JURNAL TEKNIK MESIN (JOURNAL OF MECHANICAL ENGINEERING)

VOL. 14, NO. 01, February 2025
https://publikasi.mercubuana.ac.id/index.php/jtm/index
DOI :10.22441/jtmv14i1.25515

Design and Construction of a Pineapple Skin Cutting Machine with a Pneumatic Actuator Drive Powered by a Solar Module with a Capacity of 200 WP

Rafil Arizona1, Shandy Kurniadi2
1Mechanical Engineering Study Program, Faculty of Engineering, Islamic University of Riau

2 Department of Mechanical Engineering, Sepuluh Nopember Institute of Technology

E-mail: Rafilarizona@eng.uir.ac.id

Abstract--*The main objective of this research is to carry out the design of a pineapple-cutting machine with a pneumatic actuator powered by a solar module with a capacity of 200 WP. The research methods used are literature study and experimental laboratory. The laboratory experimental method is very suitable for application to post-harvest agricultural machines with a small capacity, where the research only focuses on the actuator system's success in carrying out pineapple cutting movements automatically by utilizing pressurized air from the compressor. The variation in air pressure for the pneumatic actuator is set at the air pressure, namely 3, 4, and 5 Bar. The actual peeling capacity using air pressure of 3 Bar resulted in 160 pineapple cutting/per hour, 170 fruit/per hour for 4 Bar, 173 bar for 5 bar, and 173 fruit/per hour manually.*

Article History:
Received: February 02, 2024
Revised: January 25, 2025
Accepted: January 26, 2025
Published: February 04, 2025

Keywords: *Actuator Pneumatic, Pineapple Cutting Machine, Solar Module, Compressed air*

1. INTRODUCTION

Design and Construction of a Pineapple Skin Cutting Machine with a Pneumatic Actuator Drive Powered by a Solar Module with a Capacity of 200 WP[1]. Based on data from the Central Statistics Agency for 2021, from the last 4 years, pineapple production in Indonesia has increased significantly. In 2018, pineapple production reached 1,805,506 tons [2]. Then in 2019 there was an increase to reach 2,196,458 tons. And from 2020 to 2021 pineapple production increased respectively, namely 2, 447, 243 tons and 2, 886, 417 tons [3]. The abundant production of pineapple every year will certainly be very profitable for home industries that use pineapple as the primary raw material in making processed pineapple products into various kinds of processed products, both processed food and non-food.

The first thing to do to produce processed products from pineapple is to peel and cut the skin and flesh of the pineapple. The aim is that the pineapple flesh obtained can be processed to the next stage because pineapple flesh is the primary raw material used in making every product made from pineapple. During the peeling process, many obstacles are experienced by home industry workers processing pineapple, such as using kitchen knives manually. Powered by humans, which turns out to take a very long time. One home pineapple processing industry requires 5 people to peel 280 pineapples with a time spent of 7 hours [2]. This is certainly not effective because, over that time, it will drain workers' energy, focus, and thoughts so that work safety is no longer a top priority. If this continues, work accidents caused by cutting tools will likely injure members. Worker's body.

If you meet your own needs or in small quantities, the manual stripping method using human power is still suitable and suitable for use. However, for stripping large quantities, for example, to meet industrial needs, the stripping method can no longer be applied because of its low productivity, which ranges from 10 minutes per product. Along with society's push for technological advances, various methods have been used to create machines that can replace (manual) or traditional processes in order to obtain more cutting results with superior product quality [4].

Several previous researchers have conducted research to improve the pineapple peeling process, including designing a semi-automatic pineapple peeling machine. In this research, an electric motor is used as the main source of driving power, and the rotation from 1400 rpm changes to 110 rpm using components of 2 pulleys with diameters of 30 mm and 382 mm. The 2 V-belts used are type A 73[3].

