PSU Journal of Engineering, Technology and Computing Sciences
Vol. 1 No.1, pp. 24-32, December 2017

Prototype for Automated Pouring of Puto Mixture Equipment

Kenneth Oliver S Lopez[1], Engr., Reynaldo C. Lomboy[2], Mark JonieL Lopez[3]
[1]Computer Engineering Department, Pangasinan State University
[2] Mechanical Engineering Department, Pangasinan State University

***Abstract* — The usual process of pouring puto mixture on the 200 small containers containing approximately 7.5 ml to 10ml of puto mixture solution manually takes around 15-20 minutes of labor work. In the manual process, there is also an ample amount of waste approximately three (3) liters of puto solution per day. The objective of this project is to minimize the waste and to shorten the time of pouring through development of a machine that will pour puto mixture solution on the small containers. The researchers develop a prototype equipment that reduced the pouring time from 10-15 minutes (for 120 small containers) down to 1.2-1.5 seconds only. It could also be reduced to 100-120 milliseconds if there would be enough power supply to power up the equipment. Waste has been reduced to approximately less than 500ml per day.**

Keywords* — *prototype equipment; puto pouring; mechanize

I. INTRODUCTION

Puto is one of the major products in CalasiaoPangasinan. Most of the households in Calasiao know how to create puto. Puto is so popular in Calasiao that there is an avenue of stalls where all of the stalls sell puto. They have their own unique and original recipe of their own variants of puto mixture where most of the mixtures have a base of rice flour and water. The other ingredients or techniques vary from one puto maker to another.

One of the well-known makers of puto is Bella's Puto of Calasiao. Bella's is one of the largest puto makers in the business. Bella's has different branches in Calasiao, Dagupan, Urdaneta, and provides puto as well on private sectors and by orders. Thus, it won't be a big surprise if Bella's will bakes puto of at least 5000 pcs per day. The method of how Bella's Puto is created started from a well selected specie of rice they order from Nueva Ecija, one of the provinces that produces one of the best qualities of rice in the country. The rice is washed and then ground in their decades old stone grinder. This stone grinder, according to Bella's was the very first and original grinder that their ancestors used in making puto. It was originally thick but as decades pass by, the grinder has been reduced to almost half. The manual stone grinder has been connected to a motor and belt so the rotation of the stone is being done by the motor but the stone is still the original one. Rice soaked in water is being scooped and placed on top of the small hole on the stone grinder and then grinded by the grinder. The grinded rice along with the water will then be placed in a clay jars and set aside for several hours. Even the clay jars are as old as the grinder. After some time, Bella's didn't mention the time and other ingredients added in the clay jar, the mixture will then be poured to tiny cups baking molds, similar to the ones used in baking cupcake, and then steamed in a large bamboo steamer. One layer of bamboo steamer consist of at least 200 cups, and per set of cooking there are three layers of steamer, a total of at least 600 puto per cooking station, and they have at least three cooking station that would be at least 1,800 puto to be cooked at one time. They cook for at least three to five times per day depending on the demand and orders of the customers. That's 5,400-9,000 pcs of puto per day. The cooking process is basically steaming but Bella's shared us a secret that one of the secret aside from the good quality of rice, the grinder, the clay jars, was the method of cooking. Bella's still use an old method of cooking where they use rice hauls as fuel for cooking. They never used gas, wood, electric, or any form of steaming their puto other than rice hauls. This process and techniques has been used for generations, thus the consistency of the product.

Going back on the pouring process, they worker retrieves a jar and pour the mixture into a smaller container such as an aluminum pitcher so they could transfer the mixture to the puto cups. They manually layout the puto cups in the bamboo steamer and then carefully and slowly pour a generous amount of the mixture in the cups. The amount of the mixture is being judged "by experience" as long as it has approximately ¾ full. It takes approximately 15 to 20 minutes to layout the cups in the steamer and pours

ISSN 2599-462X (Print) *www.psurj.org/jetcs* ISSN 2599-4638 (Online)

the mixture. 200-220 cups takes approximately three (3) liters of puto mixture according to Bella's. During the pouring process, some workers are not careful enough and most of the times rush into the pouring. Instead of one cup after the other, they tend not to pause and directly moving the pitcher to the next cup without holding the flow of the mixture. Thus some spillage happens. The evidences of the spillage are seen in the base of the steamer where the cooked puto (in a different shape) are found. Based on the sizes of the cooked puto per steamer, according to the workers, there is a spillage of three to four liters per day. That's around 220-293 pieces of puto per day is being wasted, almost two (2) kilograms of cooked puto is being wasted per day.

