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Plucker Machine Design on Halal Mobile Poultry Slaughterhouse (MPSH) Prototype

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***Abstract*—Mobile Poultry Slaughterhouse Halal (MPSH) is a mobile facility designed to carry out the process of slaughtering chickens in accordance with halal principles in the Islamic religion. Making a prototype of this tool aims to test the functionality of a system or product. The machine development designed in this research uses a drive (transmission) as a combination of pulley and v-belt. The reason for using a drive system as a pulley and v-belt is that it feels easier and more efficient in the work process. This research aims to analyze the calculation of pulley and v-belt sizes suitable for the plucker machine that was developed. This research uses an experimental design method, namely carrying out measurements, observations, and calculations of the technical specifications of the machine, then analyzing the data to obtain an idea of the machine's performance, which ultimately can provide an idea of the suitability of the machine. The research results obtained: (1) pulley sizes 100 mm and 175 mm in diameter, made from ST37 steel. (2) Required v-belt length = 1,253.95 mm. (3) V-belt axis distance = 426.25 mm. (4) The circumferential speed of the driving pulley vP = 10.99 m/s. (5) The circumferential force that arises Frate = 111.37 N. (6) The number of belts used is 1 belt.**

Keywords: MPSH, Prototype, Plucker Machine

I. Introduction

Indonesia's natural resources are considered to have sufficient potential to be cultivated and utilized as a source of income, including in the fields of agriculture, plantations, fisheries, and others. One of the subsectors that contributes to the improvement of the national economy and is able to absorb labor significantly is livestock, and this is proven by the results of the 2018 Inter-Census Agricultural Survey, which shows that the number of households that rely on the livestock sector reached 13.56 million households (Central Agency Statistics, 2020). Of the many livestock products available, one of them is chicken meat. In this section, the author(s) should include the main reasons/background for selecting the research topic. Author(s) should also describe the literature review, which contains other previous related research outcomes, including author(s) related to previous research. The referencing method is exclusively following the IEEE referencing standard such as [1].

The Central Statistics Agency noted that the level of consumption of chicken meat by the Indonesian population in a week was only 0.14 kilograms in 2021. However, that year, the trend of chicken meat consumption by the public increased by 9.23% compared to the previous year. In terms of trend, per capita chicken meat consumption in Indonesia tends to increase during 2011-2021. The peak occurred in 2014, which increased by 19.76 from the previous year. As a result, people's need for chicken meat has increased.

Halal mobile poultry slaughterhouses can be one way to solve this problem and increase production by replacing the slaughtering method from the previously conventional (manual) to a more modern (automatic) method. One application of this modern method is MPSH (Mobile Poultry Slaughterhouse Halal). Apart from slaughtering and processing chicken meat automatically or using modern machines, MPSH is also designed to be able to move from place to place according to consumer needs. This is different from modern chicken slaughterhouses, which generally slaughter chickens only in one place and cannot be moved (mobile).

The existence of an automatic slaughtering system further helps increase chicken productivity to supply people's needs. In this case, the plucker machine or

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chicken feather removal machine is one of the important components needed by MPSH to produce clean and quality chicken meat. Using a plucker machine will make it easier and you won't waste a lot of time plucking chicken feathers manually. What it takes for a worker to do it manually takes around 15 to 20 minutes per head. To overcome the difficulties in plucking chicken feathers, the invention of this chicken feather plucking machine is very meaningful for humans. This machine can pull chicken feathers clean without causing injury. This machine is quite capable of cleaning chicken feathers after cutting. In short, this machine can pull chicken feathers clean in about 1 minute.

II. Research Methodology

2.1 Flow Chart

The flow diagram for the design of the Plucker Machine for the Halal Mobile Poultry Slaughterhouse (MPSH) Prototype is as follows.

