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Optimization measurements on feeding machines with automated control system for aquaculture

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Abstract. This paper discusses about the measurement of optimization on feeder machine with automatic system control for aquaculture. This paper mainly aims to observe four main parts of feeding machine of aquaculture: major inlet, scale system, spiral tunnel, and throwing system. The observation done includes the energy of electricity usage of each unit of feeding weight which is processed, duration of process of each part, the exchange of rotor speeds, and the flow of feeding speed rate in gram per second. In this research, the design of feeding machine with automatic system based on Arduino Uno is conveyed. The feeds size used in this research are 2mm and 4mm. The measurement of optimization aims to consider the weight of the feeds, and the system of machine that works optimally. The result from the experiment releases that the machine designed is able to work optimally on 2kg feeds of each process by 70 seconds and 71 seconds, and 0.085Wh on energy of electricity usage.

1. Introduction

Time accuracy, quantity and quality of the fish feeds are the main key of successful aquaculture industry, especially in the large scale. The implementation of technology in the system of feeding is the appropriate solution since the establishment of public opinion that the involvement of technology improves the industrial productivity, especially in the large scale of aquaculture industry. Automatic system designed for feeding machine that can be programmed becomes an interesting case to be discussed, because the feeder machine produces more feeds from manual techniques [1].

Feeder machine developed by H. Wei (2017) provides a good technique on feeder system [2]. However, the weakness is that the machine should be placed above the fishpond. This affects to the container to get the steam from the fishpond evaporation directly and then create the feeds becomes humid. In this paper, we purpose the technique of making feeder machine that can be placed on the edge of the fishpond to avoid the humidity of the feeds. This is different from what have been done by Wei (2017), Atoum et al (2015) and Nirwan et al (2017) [2-4]. The proposed machine consists of several types of conveyer to flow the feeds from the container to the throwing system.

Besides the quality of feeds, a feeding method affects the fish growth in the pond [5], therefore, several studies discussing automatic technology-based fish feeding technique have been introduced by several researchers [2-4, 6-8]. However, conventional feeding-based techniques, namely integration of sheep stall also becomes a concern for fish farming [9], because it provides multiple benefits.

Arduino Uno is a control board and feasible to be implemented on an industrial scale, such as the main control board on the needs of wireless communication [10], Smart and Intelligent System [11], [12] as well as on pond fish feeder machine. The design of the feeding machine based on Arduino Uno had ever been purposed by M. Endebu (2016) where the technique offered is very simple for a small scale [4]. Feeding technique with an intelligent based control approach could decrease human labor costs [13]. The technique of throwing the feeds into fishpond is also purposed [2]. The need of power supplier for automatic feeder machine is also produced from solar panels [7].

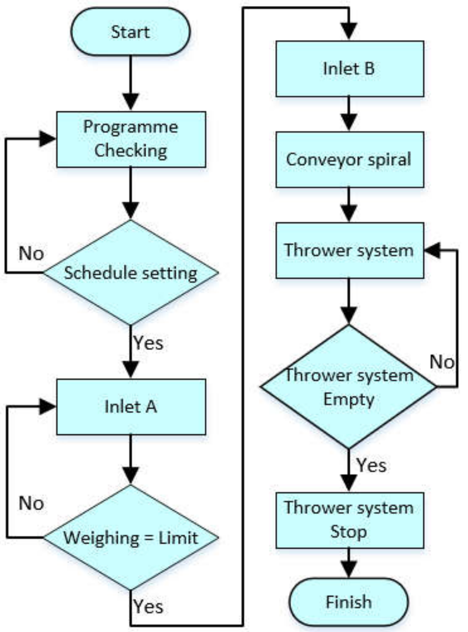
In addition to automatic based feeding technique, visual approach using camera to detect the activities of fish in the pond which can then determine the amount of the feeds given [3] becomes a new technique in aquaculture. However, there are still barriers to perfect the proposed system [3]. The main objective of this paper provides the design of automatic feeder machine, and also the measurement of electricity usage on several parts of prototype designed. There are four main parts that will be observed: main inlet (Inlet A), the system scale (Inlet B), spiral tunnel (conveyer spiral) and the throwing system. The development included information of the electrical energy consume when the system was working, the duration of each process, the changes of speed rate of the motor or conveyer, and the feed flow rate flow in grams per second of each part observed.

