Design and Analysis a Harvesting Mechanism of Swiftlets Nest

S N Syafiqah¹, H Radhwan¹,², M N M Saad¹,², A R Irfan¹,², R Hussin³, M S I M Dawi¹ and W A R Asyahid¹,²

¹Faculty of Mechanical Engineering Technology, Universiti Malaysia Perlis, Perlis, Malaysia.
²Center of Excellence Geopolymer and Green Technology, Universiti Malaysia Perlis, Perlis, Malaysia.
³Faculty of Electronic Engineering Technology, Universiti Malaysia Perlis, Perlis, Malaysia.

Email: radhwan@unimap.edu.my

Abstract. Industry swiftlets nest is not a new industry in Malaysia. It gets very high demand from China. Harvesting swiftlets nest is one of the processes to produce any products that made from swiftlets nest. Currently, they are using manual harvesting equipment to harvest swiftlets nest without using any auxiliary equipment. It is the first step in process flow and very important role before cleaning process. The objectives of this project are to design mechanism harvesting equipment to harvest swiftlets nest and to decrease the time of harvesting swiftlets nest process in a swiftlets house in a day. The methodology of research is including collect data, brainstorming, design concept generation, concept selection and simulation analysis. The design of harvesting equipment is using CAD software and analyze using FEA analysis. At the end of this project, this research will give understanding about design using CAD software and analysis that improved the harvesting equipment.

1. Introduction

Nowadays, the entrepreneurs in Malaysia strive to compete with other country to increase the production of swiftlets nest [1]. While for the entrepreneur of this swiftlets nest from northern of Malaysia also compete with southern and east of Malaysia to increase their production. The swiftlets industry will increase income for the local populace in Malaysia either for their first income or side income if there is any improvement in the processes swiftlets nest for increase their production [2-4]. Swiftlets nest industry expands because of the exotic value and belief that this bird nest is able to make medical products [5]. Besides that, cosmetic industries also have high demand of this nest to improve their cosmetic products because of the benefits from this swiftlets nest. According to Nordin Jafri [6] belief in Chinese community about the nutrients and exotic value start from the discovered swiftlets nest and its use by Chinese traders while their shipping to archipelago to find tropical product for the material of Chinese’s pharmaceutical application in 15th of the century. Usefulness of swiftlets nest has become common knowledge for centuries. The swiftlets nest produced by the salivary glands located under the tongue. There are many benefits can get from this swiftlet nest, because of the swiftlets nest industry able to ensure the reasonable income, many entrepreneurs attracted to improve the process harvesting swiftlets nest to increase more production [7]. Now the harvesting be the biggest among the Asian other
from Indonesia. Nevertheless, the entrepreneurs need the improvement equipment for harvesting the swiftlets nest. The impact of traditional harvesting is many entrepreneurs cannot challenge the competitors because of the lack of improvement in the process flow in production of the swiftlets nest. The problems of lack improvement of harvesting process affect the value of production. So, to overcome the problems, the development of new mechanism harvesting equipment can solve it. Simple, efficient and cost-effective method of harvest can be developed. Several tools related for this case study need to study for develop new mechanism of harvesting equipment.

2. Methodology

In methodology consist of data collection, brainstorming, design concept, design selection and detail design [8-10]. Overall research methodology in flow chart as shown in figure 1 is to achieve objectives in this project.

![Flow Chart](image)

2.1. Data Collection

The purpose of interview is to collect information from the person who has experience in the field of swiftlets nest. The site visit session was made on 29 October 2016 at Kampung Bukit Pampong Dong in Raub, Pahang. The respondent of this interview session is the owner of the swiftlets house. He has experiences about five years. In the interview session, the information and data are recorded. In the video record, there is information that related to this case study. Based on the video record, at minute 7.09, the worker shows how the current method that majority used by the harvester in Malaysia to harvest swiftlets nest. At minute 7.50 shows that the worker uses energy for bring along the ladder to check and harvest every swiftlets nest.

Total of respondents are 20 people and they are among workers that involved in swiftlets nest industry. Some respondent from interview session and some from call survey. The questionnaire includes the demographic data, specification, problem statement and suggestion.

2.2. Data Analysis

Data analysis is very important thing to develop a new design. All data and information collected should be considering as problem that need to be solved. From the collection data, can interpret data and develop design. Based on figure 2, shows that the type of harvest equipment that currently used by the workers. The method is manually handling. The tool is only for harvest swiftlets nest without any auxiliary such as light and good handle. From the information, the currently harvest equipment not satisfy user needed. The new design needed based on the problems and requirements from the user.
2.3. Interpret Data

The mission statement is important to achieve the product market. Product name is important for the product to be known by the user. The target user needed to consider that suitable with the product function. The assumption is what the product can achieve in the harvesting process. The stake holder is who can affect or effected by this product market. This interprets need will show the product requirement to improve the current design. The customer statement is based on the customer need and requirement to overcome the current problem while the interpreted need is how the product will be design that can solve the customer’s problem.