II. OBJECTIVE OF THE STUDY

This study seeks to create a prototype pouring machine that could minimize if not eliminate the spillage, and increase the speed of pouring process. Specifically, it aimed to:

1. Create the design of the machine.
2. Describe the procedure the of the machine on the following:
   a. Operation;
   b. Drain; and
   c. Testing.

III. SCIENTIFIC BASIS FRAMEWORK

The basis of this project was taken form a simple pressurized water system as gleaned in Figure 1. The puto mixture solution will be sucked from the reservoir container, pressurized it using a tank and distribute the pressurized solution to the manifold all the way to the 180 hydra-electric solenoid valves[1]. The opening and closing of the valves will be controlled by the Programmable Logic Controller (PLC) [2]. The time the valve will open will be the variable to be calibrated in order to achieve the desired amount of mixture to be poured on the container. The longer the valve opened the more mixture it will pour. The challenge is to properly calibrate the time with respect to the pressure of the tank/pipes .

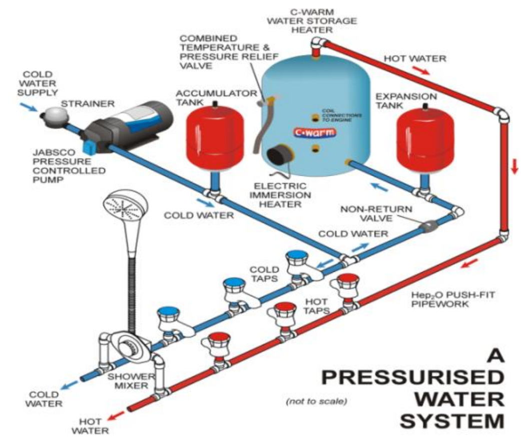

Figure 1. A pressurized water system

As seen in Figure 2, we also adopted the concept of C.P. Huber Model conceptual framework since the prototype is first of its kind for puto industry, the study is an experimental-developmental by nature, and thus the model applies.

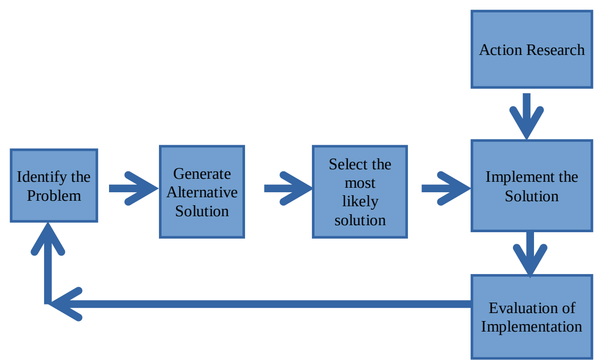

Figure 2. Conceptual Framework

IV. METHODOLOGY

Procedure

The following procedures/processes were involved in the conduct of the study:

1. Fabrication of the support frame.
2. Assembly of the 12x15 branch-valve containing 180 hydraelectric solenoid valves.
3. Assembly of the branch manifold for the branch-valve assembly
4. Interconnecting the mixture reservoir, pump, tank, and gate valves to create the pump-tank assembly.
5. Installing the branch-valve assembly, branch manifold assembly, and the pump-tank assembly in the support frame.

6. Interconnecting the pipes of the branch-valve assembly, branch manifold assembly, and pump-tank assembly.
7. Installation and configuration of the control panel assembly that consists of the programmable logic controller, power supply unit, relays, terminal blocks, and other electronics and electrical components.
8. Wiring of the 180 hydra-electric solenoid valves to the control panel.
9. Fabrication of the temporary tray to be used.
10. Testing and calibration.

Sampling Procedures

The sampling procedures are simply taking samples of how much solution has been poured on to the container with respect to a certain pressure in the tank-pipe assembly, and seconds the valve has been opened. We used the Table 2 below for the measurement of samples per container during the testing and calibration stage.

