Microscreens, Efficiencies in Aquaculture Systems

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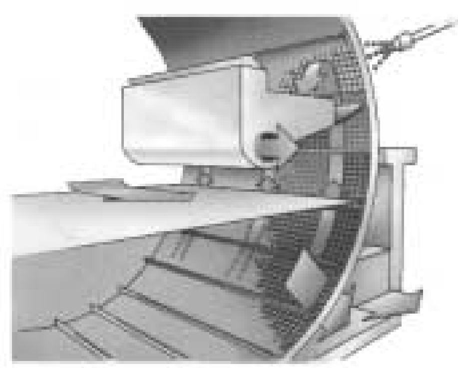
Introduction

Microscreens are mechanical filters with filteropenings from 10-100 μm. Hydrotech microscreens are run by gravitation, which is a gentle and efficient way to remove particles from a waterflow. In aquaculture facilities you often need to treat larger flows of water, Hydrotech has developed filters with capacities up to 1.500 l/s in one unit.

Hydrotech has been in the aquaculture business since 1984 and is therefore well established with extensive experience and a long list of references, with more than 3000 units in operation in farms all over the world. The main products are drum-, disc-, and belt filters. Each line of products is developed for specific applications, extending from very fine filtration, down to only 10 microns, to filters for concentration of sludge.



-Operation of a drumfilter

There are three important applications:

- Inlets to aquaculture systems
- Outlets from aquaculture systems
- Recirculated aquaculture systems (RAS)

The efficiency of a filter is dependent on many factors. Some filters are installed for protection of downstream fish farms against parasites or suspended solids affecting the health of the farmed animals. Others are installed for effluent treatment for reduction of wastes from the farms. In recirculated systems, microscreens are an essential part of integrated purification systems. In this paper, focus will be on filters in RAS, where use of water for cleaning of filter cloth on microscreens, sludge concentration and efficiency in combination with biological filters are important issues.

Hydrotech has it´s own research department that participates in international projects. These projects have been related to development of environmentally friendly systems for fish farming and processing of sludge originating from the production.

Efficiency of Filters

Evaluation of data and recommendation on choice of filters and filter openings has been investigated, and the needs are different according to applications.

Waste from farms is diluted in the large water flows often used for the production. This imposes a problem on proper measurements of parameters such as suspended solids, phosphorous, ammonia and biochemical oxygen demand. The increase through a farm is often in the range of 0,1-15 mg/L, which is difficult to measure with great accuracy. This has impaired collection and quality of data from aquaculture enterprises. A lot of data is therefore needed to prove efficiency on any type of filter. In table 2 data from many farms has been compressed into single figures, but there are of course variations.

Several factors will have an effect on the efficiency of filters, such as feed type and physical conditions, e.g. pond or tank constructions:

Table 1.

Properties	Round tanks	Square, round corners	”Race-ways”
self cleaning effect	5	4	3
residence time of particles	5	4	3
regulation of oxygen	5	5	3
use of space	2	4	5

Ratings from 1-5: 5 is the highest score.

In recirculated systems it´s very important to have high and uniform water quality. Hydrotech and Water Management Technologies(WMT) have investigated, through several projects, how important operational factors are related. Feed used in the system is the common denominator as all other biological and physio-/chemical parameters will be directly correlated to the feed added to the system, e.g. growth, size of biofilter, oxygen consumption etc.

Table 2

Component	Round tanks	"Raceways"	Pond systems
Tot. P	70-80 %	50-70 %	30-50 %
BOD	70-80 %	60-70 %	40-60 %
S.S	80-90 %	60-80 %	40-60 %
Tot. N	20-50 %	20-40 %	20-40 %
NH_3/NH_4	-	-	-

Efficiency of Hydrotech microscreens with 60µ . Above figures are based on data from different farms.

If you choose a pond construction based only on space requirements (Table 1) raceways may be the preferred type, but if self-cleaning properties are considered (Table 2), then it can be seen that the physical properties of tanks or ponds will have an impact on efficiency of downstream filters. The residence time of particles in a round tank is much shorter than in a raceway or pond system. Tests show that particle disintegration will occur very soon after the feces is expelled or a food pellet has been wasted. The special "tea cup" effect will ensure optimum conditions for gentle transport of particles out of the system.

Recirculated Systems (RAS)

This technology is expanding in many countries. There is a need of common terms to be adopted especially on definitions of degree of recirculation. A high degree of recirculation is not an adequate measure on the capacity of any RAS. E.g. if a large volume of water is re-used with a very low stocking density, it can be recirculated without any cleaning, so it appears very efficient with a traditional definition of recirculation:

Degree of recirculation: $(1 - A \div (A+C)) \times 100 = \%$ recirculation

(A is fresh water added to the system(m^3/h), C is recirculated water(m^3/h))

A better design and cost related factor is recommended as a supplement for evaluation of closed systems:

<u>**m^3 fresh water exchange per kg feed**</u>

This factor will reveal more about the technical level of the system. A typical range of closed systems are from 20-500 l of fresh water for per kg of feed added to the system.

Use of Water and Sludge Concentration

Microscreens are part of the treatment process in reuse of water. Some systems are as high as 99,9 % recirculation, changing as little as 20-30 L of water per kg of feed.

Use of water in a Hydrotech drumfilter using different mesh sizes:

Table 3 .

