STUDENT RESEARCH

Design and Development of an Automatic Fish Feeding Tower Using IoT Technology

Nguyen Tuan Quang

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I. REASONS FOR CHOOSING THE TOPIC

Vietnam is a country with a very large area of wetlands. According to statistics from the Vietnam Association of Seafood Exporters and Producers: In 2020, our country's aquaculture area is 1.3 million hectares, and 10,000,000 m3 of cage farming (7,500,000 m3 of brackish saltwater cages and 2,500,000 m3 of freshwater farming); Farming output reached 4.56 million tons. From 1995 to 2020, Vietnam's aquaculture output increased 11 times, with an average annual growth of 10%.

The fisheries industry makes an important contribution to our country's total export turnover, creating jobs for millions of workers. However, aquaculture is still manual or semi-manual and has not applied machinery or high technology like other agricultural sectors. This causes low harvest output, consumes a large amount of seasonal labor, and wastes animal foods, causing huge economic loss. Therefore, it is necessary to apply automated machinery to production to save labor, increase productivity, and increase product output quality.

Through research and study in some large livestock farming areas in Vietnam today, it has been shown that farmers encounter difficulties in the aquaculture process such as:

● Using human labor to feed fish leads to a lot of labor costs, increased prices of output products, and uneven fish feeding rates.

● Testing the quality of water sources in ponds is mostly based on animal husbandry experience, so it is not timely, causing economic losses.

● Monitoring water indicators such as dissolved oxygen concentration, pH, temperature, etc is done manually and independently, which is labor-intensive, takes time to check, and cannot be continuous at other times. together.

● Small-scale livestock farmers often cannot hire workers to monitor water indicators.

● Impossibility of monitoring the water quality of many ponds at the same time.

To solve the difficulties that farmers encounter, there are several livestock support machines on the market today; however, the existing machines only help farmers solve a few individual problems, and they have lots of restrictions:

● Singular purpose machines, such as feeding fish.

● The machine is often fixed, causing excess food to settle to the bottom of the pond and polluting the farming environment by creating ammonia and nitric gas, which lead to uneven fish growth and susceptibility to disease.

● Often using a 220V power source by gasoline or oil is dangerous for farmers and not environmentally friendly.

● Water testing machines usually only have one certain function

● There is no timely warning of changes in water indicators.

● Eyebrows are often controlled manually and cannot be controlled via smart devices such as phones, computers, etc.

Figure 1. Fixed, single-speed fish feeder using a 220AC power source

Figure 2. Image of a farmer rowing a boat to the lake and feeding fish manually.

Today, developed countries have been applying IoT technology to support aquaculture farmers. However, there are still many limitations that need to be further developed.

With the trend of globalization and Industry 4.0, applying technology and techniques to production and human life becomes easier. As students who have access to the STEM teaching model has motivated us to grasp this trend and constantly learn and research to create products. "***Automatic fish feeding tower***" to help reduce hardship and costs, increase efficiency and productivity, control important water indicators, minimize food waste in aquaculture, and promote environmental friendliness.

II. RESEARCH QUESTIONS, RESEARCH TASKS, TECHNICAL OBJECTIVES

2.1. Research question/research problem.

Starting from the above general research, the topic identifies the following major issues that need to be solved:

2.1.1 Automatically distribute food

- How to distribute food evenly on the surface of the fish tank?
- How to feed fish according to preset hours?
- How to adjust the amount of output food?

2.1.2 Simultaneously measure water environment indicators

- How to monitor the system remotely via the internet?
- How to control the water quality in the lake completely automatically?

2.1.3 The equipment uses clean, environmentally friendly energy sources

- How to provide clean power when the machine is floating on water and away from shore?

2.1.4 Communicate and control via smart devices

- How to control the system remotely via the internet?
- How to send warnings about substandard water quality to aquaculture farmers' phones?

2.1.5 Can float and move on the pond surface on its own

- How can the machine float on water continuously?

- How can the lifting system be controlled?

