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DESIGN OF A FOOD DISPENSER SYSTEM FOR FISHING ENVIRONMENT

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ABSTRACT

Due to its geographic location, Colombia has a great potential for the development of multiple fish farming; this paper describes the development of a programmable system which consist of the automation of the fish breeding process. The developed prototype is formed by a mechanical part allowing the storage and provides the exact amount of food in a safe way through a design of a rotary cylinder with a cavity for dispensing the food volume. The electronic component has oxygen and temperature sensors, an electronic control unit based on PSOC embedded systems, supported by a MESH topology Zigbee telecommunications infrastructure, allowing establishing a direct transfer of the information to a graphic interface (Software) developed using Python. All of the elements of the prototype make it a diagnosis tool which allows the farmer to evaluate the production methods for an accurate and opportune decisions making, obtaining as a result the resources optimization, improving the wellness, the farmers life quality and their families by increasing the crops profitability.

Keywords: food dispenser, fish farming, embedded system, MESH.

1. INTRODUCTION

The Colombian pisciculture is a business sector in a constant process of growing and technification; this promissory business is based on the great water wealth and weather variety of the country, although this activity has increased in an accelerated way, the sector consolidation and development have been slow, since recently this activity has been technified. Farmers began to understand the variables involved in the nature of aquatic species, looking for specific solutions involving governmental politics of sustainable development of this resource.(Wicki, 1998)(Olele, 2011)(Andrea & Sanabria, 2012)

Keeping in mind the previously mentioned premises, it was developed an automated prototype which can work in floating cages, geo-membrane ponds or earthen ponds; this tool has a food dispenser mechanism which can be adjusted to operate during different times of day, besides it has oxygen and temperature sensors that works for monitoring the pond environment and wireless transmits the information to a data acquiring system, which stores the information so it can be consulted lately through a graphic interface in a computer.

2. METHODOLOGY

The development process start from the environment analysis, which entails to define the mechanical structure, electronic components, communications infrastructure and software components; the evaluation and integration of this series of topics gave as a result the final implementation of the project.

2.1 Work environment

For the source design it was taken into account the environment where it is going to be installed, the highly variable weather conditions to operate, the prototype is designed to operate in warm weather where there are high grades of temperature and humidity, variables which condition the materials to be used due to the handle of the food concentrated provided to fry.(Ojomo, Agbetoye, & Ologunagba, 2010) (Burgos, García, Robinson Rosado, Olaya-nieto, & Segura, 2006) (Sastre & Casallas, 2004)

It was opted to use ABS (acrylonitrile butadiene styrene) because of its ease of manufacture in a 3d printer and its behavior in a tropical weather; The prototype was implemented in a floating cage to contain the fishes, which has hexagonal shape with a radius of 5 meters and tab of 50 cm allowing the operators to perform work on the system (see Figure-1). The cage is covered by several nets to avoid aerial and aquatic predators (see Figure-2).

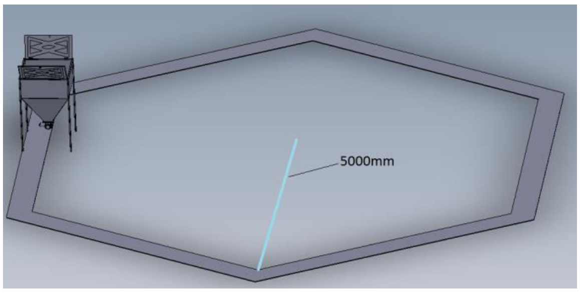

Figure-1. Feeder size compared to the cage.

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Figure-2. Design of the floating cages.

