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Design and Fabrication of Solar Operated Winnowing Machine for Grain Cleaning

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Abstract: *Winnowing process is used to remove chaff and residue from grains by the farmers. This process is carried at the farms after threshing process. Most of the farmers carry out this process manually with the help of air flow present in the environment. This process requires high human efforts. Also, it is time consuming. Hence to make this process easy and fast for farmers, we are designing solar operated winnowing machine. Solar operated winnowing machine decreases the efforts and time required for this process. Also, we are making it lightweight so it can be easily transferable from one place to another. Solar operated winnowing machine operates on solar energy. Therefore, this machine can be used easily at farms.*

Keywords: *chaff, residue, threshing, winnowing*

I. INTRODUCTION

In paddy, the grains are harvested with stalks attached. Then to remove grains from stalk mechanical force is applied. This process is called threshing. In traditional farming, threshing is done on a flat surface, where the paddy is spread and beaten, or stomped upon and shaken to extract the grains. The resulting grain is still mixed with chaff and other residue. The process of separating this chaff and other residue from grains is known as winnowing. Same process is carried out to clean wheat grains. This winnowing process is mostly carried out manually at village areas. In manual process farmers need to put grains in container and place that container on certain height from ground with the help of hands[1]. The grains present in container are thrown out slowly towards ground and grains are separate from chaff and other residue due to air flow. This process takes a lot of time and human efforts. Also, this process is totally dependent on air flow present in environment at that moment.

In Solar operated winnowing machine human efforts and time required for manual winnowing process is reduced. Air flow present in winnowing machine is not dependent on atmospheric air. Air flow is generated by fan present in winnowing machine. This fan is operated with the help of solar energy.

1.1 Problem Definition

Cleaning grains after harvest is important as it removes unwanted materials from the grain. A clean grain has a higher value than a grain that is contaminated with straw, chaff, weed seeds, soil, rubbish, and other non-grain material. In paddy, the grains are harvested with stalks attached. Then to remove grains from stalk mechanical force is applied. This process is called threshing. In traditional farming, threshing is done on a flat surface, where the paddy is spread and beaten, or stomped upon and shaken to extract the grains. The resulting grain is still mixed with chaff and other residue. The process of separating this chaff and other residue from grains is known as winnowing. Winnowing process is carried manually by farmers. Due to manual operation this process requires more time and high human efforts.

II. LITERATURE REVIEW

Oluwaseun M. Akeyo et. al, 2020 [1] Designed and Analyse large solar PV farm configurations with DC connected battery systems. The photovoltaic (PV) energy installations are fast-growing both for residential applications, as well as for utility-sized power plants. Solar PV generation is intermittent in nature, and much of the associated research focuses on employing battery energy storage systems in order to mitigate this inherent limitation.

Rahmawati Munir et. al, 2018 [2] conducted experimental investigation of the rice winnowing and develop a physical model to explain the process of segregation of rice grains having different size or density. The result can be useful to design a new method in separating
grains based on size or density.

Sharvin A Ghodekar et. al, 2017 [3] designed and Evaluate of Operated Portable Winnowing Machine. Design validation shows that one person is capable of operating whole operations of the system. Ergonomic considerations are increasing ease and working environment.

Mohammad Vahedi Torshiz, Atefeh Hosseini Mighani, 2017 [4] conducted the study of application of solar energy in agricultural systems. Solar photovoltaic (PV) cells were invented at Bell Labs in the United States in 1954, and they have been used in space satellites for electricity generation since the late 1950 s. In this technology, solar rays collected via small plates that are semiconductor photovoltaic, are converted into electricity. Photovoltaic cells can be built in two ways: concentrator and flat panel. Solar cells are the most common type of flat panels where the light is immediately brought to semiconductor and is converted to electricity.

Krishna Prasad Shrestha et. al, 2016 [5] conducted the Mathematical modeling, simulation and analysis of rice grain movement for design and fabrication of low-cost winnowing machine. This resulted in a final product having 0.16 m × 0.10 m grain outlet and 0.20 m × 0.20 m husk outlet in which 19 kg of rice grain were tested in average separation time of 70.8s for five trails

Harishankar Suresh et. al, 2014 [6] presents a solution for existing power crisis by implementing state of art techniques to tap power from solar energy. The use of Maximum Power Point Tracking technique along with the efficient charge control of the battery helps attaining a maximum output.

Nadarajah Kannan, Divagar Vakeesan, 2014 [7] presented study on Solar energy for future world. here are various applications of solar energy since it is freely available with low damage to environment. Solar energy is now applied for heating of buildings, cooling of buildings, heat generation for industries, food refrigeration, heating of water, distillation, drying, cooking, power generation and other various processes.

