STUDIES AND RESEARCH REGARDING THE UNITARY ENERGY CONSUMPTION OF A RECIRCULATING AQUACOL SYSTEM
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STUDII ȘI CERCETĂRI PRIVIND CONSUMUL ENERGETIC UNITAR AL UNUI SISTEM ACVACOL RECIRCULANT

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REZUMAT

Lucrarea de față are ca scop evidențierea consumului de energie electrică și energie calorică consumată de un sistem acvacol recirculant pentru creșterea vietuitoarelor acvatice

Energia necesară funcţionării unui sistem acvacol recirculant de creştere a peştilor se imparte in două categorii si anume energia electrică necesară acţionării diferitelor echipamente tehnologice, principalele echipamente dintr-un sistem acvacol recirculant care utilizează energie electrică fiind pompele de recirculare, filtrele mecanice (unele tipuri), instalaţiile de sterilizare cu UV și sistemele de aerare.

A doua categorie de energie consumata este energia calorică necesară pentru încălzirea/răcirea apei din sistem şi a halei

ABSTRACT

This paper aims to highlight the consumption of electricity and caloric energy consumed by a recirculating aquaculture system for the growth of aquatic life. The energy needed to operate a recirculating aquaculture system for fish farming is divided into two categories, namely the electricity needed to operate various technological equipment, the main equipment in a recirculating aquaculture system that uses electricity being recirculation pumps, mechanical filters (some types), UV sterilization facilities and aeration systems. The second category of energy consumed is the caloric energy required for heating / cooling the water in the system and the hall.

INTRODUCTION

In general, the energy required to operate a recirculating aquaculture system for fish farming is of two categories: *Electrical energy* required to operate various technological equipment and *Caloric energy* required for heating / cooling the water in the system and the hall. Electricity is needed to operate various technological equipment such as some types of mechanical filters, aeration pumps and UV sterilization installations (Bura M. 2008; David P.,2007; David(Laza) E.A,2021)

The electricity consumption per 1 m^3 of water of these equipments varies widely depending on the type, use, quantity and quality of feed administered to the fish material (fish species raised in the recirculating aquaculture system) as well as the degree of use of its, the density of population but also other factors (Cristea V., Grecu I., Ceapă C, 2002).

The pump group has the role of ensuring the circulation of water in the system. Power consumption depends on pump type, efficiency, pump height and hydraulic

resistance of the system. For the circulation of one m^3 of water at a pumping height of one meter water column, 4.6 - 6 Wh / m^3 of electricity is generally consumed (Losordo M.T., Masser P.M., Rakoci I, 1999, David (Laza) E.A,2021).

The radial, rotary, "drum" type mechanical filters, most often used for mechanical filtration in recirculating aquaculture systems, use energy to perform the rotational movement of the drum and to operate the filter material washing pump (David (Laza) E.A, 2021, Masser P.M., Rakoci J., Losordo M.T, 1999).

The unit energy consumption depends on the size of the holes of the filter material and the intensity of its washing, being in the range of 3.7 - 4.5 Wh / m^3. The role of aeration pumps is to introduce air into the water in the recirculating aquaculture system to increase the oxygen concentration in the water. The amount of oxygen that fish need depends mainly on the species, age and density of the population, as well as other factors such as water temperature and pH, ammonium concentration, nitrites and nitrates, etc. The average energy consumption for the aeration process is 3-6Wh / m^3 (David P., 2007; David (Laza) E.A, 2021).

Ultraviolet disinfection is the ability of UV light to penetrate to destroy all forms of bacteria, viruses and other small organisms present in the culture water. In order to obtain a maximum disinfection capacity with UV rays, an energy consumption of approximately 5 Wh / m^3 is taken into account (David P., 2007; David (Laza) E.A, 2021).

MATERIAL AND METHOD

The recirculating aquaculture fish farming system on which the experimental research was performed has a total volume of water of 70 m^3 and the average duration of hydraulic residence is 30 minutes (two recirculations / hour). The total volume of water circulated in the system is:

$$Q_t = 2 \cdot V_t + Q_A \quad (1)$$

where: V_t is the total volume of water contained in the system

Q_A is the volume of the addition water, which at a judicious washing of the filter represents approx. 10% of V_t

$$Q_t = 2 \cdot 70 + \frac{10}{100} \cdot 70 = 147 \frac{mc}{h} \quad (2)$$

The level difference between the suction of the pumps and the filling mouth of the buffer tank is 6 m. The pumping height, taking into account the hydraulic resistances of the network is 7 m^3.

