UNIVERSITI MALAYSIA PERLIS

3-IN-1 CLEANING PROCESS MACHINE FOR WHITE TURMERIC

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Technical Report

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Penerbit Universiti Malaysia Perlis
Kangar ○ 2021

Published by:

Penerbit UniMAP, Universiti Malaysia Perlis
Tingkat 10, Bangunan KWSP
Jalan Bukit Lagi,
01000 Kangar, Perlis. MALAYSIA.

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ACKNOWLEDGEMENT

First and foremost, I thank the Almighty, Allah Subhana Wata'ala, for giving us His blessing to complete this project. The successful completion of this project relies on the influence of many people who have generously given their times and energy in specific ways. We take this opportunity to express our gratitude.

We would like to thank to Public-Private Research Network (PPRN) Department of Ministry of Higher Education Malaysia, BR Herba Resources and Universiti Malaysia Perlis (UniMAP), for giving this golden opportunity and fund, without which we may have not experienced to undergo this project.

We thank all the people for their help directly and indirectly to complete our project. We are grateful to all of those with whom we had the pleasure to work during this project. Sincere thanks to all group members for their cooperation and great teamwork from the starting point to the ending of our project. Everyone played an important role that led to the completion of the project.

PREFACE

BR Herba Resources is a main player in white turmeric industry and this company has launched many products that based on white turmeric for cosmetic and health. The issue regarding white turmeric is its physical is very curvy with eyes likes pineapple as well as many roots. This causes difficulty during cleaning process.

Here, this project presents a solution to BR Herba resources to helping in cleaning process. The solution is to develop a 3-in-1 cleaning machine that comprised wash, clean and peel the first layer of skin. The development of machine consists of three stages of works, i. design the machine as requested by company, ii. fabricate the machine, and iii. analyze the machine performance by comparing with the conventional method. The machine was completed fabricated and tested at company's site. It operated accordingly and has better performance compared to the conventional method. The machine is able to clean 50 kg of white turmeric within 2 hours compared to 5 hours cleaning with the conventional method. Also, the machine produces less waste that showed the skin is not peeled thickly.

In conclusion, this 3-in-1 machine definitely help BR Herba Resources to solve their problem in cleaning the white turmeric.

1. INTRODUCTION

White turmeric (curcuma zedoaria), from Zingiberaceae family, a perennial stalk rhizome [1]. It grows well in Thailand, Indonesia, India and Malaysia. It is known as superior herbs and spices that has been used as raw material in traditional medicine. Nowadays, white turmeric has brought into global commercialization and widely used in cosmetic, beauty and health industry [2]. It is due to its high anti-oxidants characteristic which may benefits to human body [1-2].

In Malaysia, BR Herba Resource from Pendang, Kedah is a main player for 20 years in white turmeric plantation [3]. This company has 0.5 hectare of white turmeric and produces 20 to 50 tons turmeric per year. The white turmeric is harvested once a year and has to undergo many processes, from remove soil, clean, wash, peel in order to make powder. All the processes take four to six months to complete and need more than 10 employees. This company produces a few consumer products and a supplier of white turmeric powder. Their white turmeric powder gets high demands by health and cosmetic industry since they produce the powder according the rules and regulation standard by Ministry of Health. Also, they manage to plant the turmeric in organic ways, without chemical fertilizer and insecticides. Figure 1 shows the rhizome of white turmeric. Physically, its colour is pale yellow like ginger, but the size of rhizome is like yam. Figure 2 show the size of white turmeric plant at six months old.

This project was funded by Public-Private Research Network (PPRN), Ministry of Education in 2018 [4]. It is an innovation grant for providing a problem solution to industry players. This grant was awarded to Universiti Malaysia Perlis with BR Herba Resources. Appendix A shows the letter of appointment to Dr Marni Azira Markom, to conduct and initiate a solution for BR Herba Resources problem. The project proponent is Cement Industries of Malaysia Berhad (CIMA). All the necessary information pertaining to the project to the consultant to facilities for the upgrading the APC system designs are provided by them. The proponent concurred and acknowledges the content of this report including the design criteria.

Figure 1.1 White turmeric rhizome

Figure 1.2 White turmeric plant size with BR Herba Resources director

1.1 White Turmeric Cleaning Method by BR Herba Resources

BR Herba resources clean the white turmeric using a few men power. The cleaning process consists of washing, cleaning and peeling of their raw white turmeric rhizome. This process consumes much times and need a proper work because they really need clean and no soil on the white turmeric. In addition, the physical of white turmeric is curvy and has eyes likes pineapples. This is the reason the cleaning process takes so much times.

Hence, a cleaning machine is required. It must be able to wash, clean and peel the first skin layer of the white turmeric. The machine is designed with a motor and water pump. A few nozzles of water jet pump are attached at the machine with high water pressure. A diameter size of 0.4mm nozzles are used in order to ensure the water has high velocity and can remove the first layer skin of turmeric. Then, the soil definitely can be removed. This machine can cope 5 kg of turmeric and takes 3 to 5 minutes to finish wash, clean and peel for small size of turmeric. The duration of cleaning process is depended on the size of white turmeric. In order word, small size of white turmeric can clean fast, otherwise, it requires a long duration of times.

1.2 The Proposed Cleaning Machine

The cleaning process of white turmeric become a big issue to BR Herba Resources company. This process requires much times and a group of more than 10 employees to clean almost 30 tonnes raw white turmeric in specific period. In order to overcome this issue, a washing machine is proposed. The aims of the washing machine is such below:

i. To design and fabricate the 3-in-1 cleaning process machine that involve wash, clean and peel of white turmeric.

ii. To analyse the performance of the 3-in-1 cleaning machine by comparing with company's conventional method.

This project is limited to several scopes to be conducted so that the main focus and problems would be solved properly. The scopes are described below:

i. The machine fabrication is depended on the allocated budget, which is only RM 12,500.00 for material.

ii. The machine must be able to wash and clean the white turmeric from soil. Also, it can peel the first layer of white turmeric skin.

iii. The machine can cater 5 kg per process.

2. PROJECT DEVELOPMENT PLAN

This project plan involved with the main criteria for the machine. The main criteria here is to find out cleaning mechanism or how the automatic cleaning machine for industrials is operated. At first, the general view of automatic cleaning machine is presented, then, the main mechanisms are obtained.

2.1 Automatic Cleaning Machines

Food, health and cosmetic industries require cleanliness and safety elements, starting from their premise, machine, processing to packaging. These are compulsory and rules by the Ministry of Health, Malaysia and Good Manufacturing Practice (GMP) [5]. These have been regulated to ensure these industries produce safe and clean products to end-users or community. The rules and regulations must be adhered, then, as engineers who are responsible for machine fabrication, it is necessary to highlight the materials that will be used to fabricate any machines, purposely, for these kinds of company.