Thomas L. Gibson, Nelson A. Kelly, 2009 [8] presented study on Solar photovoltaic charging of lithium-ion batteries. Solar PV battery charging was tested by using crystalline and amorphous silicon PV modules to recharge lithium-ion battery strings. The iron phosphate type batteries were charged to their maximum capacity with optimum efficiency while avoiding thermal hazards associated with overcharging due to the self-regulating design of the solar charging system.

Petre I. Miua, Heinz-Dieter Kutzbach, 2006 [9] conducted Modeling and simulation of grain threshing and separation in threshing units. The developed equations describe and quantify the fraction of unthreshed grain, free grain and separated grain over the length of threshing space: concave and, respectively, rotor length. Grain threshing losses, separation losses and separation efficiency are also quantified. In validating the theories, the author has processed and interpreted reliable experimental data obtained from laboratory testing.

Bryan, J. M., 1948 [10] conducted the study on Aluminium and Aluminium use in the food industry with special reference to corrosion and its prevention. Aluminium is extensively used in the food industry both for domestic utensils and in factory work for equipment, food containers, seals for milk bottles, foil for wrapping foods and the like. On the health side, two points are important and both receive consideration i.e. the extent of any corrosion and the degree to which aluminium is dissolved in foods and how far such additions may be detrimental to health. Non-acid foods free from salt cause little or no corrosion.

III. METHODOLOGY

To overcome the problems arriving during winnowing process, we are designing and fabricating ‘Solar operated winnowing machine’. We also tried to address the drawbacks of already existing machines and made improvement in our project. Solar operated winnowing machine runs on solar energy so the energy problem arrives in farmers is removed, also it makes machine eco-friendly. We also designing this machine lightweight so can easily transferable from one place to another. The running and initial cost of this machine is very low.

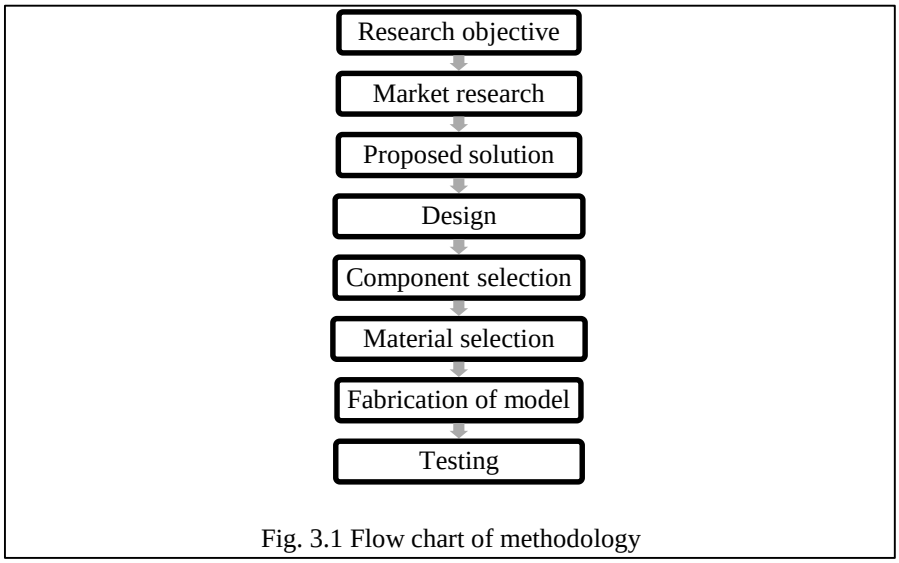

Fig. 3.1 Flow chart of methodology

3.1 Research objective

Cleaning is one of the important post-harvest steps that aids storage, processing, quality control, and pest management. However, grain cleaning is mainly done using rudimentary manual methods. For instance, majority farmers in Uganda have continued to use their conventional cleaning techniques such as winnowing trays and screens for cleaning maize even with huge maize yields. Not only do these methods contribute to poor post-harvest handling, but they are also tedious, labour-intensive, time-consuming.

3.2 Market research

Increasing demand for food products, increasing adoption of smart farming techniques, and growing adoption of agricultural mechanization are driving the growth of the Grain and Seed Cleaning Equipment Market. Agricultural mechanization helps the farmer to complete each operation faster and enhances the quality of the product. Mechanization not only helps in reducing the requirement of manual labours but also aids in speeding up the task related to post-harvesting in farms.

Moreover, increasing demand for customizable Grain and Seed Cleaning Equipment, increasing investments for the development of new products, and growing supportive loan policies and taxation are providing growth opportunities to the market. Vendors are increasingly offering customized models of equipment to meet the specific demand and requirements of end-users. This equipment can be customized for use with a variety of products such as soybeans, sunflower seeds etc.