2. Result and Discussion

2.1. Design

The automatic fish feeding system consists of six main parts: controller module, container, cylinder conveyer, the system of feeds weight validation, spiral conveyer, and throwing system. Figure 1 is the process of feeding machine purposed. It is assumed that the container is full, means that the feeds in the container is not empty, the process of system begins from the main inlet (inlet A) open or spin the conveyer, with conveyer diameter 4.5 inch and 6 parts. It is expected that the feeds would be assisted by gravity. Based on the figure 1, the conveyer of inlet A would always spin until the weight of the target attained, so that the conveyer of inlet A would stop and open the conveyer of B and also spiral conveyer. After the feeds reaches the end of spiral, then it will pass the throwing system, the feeds would be flown into the fishpond by the system of throwing.

Container is the place for feeds supply (figure 2). It is placed on the top and it should be in dry condition. The technique of keeping the container humidity is not discussed in this paper. In the main inlet (inlet A), there is a cylinder which is placed under feeds container (figure 2). The function of this main inlet is to move the feeds from the container into the scale system. The main inlet consists of cylinder conveyer (start fruit) with six parts (figure 3) and an external DC motor drive. The scale is the validator of expected feeds weight based on the instruction of controller board (figure 4). This system consists of three strong sensors and two parts of cylinder conveyer. The activator of conveyer uses DC motor with 12V. Strong sensors (figure 2) are as trigger to stop the conveyer from the main inlet and activate spiral conveyer.



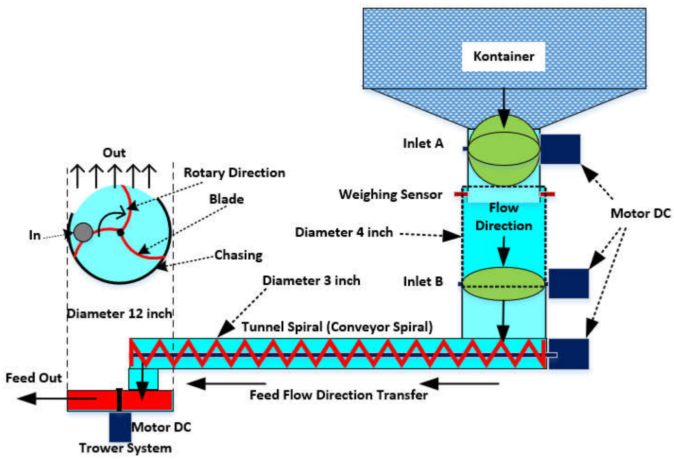


Figure 1. Workflow process of automatic feeder machine.

Figure 2. Design of automated feed control with rotary drive system.

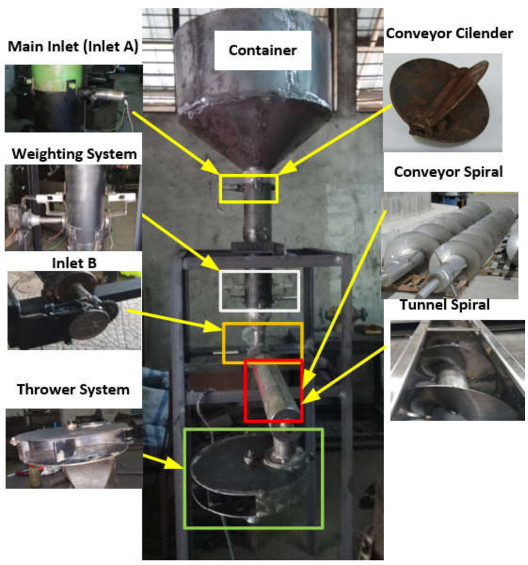


Figure 3. Automated feed control with rotary drive for large scale fish farms.

The spiral conveyer equipped by spiral conveyer serves to move the weighing system to throwing system. The length of the spiral tunnel is 70 cm. This spiral conveyer is activated by DC motor with 12V. This system functions to throw the feeds into the fishpond. This throwing system let the feeder machine to be placed on the edge of the fishpond. This throwing system is designed to spread out the feeds into fishpond. This system is activated by DC motor.