Table 2.1 a few types of cleaning machine for food purpose. Most of the machines fabricate using Stainless steel and aluminum for the frame. In Malaysia, these materials consider as material which is easy to get and affordable. Hence, for the white turmeric cleaning machine, stainless steel will be used. Also, based on Table 2.1, the design for cleaning/ washing machine can be observed, which most of the machines have conveyor, pipeline, particular nozzles and control box.

From the designs, they inspire a few ideas of machine parts and solution to the white turmeric washing, cleaning and peeling process. The consideration of machine parts involves a conveyer design and its moving mechanism as well as the nozzles attachment.

2.2 Water Pump and Nozzle Array

Water and air are suitable element for cleaning process. If water is used, a pressure is required to ensure the raw material can be cleaned, but, it must be properly set so that it is not damaged the material. Similar to water, air also required a pressure to undergo cleaning process. In this project, air is not suitable for cleaning purpose because it is only suitable for a little dirt and small particular area. Hence, water will be used.

In order to get water with pressure, a water pump can be used. It has a mechanism to force the water out from the pipe, and, with appropriate nozzle, the water can be very sharped and able to remove dirty soil from the white turmeric. Perhaps, with correct pressure, the first layer of white turmeric can be peeled.

Beside the water pump, water nozzles are required. Nozzle helps to shape the water out from the pipeline and do the cleaning work. Table 2.2 shows nozzle array design that will be attached to machine. These designs will be studies and the performance will be observed to get the best cleaning outcome.

2.3 Conveyor and Moving Mechanism

Conveyor and its moving mechanism are important criteria in the cleaning machine. It is used to move the turmeric during the cleaning process. Along the conveyer, set of nozzles will be placed above the conveyor. There will be two types of conveyors are considered to be implemented for the machine, which are steel roller and plastic roller.

For its moving mechanism, a motor will be used and it will attach with a chain, which the chain will be hold by each of roller. Both materials are easy to find in market and the prices are affordable. Table 2.3 shows the types of conveyors and its description.

Table 2.1 A few types of cleaning machine

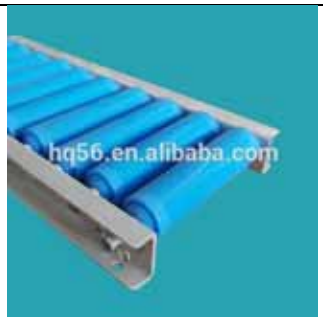
Manufacturer & price	Purpose	Cleaning/washing machine
Manufacturer: Mateen Machinery Supply, Alor Star Kedah Price: ~RM3500	Chicken Base/frame material: Stainless steel	
Manufacturer: Zibo Taibo Industrial Co.,Ltd, China Price: ~ RM23000	Fruit Base/frame material: Stainless steel	
Manufacturer: Zigma International, Tamil Nadu, India. Price: ~ RM27000	Potato Base/frame material: Stainless steel	

Manufacturer: ZhengZhou Shuliy Machinery Co. Ltd. Henan, China Price: ~ RM14500	Fruit Base/frame material: Stainless steel	

Table 2.2 A few types of nozzle array designs

No	Nozzle design	Description
1		This set of nozzle has five nozzles and they are placed at a steel bar. A few steel bars are used and attached at linear conveyor.
2		This set of nozzle has eight nozzles and they and placed at the steel bar. Two steel bars are used to clean and attached at linear conveyor.
3		This set of nozzle has a lot of nozzles which are placed at one steel bar. The bar is attached at a trommel.

Table 2.3 Types of conveyor and its description

No	Conveyor	Figure	Description
1	Steel roller		This converyor uses stainless steel bar. The bars are placed 1-2 cm side by side.
2	Plastic roller		This conveyor uses plastic roller material. The rollers are placed near to each other.

2.4 Machine Considerations

This 3-in-1 process machine is designed particularly for solving BR Herba Resources problems in order to reduce number of employees and process duration. Since, the problem is cleaning process and reducing the number of employees, hence, a few main parts have taken into consideration. The cleaning process consists of washing and peeling process at the same time. Table 3.1 describes the adoption of solution for the cleaning process.

Table 2.4 The adoption of cleaning solution for the machine

No	Consideration parts	Solution
1	Washing process	To wash the turmeric, water is required. Hence, a water pump and nozzles/sprinklers are needed to wash the turmeric.
2	Peeling process	To peel the first layer of turmeric skin, high pressure water is required. Hence, a high-pressure water jet is needed.
3	Automatic process	To make these processes automatic and reduce the number of employees, a conveyer is needed.
4	Machine body	This machine is particularly used for white turmeric. Hence, aluminum and stainless steel will be used as material for the machine body. These materials are anti-rust and suitable for food and health product machine.
5	Controller	A control box will be attached in order to switch the machine 'ON' or 'OFF'. Also, a few buttons might be used for other functions such as to control conveyer and water speed.

3. DETAIL DESIGN WORKS

In this section, detail design of works is described. The proposed designs were drew using 3D drawing software. Also, all the parameters for the machine (for example, the speed, efficiency and power) were determined theoretically using the law and rules of engineering.

3.1 Design of 3-in-1 Cleaning Machine

There are two proposed designs for this machine. The first design consisted of one layer of conveyer and nozzles rod. The design is shown in Figure 3.1. However, this design cannot be proceeded due to the physical of the turmeric rhizome. The turmeric rhizome comes in uneven shapes, has many and long roots. Due to this matter, one layer of conveyer and nozzles rod cannot provide the expected process output.

After discussion with director of BR Herba Resources company, and had site visit, the second design is finalised. The machine needed a long conveyer to ensure the cleanness of the turmeric. The second design has double layer of conveyer and two nozzles of rods. Figure 3.2 shows the machine design. Appendix B shows the real drawing (blueprint) of the machine.

