DISTRIBUTION OF VELOCITIES IN AQUACULTURE CIRCULAR TANKS WITH ROTATING FLOW AND EVALUATION OF UNIFORMITY

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Introduction

Control of velocities in aquaculture tanks is very important, since fish need certain velocities for maintaining general health and also a minimum velocity is needed to eliminate biosolids. In circular tanks or rectangular tanks with rotating flow, where water is injected tangentially to the tank wall, the average velocity is controlled by the impulse force *Fi* (Equation 1) and affected by flow rate and water velocity inlet (Tvinnereim and Skybakmoen, 1989; Oca and Masaló, 2007a). The flow discharged through the outlet placed at the center of the tank bottom, generates a free vortex in the inner region of the tank (Paul et al, 1991; Fisher and Flack, 2002).

$$F_i = \rho Q(V_2 - V_1)$$ Equation 1

Where ρ is the density of water, Q the flow rate and V_1 and V_2 the mean circulating velocity in the tank and the jet velocity from the inlet respectively.

Besides control of velocities, a homogeneous velocities distribution inside the tank is desired, in order to promote the optimal use of water volume in the tank. Oca and Masaló (2007b) used a Distribution Uniformity (DU_{50}) (Equation 2) as a measure of the uniformity of velocities.

$$DU_{50} = \frac{V_{50}}{V_1} \times 100$$ Equation 2

Where V_{50} is the mean circulation velocity of 50% area with lower values.

In a particular tank with rotating flow, high DU_{50} is desired, since it indicates greater uniformity of velocities and more homogeneous conditions inside the tank.

The aim of this work is to evaluate the differences in velocities distribution and in uniformity of velocities (DU_{50}) produced in two circular tanks with identical water inlet configuration, but changing impulse forces (*Fi*).

Materials and methods

Experiments were carried out using two circular tanks, one 98cm diameter (D) and 30cm water depth (h) (D/h: 3.27) and another one 148cm diameter and 50cm water depth (D/h: 3.00).

Water inlet consisted on a single jet placed at a mid water depth introducing water tangentially to the wall. In order to obtain different impulse forces, flow rate and inlet diameter where changed between configurations (see equation 1).

For each configuration, velocities were measured only in an axis of the tank at mid water depth, using an Acoustic Doppler Velocimeter (Figure 1).

Average velocity magnitude (V_1) was calculated for each configuration. The distribution of velocities inside the tank were represented, and DU_{50} was calculated using Equation 2. The average velocity in the tank (Equation 3) was obtained by pondering the velocity measurements by the distance from the centre of the tank to the measurement point.

$$V_1 = \frac{\sum_{i=1}^{N} V_i \cdot r_i}{R}$$ Equation 3

Where: V_i is the velocity obtained in each point with the ADV, r_i is the distance respect to the center of the tank, and R is the tank radius.

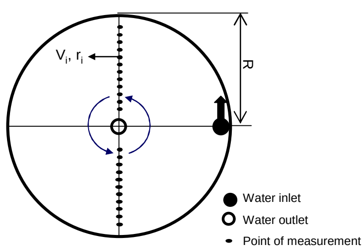
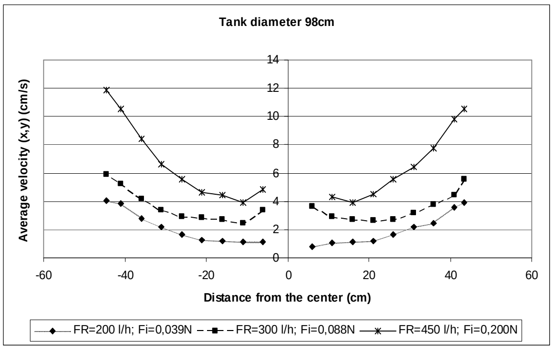
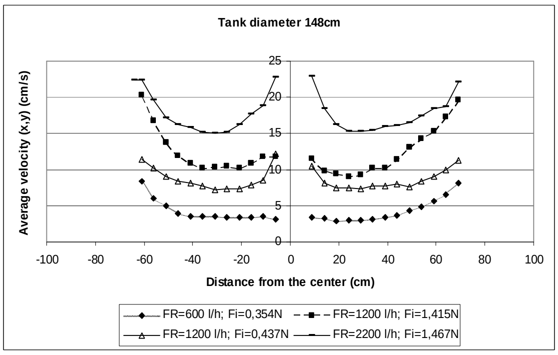


Figure 1: Points of measurement.

Results and Discussion





Tank 98cm diameter		
FR (l/h)	*Fi* (N)	DU_{50} (%)
200	0.039	58.82
300	0.088	73.29
450	0.200	65.83

Tank 148 cm diameter		
FR (l/h)	*Fi* (N)	DU_{50} (%)
600	0.354	65.60
1200	1.415	74.32
1200	0.437	84.62
2200	1.467	86.94

Figure 1 : Average velocity magnitude (x,y) obtained along the longitudinal axis with the 98cm diameter tank.

Figure 2 : Average velocity magnitude (x,y) obtained along the longitudinal axis with the 148cm diameter tank.

Velocities in the inner region of the tank (around the outlet) increased with the flow rate in both tanks, and were not determined by the impulse force. Nevertheless, velocities in the outer region were strongly related with the impulse force.

Also in the present work it has been observed that high differences between velocities in the outer and inner region of the tank showed a decrease in uniformity. For example, configurations with similar *Fi* (1.415 and 1.467, Figure 2) but different flow rates (1200 and 2200 l/h, respectively) showed differences in DU_{50} (74.32% and 86.94%, respectively). This is related with differences between velocities in the outer and inner region of the tank. Configuration with 1200 l/h showed lower velocities in the inner region than those obtained with 2200 l/h, meanwhile velocities obtained in the outer region were similar for both configurations. This fact indicates that velocities achieved in the outer region depend on impulse force, and velocities obtained in the inner region depend on flow rate, as has been indicated before.

Conclusions

In circular tanks, where water is injected tangentially to the wall, flow rate has a great influence on water velocities in the inner region of the tank, indicating that free vortex generation depends strongly on this parameter; but velocities in the outer region of the tank seems to depend on the water inlet velocity and flow rate (impulse force). Best uniformities are obtained when velocities in the inner (around outlet) and outer (close to the wall) region of the tank are similar.

Acknowledgments

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