Then [5] led in a curved shape while being moved linearly. In 2022, there will be 2 studies that focus

on designing a pineapple peeling machine using a cylindrical cutter but with different working principles and technology applied.[6] redesign the pineapple peeling machine using a pressing crankshaft for a capacity of 200 pieces/hour. The resulting pineapple peeling machine can produce a peeling force of 19 kg, a working rotation of 24 rpm, a driving motor power (P) of 935.34 Watts, and a motor power of 1.5 HP. Actual rotation 1420 rpm, voltage 220 volts, 1 phase. Then [7]
designed a pineapple peeling and slicing machine using high-pressure compressed air, which is then passed through a solenoid valve to control the air supply into the pneumatic cylinder. Automation of cylinder movement for cutting and slicing pineapple using an inductive proximity sensor where complete control is controlled using an ATMEL 89S52 microcontroller.

Then [8] developing a semi-mechanical pineapple peeler by adding ergonomic elements. The resulting pineapple peeler combines a peeling lever and a pineapple skin peeler blade that is connected directly to make the pineapple skin peel easily. Furthermore, [9] designed a pineapple skin peeling machine using an electric motor drive, and the machine was made using a galvanized hollow iron frame. The peeling machine is designed to peel pineapples of various sizes with a peeling process of 2 repetitions and an average pineapple weight ranging from 78 grams to 915 grams. The use of a hollow iron frame in designing a pineapple peeling machine was used by [10]
in his research on solar power generation technology to drive electrical energy in pineapple peeling machines. This research aims to determine whether or not the installed solar power plant can meet the electrical energy needs of the pineapple peeling machine and how long the battery can be used to supply the load requirements. This research uses a solar power plant integrated with a pineapple peeling machine. Based on the test results that have been carried out, the average input power (Pin) is 1068.74 W, the average fill factor (FF) is 0.885718, the average output power (Pout) is 149.08 W, and The length of time the battery can be used is 11 hours. This research proves that the PLTS system can provide a power supply as a driving force for the pineapple peeling machine.

In 2021 [1], a pneumatic actuator-based pineapple peeling machine was made using solar modules as an electrical energy supply. However, this research only discusses the performance of solar modules used as the primary source of electrical energy, so the weakness of this research is that there are no results that show design information for making a pineapple-cutting machine based on solar modules. At that time, the author only focused on analyzing the performance of solar modules, not on the machine design. Therefore, to find out detailed information related to the pineapple-cutting machine that has been made, the author conducted this research.

The main objective and the latest in this research is that the machine created can become the primary reference for the public, academics, and researchers to create a pineapple-cutting machine based on a pneumatic actuator powered by a solar module with a capacity of 200 WP.

2. METHODOLOGY

This research will be conducted at the Mechanical Engineering Laboratory, Faculty of Engineering, Islamic University of Riau. The research lasted 7 days, from 1 October to 7 October 2021. The research method used was experimental laboratory; the performance of the solar module was tested by activating the pineapple cutting machine, with time intervals of 30, 60, 90, and 112 minutes. In this research, an actuator-based pineapple-cutting machine acts as a load on the solar module. The materials and equipment used in the research are:

Figure 1. Mechanical Engineering Laboratory, Islamic University of Riau

Figure 2. Mechanical Engineering Laboratory, Islamic University of Riau

A. Tools

This pineapple cutting tool with a solar-powered pneumatic actuator system consists of 9 main components, which include 1). Solar panels as power supply, 2). Pneumatic actuator, 3). Valve control, 4). Pneumatic hose, 5). Pineapple peeler knife, 6). Pressure control, 7). FRL (Filter, Regulator, Lubricator)[7], 8). Compressor tank, 9). Compressor. The measuring instruments used include: 1). Vernier caliper, 2). Pressure gauge, 3). Stopwatch
.

B. Material

The materials used are Bogor pineapple, hollow iron, and several consumables, such as special rainbow cables.
The research flow in this research is as follows:
Namely as follows:

