AQS415 PRINCIPLES OF AQUACULTURE ENGINEERING

Week 7. Culture tank engineering

Cost savings have been achieved in the production of food fish with the use of large tank based systems and enhanced production management strategies. Substantial savings in both capital and labor costs can also be realized by shifting production into fewer but larger culture tanks. Our experience has been that the labor needed to care for a tank is somewhat independent of the tank size, i.e. it takes the same amount of time to analyze water quality, distribute feed, and perform cleaning chores for 1 m^3 or 100 m^3 tanks. Also, capital costs of tanks per unit volume greatly decrease as size is increased. These advantages must be balanced against difficulties that could arise within large culture tanks, such as:

- distributing flow to obtain uniform mixing and rapid solids removal;
- grading and harvesting fish;
- removing mortalities;
- isolating the biofilter while treating the fish with a chemotherapeutant;
- risk of larger economic loss per tank failure due to mechanical or biological reasons.

Of particular concern is the risk of failure because tanks typically fail as units. The more fish in a tank, the bigger the economic loss that will occur when a tank fails. However, as the experience of the management and design team increases, the risk of tank failure decreases, but should never be ignored.

Large tanks are more critically dependent upon tank hydraulic design than small tanks, because in small tanks, ≤1 m^3, the overall rate of water exchange tends to be rapid. The rapid hydraulic exchange results in reasonably good water quality, because the high turnover rate carries more oxygen into the tank and rapidly flushes wastes. Conversely, in large tanks, the hydraulic retention time tends to be lower and, as a result, the inlet and outlet injection methods and flow rate become dominant factors affecting the uniformity of water conditions in the tank (aside from the feed loading rate). The carrying capacity of a tank is influenced by water exchange, feeding rate, oxygen consumption, and waste production. Tanks used for intensive fish culture are of varied shape and flow pattern. Tanks are designed with considerations for production cost, space utilization, water quality maintenance, and fish management. There is a definite trend towards large circular culture tanks for food fish production. Tanks >10 m in diameter, which used to be referred to as pools, are now reasonable choices for culture systems in intensive indoor operations. Circular tanks are attractive for the following reasons:

- simple to maintain;
- provide uniform water quality;
- allow operating over a wide range of rotational velocities to optimize fish health/condition;
- settleable solids can be rapidly flushed through the center drain;
- permit designs that allow for visual or automatic observation of waste feed to enable satiation feeding.

The water inlet and outlet structures and fish grading and/or removal mechanisms should be engineered to reduce the labor requirement for fish handling and to obtain uniform water quality, rotational velocities, and solids removal within the circular tank.

The self-cleaning ability is a key advantage of circular tanks. Recommended tank diameter to depth ratios vary from 5:1 to 10:1 even so, many farms use tanks with diameter:depth ratios as low as 3:1 and circular silo tanks use diameter:depth ratios on the order of 1:3.

Selection of a tank diameter:depth ratio is also influenced by factors such as the cost of floor space, water head, fish stocking density, fish species and fish feeding levels and methods. Choices of depth should also consider ease of workers handling fish within the tank and safety issues of working in waters that may be more than `chest' high.

Circular tanks can approach relatively complete mixing, i.e. the concentration of a dissolved constituent in the water flowing into the tank changes instantaneously to the concentration that exists throughout the tank. Therefore, if adequate mixing can be achieved, all fish within the tank are exposed to the same water quality. Good water quality can be maintained throughout the circular culture tank by optimizing the design of the water inlet structure and by selecting a water exchange rate so that the limiting water quality parameter does not decrease production when the system reaches carrying capacity.

The rotational velocity in the culture tank should be as uniform as possible from the tank wall to the center and from the surface to the bottom, and it should be swift enough to make the tank self-cleaning. However, it should not be faster than that required to exercise the fish. Water velocities of 0.5–2.0 times fish body length s^{-1} are optimal for maintaining fish health, muscle tone, and respiration. Velocities required to drive settleable solids to the tank's center drain should be greater than 15–30 cm s^{-1} . For tilapia, an upper current speed of 20–30 cm s^{-1}.

Circular tanks are operated by injecting water flow tangentially to the tank wall at the tank outer radius so that the water spins around the tank center, creating a primary rotating flow.

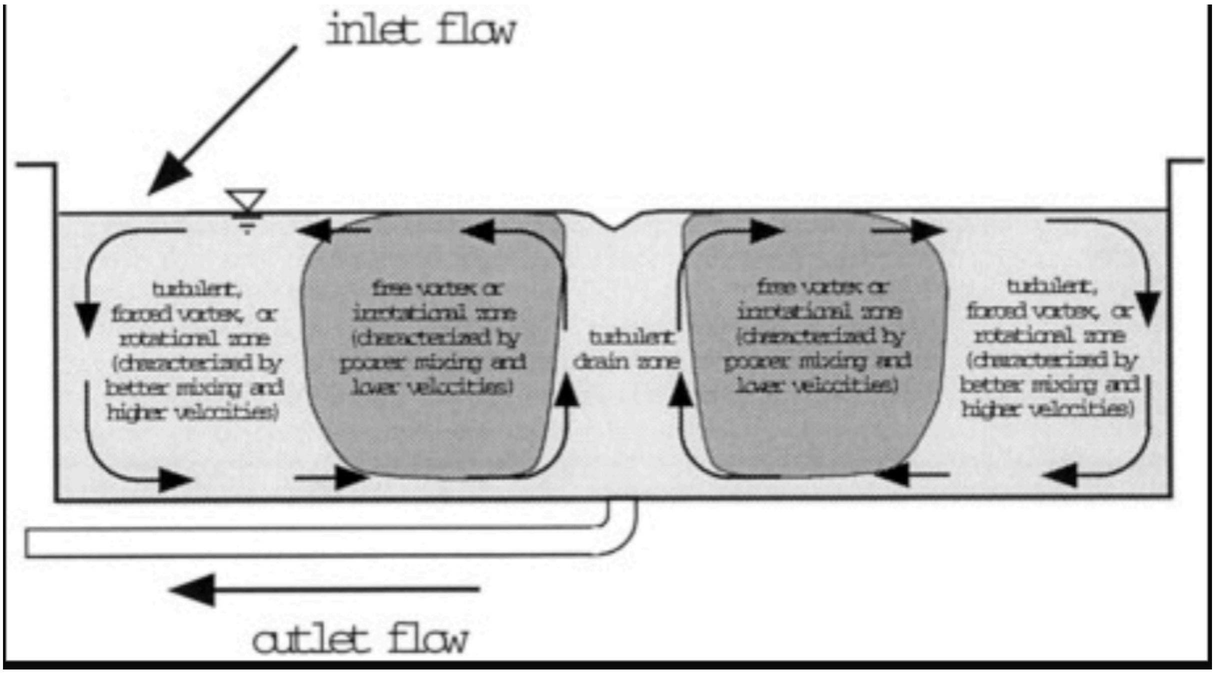

Fig 6.1.Flow directions in the tank systems (Timmons et al 1998)