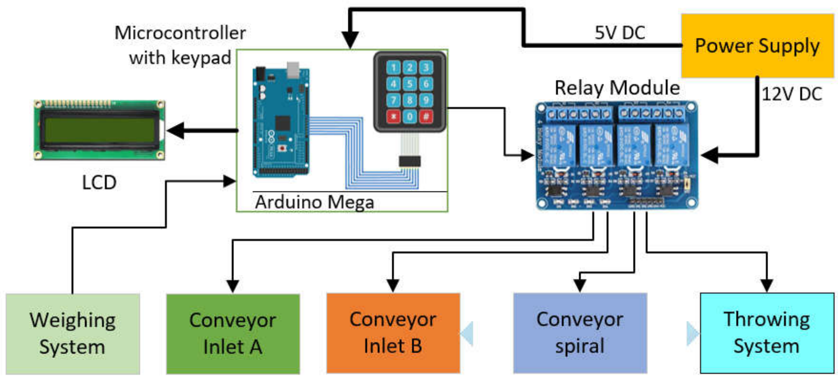
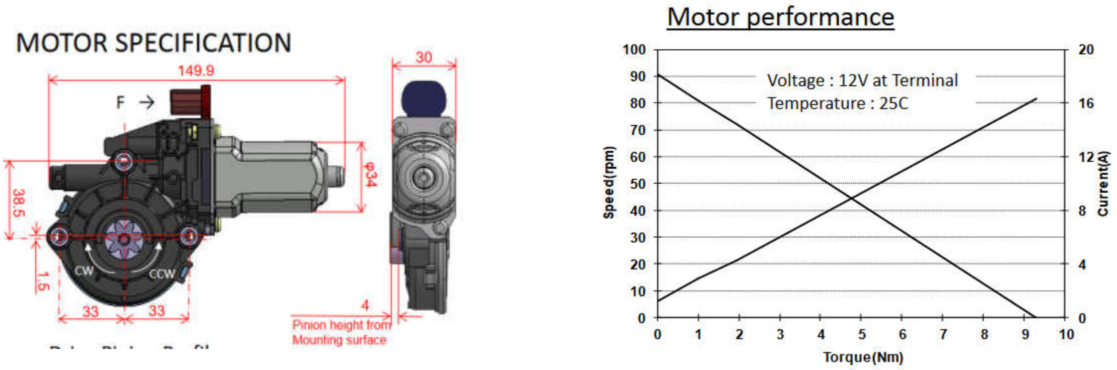


Figure 4. System architecture control.

Figure 4 shows the proposed automatic based feeder machine control architecture. Using Arduion Uno, as the main controller to handle four main parts of machine as output, which are inlet A, inlet B, spiral conveyer, and thrower system, LCD and keypad are used as input tool of feeding schedule program. The activator of those main parts uses DC motor induction with specification as shown in figure 5.



(a) (b)

Figure 5. The characteristic of DC motor rotary driver (a) motor specification; (b) motor performance.

2.2. Testing

The experiment is conducted with the feeds in 2mm and 4mm. Separately, the feeds with different sizes are put into the container and then left them through the cylinder conveyer at inlet A, and measure duration of the process, the energy usage, the changes of conveyer rotation speed, and the changes of feeds flowing in the conveyer in which 0.5kg feeds until 5 kg feeds with multiple 0.5 kg in each experiment. Each addition of 0.5 kg is tested three times. The measurement of duration process uses stopwatch. Meanwhile, the measurement of electricity energy usage uses Kyoritsu Kew 6315, and the changes of conveyer rotation speed uses tachometer.

There is no test on inlet B, because it only validates the weight of feeds that would be verified by the program. As a result, the energy usage of conveyer on inlet B could be ignored. On the other side, throwing system is activated by DC motor with a long process duration, so that it requires measurement of energy usage and the duration of the process that occurs on each unit.

2.3. Measurement result

From the result of experiment, it is obtained the measurement of duration and the energy usage in every multiple 0.5kg feeds. Duration of the process has character of energy usage which tends improved linearly based on the weight of feeds processed, but it is shown that in 2mm feeds and 4mm,

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the energy usage and the duration process increases drastically on the feeds weight greater than 2kg (figure 6).

