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Design and Development of Foot Operated Areca-Nut Leaf Plate Manufacturing Machine

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Abstract: ***This paper describes the techniques for design and development of areca-nut leaf plate making machine which uses manual power (foot operated) as the main power source. The primary purpose of this research is the utilization of generally wasted areca-nut leaf sheath for the production of bio-degradable areca-nut leaf plates by the development of machine, which can be operated easily at home. This machine mainly uses mild steel for the development of the parts such as lower and upper die, frame, pedal, connecting links and shafts. The force applied at the pedal is transferred to moving upper die, which then presses the areca-nut leaf sheath placed above the fixed lower die, resulting areca-nut leaf sheath plates within 15 seconds of pressing.***

Keywords: Areca-nut leaf, Bio degradable, Foot operated

I. INTRODUCTION

In Nepal, leaf plates are widely used to serve foods. These leaf plates are traditionally made by hand in villages. Such plates are made out of plant leaves of betelnut sheath, banana etc. Areca-nut trees are widely cultivated in Terai region of our country. There are about 3.6 million of areca-nut trees in Jhapa, Morang and Sunsari district alone. Each tree naturally sheds 8 to 9 leaves per year, which means around 28.8 to 32.4 million of leaves go to waste annually [1]. Thus, these discarded areca-nut leaf sheaths can be utilized to make the leaf plates. These have good dimensional stability and are inexpensive, hygienic and biodegradable. These leaves can be converted as a Value-Added Product.

Very few of small-scale industries are adopting machines for the production of these areca-nut leaf plates. Even though there are few plate making machines imported from countries like India, China, etc. but are not affordable to small scale producers due to the high price. Though the cost of product formed is cheap but the spare parts required for making leaf plate making machines are of high costs. The maintenance of those machines is also arduous since the operators are to be called from India or the respective countries from which the machine is imported for the severe breakdown of the machine. So, there is the need of sustainable and efficient leaf plate making machine which could be more accessible and economical as well.

II. LITERETURE REVIEW

Though leaf plate making machine was developed in early stages at different places but the development and efforts carried out in our neighboring countries like Bhutan, China, India, etc. However, Tamil Nadu is improvising the leaf plate making machine with huge resources and dedication and has been developing these machines in an efficient way. **Leaf Plus Pvt. Ltd** (2018) [2] is a socio-economic enterprise that is aimed with having impactful contribution on environment by producing and promoting areca leaf products. Leaf Plus started with the idea of replacing the paper and plastic plates used mostly in street foods serving which is very popular and tremendously increasing practice in Nepal. It is the only registered company in Nepal as a small-scale industry with limited number of plates productions and using machines imported from India. **Tiffany Clein** (2017) [3] on her article, "Areca Press Machine" said that Areca press machine is a machine that imprints the shape of die on the leaf sheath by the application of heat and pressure for a preset period of time. The right temperature and pressure give a robust built-in to the plate or any other shape of the product like glass, spoons, etc. different shapes of the product can be created by changing the shape of die with right application of temperature and pressure. Similarly, **Kumar, et al** (2017) [4] in the paper "Design and Fabrication of degradable cups making machine" reported that the leaf plates depend upon the effect of temperature, moisture content and time of operation. Effect of temperature and moisture content varies from machine to machine. The regulation of these parameters is very essential for quality product which helps in designing a high-performance machine for Areca nut leaf plate making machine. **Mohanraj K S, et al** (2017) [5] in their publication "Design and Analysis of Semi-Automatic Paper Cum areca-nut leaf plate making machine" reported that the existing machines are time consuming and require more manpower to operate and are not fully automatic. So, an automatic areca-nut leaf plate making machine can reduce idle time and increase productivity. The proprietor can be able to get the plate count via mobile App which uses Pneumatic powered Arduino controlled Android based machine.

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Though few leaf plate making machines are brought in Nepal, small number of machines is due to its high initial cost and unavailability. Similar to these projects, an attempt is made to produce sustainable solution to increase socio-economic development of small-scale industries with technological development by producing 100 percent natural, compostable and bio-degradable, and environment friendly product without any laborious task. This research might not be completely a new innovation however, the motto is to produce the products of our own and make them easily accessible and financially practicable.

III. THEORITICAL CONSIDERATIONS

A. Component Design

Areca-nut leaf plate making machine involves transformation of human foot press power into reciprocating motion of the connecting links through the pedal. The foot press transmits power from the pedal to the connecting links which is then transferred to the shaft and finally to the lower die. Slider crank mechanism, arrangement of mechanical parts designed to convert straight line (reciprocating) motion to rotary motion. Reciprocating motion is a repetitive up-and-down or back-and-forth linear motion. The two opposite motions that comprise a single reciprocating cycle are called strokes. A crank can be used to convert circular motion into reciprocating motion, or conversely turn reciprocating motion into circular motion. In areca-nut leaf plate making machine, the rotating motion of the connecting links after pressing the pedal is converted into reciprocating motion of the shaft which is connected to the lower die. By using slider crank mechanism, the lower die moves upward and downward.
If r =radius of crank, ω =angular velocity. Then, Strokes or reciprocating length = 2*r and the maximum velocity of blade = r* ω.

