

Automated White Pepper Bottle Filling Machine

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Abstract: White and black pepper production in Sarawak state keep increasing since 2009. In Malaysia, Sarawak are the main production of pepper. Based on observation at Kampung Telok Melano, 90.00 % out of 84 houses are pepper farmers. Pepper production is a main source of income for the local farmers. Farmers at the Kampung Teluk Melano, still processing the pepper in manual method which is from raw until the output product. In order to increase the production rate, the farmer need an affordable automated machine. The aim is to design bottle powder filling system layout. For system control of the was used to control the developed system machine, before fabrication process of the machine, all of the part is design in SolidWork in order to have a better dimension. To select the suitable design layout for the machine, Pugh Metrix method is applied for choosing the acceptable design layout for the machine. For fabrication of the machine, the part is made using 3D printer, stainless steel, zinc and aluminum. The auger dispenser is custom made. All of the part that involve in rotation movement are analyses by using simulation. From the finding, by referring the CAD design, the machine is able to fabricate. It was found that all of the part that involved in rotation movement able to rotate as desired. By any means, in order to verify the machine production performance, test run which involving the LLD PLC programmed.

Keywords: PLC, Auger Dispenser, Pugh Metrix,

1. Introduction

Kampung Telok Melano is one of the villages which located at Sematan, Sarawak. Base on observation at Kampung Telok Melano Sarawak, 90.00 % out of 84 houses are pepper farmers. Pepper production is a main source of income for the community as shown in Figure 1. Through interview with Puan Siti Salmah binti Karim, one of the pepper farmers at the Kampung Teluk Melano, normally pepper is processed in manual method which use river water to soak the raw pepper, dehydrate the pepper under the sun, separate the peppers from the stalks by hand as shown in Figure 2 and the packaging process are still manually using weighing scale and scooping the pepper into the plastic or

pepper using spoon rice. In average, they manage to produce 6 kg to 8 kg pepper which is completely in packaging.



Figure 1: Pepper farm at Kampung Teluk Melano

In Malaysia, based on 2018-year report from Lembaga Lada Malaysia most of the main supplier for pepper product comes from Sarawak. Most of the raw pepper comes from Kuching division which sit on which are in the position bellow Sarikei production record [1]. Nowadays, Sarawak still leading on the rate amount of production black and white pepper as shown in Table 1. The black pepper production is exponentially increasing since 2009, while fluctuating of white pepper production due to hard to produce [2].

Table 1: Malaysia year 2018 sell data [1]

PEJABAT	LADA HITAM		LADA PUTIH		JUMLAH	
	Kuantiti (Tan)	Nilai (RM)	Kuantiti (Tan)	Nilai (RM)	Kuantiti (Tan)	Nilai (RM)
Sarikei	1,120.47	11,250,422.35	68.32	1,169,321.62	1,188.79	12,419,743.97
Kuching	626.88	6,591,084.23	40.64	787,984.04	667.51	7,379,068.27
Serian	402.31	3,906,660.03	45.97	815,491.57	448.28	4,722,151.60
Sibu	252.27	2,421,519.84	14.91	246,094.95	267.18	2,667,614.79
Bintangor	223.87	2,435,997.18	16.44	317,007.05	240.32	2,753,004.23
Betong	78.07	747,799.16	45.90	887,873.10	123.97	1,635,672.26
Bintulu	35.93	361,013.57	15.23	240,807.24	51.16	601,820.81
Sri Aman	31.60	342,083.70	7.75	152,248.15	39.35	494,331.85
Johor Bahru	0.00	0.00	0.00	0.00	0.00	0.00
Jumlah Besar	2,771.40	28,056,580.06	255.16	4,616,827.72	3,026.56	32,673,407.78

The demand on pepper is high according to the pepper farmers which can reach up to 30 kg per day. Other than that, the problem faced by practicing manual powder filling operation are wastage of spilling powders, non-uniform powder volume and time-consuming manual packaging process. According to [3] these kinds of problems could be countered by using automated. This problem faced by Small Medium Enterprise (SME), Micro Enterprise (ME) and Entrepreneur manual bottling compels to take up this project. This project is meant to eliminate problem faced by small scale bottle filling system. With the system that operates automatically, every process run smooth and the process of refilling able to reduce workers cost and operation time.