2.2 Mechanical design

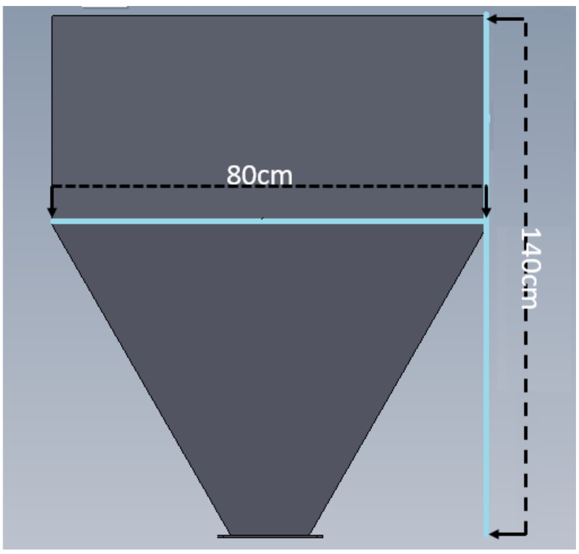
For the perfect conjunction of the system parts it was necessary the design of a structure and a mechanism which allows to store the food and dispense it in equal parts.

Feed hopper

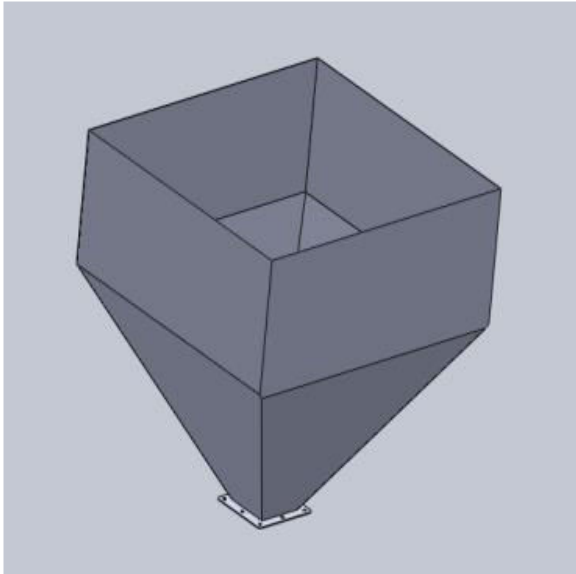
It has a conventional design, with an output hole at the bottom where couples the dispenser; its size is 140cm x 80cm, the total volume of the hopper is calculated in function of the amount of food consumed by 20 fishes a day. (García-ortega *et al.*, 2010)

$$TCA = \frac{Food\ consumed(g)}{gained\ weight(g)} \quad (1)$$

For the implementation, it was decided to use a commercial hopper which fulfills the requirements of food quantity for the fishes. The calculation of the food conversion rates were made based on a 2% of the corporal weight feeding for fishes lighter than 450 gr (see Figure-3).



a)



b)

Figure-3. a) Quota hopper b) Hopper design.

Dispensing system

It presents a cylindrical design which allows to seal the hopper while it dispenses, having a cavity in a quarter of the circle whose volume is calculated so it can deliver 1 pound of fish food concentrated, obtaining exact portions which can be handle in a simple way by the electronic system (see figure 8), to achieve this design, it started from the hopper dimensions, with the objective of fitting the pieces perfectly, giving as a result a cylinder with 12 cm height and radius 5 cm, with a notch of a 90 degrees angle (see figure 4), also, it was measured the density of the fish food (mass and volume), obtaining the following results:

$$\delta = 2{,}11\ \frac{kg}{L}$$

$$v = 236{,}6\ cm^3 = 0{,}2366\ L$$

$$m = 0{,}5\ kg$$

Once having this data, it was proceeded to use the equation of the volume of the wedge and the radius was cleared obtaining the desired volume.(Miranda, 2014)

