Design And Development Of Automatic Rebung Tools Using Variable Frequency Drive Based On Arduino Uno

Eko Nurcahyo [a,1,*], Taufik Hidayat [a,2]

[a] Institute Technology National Malang, Malang, Indonesia
[1] ekonur@lecturer.itn.ac.id *; [2] taufikhidayat@lecturer.itn.ac.id
* corresponding author

ABSTRACT

Keywords
Rebung, 3 phase Induction Motor, VFD, Arduino

In chopping Rebung for the home industry, they still use conventional methods and lack the application of technology. This of course causes the productivity and quality of the home industry products to be less than optimal. Productivity is influenced by several factors including requiring workers to be more careful so that it requires a lot of concentration, worker fatigue which makes it less optimal in using time, and the speed of the workers themselves. Therefore, an automatic Rebung chopper based on the VFD with Arduino Uno was made as to the main control system. The 3-phase induction electric motor is used as a prime mover for chopping blades and for control using VFD (Variable Frequency Drive). For the pressing system using a spring and to open the lid of the pressing tube using a servo motor, and the buzzer as a monitoring medium. The test is using VFD to adjust the rotational speed of the electric motor. The test results show that at a frequency of 20 Hz with a speed of 147.8 rpm it produces chops with a length of 3 cm in 2 minutes 54 seconds. At a frequency of 35 Hz with a speed of 221.2 Rpm, it produces 2 cm chunks in 1 minute 53 seconds. At a frequency of 50 Hz with a speed of 260.1 Rpm, it produces 1 cm chops in 1 minute 5 seconds. If chopping is done manually, it takes 5 minutes with an average length of 2 cm

1. Introduction

Along with technological developments in the electric field which are always up to date, the need for a device that can facilitate work has developed in line with the functionality and effectiveness of the devices created. Many tools are designed automatically to make it easier and help solve human needs.Likewise, the chopping of Rebungs for a home industry still uses conventional methods and lacks the application of technology. This of course causes the productivity and quality of the home industry products to be less than optimal. Productivity is influenced by several factors including requiring workers to be more careful so that it requires a lot of concentration, worker fatigue which makes it less optimal in using time, and the speed of the workers themselves. Furthermore, the obstacle in improving quality is uniformity relatively different chopped results. Therefore it is necessary to apply appropriate technology that can be used to improve the production process. The process which is deemed inefficient can be overcome with mechanical, electronic, and automatic improvements so that the resulting capacity can be maximized, its safety is maintained, and its hygiene is guaranteed. Thus it is hoped that it can increase the production capacity of spring rolls so that market opportunities are greater and add economic value. To be able to solve existing problems and achieve the intended objectives, it is necessary to implement a Rebung chopper, so that it can overcome the problems faced by the home industry which makes Rebung spring rolls.

Therefore, the author provides a solution by designing a Rebung chopper tool, using an induction electric motor as a Rebung suppressor and blade movement so that a much better and uniform chop is produced as well as a shorter time for capacity compared to conventional methods.

2. Basic Theory

2.1. Definition of an Electric Motor[1]

An electric motor is an electromechanical machine that converts electrical energy into mechanical energy, this happens if you place a magnet on a rotating shaft, and another magnet is in a fixed position, then this state will be able to produce motion. Regardless of the difference in size and type, all-electric motors work in almost the same way, i.e. an electric current flowing through the coil of wire in a magnetic field creates a force that rotates the coil, thus creating torque.

[2]Most electric motors increase their mechanical torque through the interaction of a conductor which brings current in the direction of the elbow to the magnetic field. The different types of electric motors differ in the way they regulate the conductor and field and also in the control that can be exercised over the torque, speed, and position of the mechanical output. While the load on an electric motor is grouped into three categories, namely:[3]

1. Constant torque load which has a constant load torque, but has a variable speed and energy output
2. Load with variable torque is the torque of the load that varies with the speed of operation.
3. A constant energy load is a speed inversely proportional to the varying torque demand

2.2. Speed Settings Using VFD (Variable Frequency Drive)[4]

A Variable Frequency Drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor.