Figure 2: Dehydrate process manual method

2. Materials and Methodology

2.1 Sketching and design selection

Before getting the finish design that will be selected, the first step that need to be done is brainstorming which is getting an idea which design is suitable for this project. It is needing a consideration upon the cost, assembly process and availability of material.

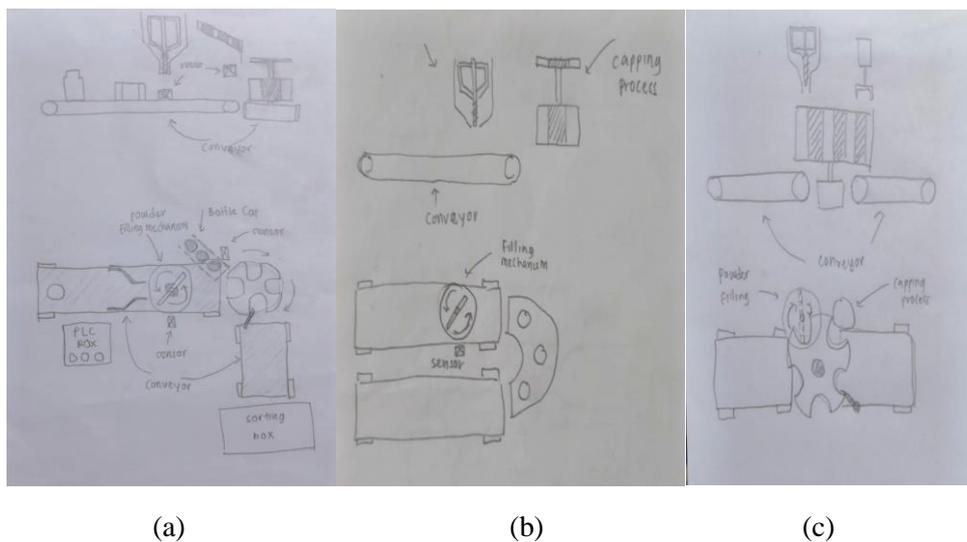


Figure 3: The sketch of different design of automated white pepper bottle filling machine

Figure 3 shown, there are three types of sketches of different of automated white pepper bottle filling machine. The sketch a has been selected because according to the neatness of the process layout and the required component installation work is very easy to handle. The design is also easy to fabricate which is not require any bending process compared to sketch b.

2.2 Design evaluation

Upon evaluation of the project design purpose, the evaluation has made by using Pugh method in order to make a wise decision upon through all of the other project layout design . There are six criterias considered in this method which is Cost, Reliability, Space consumes, Complicated stage, Fabrication process and Possible time pause every process. Since the machine have not been invented yet, the baseline for the machine design layout is based on comparison among design sketch 1, 2 and 3.

Table 2: The criteria of different design of automated white pepper bottle filling machine by using Pugh Method

Criteria	Design 1	Design 2	Design 3
Cost	-	-	-
Reliability	+	+	S
Space consumes	+	+	-
Complicated stage	+	-	S
Fabrication process	+	-	S
Pause time process	+	-	S
Sum of +	5	2	0
Sum of -	1	4	2
Total score	4	-2	2

Based on Table 2 the value of each criteria for each design are representing the advantages and disadvantages of each criteria of Cost, Reliability, Space consumes, Complicated stage, Fabrication process and Pause time process. The dimension of this machine was shown in Figure 4. This finalize design are use as reference to proceed with a fabricating process.