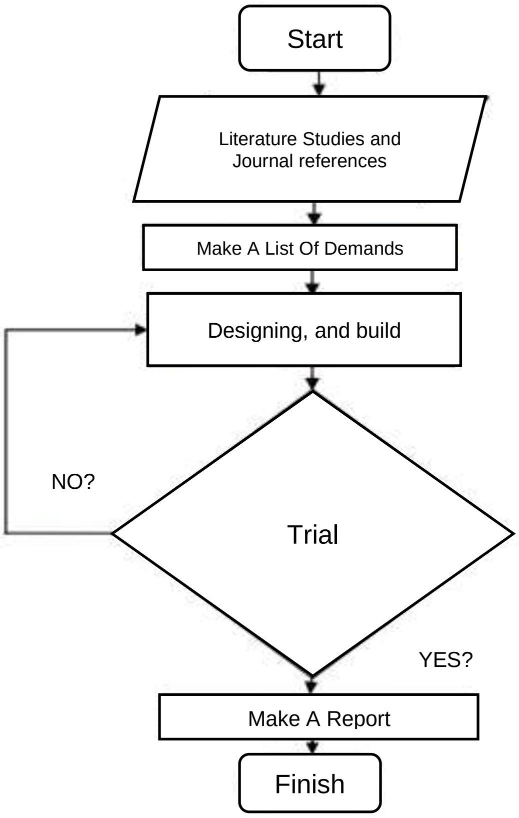

Figure 3. Research Flow Diagram

RESEARCH STAGES

1. Data Collection

Data collection is carried out using several methods to obtain the desired data. The methods used include literature studies and references from various journals. Data collection must be based on the needs of achieving goals. To find out the needs of the community about a type of tool to increase motivation and maximize results, data collection techniques carried out include:

- Survey

Namely making direct observations of the process of making pineapple skin peeling tools or pre-existing tools

- Literature Study

Data is collected from various sources related to the problems to be discussed to support the manufacture of this pineapple skin peeler. These data are obtained through various books, research journals, and the internet.

2. Making a List of Demands

At this stage, the demands to be achieved from the pineapple peeler design will be outlined. The list of demands will be grouped into two types: the main and second demands.

3. Creating Alternative Function Parts

In this stage, the function of the central part of the pineapple peeler will be described using a black box. Then, one alternative is made for each function of the pineapple peeler, along with an analysis of the advantages and disadvantages of each alternative.

4. Testing

Testing at this stage is carried out using the set list of demands.

5. Completion

At this stage of completion, the conclusion is the final achievement of the discussion and analysis process, which results in suggestions for deficiencies or advantages of the tool as well as making a report containing the design and simulation of a pineapple fruit peeler which contains an arrangement drawing, design analysis results, standard operating procedures, and simulation of movement in the pineapple fruit peeler using software which is expected to provide information about the function and usefulness of the peeler.

3. RESULTS AND DISCUSSION

3.1 Machine Planning and Design

The planning and design of a pineapple-cutting machine are adjusted to the list of demands made. The list of demands from the design of pineapple-cutting tools is as follows:

Table 1. List of Demands for Pineapple Peeling Machine made

No.	List of demands	Description
1	Key demans	
1.1	Material	The selection of ingredients must be appropriate as it relates to the food
1.2	Tool size	Tool size is customized according to fruit diameter
2	Desire	
2.1	Practical & Economical	easy to move
2.2	easy maintenance	Easy, with no need for experts or special instructions

3.2 Function Decomposition Method

At this stage, a problem-solving process will be carried out using a black box to determine the function of the main parts in the design and simulation of a pineapple peeler. The following description is done:

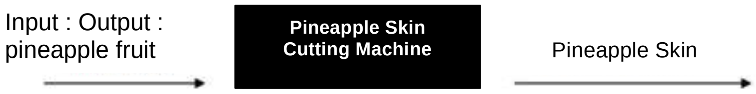

Figure 4. Black Box Diagram

Below is the scope or scheme of the design, namely:

