INFLUENCE OF THE FLOW RATE RATIO IN A JET PUMP ON THE SIZE OF AIR BUBBLES

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Contents

Abstract

- JET PUMPS ARE DEVICES THAT USE AIR BUBBLES AND ARE WIDELY USED IN WASTEWATER TREATMENT PROCESSES.
- THE OBJECTIVE OF THIS WORK IS TO STUDY EXPERIMENTALLY THE CHARACTERISTICS OF THE JET PUMP AND THE SIZE OF AIR BUBBLES IN THE LABORATORY WATER TANK.
- THE EFFECT OF FLOW RATE RATIO ON PUMP PERFORMANCE IS INVESTIGATED IN ORDER TO HAVE A BETTER UNDERSTANDING ABOUT PUMP BEHAVIOR UNDER VARIOUS CONDITIONS, IN ORDER TO DETERMINE THE EFFICIENCY OF RECEIVING AIR BUBBLES DIFFERENT SIZES.
- THIS STUDY WILL HELP IMPROVE AND EXTEND THE USE OF THE JET PUMP IN MANY PRACTICAL APPLICATIONS.

INTRODUCTION

- AMONG THESE WORKS, INVESTIGATIONS WERE FOCUSED ON BUBBLE SIZE.
- IN THE CURRENT RESEARCH PROJECT WE STUDIED PHENOMENA REGARDING THE INFLUENCE OF THE FLOW RATE RATIO IN THE JET PUMP, ON THE SIZE OF THE AIR BUBBLES IN THE WATER TANK.
- IN THIS STUDY EXPERIMENTS WERE BASED ON AN IMPROVED CONSTRUCTION OF THE JET PUMP.
- THE EXPERIMENTAL SETUP WAS BUILT IN THE HYDRAULICS LABORATORY OF

  SCE - SHAMOON COLLEGE OF ENGINEERING, IN ISRAEL.
- THE OBJECTIVES OF THE PRESENT STUDY WERE TO CONSTRUCT A JET PUMP AND DEVICE FOR RECEIVING DIFFERENT SIZES OF AIR BUBBLES, AND TO STUDY THE BEHAVIOR OF MULTIPHASE WATER FLOW WITH INCLUSION OF AIR FOR DIFFERENT FLOW RATIOS.
- THE PRESENT STUDY CONTINUES TO DEVELOP OUR PREVIOUS INVESTIGATIONS.

Experimental Apparatus

1. Tank
2. Pump
3. Throttle Valve
4. Flow meter
5. Manometer
6. Jet Pump
7. Throttle Valve
8. Thermo-anemometer
9. Vacuum gauge
10. Pitot tube
11. Pressure sensor
12. Digital canera

