Pertanika J. Sci. & Technol. **18 (1)**: 105 – 110 (2010)
ISSN: 0128-7680

Development of Automatic Feeding Machine for Aquaculture Industry

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ABSTRACT

Aquaculture is a growing industry with a great potential towards the contribution of the country's total fish requirement. Serious efforts have been done to develop and improve the production of fish by rearing high value fish in tanks or ponds. Under the Third National Agricultural Policy (1998-2010), the target is to annually produce 1.93 million tonnes of fish worth approximately RM8.3 billion by the year 2010. Consequently, the development of an automatic fish feeding machine can be very beneficial to the growth of the aquaculture industry. This device was developed to overcome labour problems in the industry and introduce a semi-automatic process in the aquaculture industry. It has the ability to dispense dried fish food in various forms such as pellets, sticks, tablets or granules into fish tanks or ponds in a controlled manner for a stipulated time. The automatic fish feeder is controlled by a digital timer and it is capable of feeding the fish in accordance with a pre-determined time schedule without the presence of an operator, and at a feeding rate of 250g/min. The feeder can be adjusted to the desired height and conveniently moved around to be positioned adjacent to the pond or tank. Meanwhile, its hopper can be covered and easily dissembled to change the size of the hopper to accommodate different capacities of feed. This automatic fish feeder can be implemented in aquaculture system to convenience to fish culturists.

Keywords: Automatic fish feeder, aquaculture

INTRODUCTION

Asia dominates the aquaculture production, contributing around 91% of the world's total by volume and 82% by value. Asian countries, such as Thailand, have been the top ten aquaculture producers in the world. The region has the highest variety of cultured species. Asia has also been the highest seafood-consuming region of the world, accounting for two-third of the world's food fish supply, the increase of which mainly came from aquaculture in recent years (Liao, 2001).

The fisheries sector in Malaysia has provided direct employment to 89,453 fishermen and 21,507 fish culturists. The consumption of fish in Malaysia is expected to increase by 14% by 2010 and currently, the country is producing 89% of the fish supply for its own consumption. With the marine harvest almost stagnating, the industry is dependent on the aquaculture to cater for the growing demand. Currently, the aquaculture industry contributes to about 13.2% of the total fish produced. Malaysia has the potential to become a major player in the aquaculture industry in Asia Pacific, if more companies enter the sector (Subasinghe, 2007; Alongi *et al*., 2003).

The importance of aquaculture in the overall fish supply is growing. In the future, aquaculture production is expected to overtake capture production of food supply. The growth in aquaculture for high value species has an important impact on international fish trade. In recent years, tilapia and catfish have also entered international trade successfully. The unit values of tilapia and catfish were surprisingly strong and have shown an increasing trend (Helga, 2006).

Received: 21 July 2008
Accepted: 10 July 2009
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TABLE 1
Feeding frequency for various sizes of tilapia at 28°C (National Research Council, Washington, 1993)

Size of fish (grams)	Times fed dairy
0-1	8
1-5	6
5-20	4
20-100	3-4
>100	3

Tilapia is the second most important cultured food fish in the world after carp. Tilapias are also among the easiest and most profitable fish to farm. This is due to their omnivorous diet, mode of reproduction, strong resistance to diseases and rapid growth (Rafeal, 2007). They grow best when fed 2-3 times per day although adequate growth can be obtained with a single daily feeding (Williams, 2000). Catfish has also become an important and popular food traded globally, with a great potential to feed the world and contribute significantly to the economies of the developing countries (Subasinghe, 2007).

Feeding fish is labour-intensive and also expensive. Feeding frequency is dependent on labour availability, farm size, as well as fish species and sizes. Large catfish farms with several ponds can usually be fed only once per day because of time and labour limitations, while this may be done twice per day at smaller farms. Generally, growth and feed conversion increases with feeding frequency. In the intensive fish culture systems, fish may be fed as many as five times a day in order to maximize growth at optimum temperatures. Table 1 shows the feeding frequency for Tilapia of different sizes.