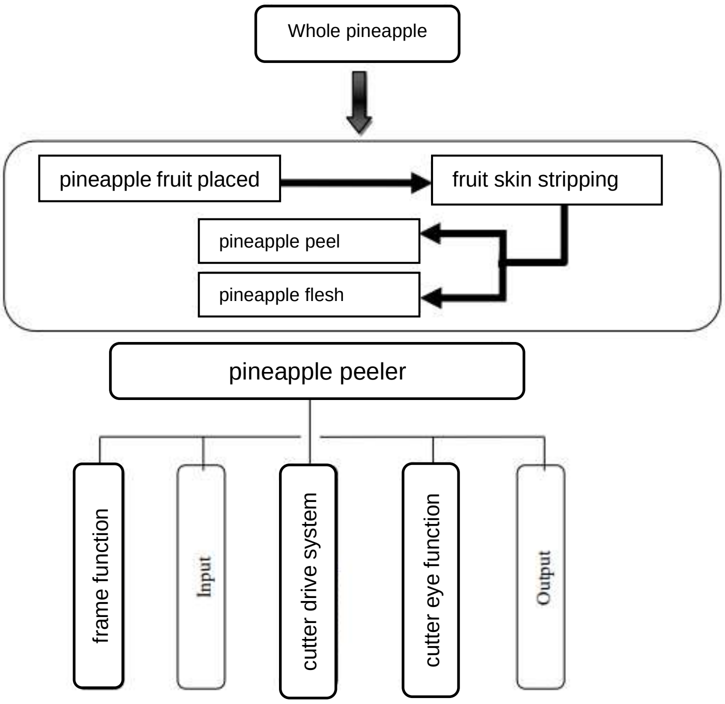

Figure 5. Sub-function divider diagram

This stage describes the desired demands of each function part so that alternatives from the function part of the pineapple-cutting machine design can be made as desired. The following is a description of the sub-functions of the part in question:

Table 2. Section Sub-Function Description

No.	Function Part	Description
1	Frame Function	The frame is able to withstand all the loads that occur, so that the components contained in the frame will be stable.
2	Input	To guide the pineapple fruit into the cutting tool.
3	Function of Cutter Drive System Parts	Used to continue the lever movement slowly
4	Function of Cutter Eye Parts	Able to separate the pineapple skin from the pulp, along with the pineapple stump.
5	Output	As the output of the peeling skin.

3.3 Design Concept

Below is a design drawing of a pineapple-cutting machine design with a pneumatic actuator drive powered by a solar module with a capacity of 200 WP.

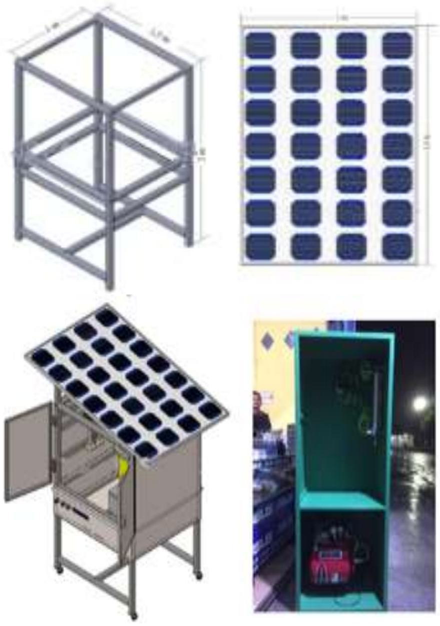

Figure 6. Pineapple Cutting Machine with pneumatic actuator drive powered by solar modules with a capacity of 200 WP.

3.4 Calculation Analysis

In this stage, the design calculation analysis of the forces that work is carried out as follows:

1. **Calculation of the Use of Pneumatic Actuator System**

The initial calculation is done on the pneumatic actuator cylinder when stripping the pineapple fruit. Known:

Diameter of the piston (d1) : 50 mm = 5 cm
Diameter of the piston rod (d2) : 25 mm = 2.5 cm
Stroke length: 300 mm = 30 cm
Number of steps: 2 steps

The cross-sectional area of the piston (A) can be found through:

$$A = \frac{d_1^2 \times \pi}{4}$$
$$= \frac{5^2 \times \pi}{4}$$
$$= 19.63\ \text{cm}^2$$

The cross-sectional area of the piston rod (Ar) can be found by:

$$A_r = \frac{d_1^2 \times \pi}{4}$$
$$= \frac{2.5^2 \times \pi}{4}$$
$$=4.90\ \text{cm}^2$$

So the working cross-sectional area/analyst area (A_R) = A-A_r

$$A_R = A - A_r$$
$$= 19.63 - 4.90$$
$$= 14.73\ \text{cm}^2$$

Table 3. Time data for the forward piston stroke and the reverse piston stroke

No	testing pressure (bar)	time the piston moves forward (seconds)	time the piston moves backward (seconds)
1	3 bar	1.18	1.22
2	4 bar	0.57	0.59
3	5 bar	0.40	0.42