Table 2. Sample Descriptive Interpretation

Amount in milliliters	**Descriptive Interpretation**	**Color**
11+	Over flow	red
10.1-11	Too much	purple
7.5-10	Good	green
5.5-7.4	Too little	yellow
0-5.4	Nothing	black

V. SCOPE AND LIMITATIONS

The main scope of the project is to create prototype equipment that could pour mixture on cups on a uniform scale. The process will involve of three basic steps. First, insert the tray on its frame. Second, push the start button. The machine will pour the mixture with minimum or no spillage at all, and after waiting for several seconds, remove the tray with filled cups. There will also be an emergency stop button for it is industry standards [3][4].

Some other limitations of the project are as follows:

Puto mixture. We had tried to buy a puto mixture from Bella's but they didn't sell us. They only sell the cooked puto not the liquid mixture. Hence, we used a homemade puto solution mixture commonly used by households that composed of rice flour combined with water and sugar. The viscosity level of the mixtures may vary but the variation is considered negligible as long as same ingredients are concerned.

Puto cups. The puto cups will hold the puto mixture similar to the mold-cup being used in baking cupcakes. Composed of aluminum material, food grade, and with dimensions of 44.5mm (top diameter), 28mm (bottom diameter), and 14mm height. Slightly smaller than the ones being used by Bella's.

Tray. The design includes a fabricated tray to be inserted in a slot underneath a frame that supports the hydra-electric solenoid valves. The number of valves is dependent on the number of cups in the tray. In between the tray and the vales are flexible tubes where the mixture will flow. The original design of the tray can hold 200 cups, but fabricators are not capable of 200. One fabricator agreed on fabricating the tray but only up to 180 cups. On the last quarter of the research deadline, the fabricators back-out on fabrication because they lack the capability to fabricate the tray. The puto cups are falling from the tray and not fixed. Also the cups have leaks since the cups were nailed on to the tray. There was no other fabricator to accept the design. The researcher has the limitation on the fabrication of tray. There was one fabricator who said that the tray could be done using a die-cast-mold to be used to press the aluminum sheet but they will be fabricating the die-cast and will not accept only one piece of order. The minimum orders of tray on such process will be at least thousands of pieces to cover the expenses on fabricating the cast. The researchers also elevated the issue to the DOST-Pangasinan II satellite office under suggested various fabricators but none of them accepted. While in search of a fabricator, the researchers are still using the original prototype tray.

ISSN 2599-462X(Print) www.psurj.org/jetcs ISSN 2599-4638 (Online)

The prototype tray is an 24" x 24" 3mm white transparent acrylic that holds 121 cups. The distance of the holes of the tray should be optimized for the holes that will hold the cups temporarily, if too near to each other, the tray will break apart. Thus the ideal distance of the holes where 45mm center-to-center allowing it to house 121 cups for the time being. Holes for each cup is 32mm where the base of the cup is 28mm, as if the cup is sitting on the hole of the prototype tray.

Hydra-electric Solenoid Valves. The valves where the key factor of the prototype. Running at 12 volts, 3 watts power, these valves will be the one controlling the amount of the mixture that will flow. At the moment there are 180 hydra-electric solenoid valves installed in the equipment but the design of the frame that holds the vales can hold up to 360 hydra-electric solenoid valves depending on how many cups the tray to be inserted can hold. As of the moment since were using the 121-tray we only "tubed" the 121 valves but all 180 valves are ready to use. They are not industry grade and currently the cheapest in the market.

Tubes. The tubes used were used to connect the hydra-electric solenoid valves to the tray. This is where the mixture will flow. The size of the tube is 5/16", flexible, transparent, non food grade.

Valve-Branch. The valve branch is the assembly of 12 valves. Each has been connected to a threaded PVC tee, and all the tee's where connected in series to each other creating a branch of 12 valves. PVC'S where used for the piping and tee's of each branch. We have 15 branches. With 12 valves per branch and 15 branches total of 180 valves.

Valve-branch frame.The valve-branch frame is a 1 ½ x 1 ½ square tube 3mm, 304 grade stainless steel. Welded on a specified design to support layers of valve-branch.