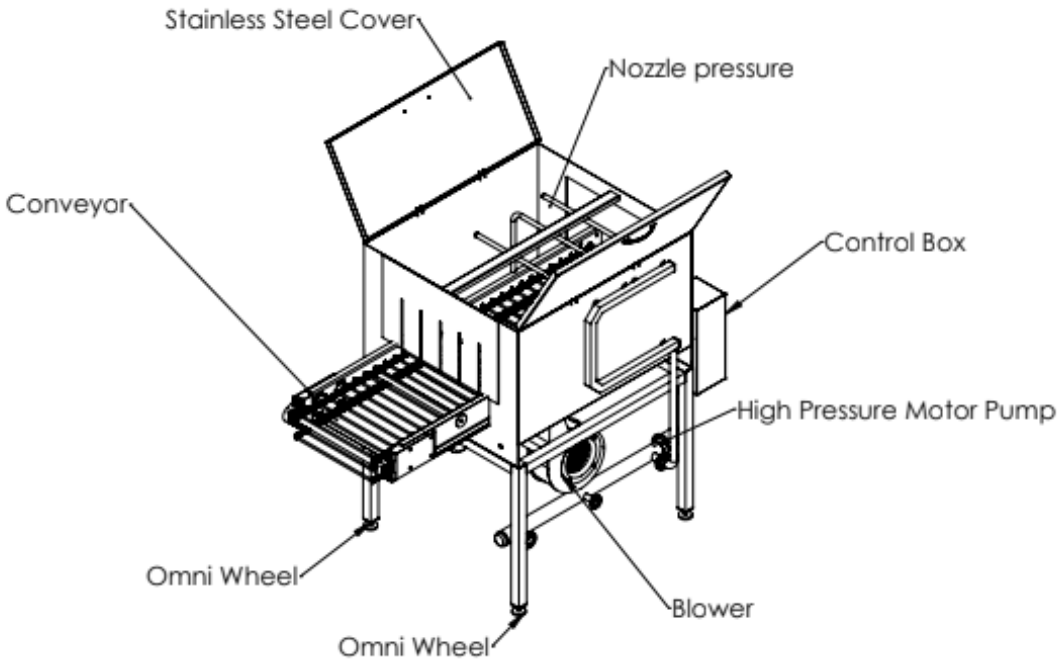


Figure 3.1 The first design for the cleaning machine

Figure 3.2 The second design of the cleaning machine

3.2 Determination of Speed and Torque for Conveyor

Once the company approved with the design, next, all parameters that included in the machine are required to be identified and determined, especially, for the conveyor and the electrical part. For conveyor, it consists of motor driver, sprocket, chain and power parameters. Here, the speed and torque to move the conveyor is necessary to estimate. The estimation calculation can be used common parameters to act as a benchmarking. Then, based on the benchmarking, the required speed can be estimated, and, the suitable real motor driver can be found in market and implemented for the machine. For this conveyor, torque is more necessary compared to speed variable. This is because, it required force to carry the load (white turmeric). Hence, in this case, driver sprocket teeth must have more number compared to driving sprocket, as shown in Figure 3.3.

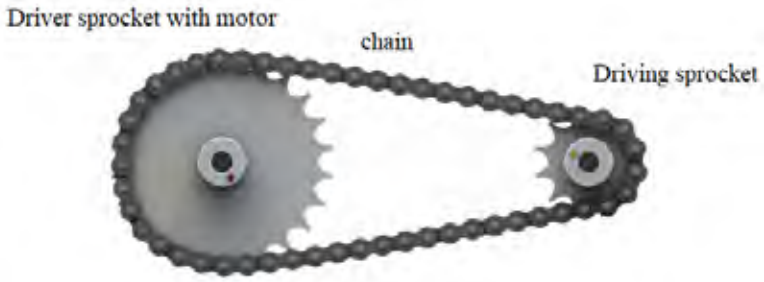


Figure 3.3 Driver and driving sprocket for the conveyor

Theoretically, torque and speed can be calculated based on sprocket ratio and number of sprocket teeth. The equation for sprocket ratio, torque and speed are described in equation (3.1), (3.2) and (3.3), respectively. The ratios are defined as function of the relative between two sprockets.

$$Sprocket\ ratio = \frac{N_1}{N_2} \tag{3.1}$$

$$Torque\ ratio = \frac{T_1}{T_2} \tag{3.2}$$

$$Rotational\ speed\ ratio = \frac{V_1}{V_2} \tag{3.3}$$

where

N_1 is number of teeth on the driver sprocket 1

N_2 is number of teeth on the driven sprocket 2

T_1 is torque on the driver sprocket 1

T_2 is torque of teeth on the driven sprocket 2

V_1 is the rotational speed of the driver sprocket 1 in rpm unit

V_2 is the rotational speed of the driven sprocket 2 in rpms unit

Also, in motor and drive theory, it states that those equations (3.1), (3.2) and (3.3) can be merged as the number of teeth of sprockets are relatives to torque and rotational speed. The merging equation is shown as equation (3.4) and (3.5).

$$\frac{N_1}{N_2} = \frac{T_1}{T_2} \tag{3.4}$$

$$\frac{N_1}{N_2} = \frac{V_1}{V_2} \tag{3.5}$$

Based on the equation, if the ratio value is equal to 1, hence, all parameters in the equations have same values. Below shows the torque and speed estimation calculation using common motor parameters;

Motor parameters:

Voltage and power: 24V and 250 Watt

Speed: 330 RPM

Torque: 7.5 N-m

Driver sprocket:

Teeth: 11

Driven sprocket:

Teeth: 9

Torque calculation using equation (3.4)

$$\frac{N_1}{N_2} = \frac{T_1}{T_2} = \frac{11}{9} = \frac{7.5}{V_2}$$

$$T_2 = 7.5 \times \frac{9}{11} = 6.14 \text{ N-m}$$

Speed calculation using equation (3.5)

$$\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{11}{9} = \frac{330}{V_2}$$

$$V_2 = 330 \times \frac{9}{11} = 270 \text{ rpm}$$

Based on the calculation above, the value of torque and speed for the conveyor are acceptable. The torque is expected to be capable of carrying loads with the amount of speed.

3.3 Determination of Power and Efficiency

There are two more important parameters that should be considered when developing the machine, namely, power and efficiency. Both parameters are used to check the power loss or efficiency of the machine. The power loss basically is a power conversion to the heat. An efficient motor is a motor that able to less operate and run cooler or convert more power per volume. The efficiency value can be determined based on output power divided by input power, with the difference being losses due to imperfections in design and other inevitabilities. While, the input and output power are defined as power consumed by a motor and power supplied by a motor, respectively. Both can be determined based on the current, voltage, torque and speed of the motor. All the equations as shown in equation (3.6), (3.7), (3.8) and (3.9).

Input power (Watt), $P_{in} = V \times I$ (Supplied current) (3.6)

Output power (Watt), $P_{out} = \tau \times \omega$ (3.7)

$$\omega = rpm \times 2\pi/60 \quad (3.8)$$

Efficiency, $\eta = \frac{P_{out}}{P_{in}} \times 100\%$ (3.9)

Where

V is voltage supply of the motor measured in Volt (V) unit.

I is current supply of the motor measured in Ampere (Amp) unit.

τ is torque of the motor measured in Newton.meter (N.m) unit.

ω is angular speed, measured in radians per second (rad/s) unit.

rpm is rotational speed in revolutions per minute.

π is mathematical constant, pi (22/7).

60 is number of seconds in a minute.