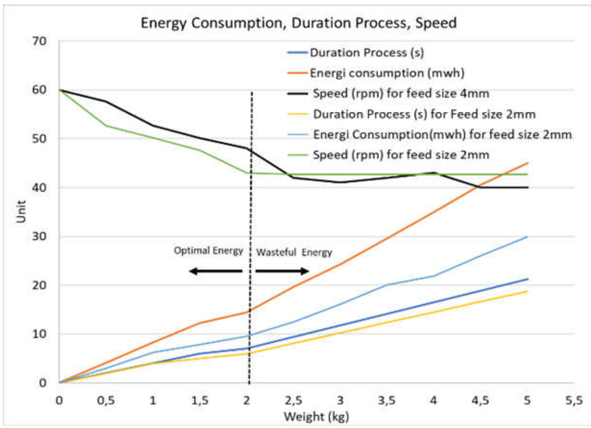

Figure 6. The result of duration process measurement and the change of energy in 2mm feeds.

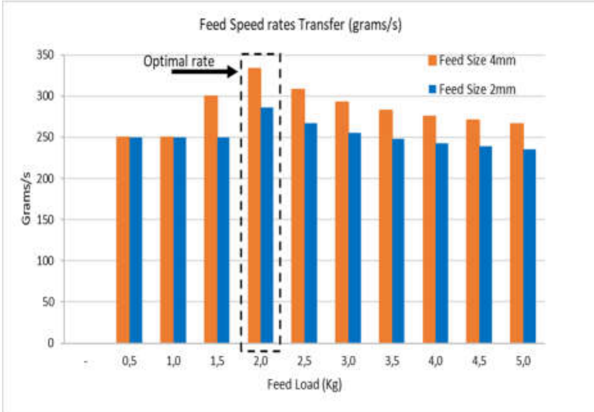

Figure 7. Feed Speed Transfer Rate in main inlet (inlet A) with feed size of 2mm and 4mm.

The size of the feeds also influences the energy of electricity usage. Figure 6 showed that 2mm feeds with weight 2kg consumes energy of electricity 0.0096Wh and 6 seconds in the duration of process. On the other side, 4mm feeds with weight 2kg consumes energy of electricity 0.014Wh and 7 seconds in the duration of process. The amount of the energy usage of 2kg or more feeds, then there will be an increase of electrical energy usage significantly, both for 2mm and 4mm. As a result, it can be concluded that the amount of inlet A is maximum of 2kg.

Figure 7 shows the result of feeds rate experiment in the conveyer of main inlet (inlet A). In 2mm feeds with 0.5kg to 5kg, it is obtained the exchange of feeds speed rate. The highest feed transfer rate is obtained at a load of 2kg which applies to feed sizes of 2mm and 4mm. Thus, it can be concluded that the optimal feed rate is at 2kg feed weight.

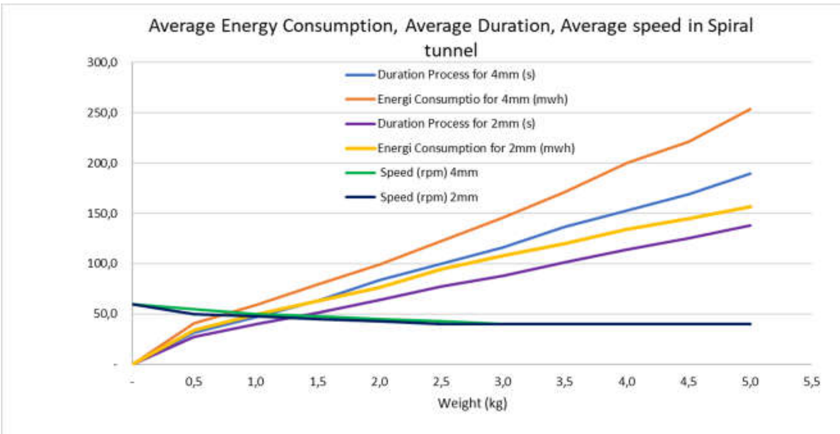

Figure **8.** The result of process duration measurement and changes of energy of 2mm feeds and 4mm on spiral tunnel

