Improvement of automatic fish feeder machine design

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Abstract. Nation Plan of action for management of fishing is target to achieve an efficient, equitable and transparent management of fishing capacity in marine capture fisheries by 2018. However, several factors influence the fishery production and efficiency of marine system such as automatic fish feeder machine could be taken in consideration. Two latest fish feeder machines have been chosen as the reference for this study. Based on the observation, it has found that the both machine was made with heavy structure, low water and temperature resistance materials. This research’s objective is to develop the automatic feeder machine to increase the efficiency of fish feeding. The experiment has conducted to testing the new design of machine. The new machine with maximum storage of 5 kg and functioning with two DC motors. This machine able to distribute 500 grams of pellets within 90 seconds and longest distance of 4.7 meter. The higher speed could reduce time needed and increase the distance as well. The minimum speed range for both motor is 110 and 120 with same full speed range of 255.

1. Introduction
Sufficient proteins containing all essential amino acids, essential fats, vitamins and minerals which are very important to gain a healthy balance diet. Seafood such as fish can be considered a source of these nutrition. The State of World Fisheries and Aquaculture 2016 report that a significant growth in fisheries and aquaculture production in the past fifty years, has enhanced world’s capacity to consume diversified and nutritious food [1]. In Malaysia, aquaculture industry contributed 268,500 tan (about 16 percent) to the national seafood supply, valued at about RM1.3 billion. The Department of Fisheries Malaysia has established the National Plan of Action for the Management of Fishing Capacity in Malaysia (NPOA Fishing Capacity) which was published in 2008. The long term objective of the Nation Plan is to achieve an efficient, equitable and transparent management of fishing capacity in marine capture fisheries by 2018 [2]. However, there are several factors influence the fishery production and efficiency of marine system such as the tool and machine use in fisheries management. According to the World Fish Centre, the global fish production was increased to 160 million tan in order to satisfy the high demand and the demand has growth to 238 million tan. Fish farming is one of the marine sectors to overcome the deficiency of supply. First automatic fish feeder machine was designed under intellectual pattern by Anthony Christopher Halford in 15 April 1999. Then, it had been improved by Chang et al. in 2004 by installing with programmable logic controller.
Others than that, some of the fish feeder machine was designed with solar energy such as Koisan automatic solar powered fish feeder and FIAP solar feeder.

2. Background Study
Generally, there are two types of fish which are saltwater fish and freshwater fish. Others than fishing at the sea side, fish farming is very popular in Malaysia likes fish farming with cage system, pond system, integrated recycling systems and integrated recycling systems. Fish farming usually spending higher cost, time consuming, higher human capital needed and the limited fish production as the sizes of cage system. Machinery could be taken into consideration to improve the efficiency and reduce the requirement of human capital. The machine that innovated is purposely used for fish farming especially for fish farming with cage system. There were various type of fish feeder machine had been developed.

2.1 Functionality, advantage and disadvantages of current machines
Two latest machine has been chosen as the benchmark and reference for this research. Both of the machines as shown in Figure 1(b) and (c) had been located at the real marine agriculture site to testing the functionality and suitability of machine. The functionality, advantage and disadvantages of current machines are describes as follow;

2.1.1 Machine A
Figure 1(a) and (b) show the machine fish feeder machine with solar energy and the processes of functioning the solar energy fish feeder machine respectively. Initially, the solar panel with 30 watts is used to collect the solar energy from sun and monitor to recharge battery through solar manager. Battery works as the storage of solar energy. After that, the timer for open the gate and fish feeder schedule is setting in the system. Once the timing for fish feeding has reach, the system will automatically functioning the motor and blower to drop out the fish food.

2.1.2 Machine B
Figure 1(c) shows the automatic fish feeder machine with Programmable Logic Controller (PLC). This machine was setting to 24 hour timer with direct electricity supply. Initially, the switch plug need to plug on to supplied the electricity to the control panel of the machine. The machine was tested with various quantity of fish pellets with minimum 3kg to the maximum 6kg was chosen. The determination of quantity need to be set based on the requirement. The motors stopped operation after specific time period which setting in the system depends on the quantity of pellets. There were 90 s need for 3kg fish pellets, 120 s for 4kg, 150 s for 5kg and 180 s for 6kg.

![Figure 1. (a) Schematic diagram of process for solar energy fish feeder machine (b) Machine A with solar panel (c) Machine B with PIC controller](image)
2.1.3 Advantage and Disadvantages

In machine A, the storage container was broken and expansion of fish food blocked the distribution due to hot weather temperature. The heavy solar panel of Machine A was lack of flexibility as it require to adjust and fix with specific angle in order it able to receive the solar energy. Machine A was installed with wheel set to increase the portability, but wheel setting was not suitable for outdoor marine system. The materials used for making the machine was lack of water and temperature resistance that lead to rusting and broken of fish food storage container. The machine body was very heavy and hard to mobilize the machine. Besides that, the fish food was expand due to hot weather and blocking the distribution pipe which only able to have one-point distribution.