These parameters can be calculated using a common and suitable motor and power supply for this machine. Typical motor is delivered with specifications or technical information by its manufacturer as shown below;

Motor parameters:

i. Voltage and power: 24V and 250 Watt
ii. Speed: 330 RPM
iii. Torque: 7.5 N-m

Power supply:

i. Voltage supply: 24V
ii. Current supply: 20 Amp

Hence, based on the equations from the theory and specifications, the power and efficiency can be calculated.

Input power (power consumed by a motor)

$P_{in} = V \times I = 24 \times 20 = 480$ Watt

The value is described in motor specification as given by the manufacturer.

Output power (power supplied by a motor)

$\omega = rpm \times \frac{2\pi}{60} = 330 \times \frac{2\pi}{60} = 34.56$ rad/s

$P_{out} = \tau \times \omega = 7.5 \times 34.56 = 259.2$ Watt

$\eta = \frac{P_{out}}{P_{in}} = \frac{259.2}{480} \times 100\% = 54\%$

This efficiency is acceptable because it is more than 50% without load. In theory, the efficiency will be more than this when it runs with load.

4. MACHINE FABRICATION AND TESTING

4.1 Fabrication of 3-in-1 Cleaning Machine

Once the design is agreed by BR Herba Resources director, then, the machine can be developed. Initially, it started with constructing frame of the machine. The frame is developed using aluminium bar. Figure 4.1 shows the progress of machine development at School of Mechatronic Engineering Laboratory.

Figure 4.1 Machine frame in progress

There are two sets of conveyors that have built for this machine, i. top conveyor, and ii. below conveyor. For each conveyor, it is built using a few steel rods and the rods are moved by a set sprocket and a chain. The chain is connected to a driver and heavy-duty motor. Also, for each conveyor, there are two sets of water nozzle which is used to drain high-pressure water for cleaning process purpose. For a set of water nozzle, it has five nozzles and all of them can be set their position manually to optimise the performance of cleaning process. Figure 4.2 shows a closed-up of the set of conveyors with sprocket, chain, motor as well as driver. Figure 4.3 shows the nozzle set that attached at the machine.

Figure 4.2 Closed-up the completed conveyor set with sprocket, chain, motor and driver

Figure 4.3 Closed-up the nozzle set at the top conveyor

Then, a high-pressure water pump is used to pressurize the water so that it is able to cut and remove soil and first layer skin from the white turmeric. The power capacity is similar with the heavy-duty motor. Figure 4.4 shows the high-pressure water pump that used for the machine.

Figure 4.4 The 2.5 HP high pressure water pump

4.2 Development of 3-in-1 Cleaning Machine Control Box

For the control box, it is powered up by house electricity, 220/240V. The circuit is developed using distributed board (DB) with four circuit distributors. Each of distributor has two switches, comprising red button to indicate power off and green button to indicate power on. Table 4.1 shows four purposes of the distributors in DB board of the machine. Figure 4.5 and 4.6 show the circuit block diagram and the completed control box, respectively. While, the finalised circuit diagram for the control box is shown in Appendix C.

Table 4.1 Four main parts in the DB board

Distributor	Purpose
Emergency	To switch 'ON' and 'OFF' the whole system of machine
Conveyor	To operate the top and below conveyor
Water pump	To switch 'ON' and 'OFF' the water pump
Standby	-

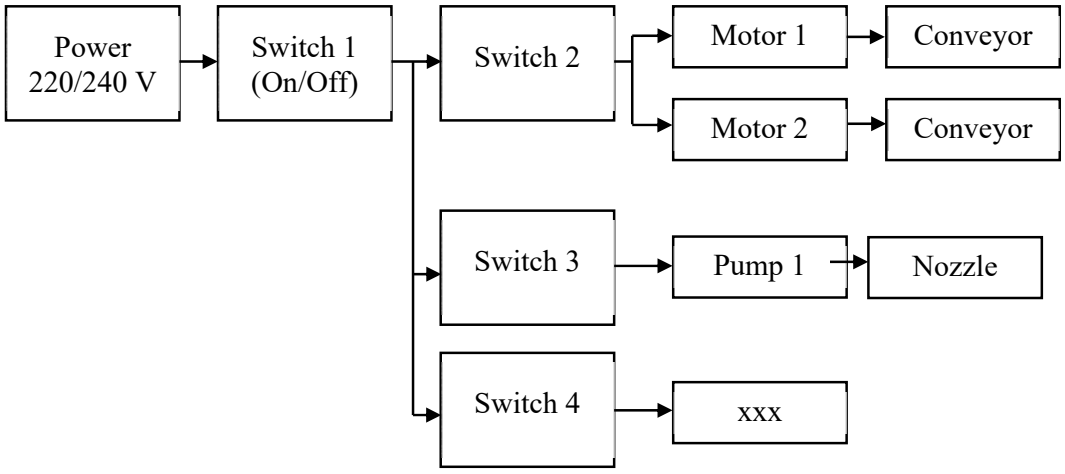
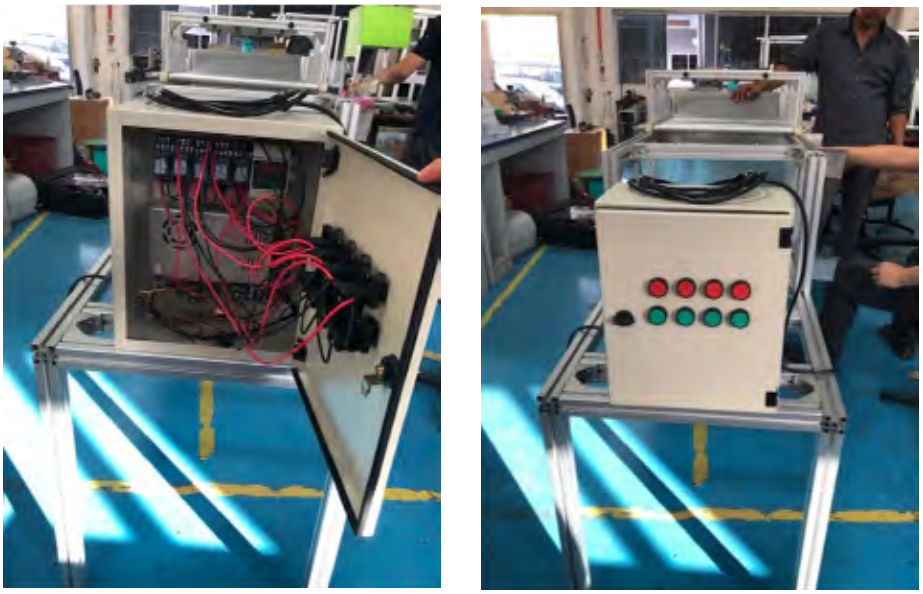


Figure 4.5 The circuit block diagram of control box



(a) (b)

Figure 4.6 The control box, (a) inside, and (b) outside

4.3 Assemble The Machine at BR Herba Resources Site

Once the cleaning machine has been tested and worked accordingly, then, the machine was delivered to BR Herba Resources Site at Pendang, Kedah. Here, the machine was assembled and tested using real material, white turmeric. Figure 4.7 shows a few photos during the assembled work at the site. Figure 4.8 shows the successful assembled of the cleaning machine at BR Herba Resources company.