Figure 8 shows the result of measurement of electrical energy usage and duration of the processing time for each 0.5kg increase in spiral tunnel. Based on the result of measurement, it is known that the more size of feeds, the more the energy usage needed will be. For 2mm feeds with 2kg needs 64 seconds duration of process with the energy usage 0.0762Wh. On the other side, for 4mm with 2kg

needs 84 seconds duration of process with the energy 0.0994Wh. The speed of rotation is also reduced as the weight of feeds in the spiral tunnel.
Based on the exchanges of speed rate on the conveyer of figure 8, 2kg feeds with 45rpm speed rate of rotation is assumed to be accepted from 60rpm rotation with no burden. It means that by the regulation of 25% is still considered workable. The amount of lower rpm (less than 40rpm) would cause excessive heat on the motor and impact on reducing the life time of motor.

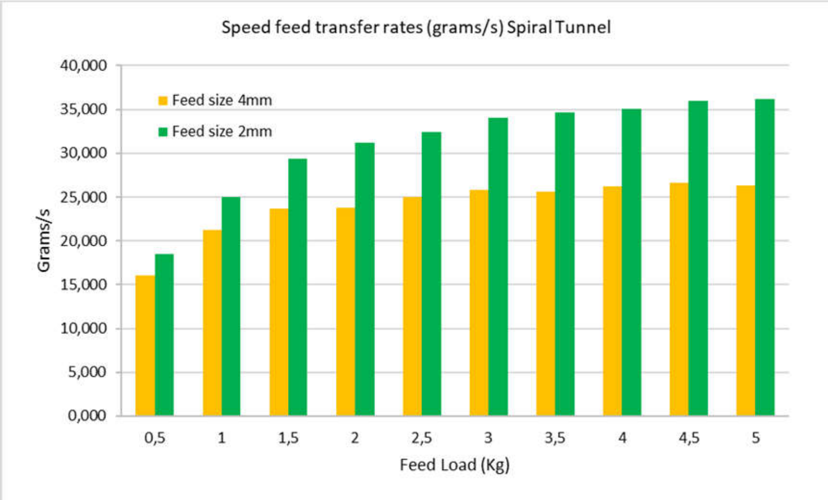

Figure 9. Feed Speed Transfer Rate in Spiral Tunnel with feed size of 2mm and 4mm.

Figure 9 shows the result of the experiment on feeding speed rate of spiral conveyer (spiral tunnel). At a feed size of 2mm feeds with a feed load ranging from 0.5kg to 5kg, it is obtained the change of the amount of feed rate against the time. The more feeds, the more speed rate of feeding in grams per second will be. However, there is stability on the feeds more than 3.5kg, there is 25 grams/s for 4mm feeds. On the other side in 4.5kg or more, there is 36 grams/s for 2mm feeds size.

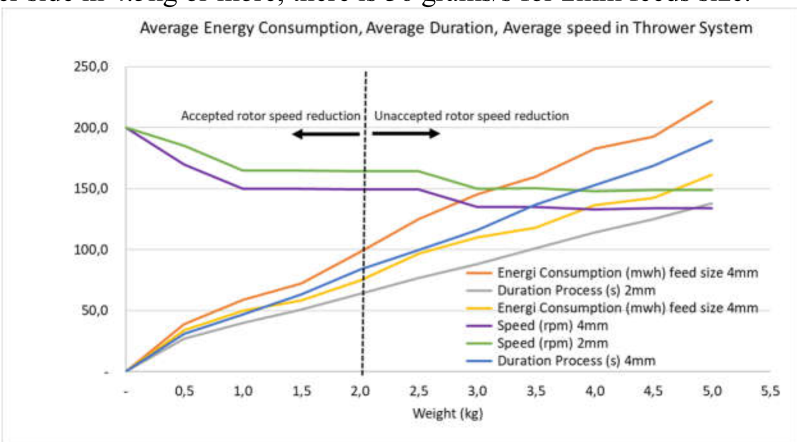

Figure **10.** The result of process duration and energy usage on the system of throwing in 2mm and 4mm.

Figure 10 shows the exchanges on the energy usage, duration of the process, and speed rate rotation of feed load given. At a maximum of 2kg feeds with 2mm, the energy usage is 74.8mWh and duration of the process is 64 seconds. While at a feed size of 4mm, the energy usage is 98.2mWh with 84 seconds of duration of process.