Flexible hose. Flexible hose used are used to connect the valve-branches to the main line that connects the valve-branch to the pump-tank assembly. The flexible hose is 1/2" x 1/2" x 12" stainless.

Main line. The main line is series of pipes, tees, gate valves, elbows that consist of combination of PVC and stainless tubes that are used to distribute the pressurized mixture to the valve-branch assembly.

Pump-tank assembly. The pump-tank assembly is composed of ½ horsepower pump and an eight liter diaphragm tank connected to each other and controlled by a pressure switch calibrated at 10psi and 20 psi for cut-on and cut-off pressures respectively.

Electronics Control Panel. Electronics area are composed of the PLC, relays, power supplies, push button assembly, wires, terminals, all that involves electrical signals.

All of the parts and equipment in the piping and electronics are available in the local hardware. Only some such as the hydra-electric solenoid valves, PLC, terminal blocks, power supplies, and other hard to obtain parts were ordered on-line coming from overseas.

V. RESULTS AND DISCUSSION

Design of the Machine

The main size of the machine depends on the current size of steamer they are using. The size of the steamer will then be the basis of the size of the tray to be fabricated. The maximum size of the tray will be not more than 28" diameter since the size of the steamer is approximately 28.5". The fabricated tray will hold the puto cups to be placed inside the steamer. The average size of puto cup is displayed in figure 3.

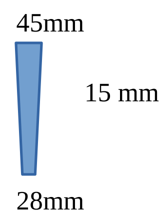

Figure 3.Puto-cup Dimension

Another main variable to consider on the sizes is the dimensions of the hydra-electric solenoid valves, tees, and pipes to be used. We have made so much revision on the original design due to the problems on the unavailability of the parts/components on the market. The prototype of the puto pouring machine is shown in figure 4.

Figure 4. Actual Image of the Prototype

ISSN 2599-462X(Print) *www.psurj.org/jetcs* ISSN 2599-4638 (Online)

Main Parts

The machine is composed of four major parts namely Table-Frame Assembly, Pump-Tank-Reservoir Assembly, Piping-Valve-Branch-Tube Assembly, and Electronics Assembly. The Table-Frame Assembly is composed of the main table and the supporting frame that is used as the main supporting backbone for the whole system. The Pump-Tank-Reservoir Assembly which is composed of the rectangular parallelepiped reservoir that will hold the puto mixture solution.

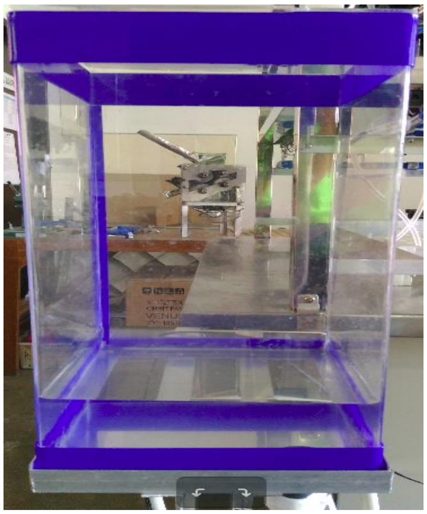

Figure 5.Puto-mixture Reservoir

The mixture is being filtered before poured in the acrylic reservoir so that no solid obstruction that might block/clog the valves. The reservoir is connected to a ½ horsepower stainless headed pump using a flexible hose.

Figure 6. Pump-tank Assembly

The tank is used to suck the mixture solution from the reservoir. It is then pushed on to the diaphragm tank to be pressurized. The pump is being controlled by a pressure switch operating at cut-on pressure of 10psi and cut-off pressure of 20psi. The original cut-off pressure was 30 psi but was then reduced to 20 psi due to some pressure-related problems shown by the valves at 30psi. There are two ball valves connected after the pressure gauge. The red one is used for drain, and the yellow ball valve is the one that controls the flow going to the Piping-Valve-Branch-Tube Assembly.

The Piping-Valve-Branch-Tube Assembly is used to distribute the contents of the tank to the puto cups. First, the mixture released by the yellow ball valve is being transferred to a piping setup that will distribute the mixture to the two main levels of the valves as shown on the figure below (left).