$$v = \frac{\pi r^2 \alpha}{360°} * h \quad (2)$$

$$r = \sqrt{\frac{v * 360°}{\pi \alpha h}}$$

$$r = \sqrt{\frac{236{,}6\ cm^3 * 360°}{\pi * 90° * 12cm}}$$

$$r = 5{,}01\ cm$$

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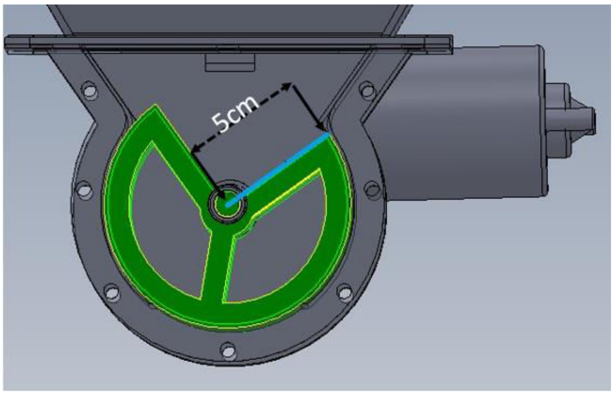

Figure-4. Dispenser design.

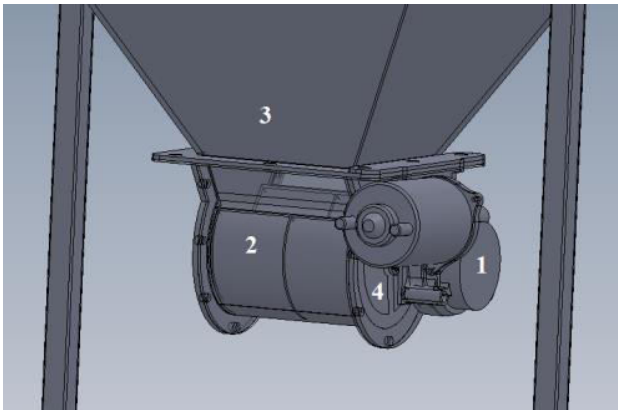

Figure-5. Structure and motor.

Its removable pieces coverage is designed to ease the assembling and maintenance of this mechanism, the complete design from another perspective can be observed at Figure-5, where its components are: 1. Motor, 2. Case, 3. Hopper and 4. Hopper. The final hopper and dispenser iteration is shown in Figure-6.

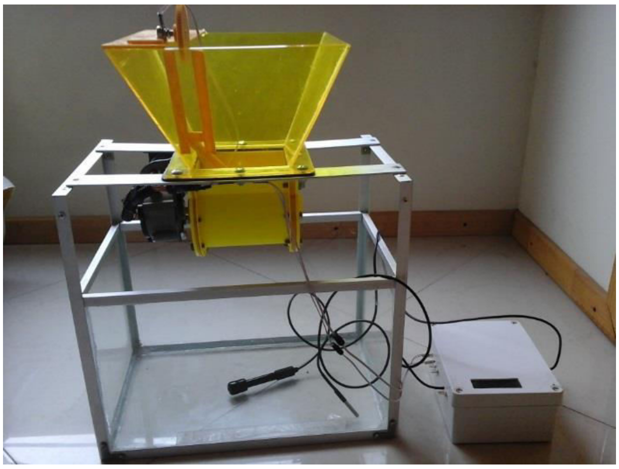

Figure-6. Final assembled dispensing prototype.

2.3 Electronic design

Basically the electronic control unit designed is based on a PSOC microcontroller in charge of manage the actuators, sensors and communication modules for the device as shown in Figure-7.

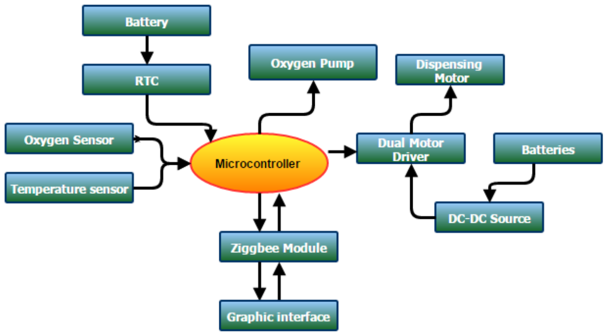

Figure-7. Block diagram.

