GAIN
Green Aquaculture Intensification

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773330

Valorization of aquaculture side streams
(II) removal of particulate matter from wastewater

Christian Bruckner, Martiña Ferreira Novio, Johan Johansen & Hallstein Baarset

Salten Havbrukspark waister ANFACO CECOPESCA

Welcome to the second part of this unit on the valorisation of aquaculture side streams, prepared by Christian Bruckner, Martiña Ferreira Novio, Johan Johansen & Hallstein Baarset. In part 2 we look in more detail at the removal of particulate matter from wastewater.

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Aquaculture side streams – particulate matter removal via the S3 filter dryer system

For capturing particulate matter, the "S3 filter-dryer system" was developed, including a fine meshed filter cloth (6 µm) capable to remove most particles from aquaculture wastewater, even at high flow rates. Simultaneously the resulting sludge is dried and sanitized efficiently using infrared-vacuum technology. This new system meets the regulatory demand for aquaculture emissions in Norway as a standalone unit.

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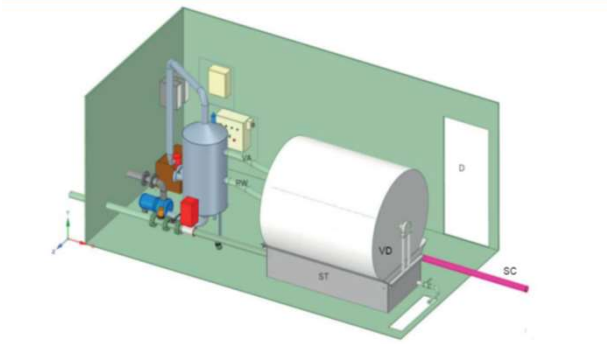

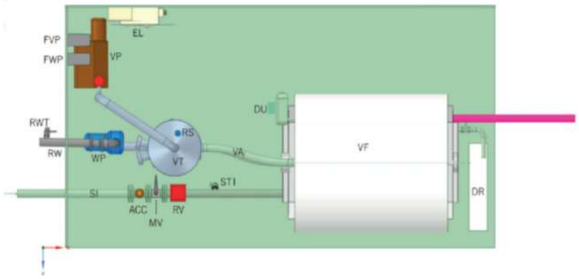

Aquaculture side streams – particulate matter removal

Overview over the most important components of the S3 filter dryer system. Please see the text below for a detailed description. ACC = Activator; BF = Buffer tank; D = Door; DR = Drain; DU = Drive unit; EL = Electrical cabinet; FL = Floor; FVP = Frequency generator vacuum pump; FWP = Frequency generator water pump; KI = Wall; IP = Inlet pipe buffer tank; MV = Manual valve; OF = Overflow pipe; OWV = One-way valve; PP = Pressure clock; PT = Pressure transmitter; RC = Radar sensor; RS = Radar sensor; RV = Regulating valve; RW = Reject water; RWT = Reject water out; SC = Screw conveyor; SI = Sludge in; ST = Sludge tank; STI = Sludge test in; VA = Vacuum air; VB = Vacuum box; VD = Vacuum drum; VF = Vacuum filter; VP = Vacuum pump; VT = Vacuum tank; VV = Vacuum Valve; WP = Water pump;

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This slide provides a detailed sketch of the S3 filter dryer system, with labels showing the main components. In the next two slides we describe briefly the main principles used to purify waste water with the S3 filter dryer.

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Aquaculture side streams – particulate matter removal by the S3 filter-dryer system