Variable speed drive or also known as VFD (variable frequency drive) or simply called an inverter is an application solution that requires further motor control capabilities, for example: setting the motor rotation according to the load or according to the value we want. The use of VFD can be used for AC or DC motor applications.

2.3. Working Principle Variable Frequency Drive[5]

The tendency that occurs in the induction motor speed control equipment results in a decrease in the torque of the induction motor at low speed. Variable Speed Drive (VSD) is a 3-phase induction motor control device with the principle of regulating the amount of frequency and voltage received by the induction motor. This simultaneous regulation of frequency and voltage causes speed to change while maintaining torque at a constant value.

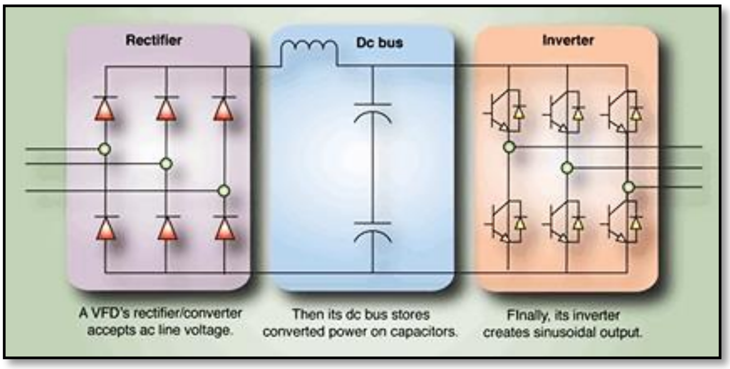


Fig. 1 Working of VFD[6]

Figure 1 shows the parts of the Variable Speed Drive Inverter which have the following working principles :

a. The 3-phase voltage from the source is rectified by a 3-phase rectifier circuit to produce a pure DC voltage after passing through the DC bus capacitor.
b. The DC voltage is used as a source that flows to the inverter through 3 arm power switches which have been controlled by control logic so that each switch in one arm works alternately and with the switch on the other arm it shifts 120^0.
c. The power switch is in the form of an Insulated Gate Bipolar Transistor (IGBT), which is a semiconductor switch device capable of working at relatively high frequencies with the ability to pass relatively large currents when compared to ordinary mosfets and transistors.

2.4. Sinusoidal Pulse Width Modulation (SPWM)

Sinusoidal Pulse Width Modulation (SPWM) or pulse width modulation is a technique for generating digital pulses through the process of comparing the reference signal with the carrier signal. The pulses generated through the pulse width modulation technique are used to trigger the IGBT power switch so that it is able to do a structured counting of the input DC voltage on the 3-phase inverter. The working principle of the SPWM signal is based on the comparison of the reference signal and the carrier signal so as to produce pulses using the method shown in Figure 2 below:

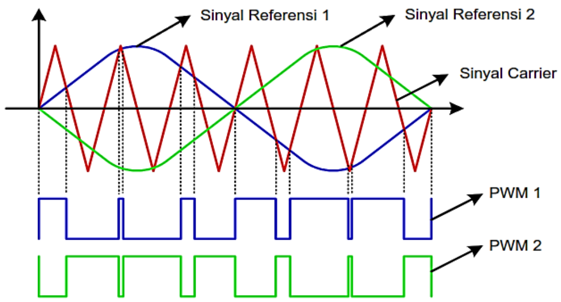


Fig. 2 Teknik Modulasi Lebar Pulsa Dengan Referensi Gelombang Sinus[6]

2.4. Arduino Uno[7]

Arduino Uno is a microcontroller board based on ATmega328 (datasheet) which has 14 input pins from digital output where the 6 input pins can be used as 6 analog input pins and PWM output, 16 MHz ceramic resonators (CSTCE 16M0V53-R0), USB connection, a power jack, ICSP header and reset button.