Similarly, upper die is designed in such a way that it is fixed on the top of the frame. It gets coupled with the lower die when the lower die when the lower die is allowed to move upward through power transmission. The external distance across the upper die was 150mm, internal width of upper die was 130mm, base diameter of upper die=98mm and Tapering angle was 40 degree. Likewise, the lower die is designed in such a way that it gets coupled with the upper die to impart the shape of the dies to the leaf plate. It moves upward and downward to during the operation for specified time. The internal width of the lower die was 150mm, External distance across the lower die was 170mm, base diameter was 98mm and tapering angle was 40 degree. Frame is designed in such a way that the dies can be placed and so that it is taken forward to punch Areca nut leaf plate. The frame is designed in Solidworks and the material used to make the frame is mild steel. The frame is made up of square pipes of dimensions 40mm*40mm. The total height of the machine is 1000mm. So, the total height of the frame was1000mm, length of the frame was 420mm and width of the frame was 380mm. Since, the leaf can hold temperatures above than 150-degree C without any damage or burn. To impart the desired shape on the plate, the heater is designed such that it will provide 140-degree C of temperature for around 20 seconds for single operation in each plate. The heater is of band type and surrounds the lower die. The effect of conduction and convection are also considered.



Fig.1: Foot Pedal

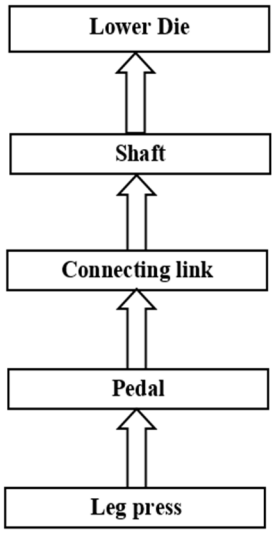


Fig.2: Upper die, lower die and heater

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B. Power Transmission

For power transmission sequence, Pedal- Connecting link- shaft- Lower die sequence will be employed. At first, the pedal is pressed with foot which is connected to the connecting link. The connecting link is further connected to shaft. The connecting link transmits power to the shaft. The shaft is further connected to lower die in which power is transmitted through the whole sequence. However, there is no any brakes and the whole sequence is controlled manually through the foot pressed pedal.



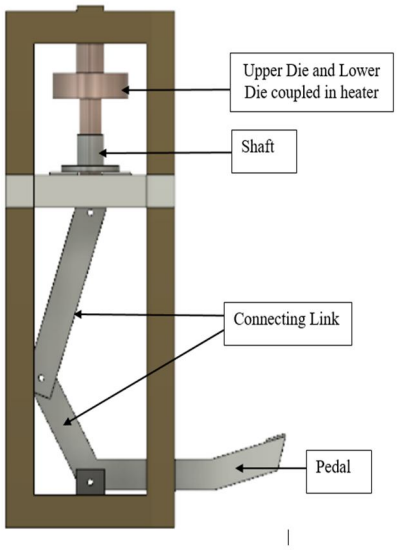


Fig.3: Block diagram of power transmission system Fig.4: Power transmission system by using slider crank mechanism

IV. WORKING PRINCIPLE

The areca-nut leaf sheaths are washed and soaked in water for around 15 minutes. Then the washed sheaths are kept in between the upper and lower dye. Heater is connected outside of the lower dye. After heating the lower dye, the foot pedal is then pressed with feet. The applied force at the pedal transfers through connecting link and shaft to lower dye. Lower dye then hits stationary upper dye with force creating a shape while two dyes are coupled. The clearance while coupling of dyes gives the required shape for the areca-nut leaf plate. The pedal is then released, two dyes separate and areca-nut leaf plate is manufactured. This simple mechanism takes around 15 seconds and cycle again can be continued.

V. SPECIFICATION OF THE MACHINE

The machine is designed with following specifications:

Table 1: Specifications of the machine

S.N.	Particulars	Details
1	Type	Manually operated
2	Source of power	Manual
3	Source of heat	Band Heater
4	Machine suitability	To manufacture Areca nut leaf plates
5	Machine dimensions Width Length Height	 380mm 420mm 1000mm

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Table 2: Specification of the heater

Particulars	Remarks
Temperature Range	Up to 140 degree C
Diameter Tolerance	+ or -1 %
Wattage Tolerance	+ or -10%
Type	Round/Band
Size	Customize
Sheath Material	Stainless Steel, Tin, Mild Steel
Heating element	80/20 Ni/Cr wire
Ceramic Connections	Stud wire, pin connector, bolt connection

Fabrication processes like metal cutting, machining, shearing, welding, drilling, grinding etc. were used during the development of machine.