- The wastewater enriched in particles by a 0.45 µm drum filter is collected in a big reservoir called the buffer tank. This tank of large capacity is holding the liquid waste before it enters the filtering system.
- The wastewater flows towards the sludge tank, which is a smaller steel tank including a partially submerged rotary drum.
- An agitator homogenizes the wastewater to prevent the solids from settling too rapidly.
- The filter drum, also termed vacuum drum, is covered by a filter cloth with a mesh size of 6 µm, appropriate for collecting sludge from aquaculture.
- A vacuum tank connected to a vacuum pump is located next to the drum to separate air and liquid discharge from the filter. The whole system is therefore exposed to the same under pressure, which is used to suck the wastewater through the filter cloth on the outer surface of the filter drum. The vacuum sucks both liquid and solids onto the surface of the filter cloth. The liquid penetrates through the mesh of the cloth while the solids are retained on the drum surface.
- A drive wheel is used to rotate the drum slowly, which allows the solids to form a filter cake on the drum surface which dries while not in contact with the wastewater.
- The resulting dry sludge is finally scraped off the drum by a knife located on the side of the drum. This "cleaned" part of the filter cloth then re-enters the wastewater and undergoes a new cycle of filter cake build-up/drying/discharge.
- By using vacuum to draw wastewater through the filter cloth, high flow rates can be achieved, in spite of the fine filter mesh size. Further, the filter material has exceptional heat transferability properties, with heat energy recovery rates around 95 % (without considering the energy in the condensate), making very energy-efficient. '
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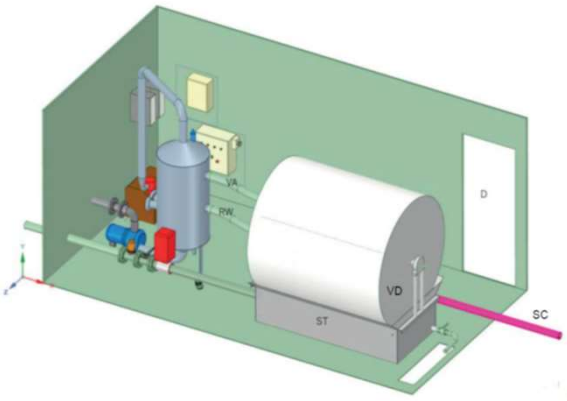

See operation in this video:
https://youtu.be/UD7csMyUVtQ

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The wastewater entering the S3 filter-drier is drawn from a large buffer tank (reservoir) containing the waste output from a 0.45 µm drum filter which is used as the primary filter for the aquaculture system water. This tank of large capacity is holding the liquid waste before it enters the filtering system.
The wastewater flows towards the sludge tank, which is a smaller steel tank including a partially submerged rotating drum.

An agitator homogenizes the wastewater to prevent the solids from settling too rapidly. The filter drum, also termed vacuum drum, is covered by a filter cloth with a mesh size of 6 µm, appropriate for collecting sludge from aquaculture. A vacuum tank connected to a vacuum pump is located next to the drum to separate air and liquid discharge from the filter. The whole system is therefore exposed to the same negative pressure, which is used to suck the wastewater through the filter cloth of the filter drum. The vacuum sucks both liquid and solids onto the surface of the filter cloth. The liquid penetrates through the mesh of the cloth while the solids are retained on the drum surface.

A drive wheel is used to rotate the drum slowly, which allows the solids to form a filter cake on the drum surface which dries while not in contact with the waste water. The resulting dry sludge is finally scraped off the drum by a knife located on the side of the drum. This "cleaned" part of the filter cloth then re-enters the waste water and undergoes

a new cycle of filter cake build-up/drying/discharge.

By using a vacuum to draw wastewater through the filter cloth, high flow rates can be achieved in spite of the fine filter mesh size. Furthermore, the filter material has exceptional heat transfer properties, with heat energy recovery rates around 95 % (without considering the energy in the condensate), making it very energy-efficient.

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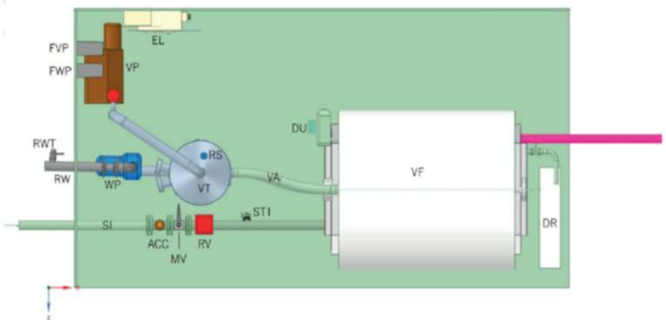
Aquaculture side streams – particulate matter removal by the S3 filter-dryer system



- For keeping a constant vacuum, the filter cake on the filter cloth needs to be airtight and to act as a seal, while the vacuum sucks the moisture off the filter cake. The remaining moisture in the dried sludge is actually 6 % – 9 % when it gets discharged from the cloth, depending on wastewater characteristics.
- The resulting sludge product is carried away by a screw conveyor for further processing.
- Water and air are passing the filter cloth flow through internal pipes towards the vacuum tank, where the purified water is discharged.
- The different components are monitored by sensors and controllers ensuring highest grade of smooth and consistent automated operation. Liquid levels are measured by radar level sensor in the buffer tank, sludge tank and vacuum tank. The respective data are transmitted to a controller unit, which adjust liquid levels within the pre-set of desired ranges. The sensor in the buffer tank interacts additionally with the vacuum pump controller, which vice versa adjusts the intensity of the vacuum to optimize the water flow through the filter cloth. The sensor in the sludge tank interacts with a regulating valve situated at the inlet side of the sludge tank. The opening of the valve is adjusted according to the liquid level in the sludge tank. The sensor in the vacuum tank interacts with the water pump controller, regulating the water pump to adjust the water flow and to keep a constant level in the vacuum tank. Additionally a pressure sensor in the vacuum tank is used as a controlling device to monitor the negative pressure inside the vacuum tank.