(a) (b)

Figure 4.7 Machine assembly at BR Herba Resources company

Figure 4.8 The completed machine of cleaning white turmeric for BR Herba Resources

4.4 Testing at The Company Site

Next, a few days were taken to test and analyse the performance of the machine. Figure 4.9 shows the testing at the site using raw white turmeric.

(a) (b)

Figure 4.9 Machine setting and testing

5. MACHINE PERFORMANCE AND ANALYSIS

Once the fabrication of machine is completed, testing was conducted at the company using the real raw white turmeric that provided by the company. The machine is able to wash and peel the first layer of turmeric skin which is it succeed to achieve the objective of this project. The cleaning process of turmeric is depended on the size of the turmeric rhizome, the small the size, the fast the cleaning process.

5.1 Performance Analysis

Table 5.1 shows the comparison between performance of the machine and the previous method that have been utilised by the company. Based on the testing, 10 kg white turmeric were used to perform the cleaning machine using the machine. With the full speed of top and below conveyors, as well as water pump, this bunch of turmeric can be cleaned in 22 minutes. Hence, if 500 kg is required to be cleaned, it can be calculated based on ratio as shown in Equation (5.1). Figure 5.1 shows the white turmeric condition before and after cleaning process at the first trial.

Table 5.1 The comparison of previous method and machine performance

No	The previous method	The machine performance
1	The washing and peeling process of the raw white turmeric is done separately.	Both processes of washing and peeling is done in the same time
2	The washing and peeling process for 500 kg took 5 days with 10 employees	Both processes of washing and peeling for 500 kg only takes 8 to 9 hours for 2 days with 2 or 3 employees.
3	10 employees contribute to almost RM 10,000 of salary	3 employees contribute RM 3000 of salary only

Calculation to get the duration of cleaning process based on machine performance (from remove soil to peel the first skin layer)

For 10 kg white turmeric, 40 minutes is the duration to clean.

$$\text{Cleaning process duration} = \frac{White\ turmeric\ amount\ (kg)}{x} \times t \quad (5.1)$$

Where, x is white turmeric amount of 10 kg, and t is 40 minutes to clean.

$$\text{Then, cleaning process duration} = \frac{500\ kg}{10\ kg} \times 40 \text{ minutes} = 2000 \text{ minutes}$$

Hence, 2000 minutes = 33 hours 20 minutes

If working hours per day is 7 hours, hence, the cleaning process may take around four and half days to complete. In addition, the suitable number of workers to operate this machine is three workers. With this number of workers, the cleaning work can be performed smoothly and less tiring.

(a) (b)

Figure 5.1 The white turmeric condition (a) before cleaning process, (b) after cleaning process

Even though the machine has shown a good performance, but there was a bit slow to large and very curvy white turmeric. For this particular turmeric, it needs to be put back into the machine. Sometimes, it takes several times in order to make it as clean as wanted. Due to this matter, this machine required an augmentation of its water pressure. This is because water pressure is the method of cleaning process. Hence, an addition of water pump can be the best option to solve this matter.

5.2 Performance Analysis of an Upgraded Cleaning Machine

Once the additional water pump is attached at the cleaning machine, a testing is conducted to ensure this machine will get better performance in cleaning results compared to the previous performance. The additional water pump is similar with the old water pump, in terms of its power capacity. Here, the additional water pump is used to drain water at nozzle set for below conveyor. While, the old water pump is used for top conveyor. Figure 5.2 shows the additional water pump in the cleaning machine.

Figure 5.2 The new machine with two water pumps

For the new testing, BR Herba Resources has supplied 100 kg of white turmeric for this purpose. 50 kg for cleaning using upgraded machine, while another 50 kg for cleaning using their conventional method. Table 5.2 shows the overall performance between the conventional method with the upgraded machine. Both methods utilised three employees.

Table 5.2 Comparison of performance results using 50 kg white turmeric

Items	Company's conventional method	3-in-1 cleaning machine (2 water pump)
Duration of washing (remove soil from white turmeric)	~ 2 hours	-
Duration of peeling process (complete cleaning process)	~ 3 hours	-
Total duration	~ 5 hours	~ 2 hours
Cleaning quality	Good	Good
Waste	~ 15 kg from 50 kg	~ 8 kg from 50 kg
Labour	3	3

Overall, both methods performed with good cleaning quality. However, the conventional method took around 5 hours to complete the cleaning process, while, the 3-in-1 cleaning machine took around 2 hours to complete. This was expected as the workers are required to clean the white turmeric one by one. Also, the conventional method required the workers to wash the turmeric, remove it from the soil, before it can continue to peel the turmeric skin. For 3-in-1 cleaning machine, both processes of washing and peeling can be done at the same time. Another good performance of the 3-in-1 cleaning machine, its waste was around 8 kg, compared to the conventional method, which has around 15 kg for 50 kg of white turmeric. This may cause by the workers who usually peel the white turmeric thickly.

Based on the performance, the speed ratio can be calculated in order to make a comparison between the conventional method and the 3-in-1 cleaning machine. The calculation is shown below;

For 50 kg of white turmeric, the cleaning process duration:

Conventional method (CM) = 5 hours

3-in-1 cleaning machine (3in1 CM) = 2 hours

Hence,

The ratio of CM : 3in1 CM = 5 : 2

The speed ratio of 3in1 CM compared to CM,

$$= \frac{duration\ of\ CM}{duration\ of\ 3in1\ CM} = \frac{5}{2} = 2.4 \qquad (5.2)$$

Then, the speed ratio of 3-in-1 cleaning machine compared to conventional method is 2.4 faster than conventional method.

If 500 kg of white turmeric is required to clean using the 3-in-1 cleaning machine, the duration of cleaning process can be estimated using equation (5.1)

For 50 kg white turmeric, 120 minutes (2 hours) is the duration to clean.

Cleaning process duration = $\frac{White\ turmeric\ amount\ (kg)}{x} \times t$

Then, x = 50 kg, and t = 120 minutes

Cleaning process duration = $\frac{500\ kg}{50\ kg} \times 120$ minutes

= 1200 minutes

Hence, 1200 minutes = 20 hours

If working hours per day is 7 hours, hence, the cleaning process may take around three days to complete.