1. Thrust force on the piston
   a) Forward thrust force testing pressure 3 Bar

$1\text{bar} = 1\ \text{kg/cm}^2 \times 10\ \text{m/s}^2$
(gravitational acceleration)
So, 1 bar $= 10\ \text{N/cm}^2$

$$F_{\text{maju}} = P_e \cdot A$$
$$= 3\text{Bar} \times 19.63\ \text{cm}^2 \times 9.8 \left(\frac{10 \frac{\text{N}}{\text{cm}^2}}{Bar} \right)$$
$$= 588.9\ \text{N}$$

b) Reverse thrust force testing pressure 3 Bar

$$F_{\text{mundur}} = P_e \cdot A_R$$
$$= 3\text{Bar} \times 14.73\ \text{cm}^2 \times \left(\frac{10 \frac{\text{N}}{\text{cm}^2}}{\text{Bar}} \right)$$
$$= 441.9\ \text{N}$$

2. Stripping air requirements
a) The air requirement for the forward step of the test pressure is 3 bar, and the cross-sectional area is 19.63 cm^2

b) Air requirements step forward testing pressure 3 bar, cross-sectional area 19.63 cm^2

$$Q_{\text{backward}} = A_R \cdot S \cdot n \left(\frac{P_e + P_{\text{atm}}}{P_{\text{atm}}} \right)$$
$$= 14.73\ \text{cm}^2 \times 30\ \text{cm}\ \frac{1\ \text{times}}{1.22\ \text{second}} \times \left(\frac{3\text{Bar} + 1.0132\text{Bar}}{1.0132\text{Bar}} \right)$$
$$= 1434.69 \frac{\text{cm}^3}{second} \times \frac{60}{1000} \left(\frac{\text{liters}}{\text{minutes}} \right)$$
$$= 86.08\ \text{liters / minutes}$$

3. Piston speed
a. The piston speed during the forward stroke of the pressure test is 3 bar

$$V_{\text{forward}} = \frac{Q_{\text{forward}}}{A}$$
$$= \frac{1976.69\ \text{cm}^3/second}{19{,}93\ \text{cm}^2}$$
$$= 99{,}18\ \text{cm/second}$$

b. The piston speed during the reverse stroke of the pressure test is 3 bar

$$V_{\text{backward}} = \frac{Q_{\text{backward}}}{A}$$
$$= \frac{1434.69\ \text{cm}^3/second}{14.73\ \text{cm}^2}$$
$$= 97.39/\text{detik}$$

2. Actual Capacity
If the actual capacity is calculated by the formula $\boldsymbol{K_P = K_t/t}$
Then, the actual capacity is :

a. The time required for one work step (stripping) with a pneumatic actuator to distribute 3 bar pressurized air.

1. Average step-down time: 1.18 seconds
2. Average step-up time: 1.22 seconds
3. Time to pick up, cut, and place the pineapple in the peeling position: 10 seconds
4. Rest time: 10 seconds

So the total time needed to peel one pineapple is = 1.18 seconds + 1.22 seconds + 10 seconds + 10 seconds = 22.4 seconds

The time needed to peel a pineapple manually (using a kitchen knife) takes:
1. Time to pick, clean the pineapple crown = 10 seconds
2. Average time when peeling the skin of a pineapple = 58.73 seconds
3. Rest time = 10 seconds
So the total time is = 1.31 minutes. Then, the actual capacity of stripping can be calculated, namely:

1. With 3 bar pneumatic actuator system

$$K_P = \frac{K_t}{t}$$
$$= \frac{1 \text{ piece}}{22.4 \text{ second}} \times 3600 \frac{\text{second}}{\text{hour}} = 160 \text{ piece/hour}$$

2. With 4 bar pneumatic actuator system

$$K_P = \frac{K_t}{t}$$
$$= \frac{1 \text{ piece}}{21.16 \text{ second}} \times 3600 \frac{\text{second}}{\text{hour}} = 170 \text{ piece/hour}$$

