AQS415 PRINCIPLES OF AQUACULTURE ENGINEERING

Week 1.

Aquaculture engineering

During the past few years there has been considerable growth in the global aquaculture industry. Many factors have made this growth possible. One is development within the field of aquaculture engineering, for example improvements in technology allowing reduced consumption of freshwater and development of re-use systems. Another is the development of offshore cages: sites that until a few years ago not were viable for aquaculture purposes can be used today with good results. The focus on economic efficiency and the fact the salaries are increasing have also resulted in the increased use of technology to reduce staff numbers. The development of new aquaculture species would not have been possible without the contribution of the fisheries technologist. Even if some techniques can be transferred for the farming of new species, there will always be a need for technology to be developed and optimized for each species. An example of this is the development of production tanks for flatfish with a larger bottom surface area than those used for pelagic fish.

Aquaculture engineering covers a very large area of knowledge and involves many general engineering specialisms such as mechanical engineering, environmental engineering, materials technology, instrumentation, and monitoring, and building design and construction. The primary aim of aquaculture engineering is to utilize technical engineering knowledge and principles in aquaculture and biological production systems.

Basics of Aquaculture

Definition:

The word ‘aquaculture’, though used rather widely for the last two decades to denote all forms of culture of aquatic animals and plants in fresh, brackish and marine environments, is still used by many in a more restrictive sense. For some, it means aquatic culture other than fish farming or fish husbandry, whereas others understand it as aquatic farming other than mariculture. It is also sometimes used as a synonym for mariculture. However, the

term aquaculture is sufficiently expressive and all-inclusive. It only needs a clarification that it does not include the culture of essentially terrestrial plants (as, for example, in hydroponics)

or of basically terrestrial animals. However, when it needs to be used to denote

1. the type of culture techniques or systems (e.g. pond culture, raceway culture, cage culture, pen culture, raft culture),
2. the type of organism cultured (e.g. fish culture or fish husbandry, oyster, mussel, shrimp or seaweed

culture),

3. the environment in which the culture is done (e.g. fresh water, brackish water, salt water or marine aquaculture or mariculture) or
4. a specific character of the environment used for culture (e.g. cold-water or warm-water aquaculture; upland, low land, inland, coastal, estuarine), the use of restrictive terms would probably be more appropriate.

The rationale of aquaculture

Aquaculture is not limited merely to socio-economic and marketing advantages. There are also scientific principles that weigh very much in favour of aquatic farming of fish and shellfish. It is a relatively efficient means of producing animal protein which can compare very favourably with poultry, pork and beef in the economies of production, when appropriate species and techniques are adopted. Poikilothermic (cold-blooded) animals, especially fish, have relatively low energy requirements, as they do not spend any energy for the maintenance of a constant body temperature and the energy spent for routine locomotory activity is normally low. Since the specific gravity of their bodies is nearly the same as that of the water they inhabit, loss of energy in supporting themselves is minimal. These advantages result in higher growth rates and greater production per unit area, taking full benefit of the three-dimensional nature of water bodies. Filter-feeding sessile shellfish, such as oysters and mussels, spend very little energy in obtaining their food. Fish are highest on the comparative list in terms of gross body weight gain and high in terms of protein gain per unit of feed intake. When fed balanced diets under favourable environmental conditions, the feed conversion ratio (wet weight gain per unit of dry feed intake) has been found to be in the range 1 : 1 to 1 : 1.25. The protein efficiency ratio (weight gain per unit of protein intake) is either equal to or higher than that for poultry and higher than for swine, sheep and steers (Hastings and Dickie, 1972). Fish are able to utilize high levels of protein in the diet, whereas in poultry almost one-half of the amino acids are deaminated and lost for protein synthesis. A weanling pig may lose as much as two-thirds of the amino acids through deamination. The absolute economics of a culture system depend very much on the species, production technology and market conditions. Basically, low trophic feeders can generally be raised at lower costs than those which are high in the food chain and which thus require a higher proportion of proteins, particularly animal proteins.

Current Status of Aquaculture

Global aquaculture has grown dramatically over the past 50 years to around 52.5 million tonnes (68.3 million including aquatic plants) in 2008 worth US$98.5 billion (US$106 billion including aquatic plants) and accounting for around 50 per cent of the world's fish food supply. Asia dominates this production, accounting for 89 per cent by volume and 79 per cent by value, with China by far the largest producer (32.7 million tonnes in 2008). The rapid growth in this region has been driven by a variety of factors, including pre-existing aquaculture practices, population and economic growth, relaxed regulatory framework and expanding export opportunities. The FAO data on aquaculture is presented in Table 1.

TABLE 1
WORLD FISHERIES AND AQUACULTURE PRODUCTION, UTILIZATION AND TRADE[1]

	1986–1995	1996–2005	2006–2015	2016	2017	2018
	Average per year					
	(million tonnes, live weight)					
Production						
Capture						
Inland	6.4	8.3	10.6	11.4	11.9	12.0
Marine	80.5	83.0	79.3	78.3	81.2	84.4
Total capture	**86.9**	**91.4**	**89.8**	**89.6**	**93.1**	**96.4**
Aquaculture						
Inland	8.6	19.8	36.8	48.0	49.6	51.3
Marine	6.3	14.4	22.8	28.5	30.0	30.8
Total aquaculture	**14.9**	**34.2**	**59.7**	**76.5**	**79.5**	**82.1**
Total world fisheries and aquaculture	**101.8**	**125.6**	**149.5**	**166.1**	**172.7**	**178.5**
Utilization[2]						
Human consumption	71.8	98.5	129.2	148.2	152.9	156.4
Non-food uses	29.9	27.1	20.3	17.9	19.7	22.2
Population (*billions*)[3]	5.4	6.2	7.0	7.5	7.5	7.6
Per capita apparent consumption (*kg*)	13.4	15.9	18.4	19.9	20.3	20.5
Trade						
Fish exports – in quantity	34.9	46.7	56.7	59.5	64.9	67.1
Share of exports in total production	*34.3%*	*37.2%*	*37.9%*	*35.8%*	*37.6%*	*37.6%*
Fish exports – in value (*USD billions*)	37.0	59.6	117.1	142.6	156.0	164.1