6. ECONOMIC EVALUATION

This project was funded by PPRN and BR Herba Resources. Total funded was RM18,700, with 90% from PPRN and 10% from BR Herba Resources. Table 6.1 shows allocation of project budget. For this project, there was allocation of honorarium to Universiti Malaysia Perlis and researchers, which is contributed to 5% and 25%, respectively. Table 6.2, Table 6.3 and Table 6.4 show the details of materials, travel and others expenses, respectively. For this project, overall spent for materials, travel and honorariums was RM 18,437.00.

Table 6.1 Overall project budget

No	Purchase details	Fund	Expenses (RM)
1	Material	PPRN	10,720
2	Allowance (2 technicians)	PPRN	500
3	Honorarium to UNIMAP (5%) and researcher (25%)	PPRN	5,610
4	Travel cost to site (include rent a lorry)	BR Herba	1,600
5	White turmeric	BR Herba	270
	TOTAL		18,700

Table 6.2 The expenditure details for materials

No.	Purchase details	Price/ unit (RM)	Quantity	Total (RM)
1	Castor and wheel	5.50	8	44.00
2	Deep groove ball	15.00	3	45.00
3	Aluminium rod bar 22mm	38.50	65	2502.50
4	Touchscreen module	196.00	1	261.00
	Cable	35.00	1	
	Plug	30.00	1	

5	Push button switch & postage	4.00	8	36.80
6	Lead screws with nuts and washer Metal rim Harden chrome linear shaft Shaft motor	82.00 52.00 25.00 57.80	1 4 1 1	372.80
7	Conveyor rod	214.10	2	428.20
8	Pressure washer water, High pressure nozzle and 12V/24V/220V coil power relay	378.00 45.50 18.00	4 16 8	2384.00
9	Metal conveyor sprocket gear Stainless steel chain for conveyor	17.80 21.00	65 6	1283.00
10	Screw	5.70	1	5.70
11	40mm teflon bar 2.4m	216.00	1	216.00
12	Bosch GSB Cutting discs Bold and nuts	250.00 35.00 33.00	1 1 1	318.00
13	High pressure water pump	918.00	1	918.00
14	Nozzle holders and contact tips	25.00	1	25.00
15	Shaft sprocket	40.00	25	1000.00
16	Screws and tools	67.50	1	67.50
17	Electric motors Electronic component	150.00 39.50	2 1	339.50
18	Custom made steel sheet (layer)	210.00	1	210.00
19	Custom made steel (cover)	220.00	1	220
	TOTAL			**10,677.00**

Table 6.3 The expenditure details for travel and transport

No.	Items	Price/ unit (RM)	Quantity	Total (RM)
1	Travel to BR Herba Resources for discussion (toll, petrol and meal)	250.00	4	1,000.00
2	Rent transport for machine delivery	250.00	1	250.00
	TOTAL			**1,250.00**

Table 6.4 Other expenditures

No.	Items	Price/ unit (RM)	Quantity	Total (RM)
1	White turmeric ≈ 110 kg	100.00	1	100.00
2	Allowance to industrial training students	100.00	3	300.00
3	Honorarium to two technicians	250.00	2	500.00
4	Honorarium to UNIMAP (5%)	935.00	1	935.00
5	Honorarium to researchers (25%)	4,675.00	1	4675.00
	TOTAL			**6510.00**

7. CONCLUSION

This project is a solution to BR Herba Resources when dealing with white turmeric cleaning process problem. The project has developed a 3-in-1 cleaning machine that able to wash, clean and peel the first layer skin of white turmeric. The overall cost to develop this project was around RM 18,700, including allowance and honorarium to Universiti Malaysia Perlis, researchers as well as technician and industrial training students.

From the performance observation, there are a few benefits to the company. The benefits as listed below;

i. It proves that the use of 3-in-1 cleaning machine can help this company to reduce their cleaning time.

ii. It helps them to reduce employee or use their employee optimally.

iii. It can reduce their waste and help them to get more production.

8. REFERENCES

[1] Lobo, R., Prabhu, K. S., Shirwaikar, A., & Shirwaikar, A. (2009). Curcuma zedoaria Rosc.(white turmeric): a review of its chemical, pharmacological and ethnomedicinal properties. *Journal of Pharmacy and Pharmacology*, *61*(1), 13-21.

[2] Putri, M. S. (2014). White turmeric (Curcuma zedoaria): its chemical subtance and the pharmacological benefits. *Jurnal Majority*, *3*(7).

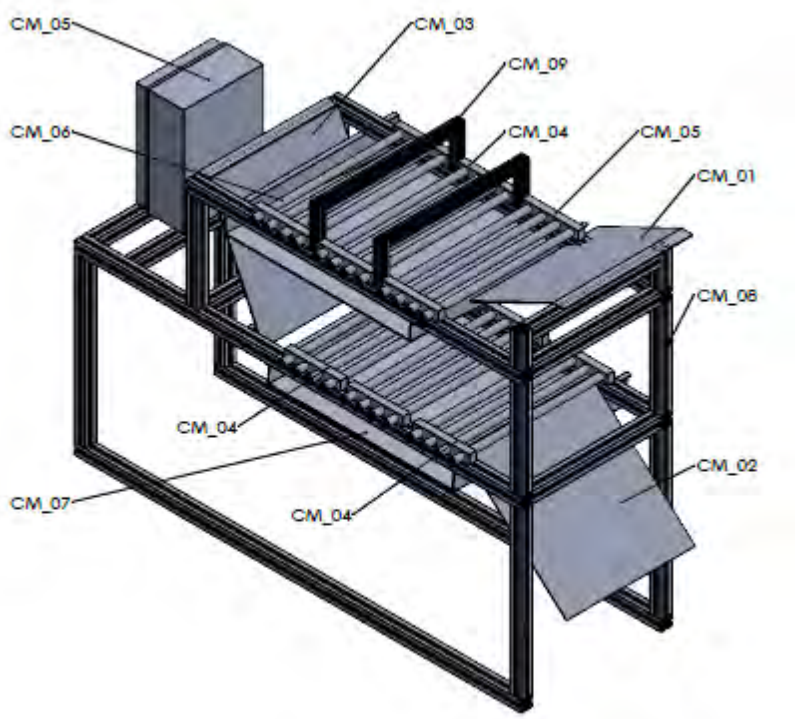
[3] Retrieved at https://brherbsresources.blogspot.com/ on Dec, 2020.