The feeding rate also varies depending upon the size and temperature of temperature. The feeding rate can be set on the basis of a percentage of the total body weight of fish being fed and adjusted for the size and total number of fish, and water temperature (Beem and Gebhart, 2000).

Feeding rates also vary with fish size and water temperature. Appropriate amount is measured as a percent of the average body weight. As the weight of fish increases, the percentage for body weight fed decreases. Fish are fed at 2–3 hour interval, and they eat more feed than their stomachs can hold. The extra feed eaten passes over the stomach and is considered wasted. The result is an increased cost of production and lower profits. Fish fed at 4–5 hour interval eat nearly the same amount of feed needed to refill their stomachs. This suggests that the optimal interval between feedings is around 4–5 hours, depending on the energy and composition of the diet (Riche and Garling, 2003).

Cultivating fish in tanks and ponds is quite common in Malaysia. One way of ensuring a continuous availability and success of rearing fish in tanks is through the implementation of the new technology. The objective of this study is to provide a fish feeding machine with a simplified means of regulating a specific amount of fish pellets during each dispensing operation. Automatic and demand feeders save time, labour and money, but at the expense of the vigilance that comes with hand feeding (Craig and Helfrich, 2002).

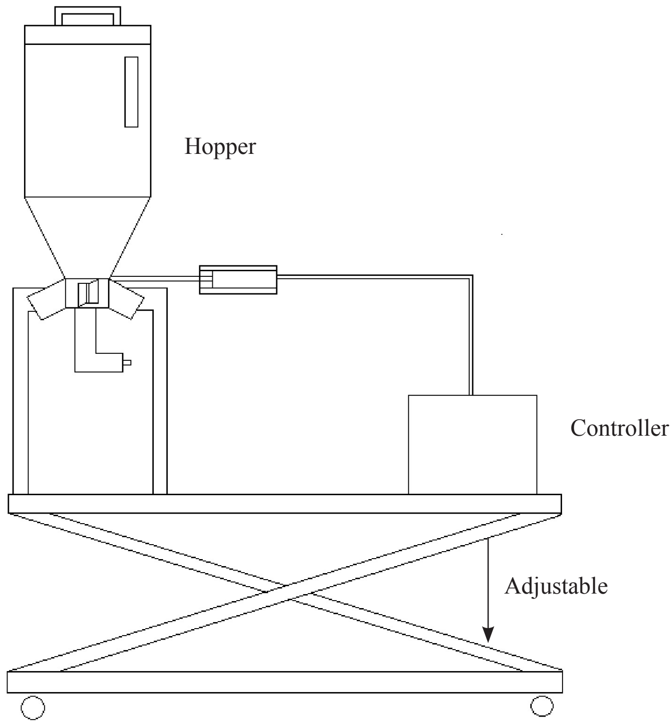

Fig. 1: Automatic fish feeder

There are several automatic feeders which have been developed to fulfil certain objectives and requirements (Chang *et al*., 2005; Velazquez and Martinez, 2005). This automatic fish feeder was developed to fulfil certain objectives and requirements with added advantages such as a detachable hopper to accommodate various sizes of hopper according to user's requirement. It was also designed to have adjustable height, speed, and opening angle to accommodate different sizes of fish tanks and ponds, as well as provide a mobile fish feeder with pneumatic system for safety reasons. These features make it suitable to be specifically used for culturing tilapia and catfish.

METHODOLOGY

In designing the feeder, several criteria need to be determined; these include the characteristics of the fish, types and sizes of fish feed, and functions of the feeder. For this purpose, data and information have been collected to gain a baseline for the design. Factors or problems influencing the process have also been considered to ensure the efficiency of the machine. The device should be simple, compact, and efficient in operation. Complete drawings were then prepared using the Autodesk Inventor 2008 software. This was followed by the fabrication of the fish feeder. Upon completion of the fabrication, the machine had to undergo several tests to evaluate its performance.