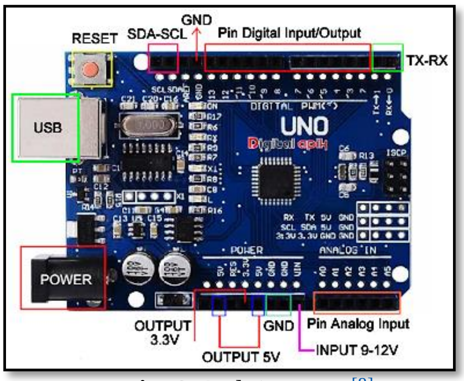


Fig. 3 Arduino Uno[8]

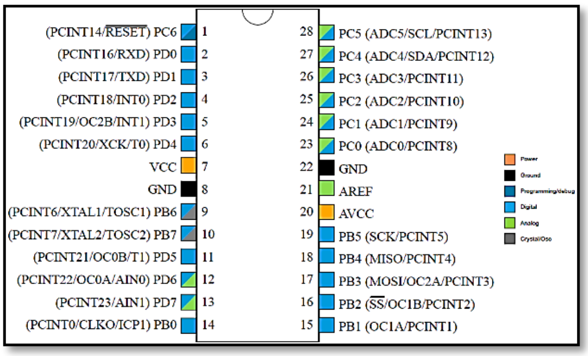


Fig. 4 Pin Chip Atmega328P[8]

3. Research Methods

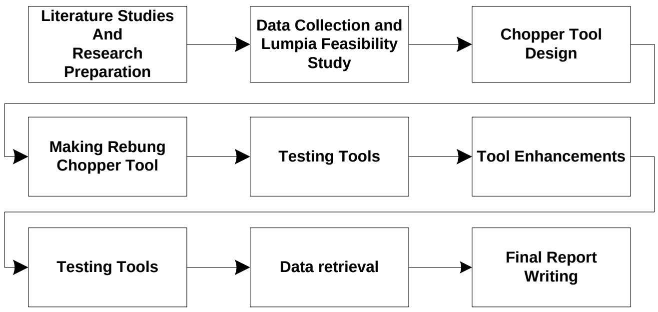


Fig. 5 Research Flow Section

In the first stage of the research, a literature study and research preparation were carried out. At this stage, observations were made about the data object in the form of rebung-based spring rolls which are commonly found in the market, besides that, observations were made about the use of traditional rebung spring roll production tools that are commonly used.

The second stage was to collect data on the production capacity of spring rolls in the market, the market's ability to absorb the product, and the need for rebung needed.

The third stage involves the design and design of a mechanical rebung chopper.

In the fourth stage, a prototype of the mechanical rebung chopper was produced and a progress report was written for the automatic rebungchopper tool.

The fifth stage was to test the mechanical rebung chopper prototype and write a research progress report for the automatic rebungchopper tool.

In the 6th stage, the mechanical rebung chopper prototype was perfected by adding an automatic control and then conducting a trial on the designed prototype.

In the 7th stage, testing and refinement of the mechanical rebung chopper prototype were carried out by adding automatic control and then conducting a trial on the designed prototype.

The 8th stage takes data from equipment that has been tested and perfected the Rebung chopper prototype

The 9th stage is to write a report from the research results

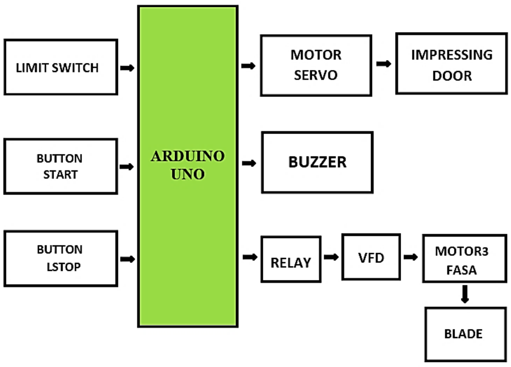


Fig. 6 Block Diagram Rebung Chopper Tool

3 Research and Discussion Results

4.1. Use of 3 Phase Induction Electric Motor in Automatic Rebung

The electric motor that is used functions as an eccentric moving knife arm that has been regulated by :