The annual energy consumption of the various equipment in the recirculating aquaculture system is:

Energy consumed by recirculation pumps, with a unit consumption of 5.3 Wh / m^3 of water, E_P:

$$E_P = 5{,}3 \cdot 147 \cdot 7 \cdot 24 \cdot 365 = 47{,}775\ kWh \quad (3)$$

Energy consumed by the mechanical filter, with a unit consumption of 4.1 Wh / m^3 of water, E_{FM}:

$$E_{FM} = 4{,}1 \cdot 147 \cdot 24 \cdot 365 = 5.280\ kWh \quad (4)$$

Energy consumed for aeration, with a unit consumption of 4 Wh / m^3 of water, E_A:

$$E_A = 4 \cdot 147 \cdot 24 \cdot 365 = 5.150\ kWh \quad (5)$$

Energy consumed for UV disinfection, with a unit consumption of 5 Wh / m^3 of water, E_{UV}:

$$E_{UV} = 5 \cdot 147 \cdot 24 \cdot 365 = 6.438\ kWh \quad (6)$$

Table 1

Values of unit electricity consumption for water circulation and treatment in the recirculating aquaculture system

Equipment	Unit consumption value Wh / m^3 of water	Remarks
Recirculation pumps	4,6 – 6 (average **5,3**)	For h = 1m
Mechanical filters (drum)	3,7 – 4,5 (average **4,1**)	For holes D = 0,07mm
Aeration pumps	2 – 6 (average **4**)	Continuous operation
UV sterilization	5	

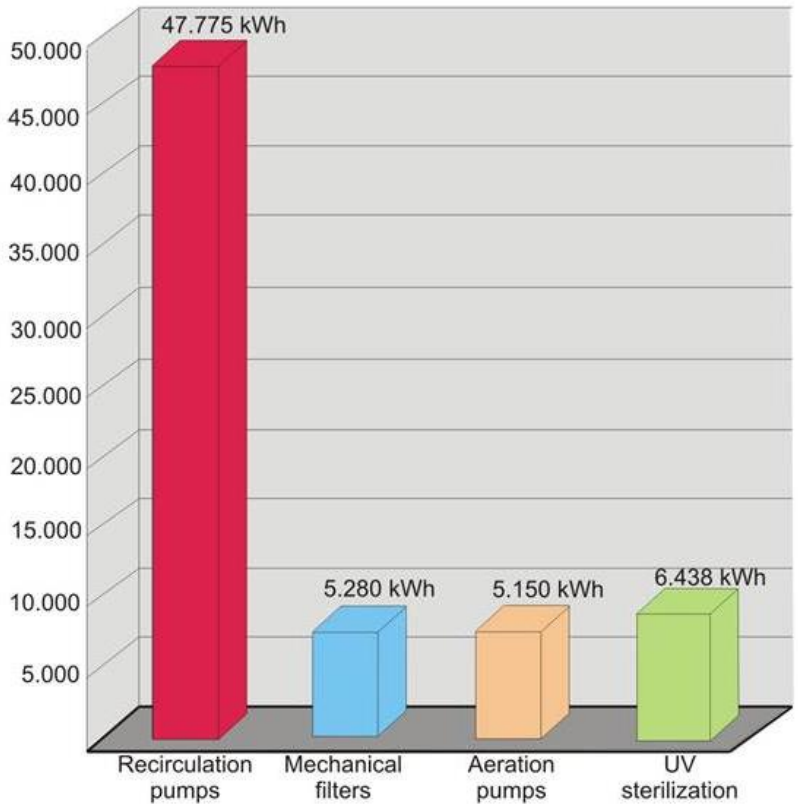

Figure 1. Graph of the annual electricity consumption for the treatment and circulation of water from a recirculating aquaculture system

Caloric energy required to heat the water in the system and the hall Caloric energy consumed to heat the water in the system E_{IA}

$$E_{IA} = e \cdot (t_a - t_f) \cdot Q_A \cdot \tau_1 \quad (7)$$

where:

e = 1, 16 kWh, caloric energy consumed to increase by 1 °C the temperature of a quantity of 1 m^3 of water;

t_a = 20°C, the temperature of the water in the growing basins;

t_f = 12°C, drilling water temperature;

Q_A = 15 m^3/24h, the amount of addition water;

τ_1 = about180 days, the number of days in a year in which the addition water must be heated;

E_{IA} = 25.056 kW h

Caloric energy consumed for heating the hall E_{IH}

$$E_{IH} = c \cdot S \cdot \tau_2 \quad (8)$$

where: c = 40 kW/m^2, he calorific value required for heating a well-insulated space in accordance with DIN 4701 (for a standard height of 3 m)