All of the components of the system are connected to an external power source of 12 and 5 volts dc, which is able to supply up to 500 watts; it has a power module, a RTC (Real Time Clock) module which send the time to the embedded system and an external battery to keep the time up to date in case of a power failure. Besides, it has a dual driver to activate the motor which rotates the dispenser and a coupling module and an optical coupled module to power on the oxygen bomb (see Figure-8).

The PSOC microcontroller captures the oxygen and temperature variables to transmit this information through serial 9600, 8, N, 1 communication using the Zigbee module, which is connected with MESH topology to the registering software storing the info in a plain file in the computer to produce graphics and being analyzed.

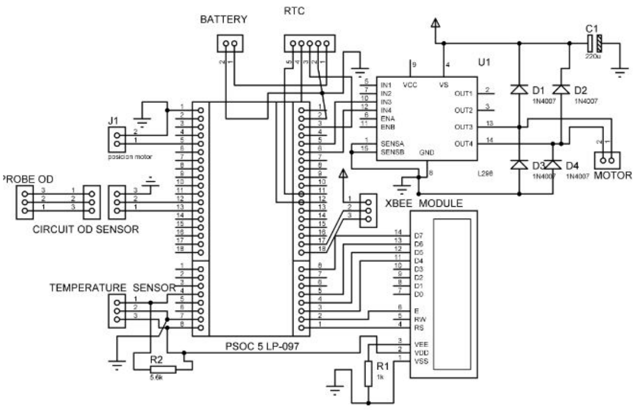

Figure-8. Electronic circuit.

Sensors

Temperature

Due to the fish characteristics and their thermophile pattern for feeding, it was captured the temperature variable through a RTD sensor, reference DS18B20. To select which sensor was suitable for the application, it was made a performance and cost

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comparative. Table 1 shows the selection criteria used as reference to select the sensor.

Table-1. Temperature sensors comparative.

Sensor	*Cost*	*Linearity*	*Sensitivity*
RTD	Moderate	Excellent	Moderate
Thermocouple	Low	Moderate	Low
Thermistor PTC	Low	Poor	Excellent
Thermostat	Low	Moderate	Excellent

Once the sensor is selected, it were performed a series of tests to determinate the behavior on this field, those tests gave as a result data which confirms the stability of the sensor with absolute error measures with no affectation to the process; the mentioned measures were taken with a high precision patron sensor and defined values for 26.5 ºC with a sampling time of 20 minutes (see Figure-9). The steps for the test were:

a) Slowly increasing the temperature to 26.5 ºC
b) Waiting for probes to stabilize ensuring the thermal balance.
c) Registering the given temperature from the sensor.
d) To repeat the procedure from step 1 to 3.

$$\text{Temp} = \text{temp\_read} - 0.25 + \frac{\text{countperc} - \text{countreamain}}{\text{countperc}} \quad (3)$$

In the previous equation, the sensor sends the data in a digital way (12-bits); "countperc" counts the quantity of pulses per centigrade, adjusting the sensor to the oscillation frequency.

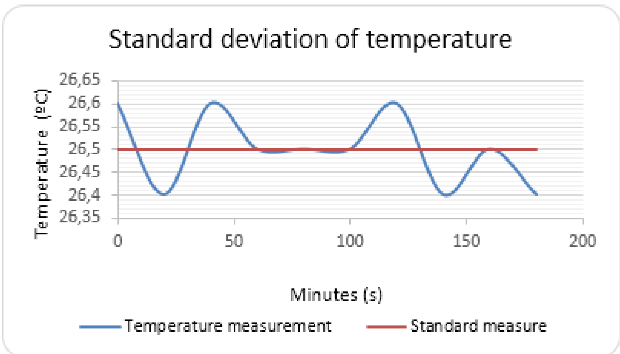

Figure-9. Temperature sensor behavior.