2.2. Research mission

Starting from the research questions/problems, the topic identifies tasks that need to be researched to solve the above problems with the goal:

- Research to create a system to help the tower float on water.
- Research documents on the mechanical mechanisms of fish feed distribution and shooting plates.
- Research on electric cylinders.
- Research the operating principle of the NODE MCU ESP8266 control circuit.
- Research applications of motor speed control circuits.
- Research the operating principles and applications of sensors that measure dissolved oxygen concentration, temperature, and pH in water.
- Research the application of the SIM808 module in sending warning messages to users' phones.
- Research the structure and operating principles of the Webserver system for monitoring, controlling, and storing information of the fish feeding tower remotely via the internet.
- Research solar panel systems and charging circuits.
- Select appropriate materials for processing and assembling the machine.
- Put into trial use to evaluate the usability and stability of the machine, adjust and perfect the product.

2.3. Technical goals

- The machine can automatically float on water and operate continuously.
- The machine can distribute food evenly around the pond surface.
- The machine can set automatic fish feeding times.
- Users can control the machine remotely via the website.
- The machine can automatically measure the water quality displayed on the website and alert the user's phone.
- The machine uses a solar panel system and 12V battery to provide energy.

III. RESEARCH METHODS

3.1. Current status of aquaculture in some localities.

Investigation of livestock households in 2 areas: in Phu Long - Cat Hai - Hai Phong and in Dai Dong commune, Thach That district, Hanoi city, combined with research through media information channels about forms of aquaculture in other regions across the country.

We realize that most farmer households today raise seafood manually, relying mainly on human power, and lacking support from machinery. If machines are used, they do not meet the necessary needs of farmers, as machines are often placed on shore, using 220V electricity to directly control mechanical

buttons without the combination of an internet network system, etc. Machines that monitor water environment indicators usually only have a single function, requiring the use of many different types of machines to measure and monitor indicators causing many difficulties and costs for livestock farmers.

Monitoring indicators of the breeding environment in the pond is crucial. Water indicators directly affect the growth and development of fish. These indicators depend on many factors which are easily influenced by the surrounding environment. As Mr. Vu Van Chien - the owner of a fish pond in Dai Dong commune, Thach That district shared: "*There were times when I lost several tons of fish because the water in the pond lacked oxygen at night and I didn't realize it."*

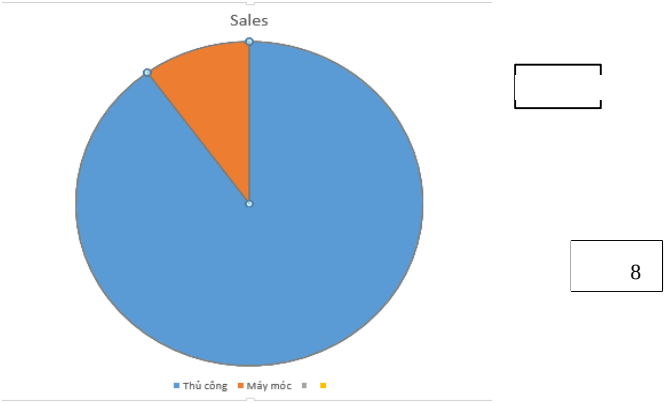

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Figure 3. Survey diagram of farmers' aquaculture methods.

3.2. Document research methods

During the process of implementing the project, we studied documents to learn and collect information as the scientific and practical basis of the project as follows:

- Advantages and limitations of fish feeding machines currently available on the Vietnamese and world markets.
- Principle of floating on the water surface of the tower is based on Archimedes ‘s thrust.
- Operating principle of Node MCU ESP8266 control circuit.
- Operating principle of the motor speed control circuit.
- Operating principle of the sensor for dissolved oxygen concentration in water, water temperature, and pH in water.
- Operating principle of SIM808 module.
- Operating principle of solar panels and charging circuit.
- How to create and manage a Webserver.