Fig. 5: Front view of the machine



Fig.6: Top view of the machine



Fig. 7: Side view of the machine

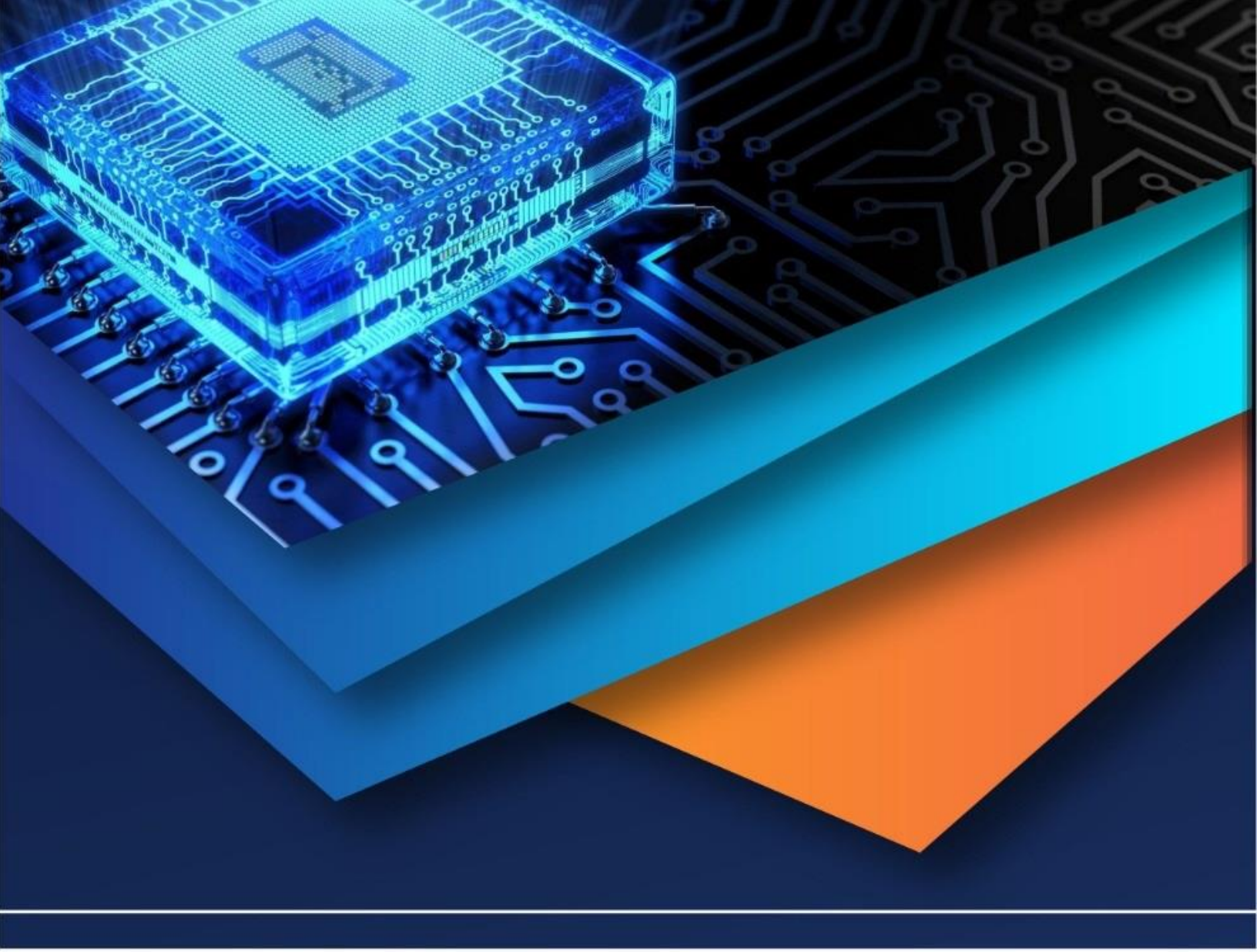
VI. CONCLUSION

The foot-operated areca-nut leaf plate manufacturing machine is designed, fabricated and tested. This machine requires electricity only for the heating purpose, leaving that the machine is foot operated. This machine doesn't require much skill and economically feasible too. This will help to utilize the millions of areca-nut leaf sheath being wasted annually in the eastern terai region of Nepal and reduce heavy reliance on plastic and paper plates. Thus, this machine will consequently help to improve the economic condition of people of the areca-nut growing regions of country.

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