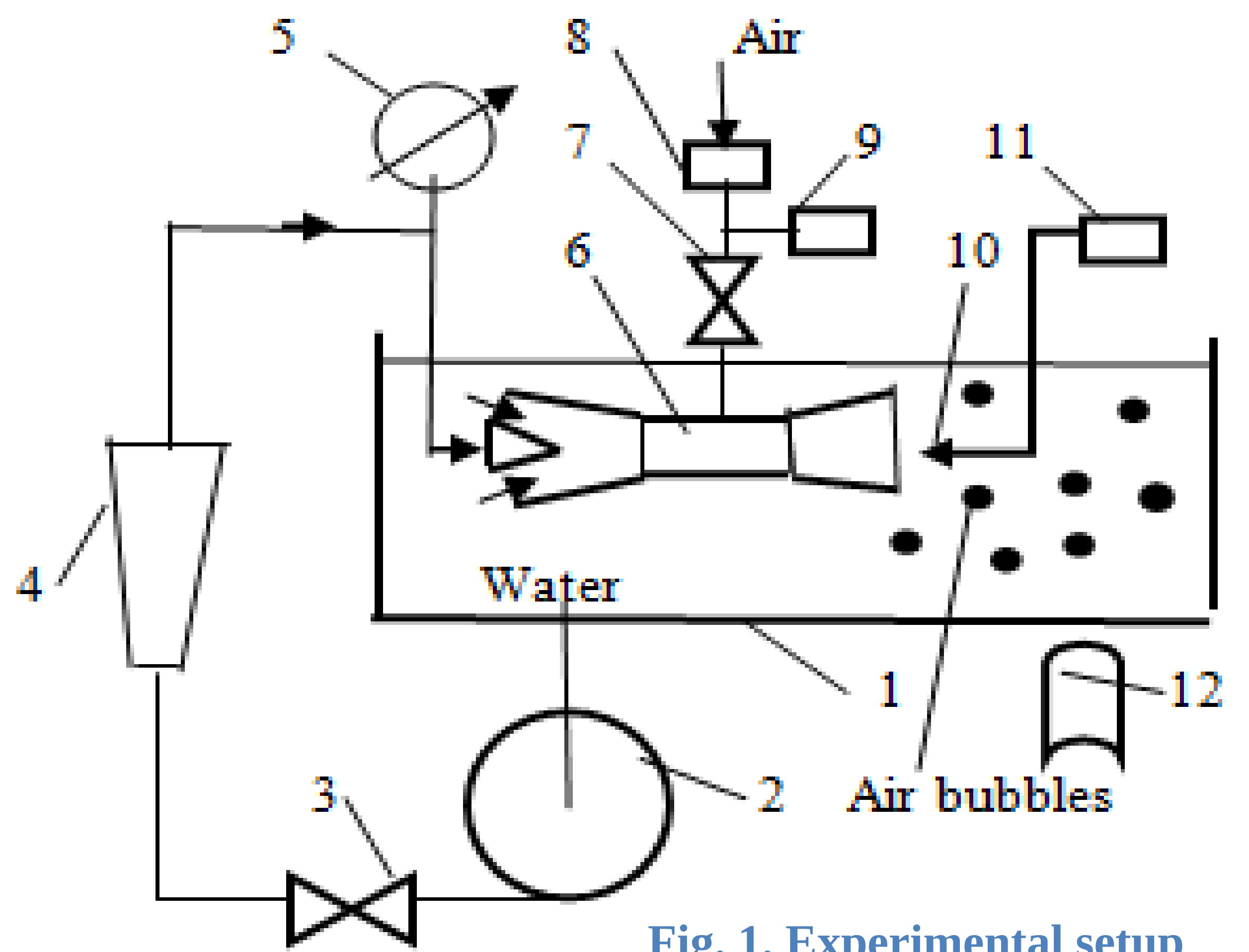

Fig. 1. Experimental setup

Experimental Apparatus

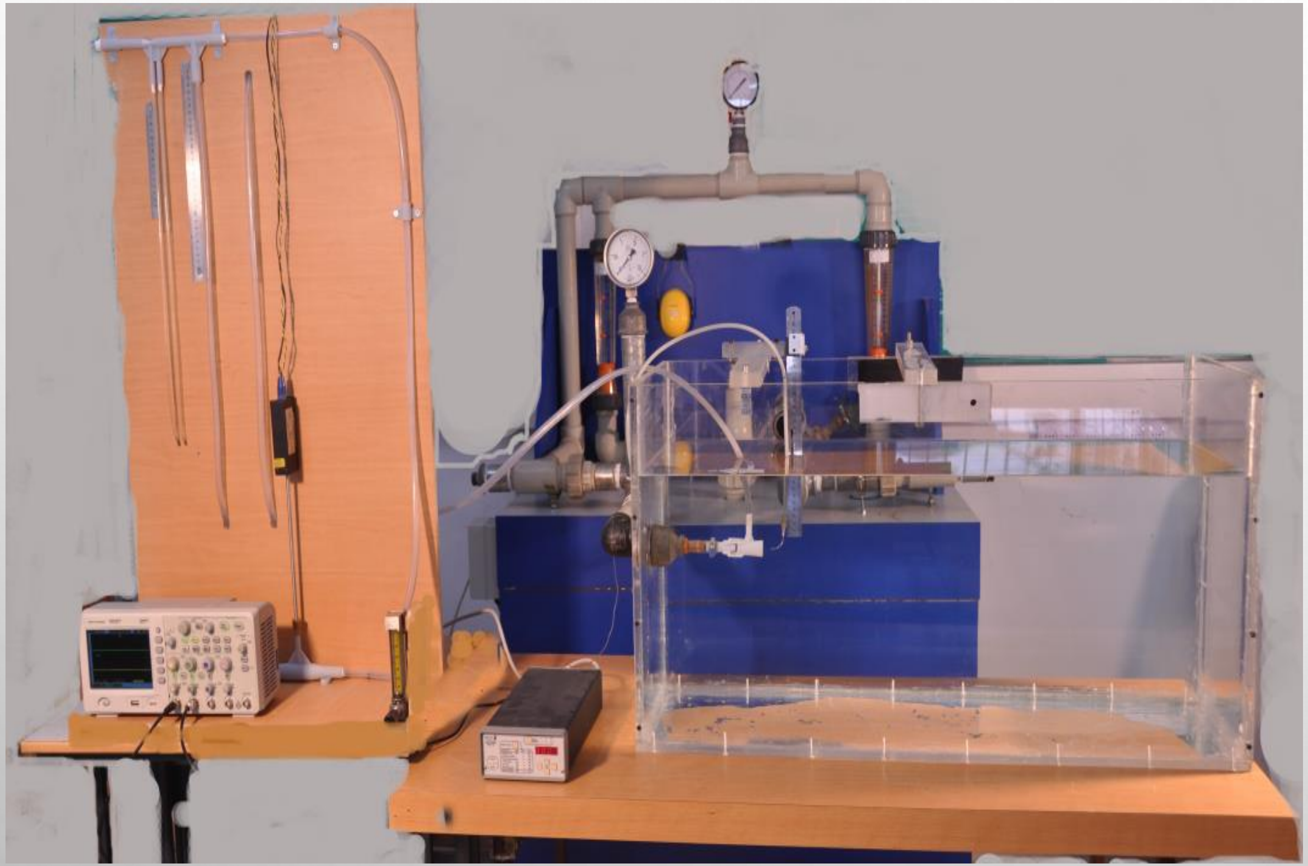