- Blade length 35 cm
- Circle to rotate 16" diameter arm
- Blade Size 10 cm x 10 cm

4.2. Specifications of the Electric Motor Used

The electric motor used for automatic Rebung chopping tools has the following specifications :

- Electric Motor : Toshiba 802
- Power (P) : 0.75 KW / 1 HP
- Frequency (F) : 50 Hz
- Current (I) : Delta (Triangle) 3.4 A / Star 2 A.
- Voltage (V) : 220 Volt
- Speed (N) : 1390 Rpm

4.3. Calculating Motor Current / Ampere

The formula for calculating the current of an electric motor :

$$I = \frac{P}{V \times \sqrt{3} \times COS\ \varphi} = \frac{750}{220.\sqrt{3}.0,8} = 2,45\ A$$

$$S = 750.\sqrt{3}.2,45 = 3,178\ VA$$

4.4. Calculates Torque and Power

From the existing motor data, the torque that the electric motor can produce is:

$$T = \frac{5252.P}{N} = \frac{5252.0,75}{1390}$$

$$= 3939 = 2,83\ Nm$$

$$P = V.I.cos\theta = 230\ .\ 0,72\ .\ 0,8 = 132,48\ W$$

The Automatic Rebung Chopping tool weighs one Rebung chopping process with a maximum weight of 1 kg with a maximum distance of 24 cm for the pressing part, then the motor torque used to move the blade is:

$$T = F.D = 1\ x\ 0{,}024 = 0{,}024\ Nm$$

4.5. Use of a Servo Motor as a Lock in the Rebung Pressing Process

The use of a servo motor, an automatic rebung chopper, is to lock the cover during the pressing process which is carried out with a spring force which is used as propulsion so that the material can move automatically.$A = \pi r^2$

4.6. Determining the Safety of the Electric Motor for Rebung Chopper Tool

In the Rebung chopper tool, it is necessary to protect an electric motor that functions as a motor safety in the event of an overload and a short circuit that occurs in an electric motor, to determine the safety of a 3-phase induction electric motor using safety in the form of MCB (Miniature Circuit Breaker). So to determine the amount of safety on the MCB as follows :

$$\mathrm{I} = \frac{\mathrm{P\ (watt)}}{\mathrm{V} \times \sqrt{3} \times \mathrm{Cos}\ \varphi}$$

$$\mathrm{I} = \frac{750\ \mathrm{watt}}{380 \times 1{,}73 \times 0{,}8} = 1{,}41\ A$$

4.7. Mechanical Speed Setting

Speed regulation can be done by using electric speed settings such as the use of VFI (Variable Frequency Drive) and dimmers, but electrically speed regulation has a limit to adjust the speed so that there is a need for speed regulation in a mechanical way to get the speed of an electric motor that is in accordance with the needs of the cutter tool rebung.

4.8. Arduino programming

The Arduino Uno microcontroller can work and process data sent from the input in the form of a limit switch sensor to send a signal to a 3-phase induction motor and servo motor so that it can work if a program has been entered in it. Programs that are entered into Arduino are created and uploaded to Arduino using the Arduino IDE 1.6.5 programming tools. The program functions here, among others, initialize which pins will be the command logic "I" or "O" which will activate or deactivate the servo motor, 3 phase induction motor, and 32 other supporting outputs in the form of a buzzer