Design of the Machine

Fig. 1 illustrates the automatic fish feeder machine. The dimensions of this machine are 0.8m (length) x 0.5m (width) x 1.6m (height). In general, the machine consists of a few components such as hopper, lift, compressor, propeller, dosing valve, and process control panel.

The design of the hopper will affect the rate and type of particle flows in the hopper. The properties taken into consideration when designing the hopper include the effective angle of internal friction, the material flow function, and the angle of the wall friction between the particles and the wall particles. Mass flow of solids in the hopper, which was chosen as the motion of dry fish food, is uniformed and in a steady state whenever any of it is drawn from the outlet. This part is the most critical part of the design, where detailed calculations were made to determine the size, angle, and the opening of the orifice. The hopper was designed based on the average bulk density for the different sizes of feed pellets. Using the Jenike Shear Tester, semi-included angle and minimum outlet dimension could therefore be obtained.

The scissor lift can be adjusted to the desired height with the minimum height of 30 cm and the maximum height of 90 cm. The height is easily adjusted to accommodate the different tank heights. The wheels of the scissor lift can be locked for stationary position. The air operated pellet propeller system is operating within 0-5 bar. The maximum rotation speed is 1000 rpm, and this can be adjusted at solenoid operated ball valve. The propeller consists of 6 vanes which are thin, rigid with flat surfaces that are readily mounted along an axis.

The operating pressure for this valve is 4 bars. The stroke for this valve is 5 cm and it is made from stainless steel to prevent food contamination. This dosing valve is reliable and easy to clean. The thickness of this valve is only 0.2 cm, and this is to avoid any damage to the pellets. This dosing valve is operated using air supply from an air compressor connected to the pneumatic cylinder. The operation of the feeder is controlled by a control panel which is connected to the pneumatic cylinder and solenoid operated ball valve. The process control panel includes a cycle timer, dispensing timer, main buttons, as well as auto start and manual start buttons. The cycle and dispensing timer can be set either in seconds, minute or hour. Moreover, it can be adjusted according to the desired interval between the feedings and the required amounts of the food.

PERFORMANCE EVALUATION

A trial run on the automatic fish feeder was conducted to determine the distance of the fish pellets being dispensed. Two types of pellets were used. The density for the large pellet used is 0.344 g/cm^3, whereas the density for the smaller pellet is 0.386 g/cm^3.

Ten kg of small and large pellets were used in testing the feeder. For the same purpose, different speeds of the propeller, height positions of the hopper and angles of the opening were also used. The speed of the propeller was adjusted at 1000 rpm, 900 rpm and 800 rpm. The height position of the hopper was set at 80 cm, 100 cm, 120 cm and 140 cm, while the angle of the opening was 0°, 30° and 60°. The minimum and maximum distances of the pellets dispense were recorded.

Figs. 2 and *3* show the distance of the small and large pellets, dispensed at different height positions and different angle opening of the hopper at 1000 rpm. The results obtained from different operating speeds (800 and 900 rpm) corroborate the findings and they are therefore not shown here. From the graphs, it can be observed that when the hopper is fixed at a higher position, the pellets will be dispensed much further. Meanwhile, the opening angle of the hopper was found to have a minimal effect on the distance of pellets being dispensed.

The dispensing widths versus height of hopper for small and large pellets at 1000 rpm are shown in *Figs. 4* and *5*, respectively. When the position of the hopper is raised, the width of the small and large pellets being dispensed will also increase. Moreover, the opening angles of the hopper have some effects on the distribution of the pellets. As the opening angle is increased from 0° to 30°, the dispensing width also increases at an average of only 20%, but the increment is more significant when the opening is at 60°, where the pellets are dispensed up to 80% further.