The ranking of customer need was determined based on the questionnaire and interview section. To produce this section, the suitable questions will be asked regarding the feedback been obtained. After completed this section, the analysis results able to gain to achieve a great design product without abandoned any characteristic wanted by customer. Based on table 1, all these ranking were sort by the number from 1 to 8. The number of 1 represented the priority customer need and increase the number represented less wanted characteristics by customer. Based on the table 2, target specification prepared to show the characteristics of the final design needed to make improvement on the product.

| No. | Customer needs   | Ranking |
|-----|------------------|---------|
| 1   | Ease of handling | 1       |
| 2   | Time consuming   | 2       |
| 3   | Easy to harvest  | 3       |
| 4   | Lightweight      | 4       |
| 5   | Portable         | 5       |
| 6   | Durability       | 6       |
| 7   | Low cost         | 7       |
| 8   | Ease of maintenance | 8   |

Figure 2. The current tool used by the worker.
## Table 2. Target specification

| Parameter          | Target specification                      |
|--------------------|------------------------------------------|
| Material Used      | Aluminum and Stainless steel             |
| Design             | According to requirement                 |
| Product size       | Extendable stick can extend to 6’         |
|                    | Extendable stick can collapse to 2’       |
| Cost of material used | < RM 150                             |
| Cost of product    | < RM 500                                 |
| Weight             | < 1 Kg                                   |
| Safety             | High                                     |
| Risk               | Low                                      |
| Operator           | 1 person                                 |

The Quality Functions Deployment (QFD) analysis is done and the House of Quality is prepared. The House of Quality is the combination of the tables which are questionnaire analysis, mission statement, interpret customer need, ranking customer need and target specification, thus it is considered as a simplified version of all those tables. This is to make it easier to others to read the tables and understand about our product specifications.

### 2.4 Design

A design concept is usually shown by using sketch or as a three-dimensional model. It is also often accompanied by a brief textual description in order to make others to understand more about the design instead of just refer to the sketch. A product concept is said as an approximate description of the technology, working principles and forms of the product. It is also describing how the product will be able to fulfil the user needs in order and requirements. Concept design is the most critical step in product development. The goal of concept generation is to choose the best of the concepts for development into products while expending the least amount of resources.

In the concepts selection, all the concept design put together to select the best characteristics. The features of these concepts were presented. All the concepts features of each of the designs, their strengths and weaknesses are analysed. Concept selection is the process of evaluating concepts with the respect to customer needs and other criteria, comparing the relative strengths and weakness between the concept designs, and selecting one or more concepts for further investigation. The selection can be described in concept screening and concept scoring.

### 2.5 Final Concept

The final concept design as shown in figure 3 is selected based on the result of concept selection method which is the fourth concept is the best design and the highest rank among concept designs. The mechanism of harvest tool selected is the adjustable stick and vibration. Before start the operation, on the torchlight for good light condition and make sure the mirror and net are in good and suitable condition. The motor vibration need to charge before use the harvest tool.
3. Result and Discussion

3.1. Design parameters

The main parameter on this analysis is the material and the force on the harvest tool. Based on the observation, the force used by manually handling is in vertical direction. The parameters are important to determine the suitable motor that can be used to the tool. The force on the tool includes the coefficient friction of material and the distance that used on the scrapper to harvest the nest according to observation. To decide the torque value, the parameter for force and distance are needed. The motor was chosen according to the value of torque. The battery was chosen based on the motor selected.

\[
\text{Torque} = \text{Force} \times \text{Distance}
\] (1)

3.1.1. Motor Description

The value coefficient of friction, \( \mu \) for wood on clean metal is 0.6. By using this value, the total force of harvest can be determined.

\[
\text{Force} = \text{coefficient of friction (} \mu \text{) \times weight tool (N)}
\] (2)

Average value mass of the tool is 3 kg where weight of tool can be determined by:

\[
3 \text{ kg} \times 9.81 \frac{\text{m}}{\text{s}^2} \text{ (force of gravity)} = 29.43 \text{ N}
\]

The force of harvest between wood and metal:

\[
\begin{align*}
F &= \mu \times N \\
&= 0.6 \times 29.43 \\
&= 17.66 \text{ N}
\end{align*}
\]