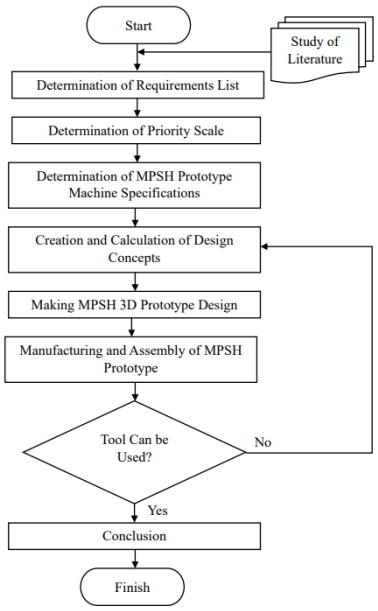

Figure 2.1 Research Flow Diagram

2.2 Determining Requirements List

This research aims to develop and design a plucker machine that will be used in the Halal Mobile Poultry Slaughterhouse prototype. To achieve this goal effectively, there needs to be a clear list of requirements that the plucker machine and prototype as a whole must meet.

This requirements list will guide the research process in identifying and evaluating the features, functions, and technical specifications needed to achieve the desired results in developing a Halal-compliant plucker machine.

In this requirements list, specific requirements are included, which include technical aspects, compliance with Halal principles, operational efficiency, and animal safety and welfare aspects. This requirements list will be the main guideline in the design, development, and testing process of the plucker machine and its use in the Halal mobile slaughterhouse prototype.

The following is a requirements list created from the results of observations that have been made. The results of the observations were identified into aspects of needs (Demand) and aspects of desires (wishes).

Table 2.1 Requirement List

Requirement list	**Description**	***Demands (D) wishes (W)***
Function	Able to clean 60 chickens in 1 hour of chicken processing.	D
Geometry	The machine components used are light and strong.	D
	Optimal and economical dimensions for prototypes.	D
Materials	The frame material is able to support the load when the machine is operating.	D
	Chicken feather remover.	D
Energy	The power source comes from an electric motor.	D
Making	Components that go through the fabrication stage are easy to make.	D
	Other components that go through the purchasing process are easy to find on the market.	W
Maintenance	Easy and cheap maintenance.	D
Operation	The machine can be operated by 1 person.	D
	The plucker machine speed on the MPSH prototype is constant.	W
	Low vibration level and no noise.	W
K3	The machine is not dangerous when operating.	D
Cost	Cheap manufacturing costs.	W

2.3 Determination of Priority Scale

After determining the requirements list, then determine the priority scale for the plucker machine in the Mobile Poultry Slaughterhouse Halal (MPSH) prototype.

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Table 2.2 Priority Scale

Requirement List	**Correlation Matrix**										**Sum**	**%**	**Rank**
Optimal and economical dimensions for prototypes.	1	1	1	1							4	40	1
The plucker speed on the MPSH prototype is constant.	0				1	1	1				3	30	2
Components are easy to find on the market.		0			0			1	0		1	10	4
Low vibration level and no noise.			0			0		0			0	0	5
The costs required for manufacturing are minimal.				0			0		1	1	2	20	3
Total											10	100	

2.4 Determination and Calculation of Design Concepts

After determining the requirements list and priority scale, the next step is determining specifications and creating a design concept. Concept decisions are made with limited knowledge. The goal in creating a design concept is to select the best alternative with the minimum expenditure of time and resources required.

The machine development designed in this research uses a drive (transmission) as a combination of pulley and v-belt. The reason for using a drive system as a pulley and v-belt is that it feels easier and more efficient in the work process. The transmission system used in this design research uses pulleys and v-belts. Meanwhile, the design of the pulley and v-belt is shown in Figure 2 as follows.

Figure 2.2 Pulley and V-Belt Design

III. Results and Discussion

3.1 Tool Design

The feather removal machine (plucker machine) functions to remove feathers or remaining dirt on the outside of the chicken. The hair removal process is carried out using a mechanical energy source from an electric motor. The electric motor used is 1 120 watt with an estimated time of 1 minute for 1 processing process.

In the plucker machine, there are transmission components that have interconnected functions.

Figure 3.1 Tool Design

3.2 Calculation

After getting the design concept, machine mechanism, and desired specifications, technical calculations are carried out on the plucker machine. The following are calculations used to determine the efficiency of the designed tool.