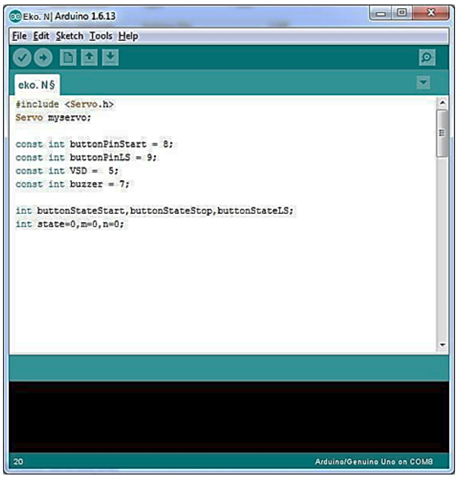


Fig. 7 The Scetch program

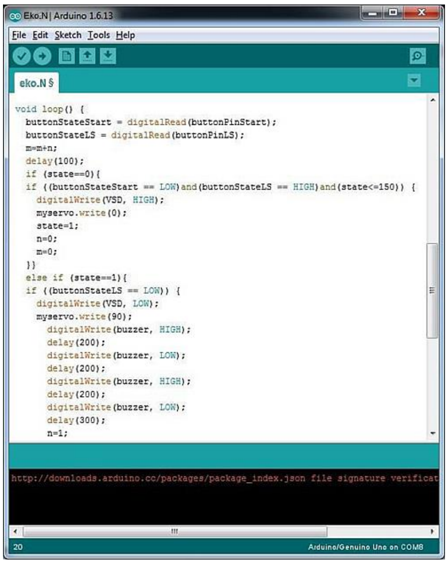


Fig. 8 2nd Arduino Scetch program

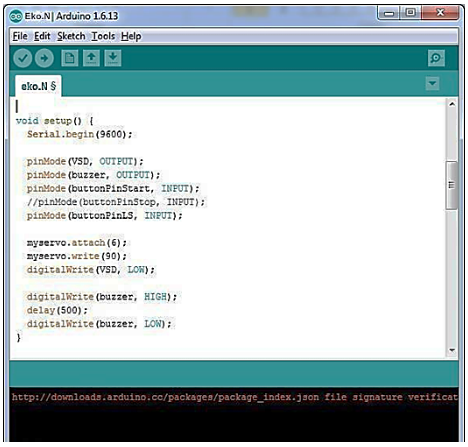


Fig. 9 3rd Arduino Scetch Program

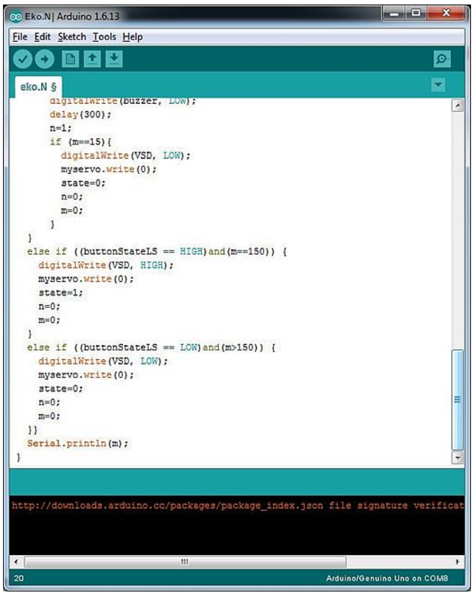


Fig. 10 4th Arduino Scetch Program

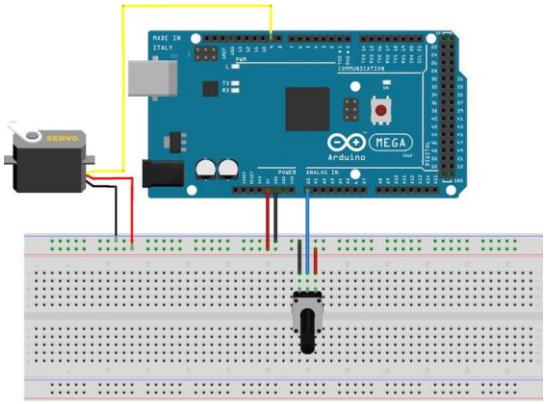


Fig. 11 Servo Motor Design with Arduino

In this design, there are 5 pin servo motor jumper cables that are connected to the Arduino. Connect the circuit as show in the Fig below :