Fig. 2. Model of a laboratory rig

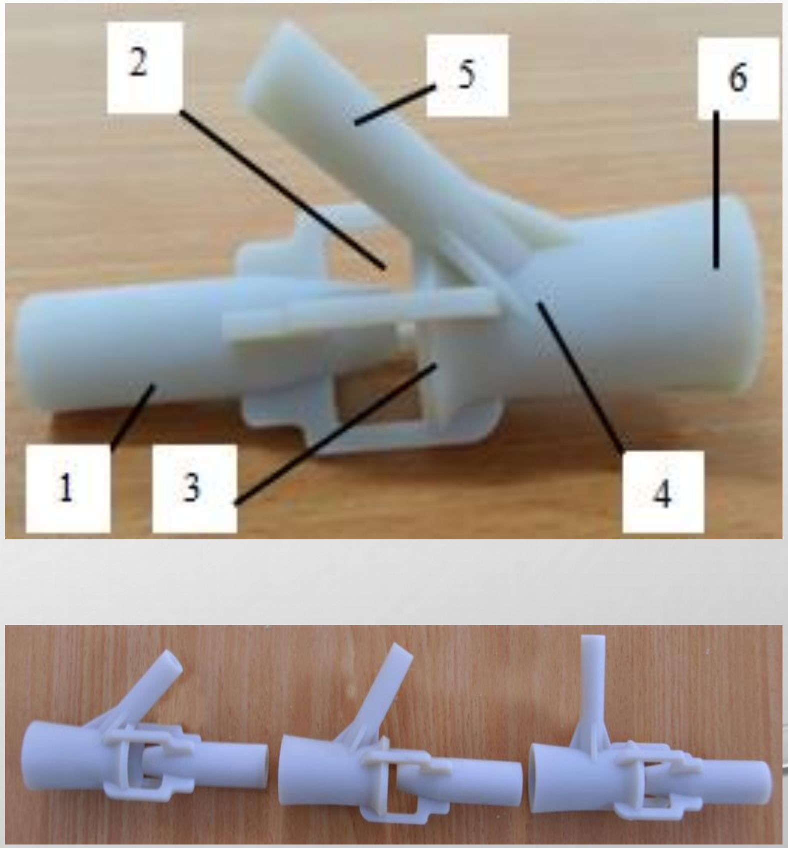

Fig. 3. Photographs of jet pumps

EXPERIMENTAL RESULTS