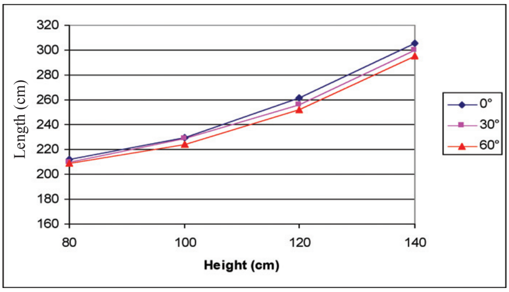

Fig. 2: Dispensing length versus height of the hopper for small pellets at 1000 rpm

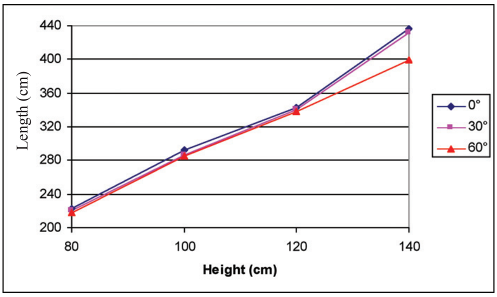

Fig. 3: Dispensing length versus height of the hopper for large pellets at 1000 rpm

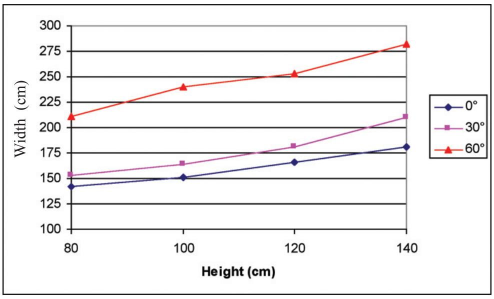

Fig. 4: Dispensing widths versus height of the hopper for small pellets at 1000 rpm

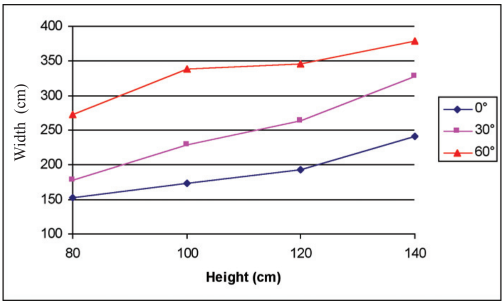

Fig. 5: Dispensing widths versus height of the hopper for large pellets at 1000 rpm

Several tests were also conducted to determine the total amount of fish pellets being dispensed at different intervals. For this purpose, different amounts of fish pellets (10 kg, 5 kg, and 2 kg) were separately put in the hopper. The dispensing rate for the small pellets is around 300 g/s and this is 200 g/s for the large pellets. Thus, the dispensing rate can be assumed constant at all times. An analysis of the moisture content in the hopper was also conducted. The automatic fish feeder was exposed to the sun and rain. In fact, the moisture content of the pellets was tested every day for two weeks. The test revealed that the moisture content of the pellets had remained constant, indicating that the feeder is moisture resistant.

CONCLUSION

An automatic fish feeding machine for aquaculture industry in Malaysia was developed in this study. It is a simple and yet reliable, feasible, and quite efficient feeding machine. The automatic fish feeder was constructed using stainless steel grade 304 to avoid contamination. It is controlled by a digital timer which allows the owner to adjust the cycle time and dispensing time as and when required. More importantly, the timing can be programmed to ensure that the feeding schedule is consistent. The feeding mechanism is easily and widely adjustable. Among other, the height of the feeder is adjustable to accommodate different heights of tanks used in the industry. Furthermore, the hopper size can be changed to accommodate different capacity of feed. Moreover, the opening angle can also be adjusted to suit the different sizes of tanks or ponds. The feeder is air operated and it is connected to the controller using air pipe. This way, the control panel can be allocated in a safe place near the power supply and the feeder can be located at any place near the tank.

ACKNOWLEDGEMENT

The authors would like to acknowledge Universiti Putra Malaysia (UPM) for the financial support given.

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