- The red color is the power cable, connected to the 5 V Arduino pin
- The black/brown color is the ground wire, connected to the GND pin on the Arduino
- The yellow color is the data/command cable, connected to pin 9 of the Arduino (can be replaced with another pin)
- Potentiometer pin 1 – 5V pin Arduino
- Potentiometer pin 3 – Ground pin Arduino
- Potentiometer pin 2 – Analog In (A0) pin Arduino

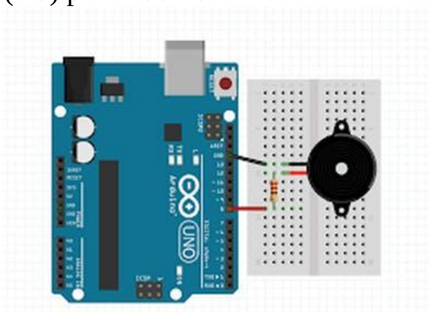


Fig. 12 Buzzer Design with Arduino

In designing this buzzer, there are 2 buzzer legs, each of which is connected to the Arduino by means of one of the legs connected to pin 8 of the Arduino and the other leg of the buzzer connected to the Arduino GND pin. Then, attach one end of 220Ω resistor to the same row as the positive (+/red) wire of piezo buzzer and connect the other end of the resistor to the row next to it