S = 589 m^2, the surface of the hall where the recirculating aquaculture system on which the experimental determinations were made is located

τ_2 = 120 days, the period of one year in which the hall must be heated

E_{IH} = 28.272 kW h

Table 2

Values of annual electricity consumption required for water circulation and treatment in the recirculating aquaculture system

Equipment	Annual consumption value kWh	Remarks
Recirculation pumps	47.775	For H = 7m
Mechanical filters (drum)	5.280	For holes D = 0,07mm
Aeration pumps	5.150	
UV sterilization	6.438	
Total	64,643	

RESULTS AND DISCUSSIONS

From the diagram in figure 2 it can be seen how the annual energy consumption of the 117,971kWh system consists of:

- energy consumed by recirculation pumps E_P = 42%
- energy consumed by the mechanical filter E_{FM} = 5%
- energy consumed for aeration E_A = 4%
- energy consumed for UV sterilization E_{UV} = 6%
- energy consumed for heating the additive water E_{IA} = 11%
- energy consumed for heating the hall E_{IH} = 32%

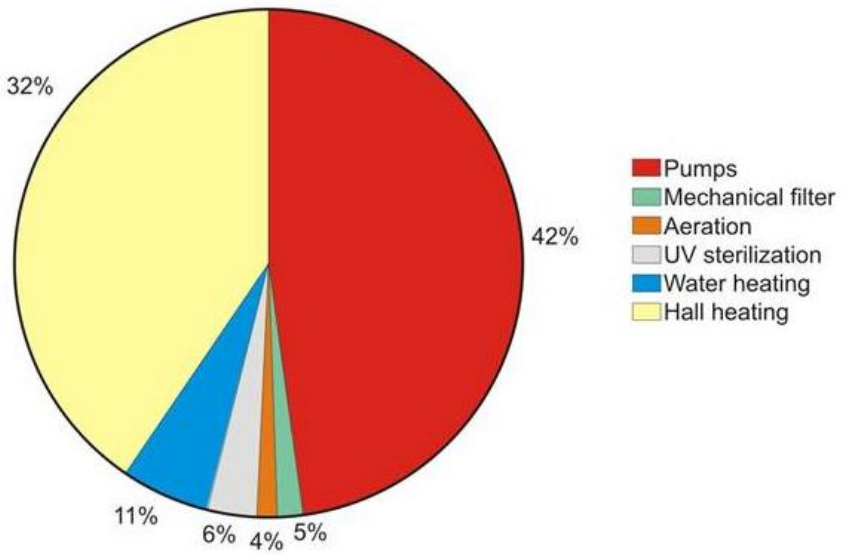

Figure 2. Total annual energy consumption of a recirculating aquaculture system

CONCLUSIONS

Recirculating aquaculture systems have an energy-consuming technology, the energy consumed by the entire recirculating aquaculture system is of two types, namely electricity needed to operate various technological equipment and caloric energy needed to heat and cool the water in the system and the hall where it is located. The most significant percentage of the total energy consumption of a recirculating aquaculture system (approx. 42%) is the energy consumed for water circulation in the system.

This consumption can be reduced by designing recirculating aquaculture systems that require a pumping height as low as possible and by avoiding unnecessary pumping of water but also by judicious design of hydraulic networks. Thermal energy costs (EIA and EIH) also account for a significant share of total energy consumption, approximately 32%.

The reduction of these consumptions can be achieved by diminishing the heat losses by isolating as efficiently as possible the constructions and the external water networks (if it is the case). An energy efficient way to reduce heat consumption is to use alternative energy sources.

BIBLIOGRAPHY

1. Bura M., 2008 – *Manual for the presentation and use of sturgeon breeding technology in a super-intensive system with recirculated water; Ed. EUROBIT Timişoara.*

2. Cristea V., Grecu I., Ceapă C., 2002 – *Engineering of recirculating systems in aquaculture; Didactic and Pedagogical Ed. R.A. Bucharest*.

3. David (Laza) E.-A., 2021 *Studies and research regarding energy efficiency of heat pumps in a recirculating aquaculture system, doctoral thesis.*

4. David P., 2007 – *Scientific substantiation of the water heating / cooling process with heat pumps, in super-intensive fish farming systems* - INMA Bucharest.

5. Losordo M.T., Masser P.M., Rrakoci I., 1999 – *Recirculating aquaculture tank production systems. A review of component opticons*; Southern regional aquaculture center, nr. 453.

6. Masser P.M., Rakocy J., Losordo M.T., 1999 - *Recirculating Aquaculture tank production systems. Management of recirculating systems*; Southern regional aquaculture center, nr. 452.