[4] Retrieved at https://www.mohe.gov.my/redesigning-higher-education/inisiatif-penyelidikan/pprn on Dec, 2020

[5] Retrieved at https://ispe.org/initiatives/regulatory-resources/gmp on, dec 2 2020

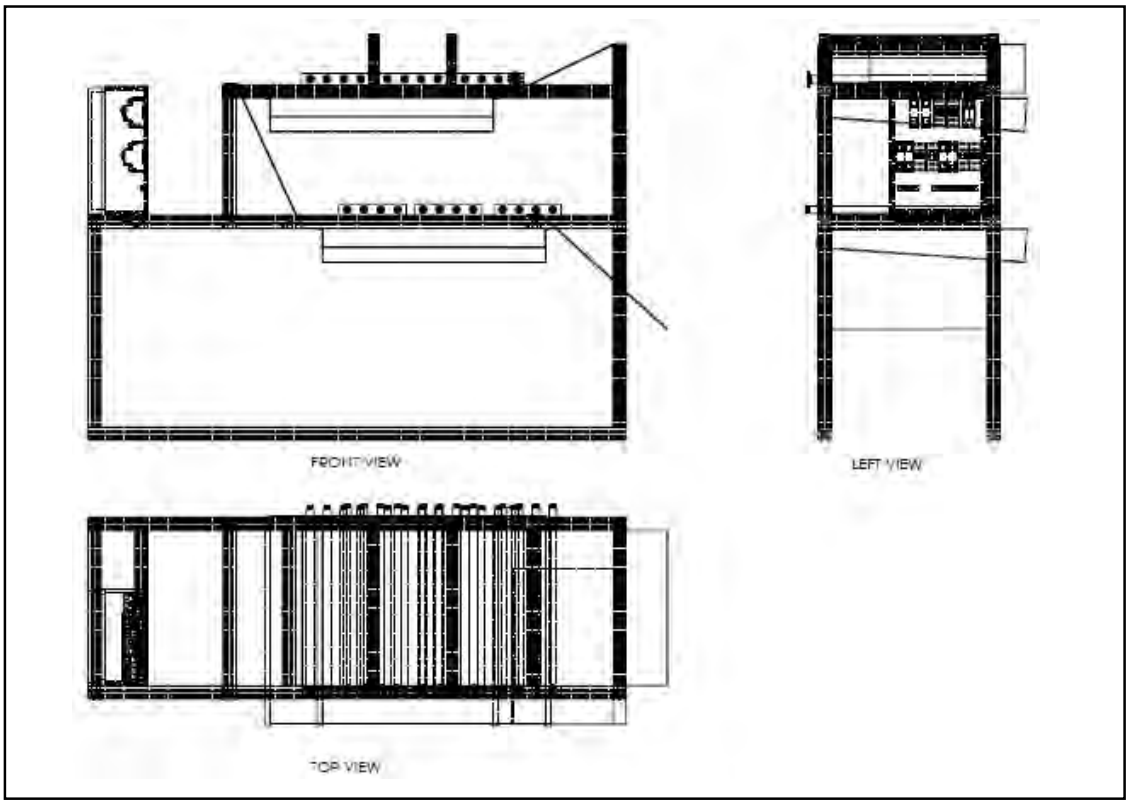
9. APPENDIX

TECHNICAL DRAWING (MECHANICAL DESIGN I)



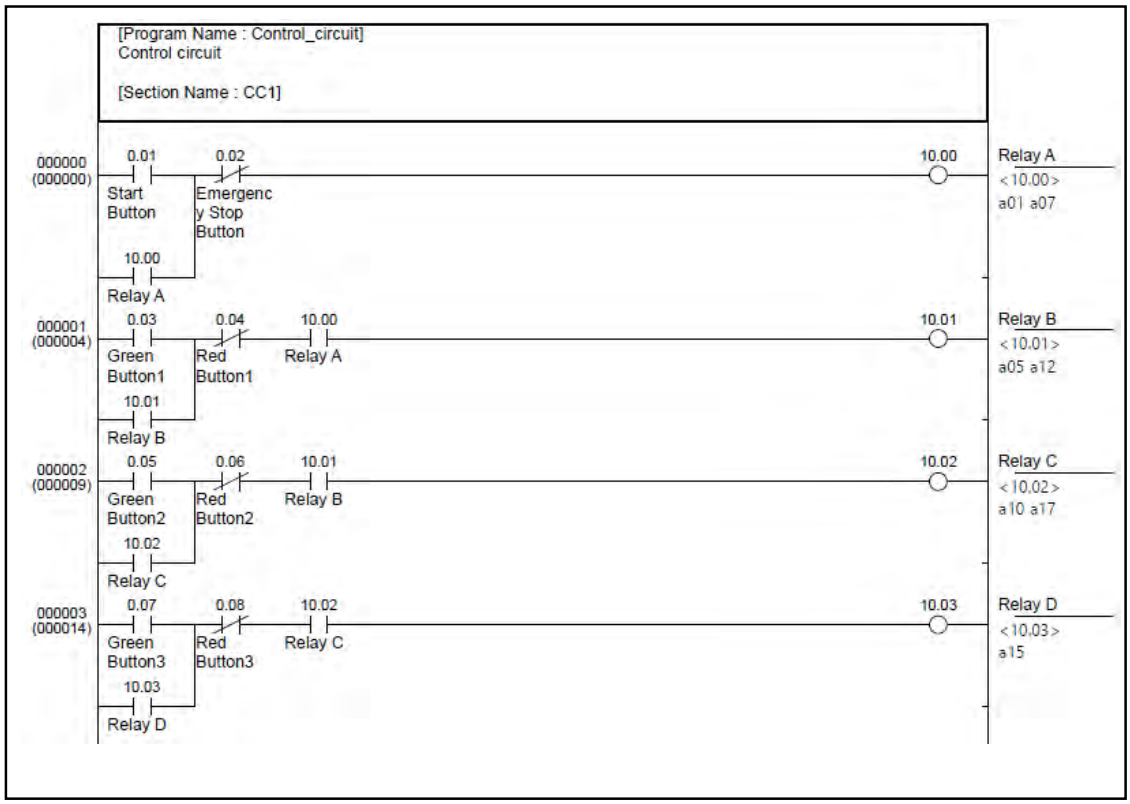
Universiti Malaysia Perlis (UniMAP_	Designed by Marni Azira & Erdy Sulino			
Institution	Approved 2019	Date 2019	Rev 2019	
Scale 1 : 20	Material: ALUMINIUM PROFILE 6063 ALUMINIUM BAR 6061			
Product Name: 3-in-1 Cleaning Machine for White Turmeric				

TECHNICAL DRAWING (MECHANICAL DESIGN II)



