on the consolidated scores.

Concepts / Parameters	Concept B	Concept D	Concept A (REF)	Concept E	Concept C
Ease of operation	0	-1	0	+1	+1
Ease of litter Cleaning	+1	-1	0	+1	+1
Ease of Disposal	0	-1	0	0	0
Durability	-1	-1	0	+1	-1
Frequency of human Intervention	-1	-1	0	+1	+1
Consumption of water	+1	-1	0	+1	+1
Labor cost	0	0	0	+1	+1
Efficiency of cleaning	0	+1	0	+1	+1

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Quantity of litter cleaned in single run for a given time	0	+1	0	+1	+1
Sum of '+ive's	+2	+2	0	+8	+7
Sum of '-ive's	-2	-6	0	0	-1
Net Score	0	-4	0	+8	+6
Rank	3	4	3	1	2

Table.1: Scoring Matrix for concept selection

With the help of the scoring concept and ranking system we are able to finalize the as concept E (Motor driven Mechanism) has more strengths than the other.

V. DESIGN PARAMETERS

Technical design and specifications are made sufficient to coordinate components and elements of the project and information for standards and construction safety which are critically assumed to be important.

Scoop

Scoop is part which is used to push litter/manure in this case.

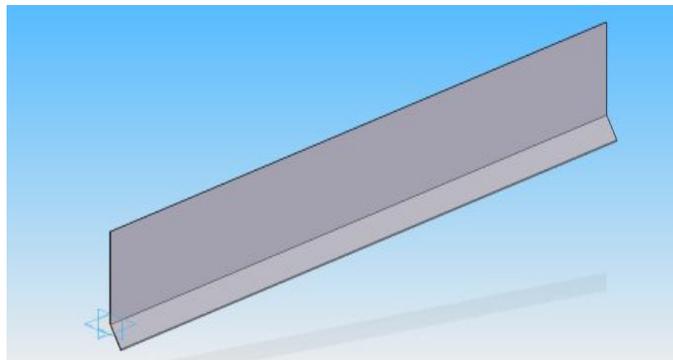


Fig.2: Scoop design

Stress,

$$\sigma_{stress} = \frac{Pb^2}{2t^2 \left(0.623 \left(\frac{b^2}{a^2} \right) + 1 \right)}$$

(1)

Where Pressure $P = 338.5 \text{ N/m}^2$, Breadth $b = 0.63 \text{ m}$, length $a = 2.3 \text{ m}$, Thickness $t = 0.0035 \text{ mm}$

$$\sigma = 6.2 * 10^{-2} \text{ N/m}^2$$

Deflection,

$$Y_m = \frac{0.0284Pb^4}{Et^3 [1,056(b/a)^2 + 1]}$$

(2)

Where $a = 2.3 \text{ m}$, $b = 0.63 \text{ m}$, $t = 0.003 \text{ m}$, $E = 210 \text{ GPa}$, $P = 338.51 \text{ N/m}^2$

$$Y_{mz} = 2.38 * 10^{-4} \text{ m}$$

Horizontal plate

Horizontal plate is a part which is welded to the main part, which is used carry load. The below figure shows Horizontal plate

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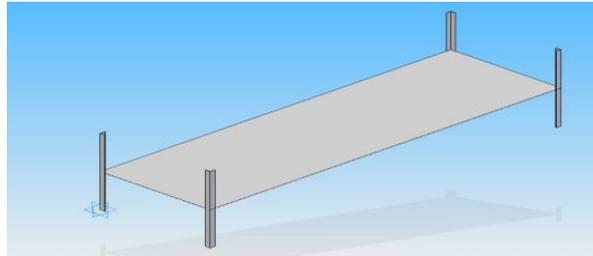


Fig.3: horizontal plate

Stress,

$$\sigma_{stress} = \frac{Pb^2}{2t^2 \left(0.623 \left(\frac{b^2}{a^2} \right) + 1 \right)}$$

Where Pressure P = 480.51 N/mm², Breadth b=0.8 m, Length a=2.55m, Thickness t=0.0035 m

$$\sigma = 6.15 * 10^{-5} \text{ N/mm}^2$$

Deflection,

$$Y_m = \frac{0.0284Ph^4}{Et^3 [1.056(b/a)^3 + 1]}$$

Where Pressure P = 480.51 KN/m², Breadth b=0.8 m, Length a=2.55 m, Thickness t=0.0035 m,
 Young's Modulus E=210 GPa

$$Y_{m2} = 0.210 * 10^{-4} \text{ mm}^2$$

Design of Shaft:

A shaft is a rotating member usually of a circular cross section (solid or hollow), which is used to transmit power and rotational motion.

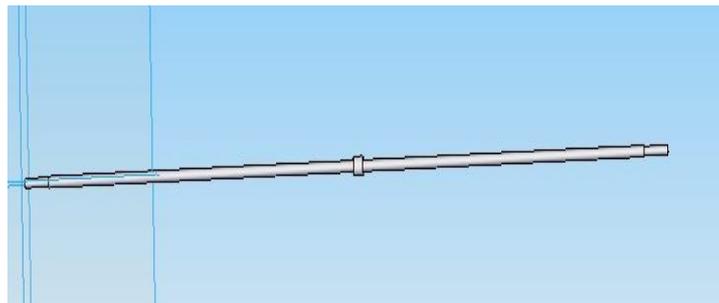


Fig 4: Design of shaft

To find the speed at which the shaft should rotate:

Total distance to be covered by the cleaner on the floor pit = 200 ft

Therefore, 200 ft = 60.96 m

Assuming average time required to cover 200 ft is 10 minutes.

i.e., Time = 600 seconds.

Therefore, linear velocity, v = Distance/Time (3)

$$v = 60.96/600$$

$$V = 0.1016 \text{ m/s}$$

Now we know that linear velocity, v = (π × D × N)/60 (4)

Where, D= diameter of shaft in mm = 26 mm, N= Speed in rpm

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Therefore, $v = 0.1016 = (\pi \times 0.026 \times N)/60$

Speed $N \approx 75$ rpm

Therefore in order to reduce the speed of the motor from 1440 rpm to 75 rpm we need to use a gear box having a ratio of **20:1**

VI. RESULTS AND CONCLUSION

Table shows the various parameters and cost involved for both machine cleaning and human cleaning methods. Parameters like initial investment, maintenance may lead people to go with indigenous method of cleaning.

Parameters	Cost for human labor	Cost for machine operated
Initial investment for housing.	10,000	30,000
Electrical expenses	200Rs/month	3,000Rs/month
Human labor wages	10,000Rs/month	2,000Rs/month
Expenses towards food	600Rs/month	200Rs/month
Travelling expenses	600Rs/month	N/A
Overtime wages	5,000Rs/month	N/A
Bonus during festivals and occasions	500Rs/month	N/A
Money spent in favor of laborer	500Rs/month	500Rs/month
Maintenance	N/A	500Rs/month
Salvage value	N/A	7,000Rs

From economic studies shows that a labor involved in cleaning a poultry farm for a year will cost around 1,50,000 INR. An automated litter cleaner indulged in cleaning will cost around 40,000 INR. This saves around 3/4th the money, which will affect to the cost of production.

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