1. Required motor power

The following is a calculation of the electric motor power on the plucker machine.

a. Look for motor rotation

$$N = \frac{(f \times 120)}{P}$$

$$N = \frac{(20 \times 120)}{2}$$

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N = $\frac{2400}{2}$
N = 1200 rpm

b. Find the required power

P = $\frac{(262\times1200)}{2626}$
P = $\frac{314400}{2626}$
P = 119,72 HP

2. Pulley Calculation

It is known that the pulley diameter on the motor (dpA) is 100 mm and the motor rotation is 1200 rpm. Meanwhile, the desired pulley rotation is 800 rpm.

$Dp_B = \frac{n_1}{n_2} \times dp_A$
$Dp_B = \frac{1400}{800} \times 100$
Dp_B = 175 mm

3. V-Belt Calculation

The belt used to transmit rotation from the motor pulley or pulley A to pulley B in the design of this machine is a V-belt type. This belt selection aims to minimize slippage when transmitting power and rotation.

Is known:
Motor pulley diameter (dp1): 12 mm
Drive pulley rotation (n_1): 1400 revolutions/minute
Pulley diameter (dp2): 15 mm
Distance between pulley A and pulley B (c): 430 mm

a. Required length of V belt

$L = 2 \times c + \left[\left(d_{pulley2} + d_{pulley1}\right)\frac{\pi}{2}\right] + \left[\frac{\left(d_{pulley2} - d_{pulley1}\right)^2}{4a}\right]$

$L = 2 \times 430 + \left[(100 + 150)\frac{3,14}{2}\right] + \left[\frac{(150-100)^2}{4\times430}\right]$

L = 1253,95 mm

The length of the V belt is not available on the market, according to the standard belt length table. So the size that is closest to the calculation above is 1245 mm.

b. V belt axle distance

$b = 2L - 3,14\ (dp2 + dp1)$
$b = 2 \times 1245 - 3,14\ (150 + 100)$
b = 1705 mm

Thus :

$C = \frac{b+\sqrt{b^2-8(Dp1-dp2)^2}}{8}$
$C = \frac{1705+\sqrt{1705^2-8(12-15)^2}}{8}$
C = 426,25 mm

c. The circumferential speed of the drive pulley (V_{pull})

$v_p = \frac{\pi \times d_{pulley} \times n_{input}}{1000 \times 60}$
$v_p = \frac{3,14 \times 175 \times 1200}{1000 \times 60}$
$v_p = 10,99\ m/s$

d. The circumferential style that arises F_{rate} (kg)

$F_{rate} = \frac{102 \times N}{v_{pull}}$
$F_{rate} = \frac{102 \times 12}{10,99}$
$F_{rate} = 111,37\ Kg$

e. Pull side force (this force is to rotate the pulley)

$F_1 = Fe\frac{e^{\mu^\theta}}{e^{\mu^\theta}}$

Where :
e = Exponential numbers = 2,7183
μ = Friction coefficient = 0,28
θ = Pulley contact angle = 173,56°

f. Saggy side style

$F_2 = F_1 - Fe$
$F_2 = 6,589 - 6,55$
$F_2 = 0,039\ Kg$

g. Number of belts worn

$N = \frac{pd}{po \times k_o}$

Where :
k_o = correction factor = 0,99
$po = \frac{Fe \times v}{102}$
$po = \frac{10,908\times7,2}{102} = 0,77\ kW$

Thus :
$N = \frac{1,76}{0,77\times0,99} = 0,808 \approx 1\ piece\ belt$

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IV. Conclusion

Research on the design of a plucker machine on a halal mobile poultry slaughterhouse (MPSH) prototype using a pulley and v-belt transmission system where,

1. The product is a transmission system using a pulley and v-belt on a plucker machine with the following tool specifications:
   a. The pulley sizes are 100 mm and 175 mm in diameter and are made from ST37 steel.
   b. The v-belt is made from rubber, cord, rubber and canvas with a thickness of 12 mm
2. Required v-belt length = 1,253.95 mm
3. V-belt axis distance = 426.25 mm
4. The circumferential speed of the driving pulley vP = 10.99 m/s.
5. The circumferential force that arises Frate = 111.37 N.
6. The number of belts used is 1 belt.

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