An experiment was taken in the building of swiftlets nest to determine the value of harvest force. The experiment was taken for ten swiftlets nest from different size and type of swiftlets nest. Every nest was took three reading of weigh where first at right side of nest, second at left side of the nest and third at centre of the nest. This three reading are according to observation on how the harvester harvest the swiftlets nest. The result is as shown in table 3.
### Table 3. Reading of harvest force

| Number of nest | Weight of weigh when applied force while harvest swiftlets nest (gram) | Average reading (gram) | Average reading – weight scrapper (250g) (gram) |
|---------------|-------------------------------------------------|------------------------|---------------------------------------------|
|               | Right side of nest | Left side of nest | Centre of nest |                                |                                |                                |
| 1             | 450                | 470                | 500            | 473.33                           | 223.33                           |
| 2             | 440                | 525                | 460            | 475.00                           | 225.00                           |
| 3             | 435                | 560                | 520            | 505.00                           | 255.00                           |
| 4             | 480                | 520                | 445            | 481.67                           | 231.67                           |
| 5             | 510                | 525                | 450            | 495.00                           | 245.00                           |
| 6             | 440                | 535                | 480            | 485.00                           | 235.00                           |
| 7             | 420                | 550                | 480            | 483.33                           | 233.33                           |
| 8             | 485                | 510                | 475            | 490.00                           | 240.00                           |
| 9             | 480                | 510                | 530            | 506.67                           | 256.67                           |
| 10            | 495                | 550                | 510            | 518.33                           | 268.33                           |
|               | **Total weight**   |                    |                | **241.33**                       |                                  |

According to the table, the force of harvest can be determined by using the value of total weight after conduct the experiment. From this experiment, the value of force can be determined by:

\[
0.241 \times \frac{9.81 \text{m}}{2^2} = 2.36 \text{ N}
\]

Therefore, the total force applied to harvest is: \(17.66 \text{ N} + 2.36 \text{ N} = 20.018 \text{ N}\)

From the observation, the common distance to harvest using scrapper is about 2cm. Thus the total torque can be determined by using formula 4.1.

\[
= 20.018 \text{ N} \times 0.0015 \text{ m} = 0.3003 \text{ Nm}
\]

Therefore, the motor that should be to select is the motor which has specification of value of torque equal or more than 0.3003 Nm (theoretical value). After finalize, the model of suitable motor that can be used for this harvest equipment is DC brushless motor which its stall torque is 0.5884 Nm with speed 200 rpm.

#### 3.1.2. Battery Description

Battery was chosen based on motor’s nominal voltage. So, the 12V battery should be chose because the motor’s nominal voltage is 12V. The capacity of battery is 1200mAh or 1A per hour. From the selected battery, its capacity is 1200mAh. From the selected motor, the current is 0.3 A and current for led light is 0.017 A. Therefore, the operating time is about three hour. Usually for one day, the harvester works about three hours where one and half hour in the morning and other one and half hour in the evening. For one and half hour, the total nest is about 10 to 20 nest.

#### 3.1.3. Stick Description

The total length of stick can be determined by handy instrument known as clinometer. The concepts used are indirect measurement and triangulation. This method involves creating an imaginary right triangle (one angle of the triangle is 90°) in which the observer stands at a distance “x” from the point that lies directly underneath the object.
Figure 4. Trigonometry method.

\[
\sin \theta = \frac{\text{Side opposite angle } \theta}{\text{Side hypotenuse angle } \theta} = \frac{\text{Height of swiftlet nest, } H - \text{Elbow height, } h}{\text{Length of stick, } L}
\]

\[
L = \frac{(H - h)}{\sin \theta}
\]

\[
L = \frac{(4.2672 \text{ m} - 2.1336 \text{ m})}{\sin 70^\circ}
\]

\[
L = 2.13 \text{ m} \div \sin 70^\circ
\]

\[
L = 2.27 \text{ m} \text{ or } 7 \text{ feet}
\]

Therefore, the height of harvest tool needed is 7 feet. Thus, the total height of people and harvest tool which is 14 feet are validates with the height 14 feet of nesting plank.

3.1.4. Clamping force on stick

Clamping that used for this stick is G-snap clamp lock. It has force that supports the strength of the stick. When the stick is clamped, automatically it will lock the stick at desired stick length. Thus, the force is calculated by formula of torque as in equation (4.5). In tightening torque, the clamping load is created in the bolt or the screw by exerting a tightening torque on the nut or on the head of the screw. An approximate relationship between the torque and the axial tensile force in the bolt or screw (the clamping force) is:

\[
T = KDP
\]

Where; \( T = \text{torque, } D = \text{nominal outside of the thread, } P = \text{clamping load and } K = \text{constant dependent on the lubricant present (} K = 0.15 \text{ if any lubricant at all is present). Bolt M6, } D = 6 \text{ mm or } 0.2362 \text{ inch, the load on screw is } 1 \text{ kg or } 2.20 \text{ lb.}\)

\[
T = 0.15 \times 0.2362 \times 2.20
\]

\[
= 0.0779 \text{ lb.in or } 0.0088 \text{ Nm}
\]

\[
F = \frac{0.0088}{0.02} = 0.44
\]