2.3 Final design

After all of the three design have been considered and evaluated, the next step is to design the selected design which is design 1 machine layout by using CAD software. Base on Figure 4, the finalize design is in isometric view and have been made by using Solidwork software. With this finalize design and all dimension that have been design, it had been used as reference for proceeding fabrication process.

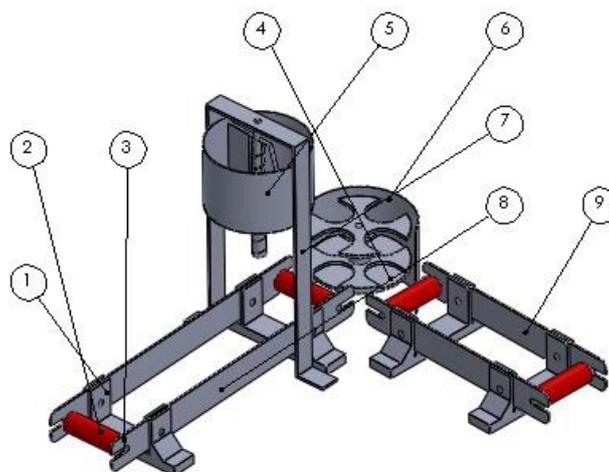


Figure 4: Finalize CAD design base automated white pepper bottle filling machine

2.4 Filling mechanism

Augur dispenser was chosen due to easy to fabricate by using the zinc plate material, riveting process and soldering which the medium used are melted aluminium. Based on observation at the Kampung Teluk Melano, the product finish of the pepper is fine grain finish white pepper. According to the [4], augur dispenser is very suitable for fine grain powder handling.

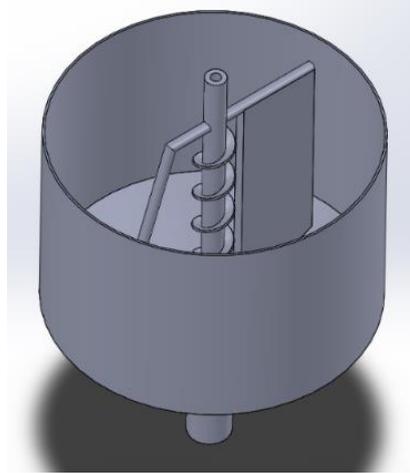


Figure 5: Augur dispenser CAD design

2.5 Control system design

PLC had been chosen for the main controller for the circuit controller for this project. All of the inputs and outputs need to be arranged in order so it can be recognised which part are it should be connected or put on and the sequence are able to recognise. Table 3 show the process flow for this project. After completing the process flow, the data are used as a reference for program the PLC[5] which using LLD (logic ladder diagram). To construct the program, CX-programmer are used as medium for constructing the program as shown in figure 6 below.

Table 3: Process flow of control system for PLC

Sequence	Input	Output
1	Press Push button 1 and push button 2	Conveyor 1 and 2 activated
2	Sensor 1	Motor actuator activated and conveyor 1 stop control by timer
3	Sensor 2	Motor bottle capping activated and motor for bottle rotation activated control by timer

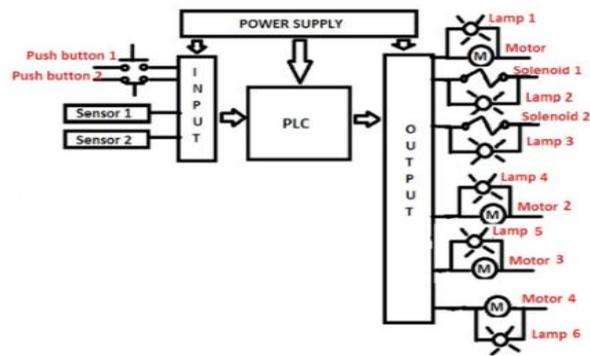


Figure 6: Schimetic diagram for control system PLC

2.6 Fabrication of automated white pepper bottle filling machine

The powder flapper and auger tool bit were welded permanently join. The powder flapper and the auger tool bit, welding process had been used as joining method as shown in Figure 7. This part consists of each part which permanently joint that attached. It must be durable for load upon the rotation for filling mechanism. This particular part was made by using drill tool bit and a steel bar where then was cut into 2 specification dimension which stated in the design before. The welding set that has been use is Arc welding set.