Machine B was lack of portability with heavy machine body and height of machine was inconvenient for farmer to refill the fish pellets to the storage as well. For this, there is a need for improvement of machine design and materials of automatic fish feeder machine to have light weight, high water and temperature resistance and low cost. Based on the machine, the machine with direct electricity supply to the control panel make the machine inconvenient to use for outdoor fish farming activities. Besides that, the materials used also lack of water resistance with heavy components. But, the machine has better food distribution that multi-point and long distance location. The quantity of fish pellets was flexible and controllable as well. As overall observation, the solar energy and wireless battery supply make the machine convenient and suitable for outdoor activities of fish farming rather than indoor fish farming in tanks. However, there are much more issues needs to take in consideration such as temperature resistance when running outdoor fish farming activities. Overall, the existing machines has located and tested at the marine agriculture site. Based on the observation to the existing fish feeder machine, it has found that the machine A and B was made in heavy structure, low water and temperature resistance materials and non-uniform distribution of fish food. The listed advantages and disadvantages has shown in Table 1.

Table 1. Advantages and disadvantages of Machine A and B

| Machine A | Machine B |
|-----------|-----------|
| Advantages: | Disadvantages: |
| • Far location food distribution | • Fish food blocking at the distributor |
| • Controllable the portion of food | • Low temperature resistance |
| Disadvantages: | One-point distribution |
| • Heavy body component | • Low water resistance |
| • Low water resistance | • Heavy body component |
| • Wiring battery supply | • Wireless |

3. Methodology

3.1 Design Procedure

Design procedure of fish feeder machine include several steps to be carried out as shown in Figure 2. Brainstorming requires five main characteristics on the new machine, such as lightweight, good water and temperature resistant, weight resistant and low cost as well. After brainstorming, the new design of machine has sketching out especially the interior design of machine. Materials selection and cost analysis is related with each another. The chosen materials must be aligned with the desire characteristics of machine. Cost analysis has been study on every single materials before fabrication. One the fabrication is done, the characteristic and some functionality of machine is tested. The data and results is recorded and analyzed as well. Finally, the last step is recommendation and conclusion of the research.

Figure 2. Design Procedure
3.2 Functionality experiment procedure
Four experiments have been conducted to test the ability of new automatic machine. These include storage, food drop time, speed range and distance of food dispersed.

3.2.1 Storage - The minimum speed rate for DC motor at upper part is 110 with 255 full speed. The motor will not function when the speed is setting under 110. At the same time, the gravity of machine also take in consideration when it fill with full tank of pellets.

3.2.2 Time needed for food drop -This experiment will started with lowest speed range. Then, recording the time taken until the food has drop all completely of the quantity pellets. The experiment is repeated with different speed rate.

3.2.3 Ability for food dispense - The time setting for both motor is based on the ratio 1:1.5 which 1 for motor 1 and 1.5 for motor 2. This experiment is testing with full storage tank of pellets. After setting all these, the motor was switched on and it will stop based on the time period that has been set. Then, measure the weight of pellets that has spread out from the PVC sockets. The experiment is repeated with different time period.

3.2.4 Distance of food dispersed - This experiment will started with lowest speed range of lower part motor. The motor will stop based on the time has set. Lastly, researcher need to choose three distance point of pellets spread out (most far, median and nearest) and measure the distance. This experiment is repeated with different speed range of lower part of motor.

4. Results and Discussion

4.1 Design improvement
Based on the Table 2, there are the solutions to eliminate the limitation of current machine. The PVC is chosen as it is lightweight, good in water and temperature resistance. Besides, PVC is low cost materials.

| Limitation                                      | Improvement                                      | Potential Solution |
|------------------------------------------------|--------------------------------------------------|--------------------|
| Low temperature resistance                     | Using high temperature resistance materials      | PVC pipe           |
| Low water resistance                           | Used high water resistance materials              | PVC pipe           |
| heavy body component                           | Used light materials                              | PVC pipe           |
| Fish food expand due to hot weather and blocking the distributor | Using high temperature resistance materials      | PVC pipe           |
| One-point distribution                         | Design more distribution with strong momentum motor to spread food | Four distribution with high speed motor |
| Lack of flexibility                            | Modify to be flexible                             | Use PVC pipe       |
| High fabrication cost                          | Used low cost materials                           | Used rubber or PVC |