Throwing system has rotor speed rate on 2000rpm with no burden, while a 2kg load with 2mm feed size, the speed rate of rotation of rotor decreases to 1645rpm, meaning it decreases 11% at 4mm feeds, the decrease of speed rotor 25% or 1297rpm. This condition in 2mm and 4mm with maximum 2kg feeds is still accepted. Feeding loads above 2kg would affect to the decrease of rotor of throwing system significantly. This condition is unacceptable.

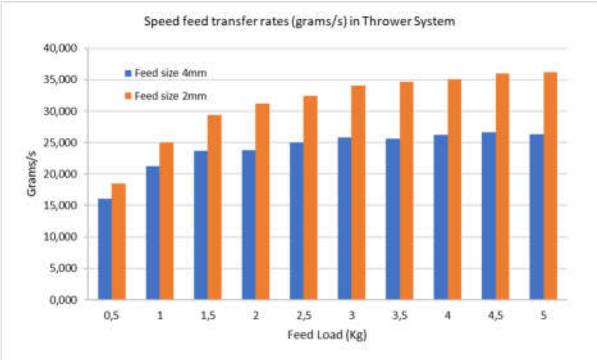

Figure 11. Feed speed transfer rate in thrower system with feed size of 2mm and 4mm.

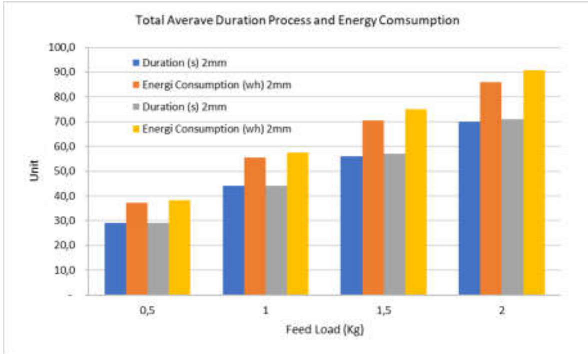

Figure 12. The electricity energy usage in total, duration of the process in 2mm and 4mm feeds

Figure 11 shows the result of experiment on feeds speed rate in throwing system. At a feed size of 2mm with a feed load ranging from 0.5kg to 5kg produces the exchanges on the amount of speed rate against time. The more feeds size, the more speed rate of the feeds in grams/s will be. Nevertheless, there is stability on the speed rate above 3kg. There is speed rate of the feeds in 34grams/s for 4mm. On the other side, there is feeds speed rate in 25grams/s for feed size of 2mm.

Figure 12 shows the total amount of energy usage, duration of the process for 2mm and 4mm feeds over all the process. In maximum 2kg with 2mm, total electricity energy usage is 85.8mWh or 0.085Wh. On the other side, in 4mm, total electricity energy usage is 90.7mWh or 0.0907Wh. Total duration of process in 2mm and 4mm in 2kg feeds is 70 seconds and 71 seconds, or 1.2minutes.

From the final result of several experiments, we concluded that the proposed design of automatic feeder machine has different performances at each feed load given. From several experiments, it is concluded that 2kg feed load for each process is the optimal amount. It means that no matter how much the feeds needed should be divided into 2kg per each process. It is assumed that the machine should flow the feeds 10kg into the fishpond, then the machine has to work 5 times of process with each process maximum 2kg.

3. Conclusions

The optimization of the machine designed is obtained. The machine could work optimally with 2kg feeds in each process, both for 2mm and 4mm feeds size. The optimization is the same in the energy of electricity usage. Another conclusion of this research is that the design of feeder machine could work normally and has less energy usage of each process. The machine only works for 2kg in maximum feeds. The motor of the main inlet should work immediately after the system of throwing is almost done, so that it is needed the speed rate of rotation on the spiral conveyer. On the other words, the speed rate of throwing system is very based on the duration of the process on the spiral tunnel. It means that the quicker the spiral tunnel works, the quicker the machine period works. Duration of the process of feeding machine for 2mm and 4mm is 1.2minutes with the total of energy usage 0.085Wh to 0.0907Wh or 0.9Wh for 10kg feeds. This design of the machine could be implemented in fish farm of catfish, shrimp, or fish farm in the offshore.

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