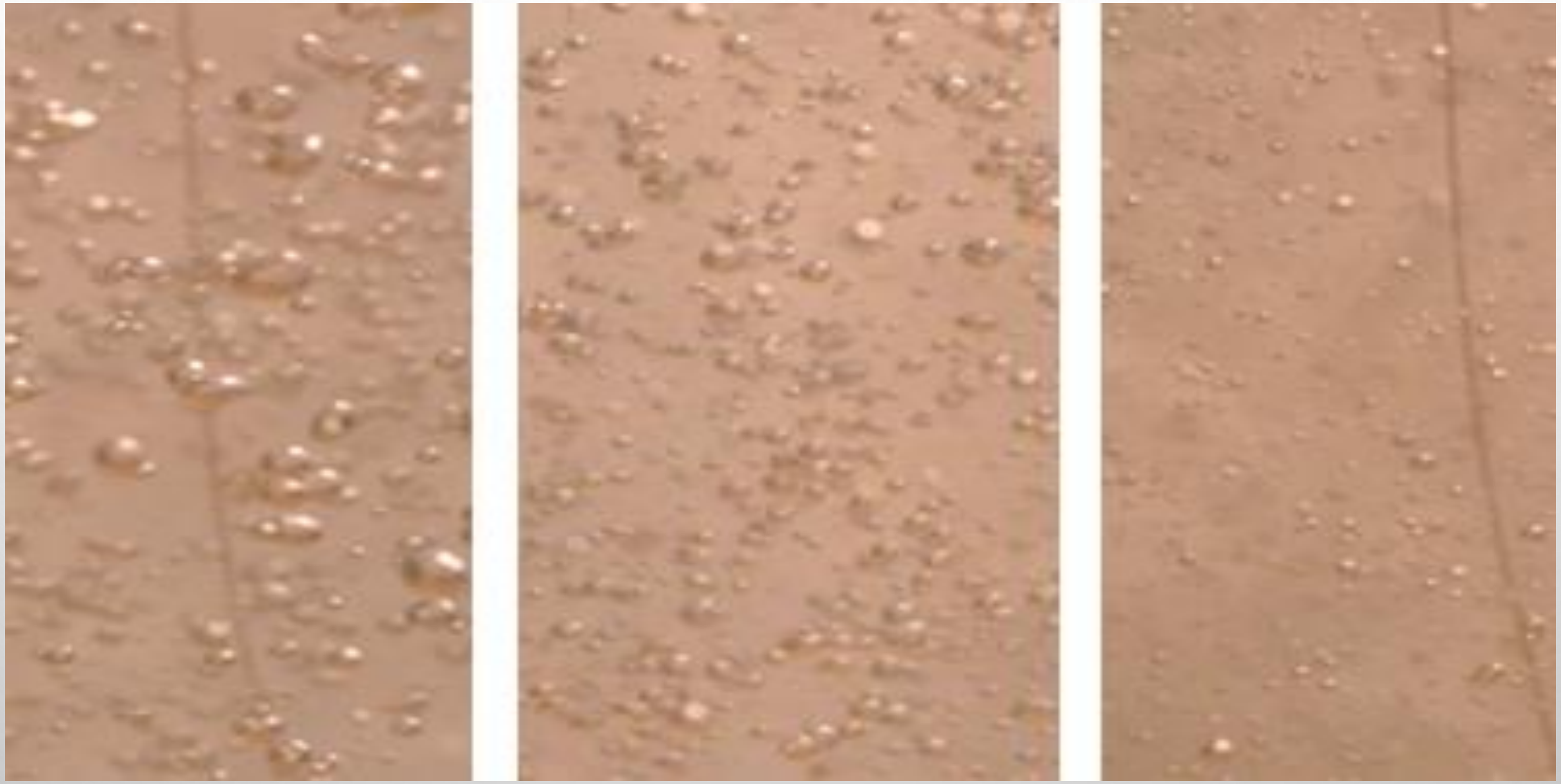

Fig. 4. Photographs for typical images of bubbles in the water for different gas- liquid flow rate ratios