Figure 7. Branch Manifolds

Figure 8. Valve-Branch Assembly

First level is on the lower level and the second is on the higher level. First level has eight (8) branches and the second level is composed of seven (7) branches, where each branch is composed of 12 hydra-electric solenoid valves (as shown on figure above on the right side).

The hydra-electric solenoid valve is the one controlling the flow of the mixture to attain the desired amount to be poured at a given time. The hydra-electric solenoid valves are then connected to a flexible hose where the mixture will flow down to the puto cups.

Figure 9. 15x12 Valve-Branch Assembly

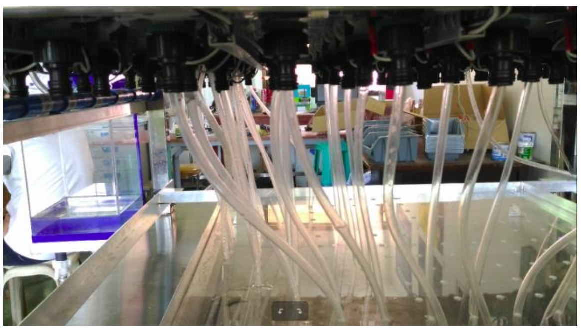

Figure 10. Pipes connecting the valves to the tray

In between the flexible transparent tube and the puto cups is the tube-frame that holds each ends of the tubes so the tubes will stay in place as the mixture pours down the puto cups.

Figure 11. Tray-frame assembly

During the normal operation, from the reservoir to the pump, then to the tank, then to the piping and valves, the mixture will stay there as long as the operation is done. During the draining and cleaning stage the mixture will exit to the exit manifolds the exit valve as shown below.

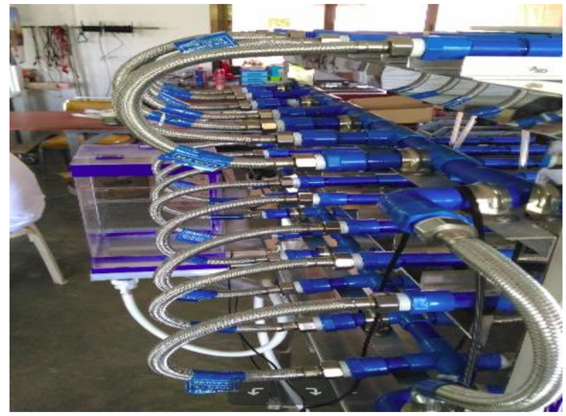

Figure 12. Exit-manifold Assembly

Figure 13. Control Panel

The hydra-electric solenoid valves are 12V 3 watts. They are being controlled by the Electronics Assembly composed of PLC, power supplies, terminal blocks, relays, connecting wires and push button assembly as shown below. Most of the electronics components are housed in the pannel box as shown below. The push button switch was temporarily removed from the outside mount due to students play with it.

ISSN 2599-462X(Print) *www.psurj.org/jetcs* ISSN 2599-4638 (Online)

Operation Procedure

The operation procedure is simple. First is to fill up the reservoir with enough puto solution mixture. It allocates at least 3-5 liters of solution in order to fill up the piping assembly to reach the 20psi pressure level.

Insert the tray underneath the tray frame and then press the green button on the push button assembly. The tray will be filled up within 1.2-1.5 seconds. Far better than the manual process of 10-15 minutes for 120 puto cups. If only there is an available 12V 60A power supply, we could trim down the 1.2-1.5 sec to 120 milliseconds only.

Prior to the normal operation, the equipment need to run an initialization/start up procedure. Upon filling up and reaching up of 20 psi of the tank, the first time you press the green button to disperse the mixture, the cups won't have equal amounts due to the air compressed inside the pipes. In between the fifth to seventh time, that we press the button, the dispersion of the solution is already almost equal to each other. Make sure to place a pan that will serve as drain pan for the tubes during the first five to seven cycles of operation. After the initialization phase, it will run on normally. The sample of the output is shown below.

Figure 16. Sample output of the Prototype

Drain Procedure

The drain procedure is simple. First is to drain the contents of the reservoir. When the reservoir is fully drain, return it to the its frame. Next is to place a container underneath the red ball valve, the drain valve simultaneously with the other drain valve located in the exit valves manifolds. Upon draining the red ball valve and drain valve, place a pan underneath the tray frame and press the green button several times similar to the initialization procedure to drain the once inside the hydra-electric solenoid valve. Replace close all the valves and then place a luke warm water if possible inside the reservoir that will serve as rinsing water to wash away the remained solution in the piping system. Turn on the machine and operate as if running a normal operation in order to fully wash and clean the hydra-electric solenoid valve. Repeat the process until the water flowing out the hydra-electric solenoid valves are clean.

