Simon Pedersen and Torsten Wik

Department of Signals and Systems
CHALMERS UNIVERSITY OF TECHNOLOGY
pesimon@chalmers.se

SIMULATION OF RECIRCULATING AQUACULTURE PLANTS

Recirculating aquaculture is the practice of farming aquatic species such as fish in tanks or basins on land with integrated water treatment.

Benefits over traditional farming:

- ✚ Reduced nutrient emissions
- ✚ Less risk of infections
- ✚ Reduced catch of wild fish
- ✚ Temperature and light control
- 〓 Environmentally friendly fish production

Despite this, recirculating aquaculture systems are not yet common.

Plant design is complicated by:

- ━ Complex system dynamics
- ━ Very high stiffness
- ━ Lack of sensors for most variables
- 〓 Difficult to predict behavior

The water treatment system consists of

1) A number of bioreactors, in which micro-organisms degrade the unwanted material.
2) A filter to remove particulate feed loss and feces.
3) Pumps and air compressors, which are the main energy consumers.
4) Other auxiliary equipment (e.g. disinfection)

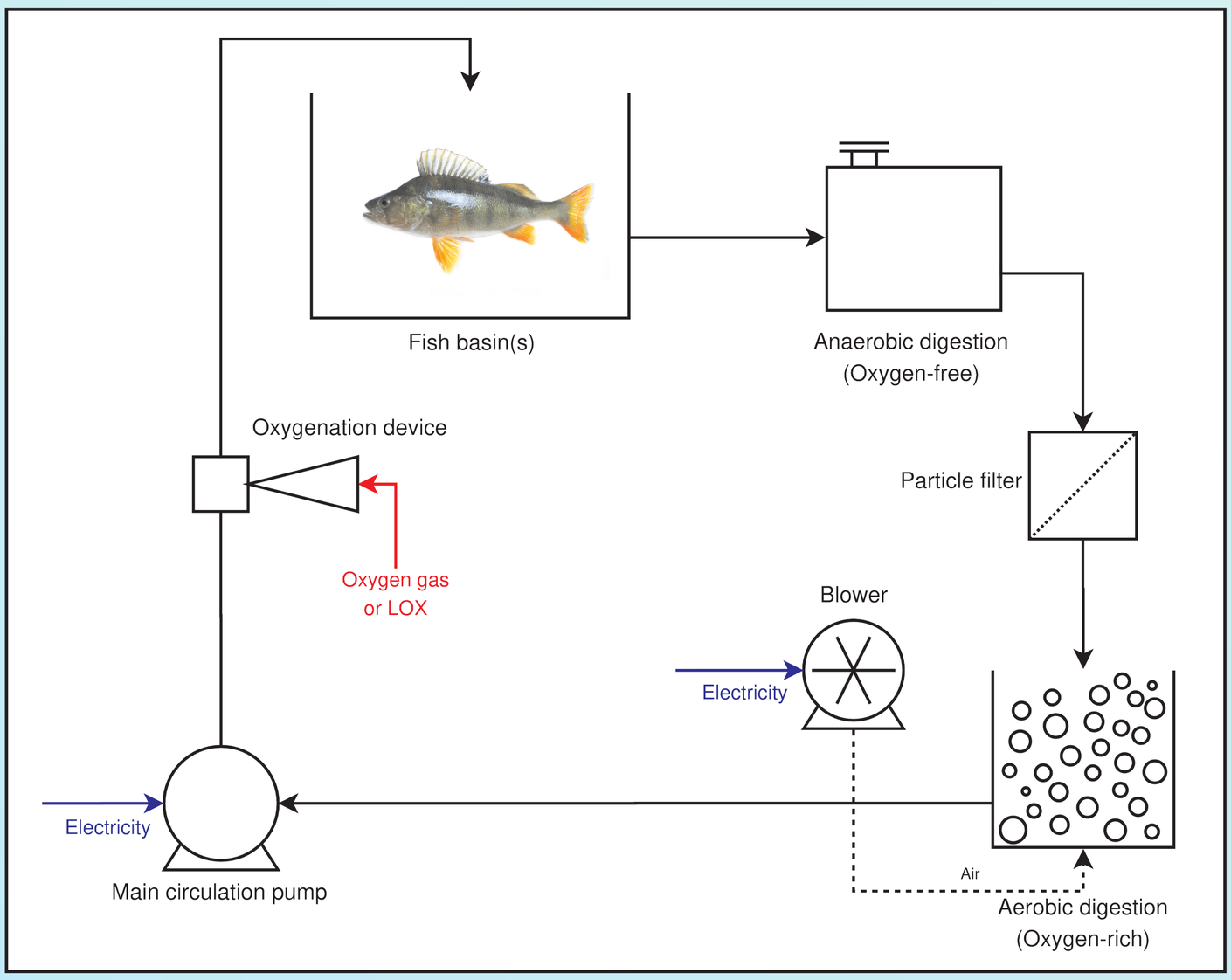

Figure 1: Principal drawing of a recirculating aquaculture system.

As the system is biological in nature, it has time constants on the order of months (and on second-scale, too!) and with large natural variations. As such it is difficult and expensive to perform experiments. A simulator would therefore be very useful in developing recirculating aquaculture systems. Two marine species have been identified to be of particular interest for Sweden:

Wolffish (Citron / CC-BY-SA-3.0)

European lobster

Promising as they may be, recirculating aquaculture systems must be profitable to be of commercial interest. Electricity is, next to feed, one of the largest expenses in operating a recirculating farm. Minimizing energy use, or more generally costs, is thus of great importance for the future of recirculating aquaculture.

Can we simulate and optimize recirculating aquaculture systems?

- Bioreactors are non-linear (30 states)
- Fish are (hopefully?) simple: 2nd order sys.
- Mass transfer and chemical equilibria
- Energy equipment (pumps, blowers, heaters, chillers)

Yes we can!

Simulation has been shown to work previously but the implementation suffered from numerical issues. Its bioreactor models are now converted to Modelica code.

Goals

A robust and flexible simulator that can be used by researchers, operators and plant designers, leading to

- New, stable and robust designs
- Optimal sizing of components
- Improved operation strategies
- Reduced cost and use of resources

CHALMERS