EXPERIMENTAL RESULTS

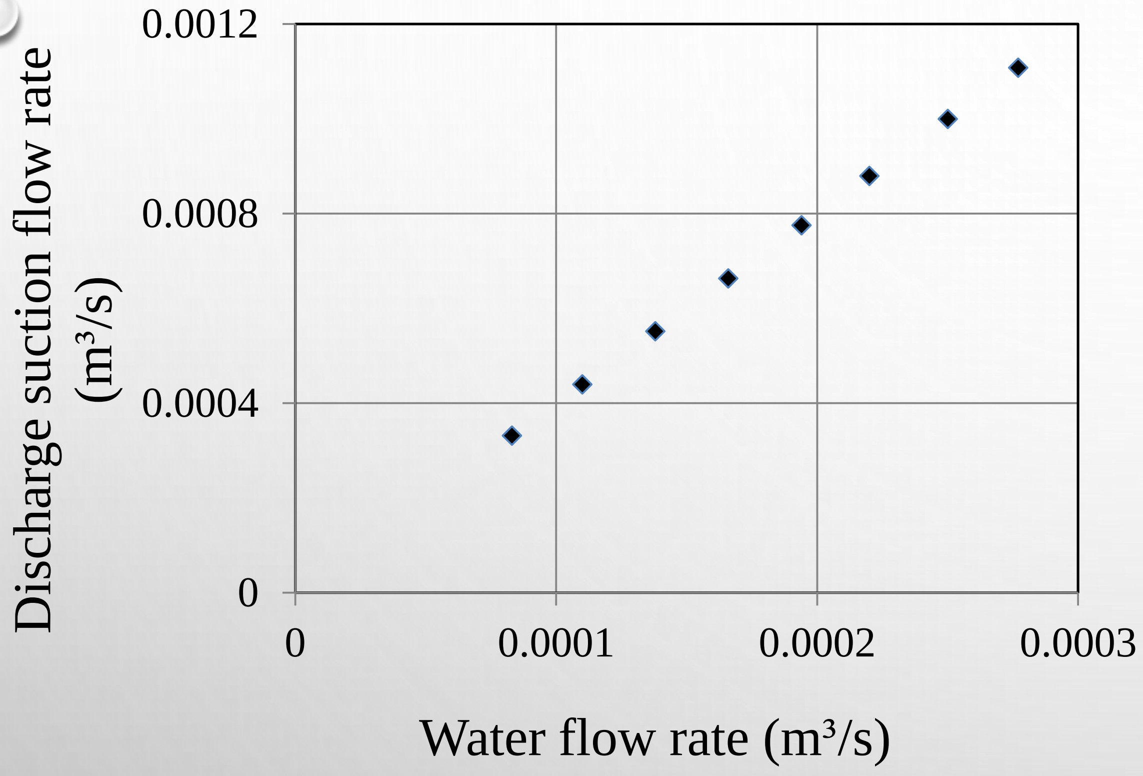

Fig. 5. Relation between water flow rate entering through suction chamber, and the water jet flow rate