3.3 Experimental method

*** Installation process of machine modules:**

- Check the operation of devices (Node MCU ESP8266 control circuit, motor speed control circuit, solar panels and charging circuit, etc.) before and after installing each module.
- Check the operation of the machine once fully installed.

* **Stage of trial use:**

After manufacturing, the machine was put into trial use in a number of ponds, lakes, shrimp or fish farming ponds in the district/province and neighboring localities. From practical applications, comments and suggestions from users, we will evaluate the stability as well as issues that need to be adjusted and perfected.

3.4. Expert consulting methods

The project is carried out under the guidance and advice of teachers and experts (finding reference materials, selecting materials, designing, and installing, etc).

IV. RESEARCH PROGRESS

4.1. Point out the limitations of fish feeding machines on the market

No	**Product**	**Food distribution function**					
		Image	***Only shoot in one direction***	*Divider plate 360^0*	*Form spray*	***Causes settling in one place***	***Not** settling in one place*
1	Automatic fish feeding tower			**x**			**x**
2	3A90W		x		x	x	
3	Shrimp/fish feeding machine 2 original		x		x	x	
4	A human invention people		x		x	x	
5	Snakehead fish feeding machine			**x**			**x**

No	**Product**	**Abilities to move on water**						
		Image	***Can not***	*Can*	*create air bubbles*	***Not** create air bubbles*	***Not** Control via Web*	*Can control via Web*
1	Automatic fish feeding tower			x	x			x
2	3A90W		x			x	x	
3	Shrimp/fish feeding machine 2 raw		x			x	x	
4	An invention of the people		x			x	x	
5	Snakehead fish feeding machine			x		x	x	

No	**Product**	***Abilities to measure water environment***			
		Image	***pH***	t^0 C	*DO*
1	Automatic fish feeding tower		Can	Can	Can
2	3A90W		Can not	Can not	Can not
3	The machine feeds 2 shrimp/fish		Can not	Can not	Can not

4	An invention of the people		Can	Can	Can not
5	Snakehead fish feeding machine		Can not	Can not	Can not

No	Product	Communication and control function via internet		
		Image	***Can not***	*Can*
1	Automatic fish feeding tower			x
2	3A90W		x	
3	The machine feeds 2 shrimp/fish		x	
4	An invention of the people		x	
5	Snakehead fish feeding machine		x	

No	Product	Energy used			
		Image	***Electricity 220V***		***Solar***	
			Not have	*Have*	***Not have***	*Have*
1	**Automatic fish feeding tower**		x			x
2	3A90W			x	x	
3	The machine feeds 2 shrimp/fish			x		x
4	An invention of the people			x	x	
5	Snakehead fish feeding machine			x		x

4.2. Determine the functions of the automatic fish feeding tower.

No	Function of automatic fish feeding tower	***Have***
1	Ability to float on water and operate continuously.	**x**
2	Food distributed evenly around the surface of the pond.	**x**
3	Fish feeding hours set automatically or controlled remotely.	**x**
4	The Machine's elevation adjusted via the website.	**x**
5	Ability to monitor and control the machine remotely via the website.	**x**
6	Automatically measure and alert water quality to the user's phone.	**x**
7	Solar energy system and 12V battery to provide energy.	**x**
8	Ability to travel on the lake surface	**x**
9	Adjustable food quantity and dividing speed	**x**
10	Propeller combined with air foam	**x**

4.3. Identify machine modules

- The float and food sharing plate module include the following main equipment: one float frame with four 20L plastic bottles; three 520DC deceleration motors; one KAG engine type M80X80; one 2-layer food sharing plate; one rotating tray to dispense food; and one electric cylinder.

- The time setting and automatic food portioning speed adjustment modules includes the following main devices: 01 central control circuit NODE MCU ESP8266; four BTS7960 43A DC motor speed control circuits.

- The water quality control and warning module in the pond includes the following main devices: 01 DO sensor to measure the amount of dissolved oxygen

in water, 01 sensor to measure water temperature DS18B20, 01 sensor to measure the pH of water, and 01 SIM808 module.