Figure 7: Auger tool bit

For assembly process, each of the part and main frame for the machine are required to be fit and can withstand any vibration that may occur during the machine turn on. To make it durable enough to withstand the vibration that may occur, the base plate for the machine is made by using plywood with thickness of 10mm. For preventing the part moving any direction, all of the part attach to conveyor bracket, dispenser bracket and bottle rotation base are screw up to the base as show in figure 8.

Some parts in the machine were fixed with ball bearing and bosh, such as conveyor roller, bottle rotation mechanism and auger dispenser. The purpose of using this particular item was to make sure that every part that involve in any rotation's movement move smoothly and have less friction that may cause the machines work disorderly.



Figure 8: Assembly process

2.7 Bill of material types used on automated white pepper bottle filling machine

Every material that has been used to fabricate this project will be show in a table 4. Base on table 6 and figure 4 show that each part involves in the finale design for this machine and the material use in designing each part.

Table 4: Material use in designing each part

No of part	Material (actual)
1	PLA
2	PLA
3	Steel
4	PLA
5	Steel and Zinc
6	Aluminium
7	Steel
8	Stainless steel
9	Stainless steel

3. Results and Discussion

3.1 Design evaluation result and analysis

The selection was made up by using a Pugh method where it was consisting of three different machine design layouts. This evaluation also, was been setup with a criterion needed for the pepper powder bottle filling machine. The result of this evaluation was shown in Table 5.

Table 5: Pugh method result

Design layout	Total sum of criteria
	Sum of + = 5
Design 1	Sum of - = 1
	Total score = 4
	Sum of + = 2
Design 2	Sum of - = 4
	Total score = -2
	Sum of + = 0
Design 3	Sum of - = 2
	Total score = -2

Based on Table 5 shows that the total of design 1 for + and - is equal to 4 since it was setting to be the baseline for the comparison guideline. For the design 2 the sum of + was equal to 2 and the sum of - was equal to 4. The total score of the design 2 was -1 since $2 - 4$ is equal to negative 2. However, at the design 3, the sum of + and - was equal to 0 and 2 and after adding, the total score was equal to -2. By comparing the value of the total score, it shows that the design 1 had the larger value compared to the others concept. With this the design 1 was chosen to be the finalize design machine layout.

In discussion the result obtain in the Pugh method was show that the first design layout of the sketch design is the most considerable compared to the other design layout and was selected as the finalize design for the fabrication process this was proven by Stuart Burge where the evaluation usually decided by scaling of 1 to 5, where the 1 was representing of the lowest and 5 is the highest [6]. However, in this evaluation of machine design layout was shown the total score for the first design has the higher score. With this the first design layout was selected as the finalize design.

3.2 Solidwork motion analysis

Solidwork motion analysis was necessary to determine critical part such as conveyor roller, auger dispenser and bottle rotation mechanism that will be applied with the rotation motion by motor for not failed. The analysis was applying the capability of part to rotate properly without any obstruction. The first result of this analysis was collected on video analysis by simulation upon the conveyor roller. The result also shown that every driven conveyor roller rotates properly along to axis. However, this analysis is based on visualise rotation motion applied as shown in Figure 9.