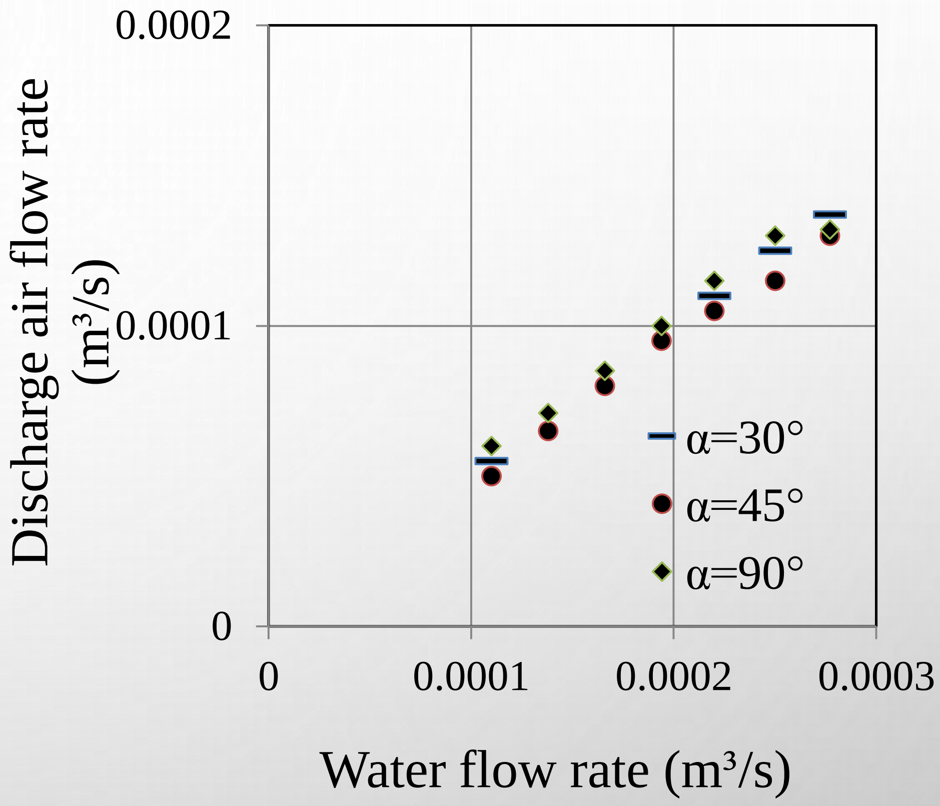

Fig. 6. Relation between flow rate of air through the suction nozzle, and water flow rate entering through the driving nozzle, for different slope angles of the air suction nozzle