Oxygen

To guarantee the fish survival it is essential to have the suitable oxygen measure, whereby this project select the sensor Dissolved Oxygen Kit (DOK) from the Atlas Scientific company, as the more suitable for the implementation; the reasons for the selection are the work range (0-35mg/l) and its easy implementation with a microcontroller (RS232 ó I^2C).

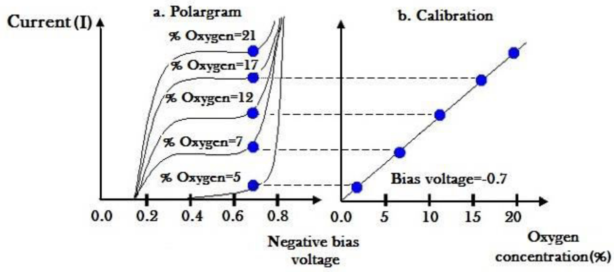

Figure-10. Linearization parameters for the oxygen sensor calibration.

Like the temperature sensor, tests were made to the oxygen sensor, which were satisfactory, giving a relative error of 0.17%, less than the maximum allowed, ensuring an exact measured of the process as seen in Figure-11. To obtain these results, it was necessary to perform a graduation of the device, which was calibrated using two points of reference, one regarding the solution included with the sensor and the other one with atmospherically air. This calibration point is not quite necessary but provides more resolution to DOK with values of 1.0 mg/L to 0.1mg/ L., as shown as follows:

a) Remove the DOK probe cover.

b) Immerse the probe into fresh water. This so the probe detection area is wet. (Do not use salt water to wet the probe detection area)

c) Leave the probe alfresco during approximately 3-5 min.

d) Use the calibration command (Cal) or (Cal, 0) if the 0 DOK solution is being used.

e) Immerse the probe into the 0 DOK solutions.

f) Wait for the measures to decrease and stabilize.

g) If the measured are close to cero calibrate. If the measures are less than 1 mg / l, may not calibrate. If cero DOK.

To calculate the saturation and readjust in the electronic control card, it was used the saturation(Atlas Scientific, 2017)of the following equation:

$$Saturation\% = ((mV\ in\ water)/(Mv\ in\ air))$$

These steps only applies for the dissolved oxygen kit, taken from the provided datasheet; Is to clarify that to use the dissolved oxygen measure probe, it must be taken into account the linearization equations, due to its more complex characteristics (see Figure-10).

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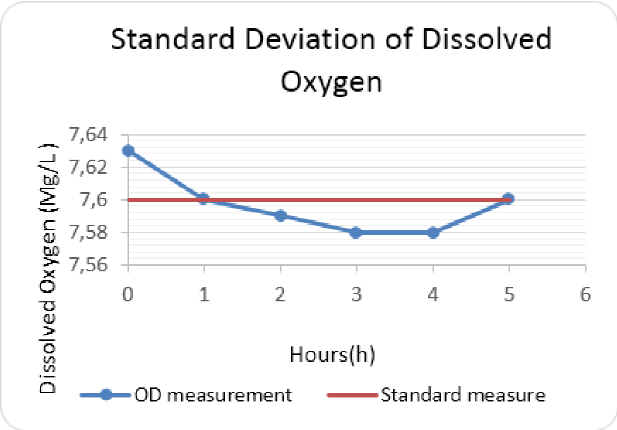

Figure-11. Dissolved oxygen sensor behavior.

Communication system

As communication infrastructure between the store data and the electronic control card, were used series 2 XBEE modules configured in MESH topology with coverage in line of sight of 300 meters. This technology allows to monitoring several cages at the same time, integrating two operative roles (Router and Coordinator) expanding the wireless coverage for the proposed network. Figure-12 shows the addressing parameters used in the wireless network.