Mesh size, µm	Liter of rinse water per kg of feed
100	50
60	100
30	200

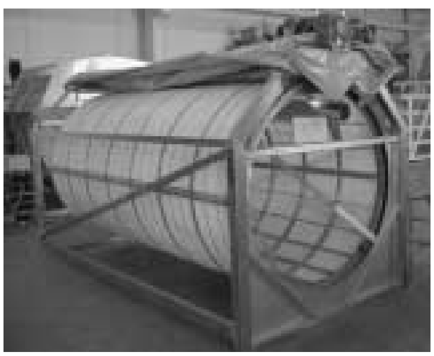
Data from: EC, fair program CT98-9158 Development of a "blue label" for fish farms.

As can be seen from Table 3, further re-use of water must be achieved to reach 20-30 L per kg of feed applied to the system. In some RAS, sludge from microscreens (still quite dillute) is added polymers and drained on beltfilters.

By adding this technology, TSS in resulting sludge is increased from 0,05-0,1 % up to 8 %-12 %.

The filtered water is returned to the system, usually through a de-nitrification unit, which will reduce an otherwise unacceptable high level of nitrate. In some systems without de-nitrification units, water is piped back in front of biological filters.

Picture 1



First step is effluent treatment by drumfilter or discfilter

Picture 2

A mixer tank and a beltfilter for sludge concentration

The amount of sludge is reduced to only a fraction of the usual flow of rinse water from filters. On back-washing of biofilters, the sludge can be treated the same way as from mechanical filters. In most cases the resulting concentrated sludge will be used as fertilizer for distribution on agricultural land.

Biological Filters

Dissolved wastes will not be reduced by microscreens, this is primarily the fraction of organic matters(BOD/COD), which is dissolved, ammonia (NH_4^+/NH_3) and carbon dioxide (CO_2). The first two parameters must be degraded or transformed into harmless residual products in biological filters. Carbon dioxide has to be ventilated in trickling filters or degassed by aeration.

As can be seen from Table 2, a larger portion of wastes are removed by first mechanical step, but special conditions are prevailing in RAS as degraded organic material will be transformed into "biological film", thereby contributing to suspended solids in the system.

In Table 4 efficiency of a microscreen in terms of mass balances in a RAS, has been calculated. :

Table 4.

Parameter	30 micron filter	60 micron filter	100 micron filter
Suspended solids	75 %	36 %	16 %
Total nitrogen	62 %	29 %	14 %
Total phosfor	43 %	39 %	20 %

Removal efficiency of different mesh sizes of a Hydrotech microscreen as a percentage of particulate matter directly originating from feeding. "Blue label" project, Fair-CT-98-9158.

Above data only relates to eel farms, figures may be different on various species! It can be seen that 30 microns is significantly better than coarser screens.

This data is in accordance with former investigations on particle distribution in RAS. If microscreens are part of the system design, turbidity will be low, as well as total amount of SS. But the relative distribution of particles will be in favour of small particles, less than 20 microns. If very low turbidity is needed, fine microscreens or submerged biofilters have to be part of the system. Submerged filters will adsorb the fine fraction of suspended solids, and with proper management, the resulting sludge can be "back-flushed" out of the system. As an alternative, microscreens as low as 10 microns can be installed at filter openings.

Technology has to be Adapted to Farmed Species:

Each combination of technology has to consider water quality demands from the farmed fish species, e.g tilapia are more than happy with more "muddy" water, whereas salmon are very sensitive to particles in the water.

The most important sizing figures in RAS are: BOD, (biochemical oxygen demand), SS (Suspended solids), NO_3 (nitrate), NH_4/NH_3 (ammonia) and CO_2 (carbon dioxide). In Table 5, water quality in different RAS configurations with or without microscreens (+/-) has been evaluated based on experience and knowledge about process design.

If there is a “variable” it means fluctuations, which is not acceptable in a commercial farm. Low, medium and high are considered as relative figures. If you want to farm Tilapia you can accept a high figure on suspended solids, but not on e.g. Ammonia.

Table 5:

Water Quality Parameters					
Type of biofilter	Organic, BOD	Suspended solids, SS	Nitrate, NO_3	Ammonia, NH_3/NH_4	Carbon dioxide, CO_2
Sandfilter:					
+ microscreen 60µ	Low	Low	High	Low	High
- microscreen	Variable	Variable	High	Variable	High
RBC:					
+ microscreen 60µ	Low	Medium	High	Low	Medium
- microscreen	High	High	High	Variable	Medium
Trickling Filter:					
+ microscreen 60µ	Low	Medium	High	Low	Low
- microscreen	High	High	High	Variable	Low
Trickling- + Submerged biofilter:					
+ microscreen 60µ	Low	Low	Medium	Low	Low
- microscreen	Variable	Variable	Medium	Variable	Low
Submerged Biofilter:					
+ microscreen 60µ	Low	Low	Medium	Variable	High
- microscreen	Variable	Variable	Low	Variable	High
Moving bed bio filter: *Microfiltration before biofilter:	Medium	Medium	High	Low	Medium
Moving bed bio filter: Microfiltration before and after biofilter:	Low	Low	High	Low	Medium

* Microscreens are usually an integrated part of systems with moving bed biofilters. 60-80 µ before biological filter and 20 µ after biological filter.

Technical solutions should meet the water quality requirements of farmed aquatic species. Table 5 can be used as a guide to combine mechanical and biological filters to achieve this goal. There are advantages and disadvantages of each type of biological filter, so combinations are therefore often seen. Submerged biofilters and trickling filters in combination is a common choice, the submerged biofilter is efficient for biological degradation of dissolved wastes, but carbon dioxide is not degassed, this is achieved in a downstream trickling filter.

Choice of technology will set the standard of water quality in the fish farm, but only if sizing of each unit is in accordance with production figures, this is the next important step in planning of a successful aquaculture enterprise.