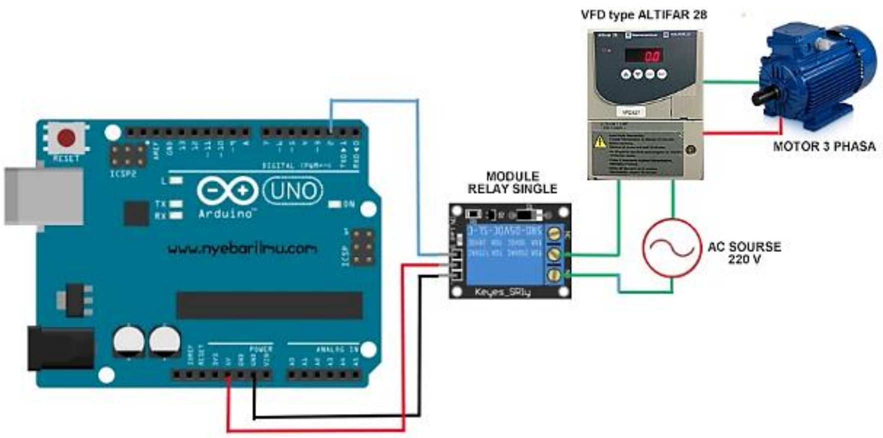


Fig. 13 Motor Control Circuit using VFD with Arduino

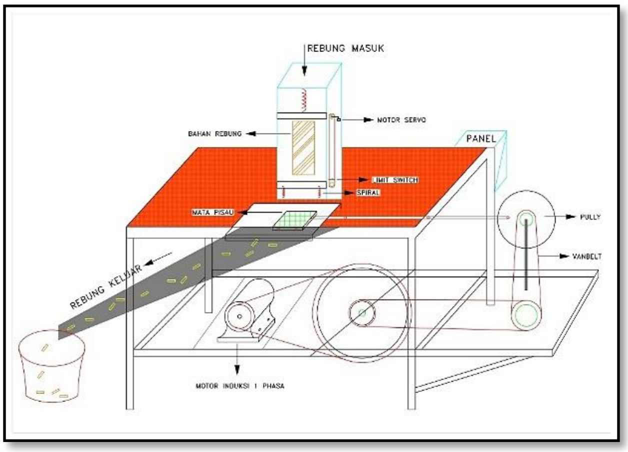


Fig. 14 Design Result

5. Testing and Measuring Tools

5.1. Testing On 3 Phase Electric Motors

Testing the electric motor on the Rebung Chopper Tool using a Tang Amper measuring tool which is assembled on the input of the electric motor that is on the Rebung Chopper Tool. In testing electric motor speed settings with VFD (Variable Frequency Drive) a tachometer is used to determine the motor speed of the Rebung chopper when it is not burdened with chopping the Rebung and it is loaded when chopping Rebung.

5.2. Current and Speed Measurement on Induction Motor

Frequency 20 Hz Frequency 50 Hz

Fig 15 Motor Speed Not Loaded

Frequency 20 Hz Frequency 50 Hz

Fig 16 Loaded Motor Speed

Frequency 20 Hz Frequency 50 Hz

Fig 17 Motor Current when Loaded

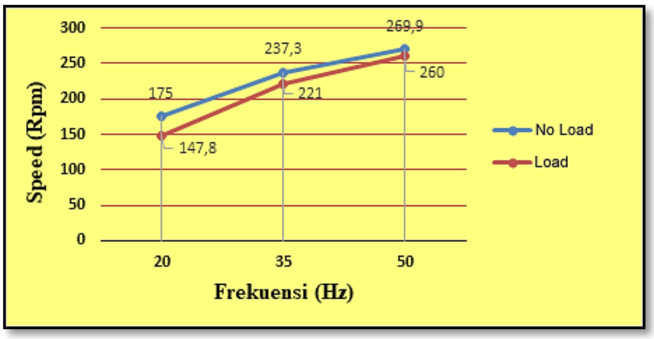
Frequency 20 Hz Frequency 50 Hz

Fig 18 No-Load Motor Current

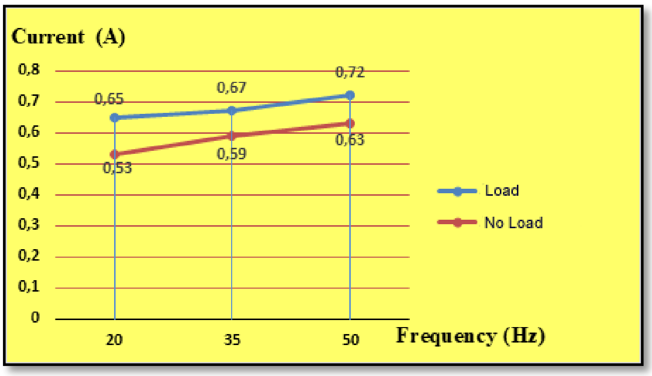
Table 1. Induction Motor Measurement

No	VFD (*variable frequency drive*) (Hz)	Motor Speed Not Loaded (Rpm)	Motor Speed Loaded (Rpm)	No-Load Current (Amp)	Loaded Current (Amp)
1.	20 Hz	175 Rpm	147,8	0,53	0,65
2.	35 Hz	237,3 Rpm	221,2	0,59	0,67
3	50 Hz	269,9 Rpm	260,1	0,63	0,72

Graphic 1 Speed of 3 phase Induction Motor on Rebung Chopper



Graphic 2 Current in the 3-phase electric motor in the Rebung chopper



6. Results and Discussion

6.1. Adjustment of Electric Motor Rotations on Chopping Results

The goal is to find out that the motor speed affects the results of chopping Rebungs, at a voltage of 230 V and a frequency of 20Hz-50 Hz. Using a Rebung load of 1 kg.