- Solar battery module and 12V battery system include: 01 solar panel, battery charging circuit from solar battery, low voltage circuit.

Storage box (box with a compartment containing the machine's electrical circuits and electricity components)

4.4. Material selection

* ***Criteria for selecting equipment and manufacturing materials:***

- Materials are easy to find and accessible on the market.
- Ensure safety and stability when used.
- Low cost.

**** Manufacturing equipment and materials:***

The basic materials and equipment needed to make an automatic fish feeding tower are listed in Table *1*.

Table 1. Some materials and equipment needed to make an automatic fish-feeding tower.

No	Device name	Technical specifications	Quan	Image
1.	Solar panels	- Dimensions: 430mm*350mm*23mm (length x width x height) -Weight: 2kg -Power: 20W	01 panel	
2.	Water jars	- Capacity 20L - Plastic material	04 jars	
3.	KAG Type M80X80	-Operating voltage: 20-21V -Speed: 3200 rpm	01	
4.	520DC gear reduction motor	-Operating voltage: 12VDC -Speed: 200 rpm	03	
5.	Module NODE MCU ESP8266	- Chip: ESP8266EX - WiFi: 2.4 GHz supporting 802.11 b/g/n standard - Operating voltage: 3.3V	01	
6.	DC Motor Control Circuit BTS7960 43A	- Input voltage: 6~27V - Circuit load current: 43A - Control logic signal: 3.3 ~ 5V. - Maximum control frequency: 25KHz. - Size: 40 x 50 x12mm.	04	

7.	Water temperature sensor DS18B20	- Operating voltage: 3-5.5VDC - Measuring range: -55*C – 125*C - Measurement error: 0.5*C	01	
8.	The DO sensor measures the amount of dissolved oxygen domestic	- Operating voltage: 3.3-5VDC - Measuring range: 0 – 20 mg/L - Pressure range: 0 – 50 PSI	01	
9.	pH sensor	- Operating voltage: 5VDC - pH index measuring range: 0 - 14 pH - Working temperature: 0-60°C - Output data: Analog - Accuracy: ± 0.1pH (25°C) - Response time: ≤ 1 minute - Output connection: PH2.0 3 legs	01	
10.	Module SIM808	- Operating voltage: 5VDC - Band: 850/900/1800/1900 MHz - Support: GSM/GPRS/GPS	01	
11.	12V battery charger and voltage stabilizer	-Input voltage: 12VDC-50VDC -Maximum current: 30A	01	

12.	12V battery	-Voltage: 12VDC -Capacity: 7Ah	01	
13.	Low voltage circuit	- Input voltage: From 3V to 30V - Output voltage: Adjustable between 1.5V and 30V - Maximum response current is 3A - Power: 15W	01	

14.	Electric cylinder	- Input voltage: 12V -Speed: 30mm/s -Lifting force: 500N	01 femal e	

4.5. Design and installation

4.5.1. Mechanical design of the device.

The mechanical frame is made from rust-proof, anti-corrosion 304 stainless steel when having to operate underwater for long periods of time.

The mechanical frame consists of 3 parts: the float base, the food-sharing plate, the food-shooting mechanism, and the solar rack placed above.

The float base is a 304 stainless steel frame with a system of 4 tanks with a volume of 20 liters, with 1 tank used to balance the structure on the water surface. The food shooting mechanism above includes a food discharge box with a rotating discharge door attached to the engine, below is a fan shooting mechanism that shoots food using an engine , KAG Type M80X80, and is controlled directly by the motor governor circuit. At the top is a solar panel mount to supply electricity to the battery (the battery has the role of providing power for the whole system).

+ Shell material: Hard aluminum aluminum plate, 3mm thick, white.

+ Frame material: Anti-corrosion 304 stainless steel.

+ Food container size: 500mm x 500mm x 500mm (length x width x height).

+ Overall dimensions of the machine: 850mm x 850mm x 2100mm (length x width x height).

+ Dimensions of the machine without lifting: 850mm x 850mm x 1850mm (length x width x height).