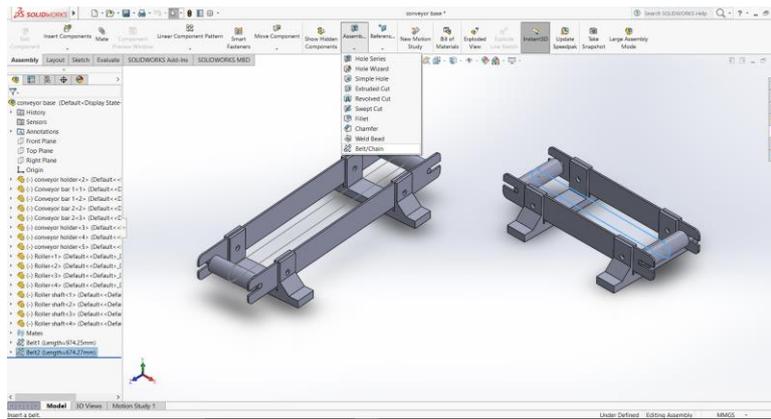


Figure 9: Solidwork motion process conveyor base

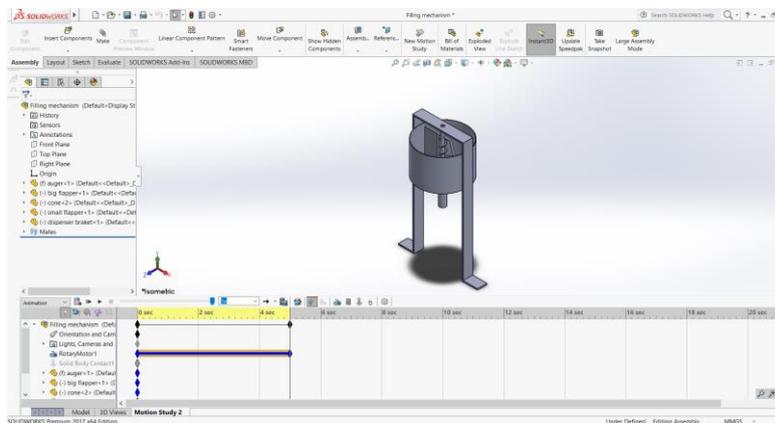


Figure 10: Solidwork motion process auger dispenser

The second result of this analysis was shown in Figure 10 with rotation motion apply to auger tool bit in 100 rpm. This attempt of analysis has shown that the auger dispenser rotates well. However, with only simulation was conducted, the amount of powder pepper cannot be determined, and which rotation side are required either clockwise or anti-clockwise.

3.3 Machine specification

Based on the analysis obtain from analytic procedure, the specification can be created for this development of automated powder bottle filling machine. This specification was made in order to serve as a guidance for a user to operate the machine properly. The specification of machine was shown in Table 6.

Table 6: Specification of automated powder bottle filling machine

No	Specification	Description
1	Capacity	1 bottle per dispense
2	Product	Fine grain pepper powder
3	Process flow of production	<ul style="list-style-type: none"> i. Empty bottle onto conveyor ii. PB1 switch on to switch o the machine iii. Sensor 1 detect activate auger dispenser iv. Sensor 2 bottle rotation activate

		v. Bottle capping activate by timer
		End conveyor transfer to box
		i. Ball bearing
4	Breakdown major equipment list	ii. Belting
		iii. Motor
		iv. Auger tool bit
5	Raw material	White or black pepper powder
6	Consumption	Electricity
7	Workplace	Open ground which is clear from dust for hygiene purpose
8	No of operator	1 person

Based on Table 6 show that the machine capacity was capable to produce 1 bottle per dispense and the product use are fine grain pepper powder. The process flow of production start by switch on the PB1 to activate the machine, sensor 1 detect the bottle and activate the auger dispenser, Sensor 2 activated the bottle rotation mechanism, the bottle capping process activated by timer and lastly the end conveyor transports the product into the box. The breakdown major equipment used to run the machine is ball bearing, belting, motor and auger tool bit. This automated powder bottle filling machine was focus on powder pepper where the major consumption energy of the machine is electricity. This machine was suitable to use at open ground area which are clear from dust for hygiene purpose and required 1 operator to handle it