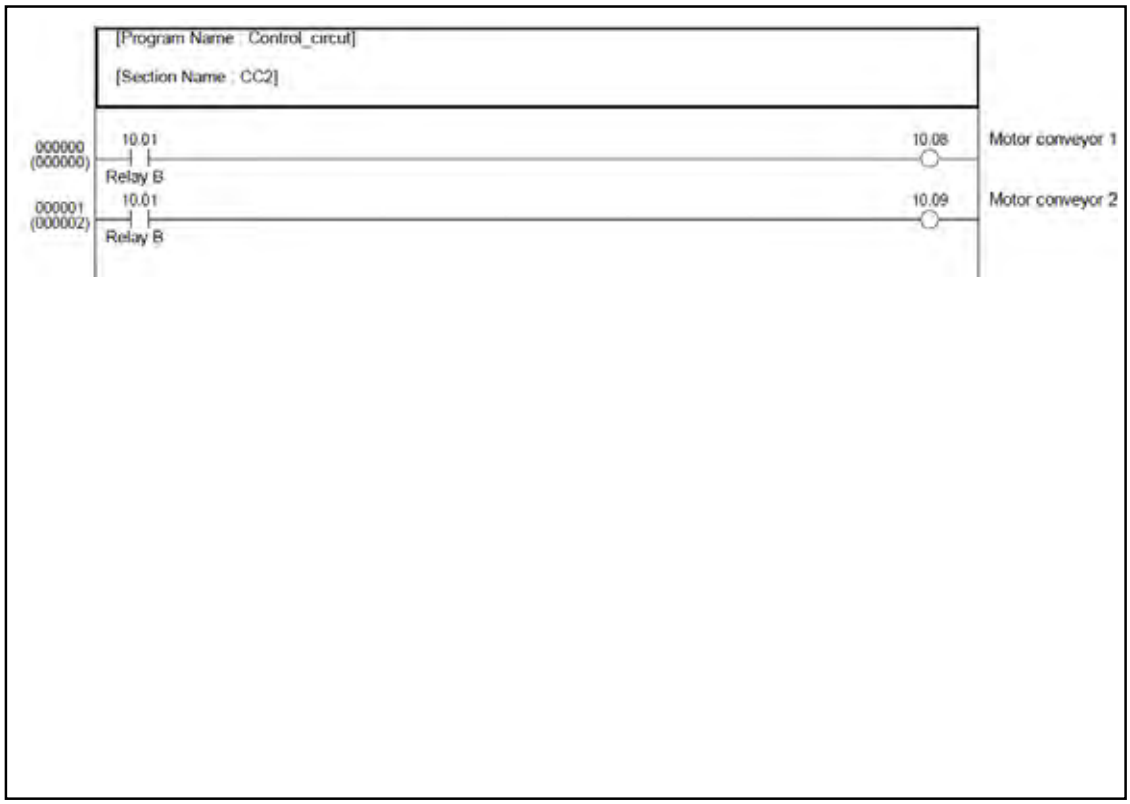
Universiti Malaysia Perlis (UniMAP_	Designed by Marni Azira & Erdy Sulino			
Institution	Approved 2019	Date 2019	Rev 2019	
Scale 1 : 20	Material: ALUMINIUM PROFILE 6063 ALUMINIUM BAR 6061			
Product Name: 3-in-1 Cleaning Machine for White Turmeric				

TECHNICAL DRAWING (ELECTRICAL DESIGN I)



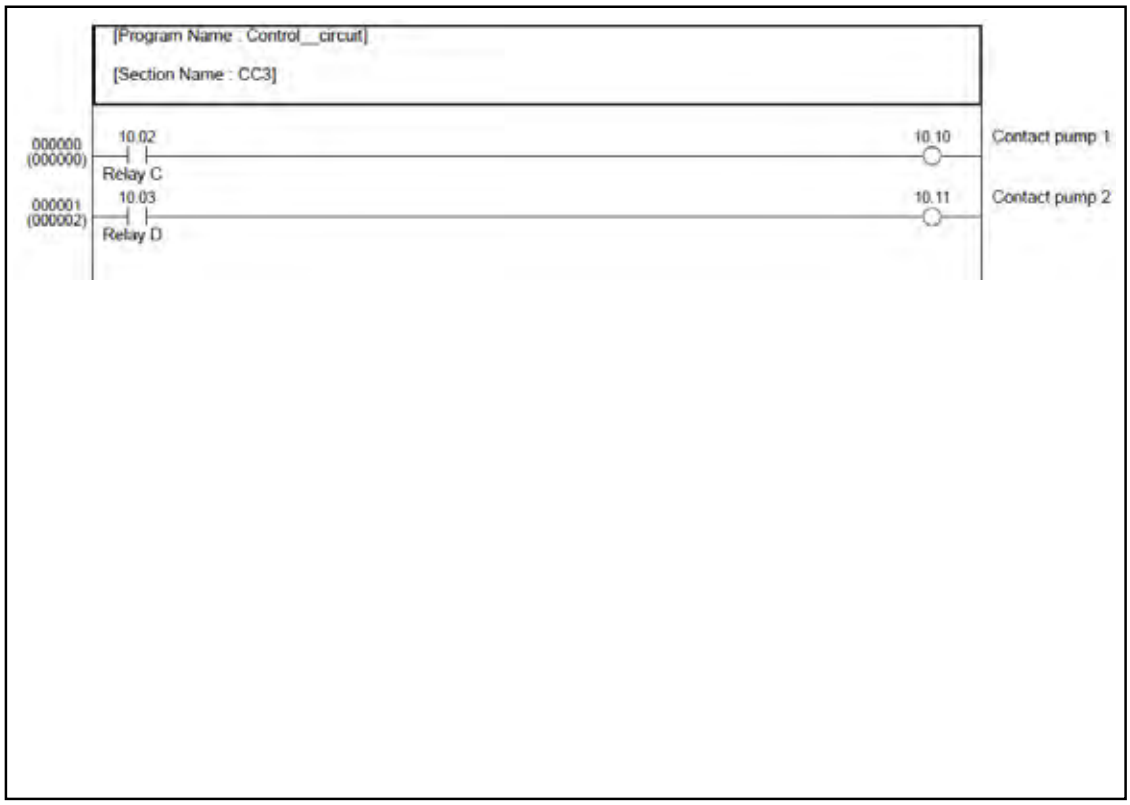
Universiti Malaysia Perlis (UniMAP_	Designed by Marni Azira & Erdy Sulino			
Institution	Approved 2019	Date 2019	Rev 2019	
Scale 1 : 2	Material: -			
Product Name: Control circuit I for 3-in-1 cleaning machine for white turmeric				

TECHNICAL DRAWING (ELECTRICAL DESIGN II)



Universiti Malaysia Perlis (UniMAP_	Designed by Marni Azira & Erdy Sulino			
Institution	Approved 2019	Date 2019	Rev 2019	
Scale 1 : 2	Material: -			
Product Name: Control circuit II for 3-in-1 cleaning machine for white turmeric				

TECHNICAL DRAWING (ELECTRICAL DESIGN III)



Universiti Malaysia Perlis (UniMAP_	Designed by Marni Azira & Erdy Sulino			
Institution	Approved 2019	Date 2019	Rev 2019	
Scale 1 : 2	Material: -			
Product Name: Control circuit III for 3-in-1 cleaning machine for white turmeric				