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The resulting sludge product is carried away by a screw conveyor for further processing.
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The different components are monitored by sensors and controllers to ensure smooth and consistent automated operation. Liquid levels are measured by radar level sensors in the buffer tank, sludge tank and vacuum tank. The respective data are transmitted to a controller unit, which adjusts liquid levels within desired range pre-sets. The sensor in the buffer tank interacts additionally with the vacuum pump controller, which adjusts the intensity of the vacuum to optimize the water flow through the filter cloth. The sensor in the sludge tank also interacts with a regulating valve situated at the inlet side of the sludge tank. The opening of the valve is adjusted according to the liquid level in the sludge tank. The sensor in the vacuum tank interacts with the water pump controller, regulating the water pump to adjust the water flow and to keep a constant level in the vacuum tank. Additionally a pressure sensor in the vacuum tank is used as a controlling device to monitor the negative pressure inside the vacuum tank.

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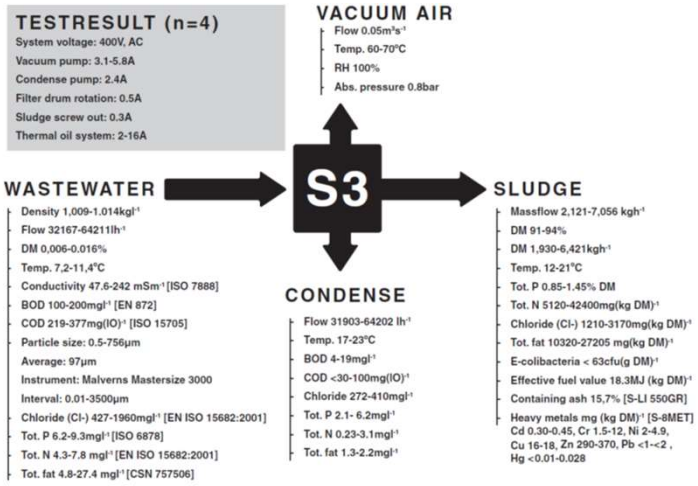

Summary of the main achievements and technical characteristics of the S3 filter system. Wastewater = smolt production wastewater enriched in particles by a 45µm drum filter; Abs = Absolute; AC = Alternating current; BOD = Biochemical oxygen demand; COD = Chemical oxygen demand; Condense = Purified wastewater; DM (I) = Dry matter content; DM (II) = production rate of dried sludge; RH = Relative humidity; sludge = Accumulate particles removed from wastewater; Temp = Temperature; Tot. = Total;

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The slide contains a summary of the performance and technical characteristics of the S3 filter system with respect to inflow water quality and resulting outflows of air, filtered water and sludge.

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Aquaculture side streams – particulate matter removal by the S3 filter-dryer system

- DM content of the sludge produced by the S3 system ranges between 91 % and 94 %, depending on wastewater characteristics.
- This exceeds by far the DM content achieved by classical 45 µm drum filter systems, producing sludge with typical DM contents between 0.1 % and 5 %.
- The S3 system can be applied as a standalone unit not only to filter aquaculture wastewater efficiently, but to produce in parallel a dry and sanitized, stable sludge product.

S3 filterdryer demonstration unit as produced by Salten Havbrukspark/LS Optics AB. Right frame show the details of the filter during change of filter cloth. See https://youtu.be/UD7csMyUVtQ for operation.

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Here we summarise the achievements of the S3 filter-dryer system:

The Dry Matter content of the sludge produced by the S3 system ranges between 91 % and 94 %, depending on wastewater characteristics.

This exceeds by far the Dry Matter content achieved by classical 45 µm drum filter systems, which produce sludge with typical Dry Matter contents between 0.1 % and 5 %.

The S3 system can be applied as a standalone unit, not only to filter aquaculture wastewater efficiently, but to produce in-parallel a dry and sanitized, stable sludge product.