3.2. Product description

3.2.1 Size of the product

The length of the product is 7 feet or 2.13 metre when extended and 1 feet or 0.30 metre when collapsed. The length of the adjustable stick is 6 feet or 1.83 metre and the more 1 feet length of tool
include scrapper, motor mechanism casing and led mirror. The diameter of the handle is 0.04 metre or 4 cm which is according to the ergonomic size of the handle. Size of scrapper can be variable according to the workers but for this tool use scrapper with width 6 cm and length 8 cm. The suitable thickness of scrapper used is 0.8 mm compared to 0.5 mm. This is because the 0.8mm scrapper is more durable and comfortable than 0.5 mm scrapper.

3.2.2. Material of the product

This harvest tool is operated by automatic handling. Motor mechanism make the tool operate automatic handling without apply more force and manpower from the worker. The suitable motor used for this tool is 12v dc brushless motor. This motor has high torque with low speed. The motor is made up from aluminium. Battery used for operates this tool is from type Nickel Metal Hydride (NiMH) rechargeable battery pack. Portable rechargeable battery can save cost in a year compared to disposal battery. It also can cut down on spending over time. 12v rechargeable battery pack can power up the 12v dc motor in the tool to operate in anytime and everywhere. The capacity of the battery is 1200mAh which can be able the harvest tool to operate about three hours in a day. The adjustable stick is made up from aluminium which has affordable cost compared to high carbon steel. Aluminium stick is also lightweight and easy for the workers to use. The handle is grip handle which is made up from rubber that can avoid hand slip from handle and make the workers comfortable to grip the handle. The scrapper is stainless steel blade that can prevent from occur corrosion easily.

4. Conclusion

The new design harvest tool has an automatic motor so that the workers no need to apply more force to harvest swiftlets nest. DC motor was chose based on the force requirement for harvest. Suitable DC motor is important in this tool to make the tool function efficiently. Adjustable stick also important for safety because work at height place is one of the safety hazards in working place. Other than that, time is also affected by climbing the height area. So, with the adjustable long stick will avoid the dangerous work and save the time. LED light is included because the insufficient lighting condition in the dark swiftlet building. Mirror in this new development tool is for checking the condition in the swiftlet nest. This is to protect the new born of the swiftlet. Workers can save manpower and time to harvest swiftlets nest. Entrepreneurs will save money spend for their workers. They also no need apply large force to harvest sticky nest.

The new harvest tool helps the workers to eliminate the manually handling and save their time. The conclusion for the result data are as follows:

i. The objectives of the study are achieves at the end of this project which is the data analysis are completely collected, the design the harvest equipment to ease the user is developed and finally the analysis result had done and for result static analysis will not occur any plastic deformation.

ii. The problem statements and insufficient equipment in the current tool have been eliminated in an improved design harvest tool. The harvest tool accordance to new design has automatic movement of scrapper, adjustable long stick, LED light and mirror will easier the workers and save manpower. No need more workers and save the cost to give them salary every month.

iii. Industry swiftlets nest in Malaysia that have expanded now enter new phase that more complex and need new initiative for harvesting the swiftlets nest. Product has potential to expand because of the rapid economic growth of the swiftlets nest still continuous. The entrepreneurs export their production to the China, Hong Kong and Taiwan because of the high

Reference

[1] Looi Q H and Omar A R 2016 Pertanika Journal of Scholarly Research Reviews 2 32-48
[2] Ibrahim S H, Teo W C and Baharun A 2009 Int. J. Civ. Eng. Technol. 1 1-7
[3] Azahar I, Abdul-Aziz A and Munirah A R 2014 Asian J. Agric. Res. 8 1-16
[4] Shamsul Bahri M T, Irwan Syah M Y, Aini M S, Ng Yee G and Ippei M 2015 In Proceedings 19th Triennial Congress of the IEA
[5] Ssomad M A H A, Hudzari R M, Noordin M N A, Sapuan S M, Norhayati N and Soran A J 2013
Proc. Eng. 68 219-224
[6] Information on https://www.thepatriots.asia/sarang-burung-walit/
[7] Kaljun J and Dolšak B 2012 Int. J. Ind. Ergon. 42 162-171
[8] Radhwan H, Effendi M S M, Rosli M F, Shayfull Z and Nadia K N 2019 IOP Conf. Ser. Mater.
Sci. Eng. 551 012028
[9] Radhwan H, Shayfull Z, Nasir S M and Irfan A R 2020 IOP Conf. Ser. Mater. Sci. Eng. 864
012144
[10] Radhwan H, Shayfull Z, Farizuan M R, Effendi M S M and Irfan A R 2019 AIP Conf. Proc. 2129
020153