Figure 5. Dimensions of the machine.

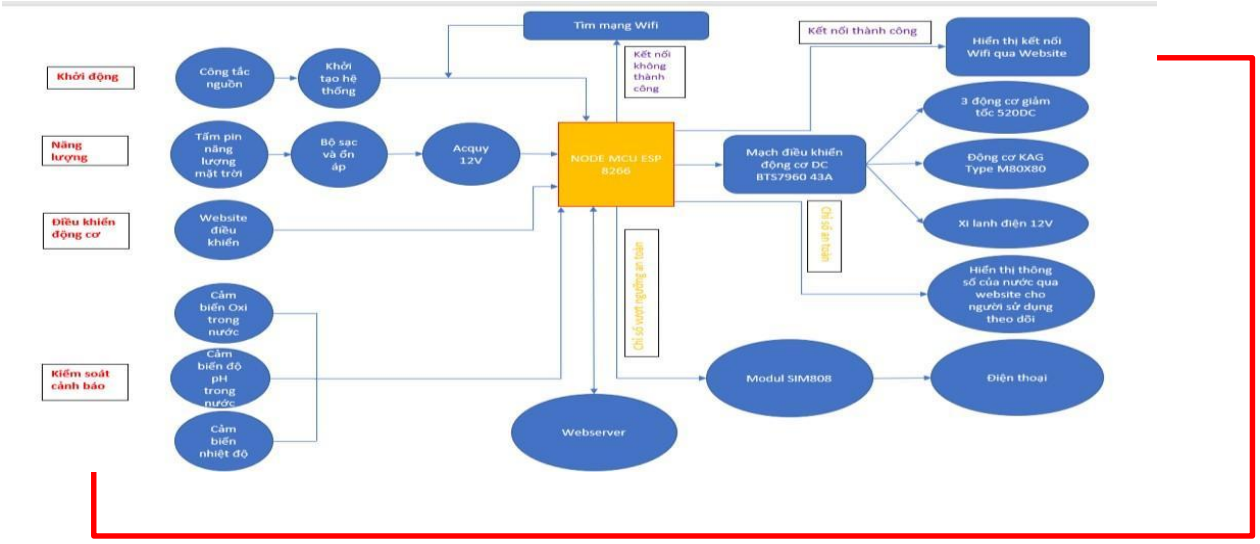

Figure 6. System block diagram.