The new machine made by PVC pipes and PVC socket which assistant to easily wash. The interior distribution divider also make with PE rubber which is good in water resistance. Besides that, new machine also design with four distributions rather than one-point distribution. The sketching of machine as shown in Figure 3. As it can be seen that the funnel is located inside the container and composite panel is used to modify the funnel in order to fit properly with the container. The machine has two parts, one for food dispenser and the other part for distributor. The rotating blade plate will turn and pushing the fish food out from the PVC socket.
The funnel is located at the upper part of the machine with the food drop which locates a dispenser. A DC metal gear motor is installed at the side of the rubber container. The motor installed out of rubber container for maintenance purposes. The dispenser is placed together with the funnel and PVC which under the funnel. After that, the largest PVC pipe will be connected together with the rubber container. For the lower part of the machine, the distribution divider was placed at the bottom part of the PVC socket to ensure the food distribute into four points. Part A is a storage space for fish pellet and part B is the food space before fish food has drop out from the food gate as shown in Figure 4. The funnel has made specially to lead down the food to the food gate. The container is connected with the PVC pipe and dispenser at the lower part. The DC metal gear motor is installed at the side of rubber container. The dispenser will rotate and drop down the food. Meanwhile, the part C is the distribution space that food pellet will spread out. The part D is the PVC pipe which play a role as the stand of the machine and locates the DC geared motor with U support clip.

![Figure 3. The sketch of current machine](image)

![Figure 4. Current machine design](image)
4.2 Experiment Result

4.2.1 Storage
Based on the experiment, the rubber container able to fill 5 kilograms of fish pellets. This quantity is the maximum amount for the container. The DC motor 1 and gravity of machine has been tested with the full tank quantity. The DC motor which using for upper part is DC metal gear motor with 15 RPM and 15 kg/cm torque. This motor able to functions when the storage is full of tank. Besides that, the RPM of motor is quite low but it has perfect match with time and speed of DC motor of lower part. The heavy storage of pellets or full tank of pellets not effect on the functionality of the machine.

4.2.2 Time needed for food drop
The experiment has been done to study the time needed with various speed rate of DC geared motor. The quantity amount of 600 grams of fish pellets has chosen to use for the experiment. Based on the results from Figure 5, 54.7s was required to drop out all 600g pellets with minimum speed rate. This motor was unable to function if it setting under 110 of rpm. As the speed increase, the time need is shorter. The shortest time is 25.14s with the speed 250 rpm. However, the full speed of motor is 255 was used. The differences shows the time reduce is inconsistent.

4.2.3 Ability for food dispense
The experiment was proceed to test the ability of DC motor to distribute food at one time. Based on the results in Figure 6, there was 583g of fish pellets could spread out in 90s of DC motor and 60s of DC geared motor. According to the previous study, the Patin fish feeding schedule was twice a day and 500 grams for once time of feeding. For this, this machine could be very effective as it able to distribute more than 500 grams of pellets. DC geared was able to drop out 500 grams of food within one minute with lowest speed rate. For this, the motor is setting at 110 rpm for upper part and 255 rpm for lower part.

4.2.4 Distance of food dispense
Another experiment was run to study the distance of food distribution. For this, the speed rate of upper part motor and quantity of food is fix. The time was setting around 5 seconds for upper motor and 8 seconds for lower motor. From Figure 7, the shortest distance is 0.12 meter, 1.09 m and 2.16 m with 150 rpm. The speed rate of 200 could distribute the pellets to 0.20 m, 2.26 m and 3.47 m. lastly, the speed rate 250 is able to distribute the pellets to distance 0.18 m, 2.28 m and 4.7 m. The full speed of motor at lower part is 255, the distance for distribution could be higher than 4.7 m when it function with full speed.
5. Conclusion
This research was conducted to study and improve the current automatic fish feeder machine with better materials and low cost. The materials selected must be good in water and temperature resistance. Besides that, the machine should design with smaller physical body to make it portable for outdoor fish farming. However, this machine storage is smaller than the previous machine as to make it portable. Based on the results and new design of this machine, most part of this machine is fabricated by using PVC rubber and PVC pipe. PVC rubber is very good in temperature and water resistance with low cost as well. There were two DC motors used to functioning the machine. The functionality of food drop from food gate is faster than the food distribution at the lower PVC part. Matching the time period to match both motors is very important. Besides that, the maximum quantity for lower part PVC pipe is 500 grams. The food should not drop more than 500 grams as the quantity will effect to the functionality of food distribution. For complete cycle of distributions, the speed range of DC motor at upper part is 110rpm and 255rpm for motor at lower part. The machine could distribute 500 grams of fish pellets within 90s.

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