Mixture. Temperature was one of the problems in testing. Since the materials used are primarily plastic based, the main problem is that the solution mixture smells like PVC when the testing is being done during day time. Thus we make the testing on the night time.

Hydra-electric solenoid valves. During the durability test, we encountered a major problem. We found some abnormalities on the valves itself. After the success of the calibrating the valves into appropriate timing to achieve the desired output, we conducted a durability test by means of operating the machine. After some time of running, at this test shows two valves indicating "too much". Too much means some valves dispensed too much mixture. Too much mixture due to despite the current has been discontinued, the valve is not thoroughly closed, and thus disbursing drops of mixture. Researchers were not yet alarmed.

We have presented and consulted the Mechanical Engineering Department on the issues concerning the valve and it was concluded that the main problem here was the valve itself. There is no other means on solving this problem other than replace the valve by more durable efficient valve. Unfortunately, this is one of the limitations of the project.

Other than that, we also observed that the valves have inconsistency on its output during day time. We are looking at the temperature variable since we observed that the output of the test is more consistent during night time compared to during day time.

VI. SUMMARY, CONCLUSION, AND RECOMMENDATION

Summary

1. From 10-15 minutes of pouring 120 puto cups, we reduced the time it will take down to 1.2-1.5 seconds only. If only there is a readily available 12V 60A power supply, we could reduce the pouring time down to 100-120 milliseconds only. Over all, the size of the machine is 160cm x 120cm x 160cm (l/w/h).

2. Due to budget reduction, some parts of the machine were replaced by nonfood grade components particularly the main component which is the hydra electric solenoid valve was replaced by the cheapest valve available. Pipes, fittings, tubes, and others were

ISSN 2599-462X(Print) *www.psurj.org/jetcs* ISSN 2599-4638 (Online)

replaced by plastic/pvc instead of stainless and food grade materials. Hence some of the components replaced we encountered some major variables to take into consideration:

- Valves are not durable and show malfunction after some time during the durability test.
- The mixture solution is acceptable when testing is done during night time but there is a presence of smell of pvc in the mixture when operating during day time.

3. Despite that some of the components were nonfood grade, the puto mixture was surprisingly edible and consumed by selected faculty, staff, students, of Pangasinan State University Urdaneta City Campus. Even the Campus Executive Director, Dean of College of Engineering and Architecture, and Dean of Computing Studies, and of course the researches, ate the puto mixture that came out from the prototype machine.

4. Fabrication of the tray became a problem for we don't have the capability to fabricate one and no one would like to fabricate a single tray and only accepts bulk orders.

Conclusion

1. The prototype was a success. It solved the problem by reducing the pouring process of 10-15 minutes down to 1.2-1.5 seconds only, and possibly 100-120 milliseconds if there is an available power supply. It also minimized the waste drastically.
2. The fabrication of tray caused too much delay. We need more equipment that could create the tray we need and we don't have that equipment nor the skill to fabricate such tray.

Recommendations

Here are the following recommendations for this design:

1. Replace the hydra-electric solenoid valves by a more durable and efficient valve.
2. Replace all PVC/plastic pipes and fitting by stainless steel type.
3. Redesign the puto-cups that have an overflow limit that will still give the desired amount even there is an overflow in the solenoid valve.
4. Look for a tray fabricator capable of fabricating the designed tray.

REFERENCES

[1] Ubina, Thomas., et., al. , Design and Development of Automated Hot Water Treatment Proposal, MMSU, 2008-2010

[2]https://www.labvolt.com/downloads/88270_f0.pdf

[3]https://c4b.gss.siemens.com/resources/images/articles/e20001-a1120-p271-x-7600.pdf

[4]http://www.maximintegrated.com/en/app-notes/index.mvp/id/4701

ISSN 2599-462X(Print) *www.psurj.org/jetcs* ISSN 2599-4638 (Online)