3.4 Actual result

Fabrication result

After all the analysis process has been conduct, the machine can be proceeded for fabrication process. For fabrication of the machine, all of the dimension is followed by referring the CAD design to avoid any miss alignment of the machine. In order to test the functionality of the machine, all of the part that involve in rotation movement are test by using motor to ensure the smoothness of the rotation part as shown in Figure 11. All the parts that involve in rotating movement able to rotate as desired. To rotate the parts, high torque 12 V DC motor has been used. The motor is manually connected to power supply and link up using pulley and belt. The machine is able to transport the bottle to the auger dispenser, bottle rotation mechanism and end conveyor. The program of LLD for the PLC machine are also have been construct for control the movement of the machine. The program is for controlling every movement of the machine which is program with LLD.

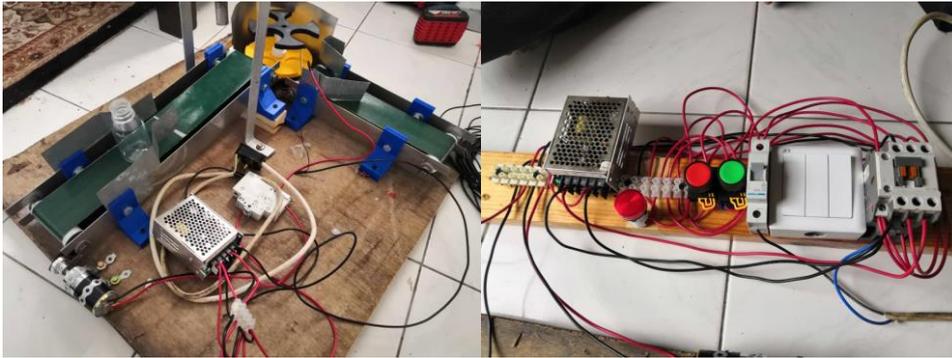


Figure 11: Machine test process

The cost of fabrication for the machine also less than the machines that are already available in the market which minimum it will cost the farmer RM1200. This due to by using the cheaper material and applying the new technology such as 3D printing. The Table 7 show total cost upon fabricating the machine. On the test run process, there are 5 test runs have been conducted to ensure that the machine is constantly can complete the cycle of the process desired. The time taken result are shown in table 8. To support all the theory and simulation process above, fabrication process has been conducted. By observation, the project will be able to run the process properly. In order to verify of this machine effectiveness, this particular project must be test run to ensure that data output can be collected.

Table 7: Cost of fabrication

Item	Bill	Cost (RM)
Ball bearing	10	RM150
Roller	4	RM48
Screw and nut	30	RM24
3D print service	6	RM55.90
Stainless steel plate	1	RM12
Auger tool bit	1	RM12
Aluminium plate	1	RM6
Zinc plate	1	RM15.20
	Total cost	RM323.30

Table 8: Time taken result

Test run	Time/seconds
First	15
Second	15
Third	14
Forth	15
Fifth	14

4. Conclusion

On completion of the project, it can be concluded that the selected design layout that used to develop the automated powder bottle filling was fully fabricated. The filling mechanism for the machine also has been design and fabricated. Base on simulation and test run that have been conducted, the conveyor base, bottle rotation mechanism and auger dispenser can rotate with motion desired.

The LLD program also has been construct for the machine movement control. A safe overall conclusion is that the general objective of this project has been achieved by selecting the best machine design layout of automated powder bottle filling by using Pugh method, selecting material and joining process to fabricate the machine and analyzing the specimen produced in order to come out the specification of machine. The project is viable and recommended for further work.

Recommendations are important to improve the machine, method and product. These are some recommendations for further research in the near future through the test and analysis that had been carried out. The recommendations are as follows as a change's auger tool bit due to the present design was have not been tested and this particular machine needed to be test run in order to verify the performance. Lastly, try using another unit of controller such as microchip and Arduino.

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