3. With 5 bar pneumatic actuator system

$$K_P = \frac{K_t}{t}$$
$$= \frac{1 \text{ piece}}{20.8 \text{ second}} \times 3600 \frac{\text{second}}{\text{hour}} = 173 \text{ piece/hour}$$

Meanwhile, if you peel it manually, you will get the following results:

Manual method:

$$K_P = \frac{K_t}{t}$$
$$= \frac{1 \text{ piece}}{78.73 \text{ second}} \times 3600 \frac{\text{second}}{\text{hour}} = 45 \text{ piece/hour}$$

4. CONCLUSIONS

A machine with a solar-powered pneumatic actuator system can peel pineapples with a minimum pressure of 3 Bars, cutting 160 pineapples/per hour, 170 pineapples/per hour for 4 Bars, and 173 pineapples/per hour for 5 bars, and manually only 45 are obtained. Fruit/hour. Based on experimental results, air pressures of 3, 4, and 5 Bar were chosen because if less than 3 bar, the cylindrical knife powered by a pneumatic actuator cannot cut the entire pineapple; the condition of the cylindrical knife at a pressure of less than 3 Bar is only able to cut a quarter of the pineapple. Moreover, if the air pressure exceeds 5 Bar, the pineapple will be destroyed. So, the best air pressure that a pneumatic actuator can use to cut Bogor pineapple, ideally using a cylindrical knife, is 3,4 and 5 bars. It is not recommended to use a pneumatic actuator air pressure distribution less or more than the air pressure proposed by the author.

REFERENCES

[1]. R. Arizona and S. Kurniadi, “Studi Kinerja Pemanfaatan Modul Surya Pada Mesin Pemotong Nanas Berbasis Aktuator Pneumatik,” Jurnal Teknik Mesin, vol. 10, no. 3, pp. 158–167, 2021.
[2]. I. Fahrizal, B. Ningsih, E. Parhadi, and L. D. Anjiu, “Pembuatan Alat Pengupas Nanas Sistem Press,” vol. 1, no. 1, pp. 17–21, 2023.
[3]. A. Dzulqornaini and P. Adiwibowo, “Rancang Bangun Mesin Pengupas Kulit Nanas Semi Otomatis,” Jurnal Rekayasa Mesin (JRM), vol. 02, p. 6, 2015.
[4]. M. Dan Nurdiana, “MEKANIK,” Jurnal Ilmiah Teknik Mesin ITM, vol. 6, no. 1, pp. 1–9.
[5]. P. G. A. L. Siriwardhana and D. C. Wijewardane, “Machine for the Pineapple Peeling Process,” Engineering and Technology of the Open University of Sri Lanka, vol. 6, no. 1, pp. 1–15, 2018.
[6]. Mansur and Nurdiana, “Rancang Ulang Mesin Pengupas Nanas Dengan Menggunakan Engkol Penekan Kapasitas 200 Buah / Jam,” Jurnal Ilmiah Teknik Mesin ITM, vol. 6, no. 1, pp. 1–9, 2020.
[7]. M. U. M. Krishna Prakasha, Vinay B U Shivakumar, “Automated Pineapple Peeling and Slicing Machine,” International Journal of Current Engineering and Scientific Research (IJCESR), vol. 4, no. 4, pp. 12–15, 2017.
[8]. R. E. Putri, D. I. Maulana, and A. Hasan, “Pengembangan Alat Pengupas Kulit Nanas (Ananas comosus) Semi Mekanis,” Jurnal Keteknikan Pertanian Tropis dan Biosistem, vol. 9, no. 2, pp. 183–193, 2021, doi: 10.21776/ub.jkptb.2021.009.02.09.
[9]. H. Rahman and Sunarto, “Rancang Bangun Mesin Pengupas Kulit Buah Aren Menggunakan Motor Listrik Sebagai Tenaga Penggerak,” Inovtek seri mesin, vol. 3, no. 1, pp. 39–44, 2020.
[10]. W. Yenanta and S. Khalis Utama, “Teknologi Pembangkit Listrik Tenaga Surya Untuk Penggerak Energi Listrik pada Mesin Pengupas Nanas,” Sinergi Polmed: Jurnal Ilmiah Teknik Mesin, vol. 04, no. 02, pp. 87–94, 2023.