Table 2. Testing the Speed of an Electric Motor Against the Results of the Slice

No	VFD (Hz)	Loaded Motor Speed (Rpm)	Yield Length (Cm)
1	20 Hz	147,8 Rpm	3 cm
2	35 Hz	221,2 Rpm	2 cm
3	50 Hz	260,1 Rpm	1 cm

Based on the results of the test table above, the greater the frequency, the higher the chopping speed, but the shorter the length of the rebung.

Fig.19 Rebung Raised Results Based on VFD Settings
(a) Frekwensi 50 Hz (b) Frekwensi 35 Hz
(c) Frekwensi 20 Hz

Fig.20 Results of Chopping by Manual

6.2. Comparison of the Length of Chopping Time Manually and Automatically

6.2.1. Testing the Speed of Automatic Rebung Chopping Based on Time

Fig.21 Time of chopping at a speed of 147,8 Rpm

Fig.22 Time of chopping at a speed of 221,2 Rpm

Fig.23 Time of chopping at a speed of 260,1 Rpm

Table 3 Time of Testing for Rebung Chopping Based on Motor Speed Automatically

No	VFD (Hz)	Loaded Motor Speed (Rpm)	Time (t)	Yield Length (Cm)
1	20 Hz	147,8 Rpm	2,54 menit	3 cm
2	35 Hz	221,2 Rpm	1,53 menit	2 cm
3	50 Hz	260,1 Rpm	1,05 menit	1 cm

Table 4 Time of Testing for Manually Chopping Rebung

No	The weight of the Rebung (Kg)	Time (Minute)	The average length of the slices (Cm)
1	1 Kg	5 menit	2 cm

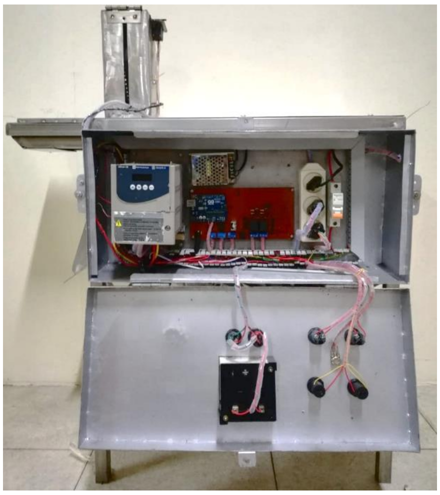


Fig. 24 Rebung Equipment Circuit and Wiring

7. Tool Specifications

Fig. 25 Rebung Chopper Tool

Specifications on the Rebung chopper are as follows:

- The size of the Rebung chopper tool is 60 cm x 40 cm x 72.5 cm
- The size of the upper frame is 80 cm x 40 cm
- The size of the pressing material 10 cm x 10 cm x 24 cm
- The size of the chopping knife is 10 cm x 10 cm
- The size of the circular disk is 16 cm in diameter
- The sleeve length for the blade is 35 cm
- 3 Phase 1 Hp Induction Electric Motor with a speed of 1390 Rpm, Frequency 50 Hz
- 5 Volt Servo Motor, Torque 8 Kg -13 Kg
- The voltage of the Rebung Chopper is 230 Volt
- The current of the Rebung chopper is 0.95 Ampere
- The power of the Rebung chopper is 132.48 watts

8. Conclusion

From the research conducted, the following conclusions can be drawn :

1. For the results of chopped Rebung with a length of 3cm are produced at a frequency of 20 Hz with a motor speed of 147.8 rpm, while a length of 2 cm is produced when a frequency of 35 Hz with a motor speed of 221.2 rpm, for a length of 1 cm at a frequency of 50 Hz and a speed of 260,1 rpm
2. For Rebung slices with a length of 3 cm it takes 2.54 minutes, for a length of 2 cm it takes 1.53 minutes, while for a length of 1 cm it takes 1.05 minutes.
3. Chopping time if done manually takes 5 minutes with an average chopping length of 2 cm
4. The time needed in chopping is automatically faster and more even than manually.

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