3.3 Proposed solution

As this machine is used in rural areas and the use of solar operated grain cleaner machine has been reduced the hazardous health implications and makes it safe for human consumption and the solar product appeals better and affordable by common people. No electricity is spent so this product saves the energy and save the environments from getting polluted and mainly very needful for small and medium class farmer. Main advantage of solar operated grain cleaner is reduced manpower and minimum time consumption in low cost. Also, we tried to make this machine lightweight for easy transfer from one place to another place.

3.4 Components

3.4.1 Battery

Battery provided is 20v, 7.2 amp,147watt DC battery which provides power to the fan through DC controller.

3.4.2 DC controller

1.8V-12V 2Amp DC controller is provided to regulate the fan speed to control the air flow.

3.4.3 Fan

12V 0.15A DC fan is provided to create air flow.

3.4.4 Solar Panel

20watts solar panel is used to recharge the DC battery which provides power to the fan.

Sr. No.	Component name	Description	Quantity
1	Battery	20v,7.2amp, 147watt	1
2	DC controller	1.8V-12V 2A	1
3	Fan	12V 0.15A	1
4	Solar Panel	20watts	1

Table 3.4 Components list

3.5 Material

Material used during construction of body of machine is Aluminium. Aluminium is one of the most used material in food industry. So, it is safe for grains. Also, there are many advantages of using Aluminium like lightweight, good corrosion resistance, low initial cost etc.

3.6 Construction and working

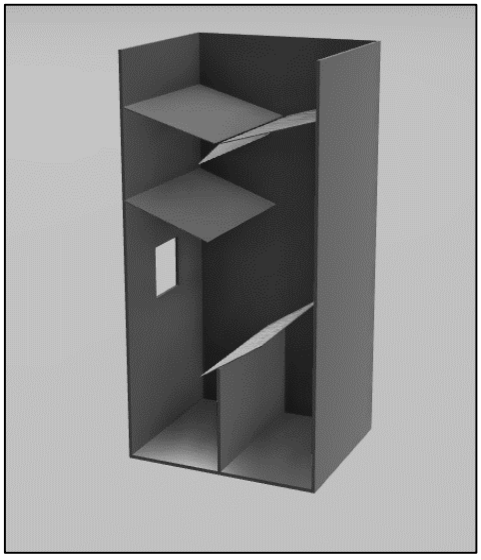

Fig 3.2 3D model of machine frame

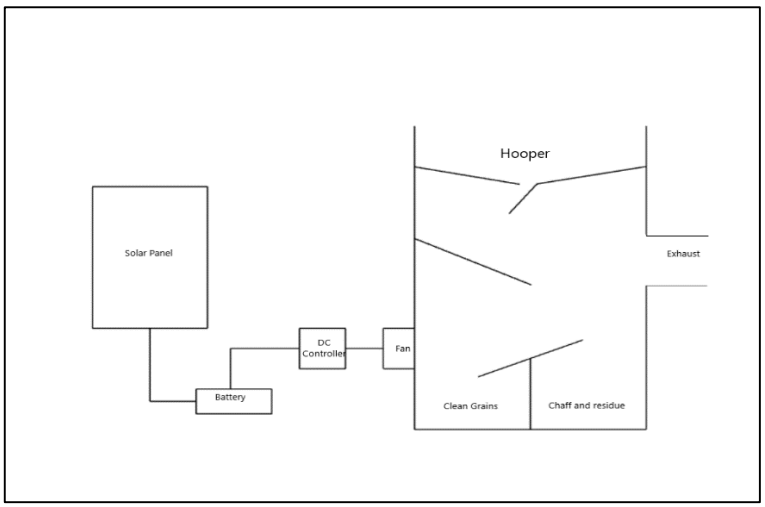

Fig 3.3 Block diagram of solar operated winnowing machine

Fig. 2.3 shows the block diagram of solar operated winnowing machine. Construction of solar operated winnowing machine is shown in above figure. Grains with chaff and residue are added in hooper small gap is present in between two plates. The mixture of grains and residue fall on plates which are placed in tilted angle. Fan is present on the bottom section of machine. The fan is connected to battery through DC controller which regulate the fan speed. Fan speed is controlled according to grain type. The batteries provided are charged using solar cells. The Grains are heavy in weight as compared to chaff and residue. So due to air flow generated by fan chaff and residue move towards right section present in machine and grain falls in left section. In this manner mixture is separated.

3.7 Results

In this winnowing machine we separate grains and residue without any human efforts and any external power source. In this solar operated winnowing machine we can clean maximum 15 kg of grains in one time operation. Also, this machine can used for cleaning of various grains.

IV. CONCLUSION

As this machine is used in rural areas and the use of solar operated winnowing machine has been reduced the hazardous health implications and makes it safe for human consumption and the solar product appeals better and affordable by common people. No electricity is spent so this product saves the energy and save the environments from getting polluted and mainly very needful for farmer. Main advantage of solar operated winnowing machine is reduced manpower and minimum time consumption.

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