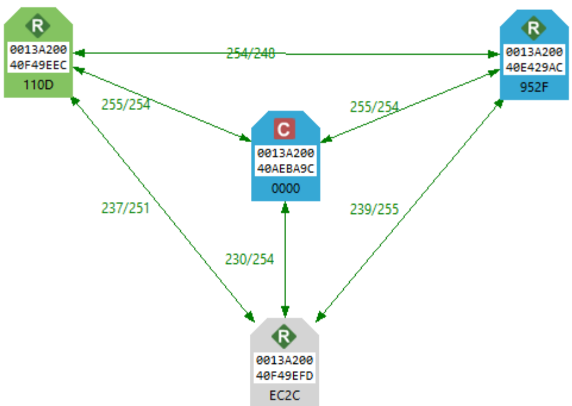

Figure-12. Zigbee module in MESH topology.

Graphic interface

It was developed using PyQT with Python process motor, it has 3 subroutines called: configuration, farming and monitoring (see Figure-13); this last one is in charge of receiving the data from the embedded system and to store it in a plain file named using the crop date and identification, also, it allows to activate the visual alerts when the system found itself between the established ranges, see Figure-14.

The developed software has a tracking form for the crop which is stored in the database and has the following fields: daily deaths, food entered, crop identification, oxygenation and observation. The configuration subprogram sends the data to establish the parameters at the microcontroller like: feeding hour, portions, oxygen range and storing in the database the provided information from the operator, so it can be consulted by the "*cultivo*" subprogram, completing the communication between the operator and the feeding system.

Figure-13. Interface's flow diagram.

3. RESULTS

The correct function of the dispenser was proven with other organic origin food as Cassava starch (the amount of biomass provided with this food changed due to the dispensing system which calculates the weight in function of the fish concentrated food).

The storage capacity for the hopper is 160 kg and the dispensing speed is 8.5 kg per minute, giving away the whole hopper in 20 minutes if is required; Likewise with the oxygen monitoring values were establish between 4,5mg/l and 8,4mg/l.

The electronic control configuration allows to carry on a control of the feeding times and the amount of food provided to the fishes, being able to establish different amount of food if is required. The amount of food provided differs according to weeks of life and a maximum unload for the system, are calculated as in the hopper case with the 2% of the corporal weight, being as maximum 450g, which gives as a result the maximum hopper capacity.

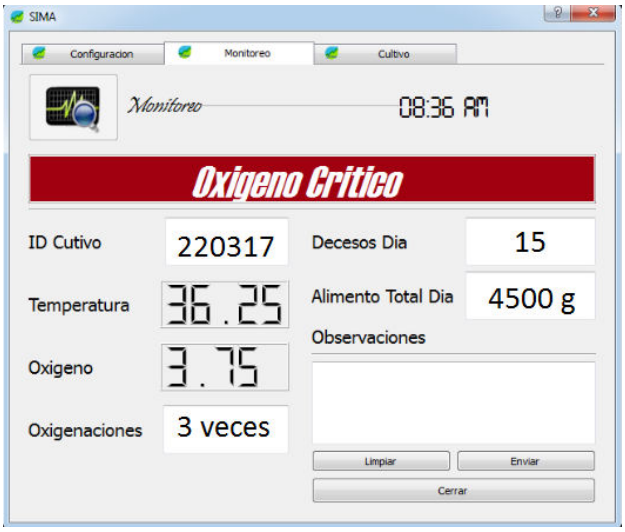

Figure-14. Graphic interface.

4. CONCLUSIONS

The development set of the automatic dispensing system is a tool that provides the operator with information about the crop, prioritizing the data capture and information through variable acquisition like: amount of food supplied to the fishes, measure of the water oxygen and temperature measure, attempting to determinate which are the feeding patterns in function of the physics variables which are more suitable for the fish breeding.

By encountering the stability patterns in the process, the farmer could decrease the variation between crop cycles and by consider the given data from the system, soul make decisions in the field attempting to reduce the risk inherent in the process, decreasing the food wasted and the crop affectation by the surrounding environment, which are relevant factors for the activity development.

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