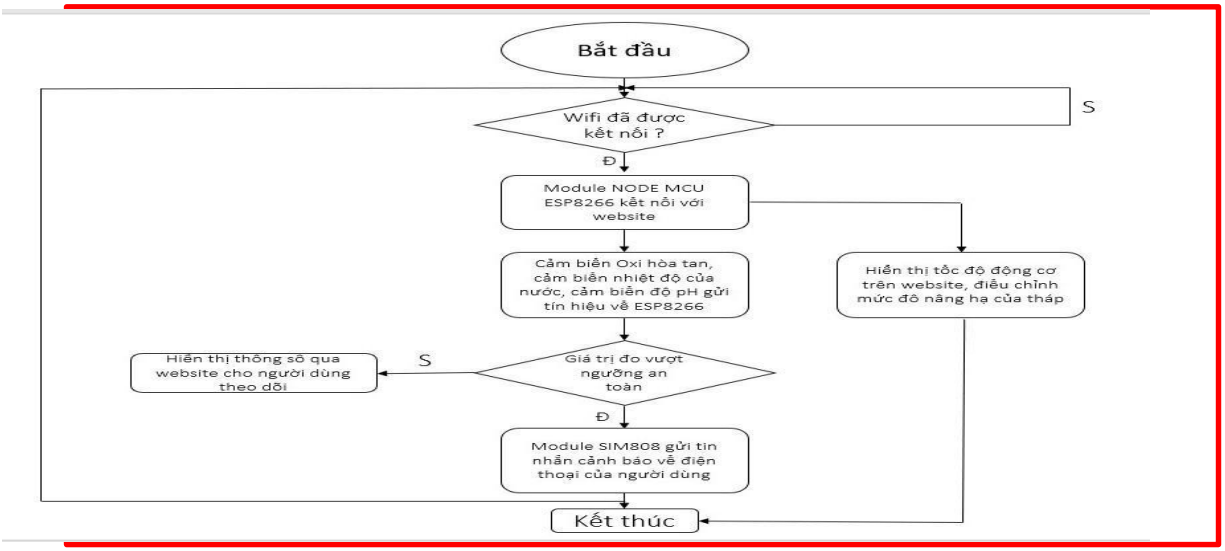

Figure 7. Algorithmic flow chart of the system.

4.5.3. Principle of operation

- When starting to use the machine, the user will turn on the power switch to provide energy for the machine to operate through the solar system and 12V battery. Then the power light will turn on, signaling that the machine is ready to operate.

- Next, the motor system, NODE MCU ESP8266 motherboard, motor control circuit DC BTS7960 43A, booted up and ready to receive signals from the user.

- First, NODE MCU ESP8266 will test the Internet connection through the pre-programmed Wifi network (WiFi name: KHKT; password: 12345678). If the connection is successful, the message "Wifi connected" will appear on the website. If the connection is not successful, NODE MCU ESP8266 will continue to check for other Wifi networks around until it successfully connects to the Internet.

- Next, the user will access the website on their smartphone/laptop to remotely control the device. At the interface, users can turn the system on/off, set the machine's operating time, and adjust the speed of the food dispenser.

- After the parameters have been set by the user on the website, data will be automatically sent to NODE MCU ESP8266. NODE MCU ESP8266, after receiving the data, will control the motor control circuits to operate the machine according to the preset time and the user's desired speed.

- With automatic quality measurement function. The sensor that measures the amount of dissolved oxygen in water, the water temperature sensor, and the pH sensor will send signals to the NODE MCU ESP8266 for processing. If the indicators are within the safe threshold, NODE MCU ESP8266 will display the parameters on the website for users to monitor. If the indicators are outside the safety threshold, NODE MCU ESP8266 will immediately activate the SIM808 module to send notifications via SMS to the user's phone to warn about the current water quality in the lake.

- The entire system will be powered by solar panels, relayed through chargers and voltage stabilizers, before the current is stored in the 12V battery system.

4.5.4. Installation

Figure 8. Image of the food storage unit

Figure 9. Upgrading the legs and upgrading the lifting and lowering function.

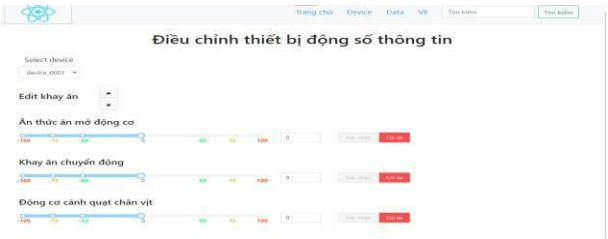

Figure 10. Above control interface website.

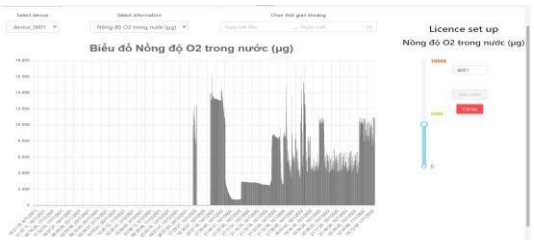

Figure 11. View parameters of Oxygen concentration in water on the website.

Figure 12. View water pH parameters on the website

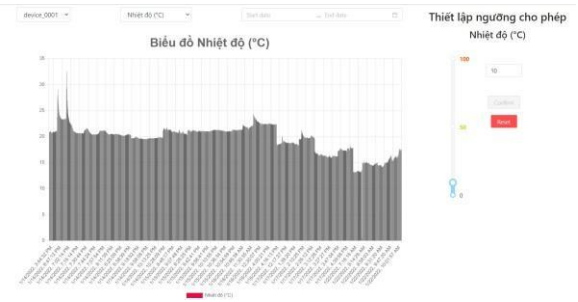

Figure 13. View water temperature parameters on the website

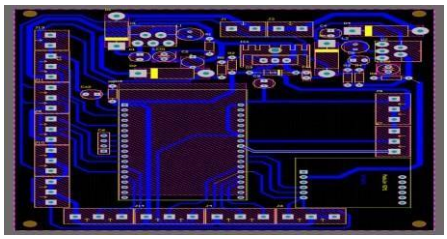

Figure 14. 2D image of printed circuit

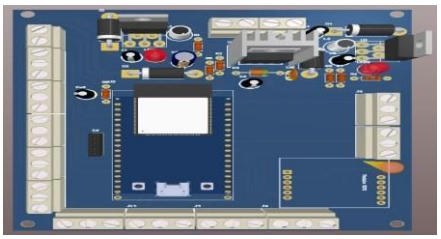

Figure 15. 3D image of printed circuit

Figure 16. Top view of printed circuit

4.6. Use test

- After installation, the machine has been used for testing from June 2021 to the present
- After 6 months of continuous use, the machine has provided great support to farmers, and is considered by users to be convenient, highly stable, and rarely damaged.
- The machine was tested and achieved the set goals.
- The machine has received positive reviews and acceptance from local farmers and has been given comments to research and upgrade improvements, contributing to bringing the product into commercialization and soon be widely applied.

Figure 17. Image of the machine being actually tested.

V. CONCLUSION

- **Successfully built an automatic fish feeding tower with the following functions:**

- Floats on water continuously, without human attention.

- Automatically feed fish according to pre-set hours, adjust the food shooting speed, and raise or lower the tower to adjust the high and low shooting range via the website.

- Automatically control and give warnings to users about water quality in aquaculture ponds.

- Convenient product, suitable for all scales of aquaculture from small to large.

- The product can be used continuously thanks to power from solar panels and energy stored in a 12V battery.

- Using it contributes to reducing the workload of farmers, increasing labor efficiency, and saving excess animal feed.

- Safe for users, environmentally friendly.

- High stability and durable, rarely damaged.

Technical data sheet:

Tên sản phẩm	Kí hiệu	*Công suất rải thức ăn kg/giờ*	*Công suất của mô tơ (W)*	*Nguồn điện (DC)-V*	*Bán kính bắn thức ăn không nâng (m)*	*Bán kính bắn thức ăn khi nâng (m)*	*Tải trọng Cám đầy phễu (kg)*	*Thời gian hoạt động tối đa đủ tải (điều kiện không có nắng) (h)*	*Chức năng đo*		
Tháp cho cá ăn tự động	TCA01	*30*	*108*	*12*	*3*	*4*	*15*	*2*	*pH*	*DO*	*t°*

➢ Novelty and creativity:

- Thanks to the use of a floating buoy mechanism, battery system and 360-degree rotating disc system, the machine can spread food evenly around the aquarium, thereby increasing the efficiency of feeding fish, reducing excessive food compared to machines on the market.

- The machine does not need to use an AC220V power source, is safe for users, and is environmentally friendly.

- The machine uses IoT technology, helping users easily set fish feeding schedules and adjust the feed shooting speed via the Website.

- The machine integrates a fully automatic water quality sensor system, helping users easily control and adjust the quality of water sources for aquaculture..

- The integrated warning system, automatically sends notification messages to users' phones when water quality is outside the safe threshold.

- Integrated solar battery system and 12V battery help the machine operate continuously, in all weather conditions.

- Familiar materials, easy to find;

➢ Next development direction:

- Add a feeding pump system to the tank.

- Added food level warning to tell if tank full or empty.

- Continue to develop and perfect to transform into commercial products, participating in the creative start-up process of students.

- Features such as surveillance cameras can be added to ensure remote aquarium security.

- Multiple firing systems can be integrated on the same tower to improve the efficiency of the machine.

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