EXPERIMENTAL RESULTS

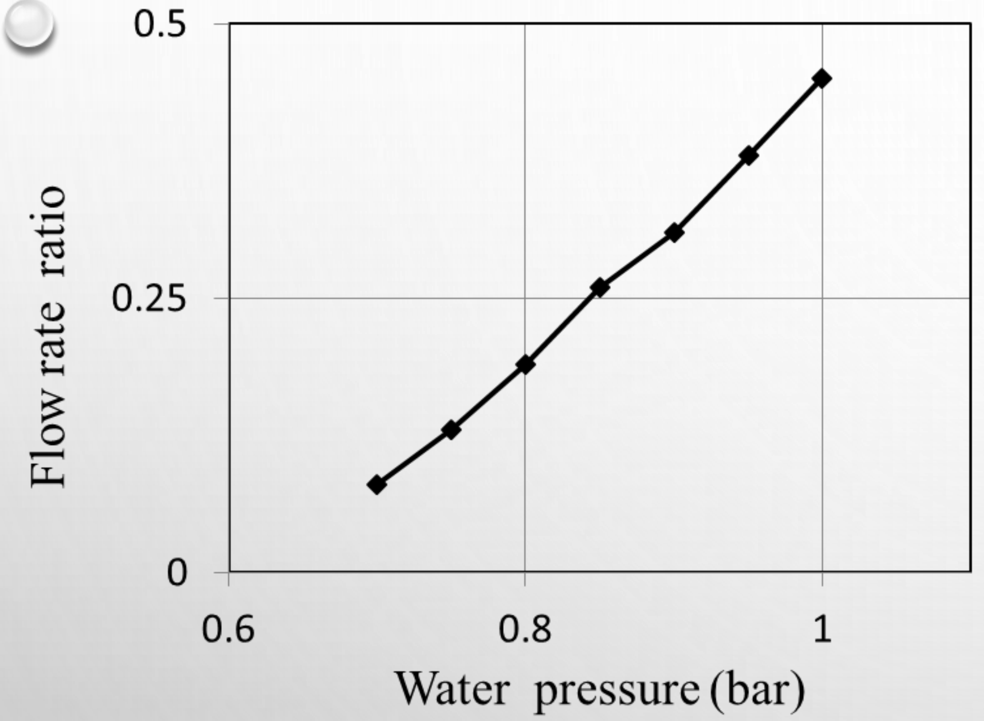

Fig. 7. Relation between air to water flow rates and water pressure

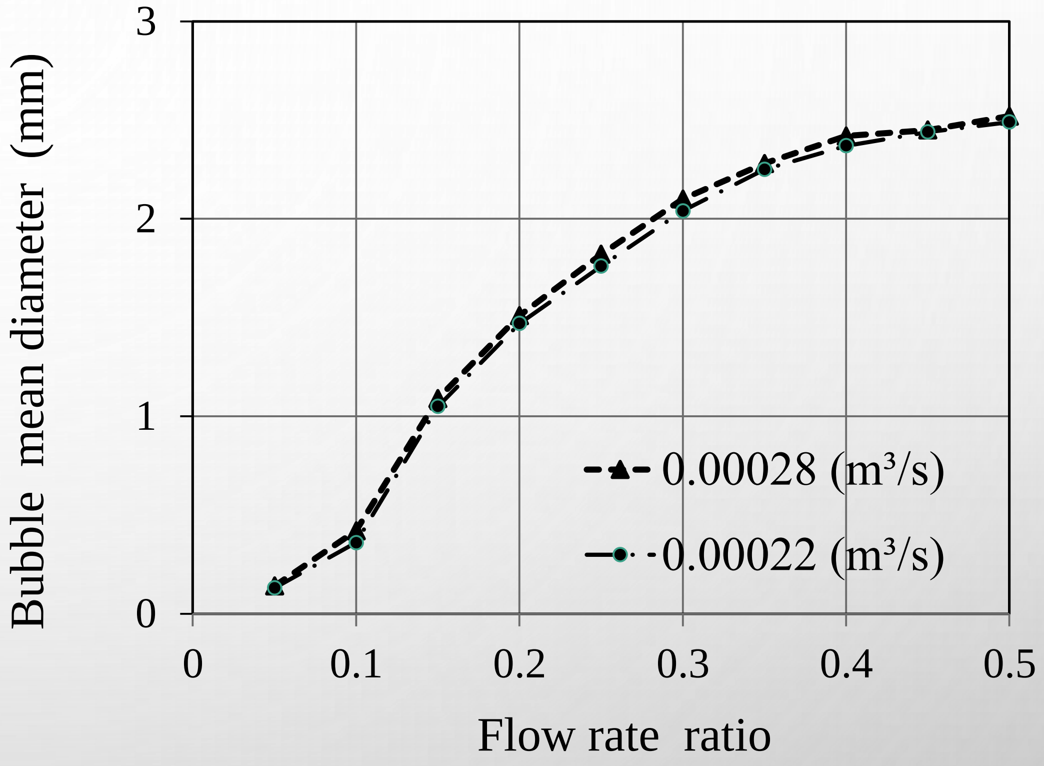

Fig. 8. Effect of change in flow rate ratio upon the mean bubble diameter

Dimensional Analysis

TABLE I

DIMENSIONS OF PHYSICAL PARAMETERS

Symbol	Quantity	Dimensions
L	length of the tank	L
B	width of the tank	L
H	height of the tank	L
h	submergence of jet pump	L
q_a	discharge air	L^3T^{-1}
Q_w	discharge water	L^3T^{-1}
ρ	density of water	ML^{-3}
μ	viscosity of water	$ML^{-1}T^{-1}$
g	gravity	LT^{-2}
d_b	mean diameter of bubbles	L
K_La	mass transfer coefficient	T^{-1}
D_a	coefficient of molecular diffusion	L^2T^{-1}

ASSUMING THAT THE MEAN DIAMETER OF BUBBLES DEPENDS ON THESE GEOMETRIC AND DYNAMIC PARAMETERS, THE FOLLOWING EXPRESSION CAN BE WRITTEN:

$$d_b = f(L, B, H, h, q_a, Q_W, \rho, \mu, g, K_L a, D_a) \qquad (1)$$

WE APPLIED DIMENSIONAL ANALYSIS TO THESE VARIABLES TO FIND A SET OF PARAMETERS. THE FOLLOWING DIMENSIONLESS COMPLEXES WILL BE ACHIEVED:

$$\frac{d_b}{\mathrm{H}} = \mathrm{R_E} \cdot \mathrm{F_R} \cdot \mathrm{SH} \cdot \left(\frac{\mathrm{Q_A}}{\mathrm{Q_W}}\right) \cdot \left(\frac{\mathrm{B \cdot H}}{\mathrm{L^2}}\right) \qquad (2)$$

Where:

$$R_e = \frac{Q \cdot \rho}{\mu \cdot L} - Reynolds\ number,$$

$$F_r = \frac{Q}{\sqrt{g \cdot L^5}} - \text{ Froude number,}$$

$$Sh = \frac{K_L\, a \cdot L^2}{D_a} - Sherwood\ number.$$

The mean bubble diameter can be expressed as shown :

$$d_{32} = \frac{\sum_{i=1}^{N} (N_i d_b^3)}{\sum_{i=1}^{N} (N_i d_b^2)} \qquad (3)$$

EXPERIMENTAL RESULTS

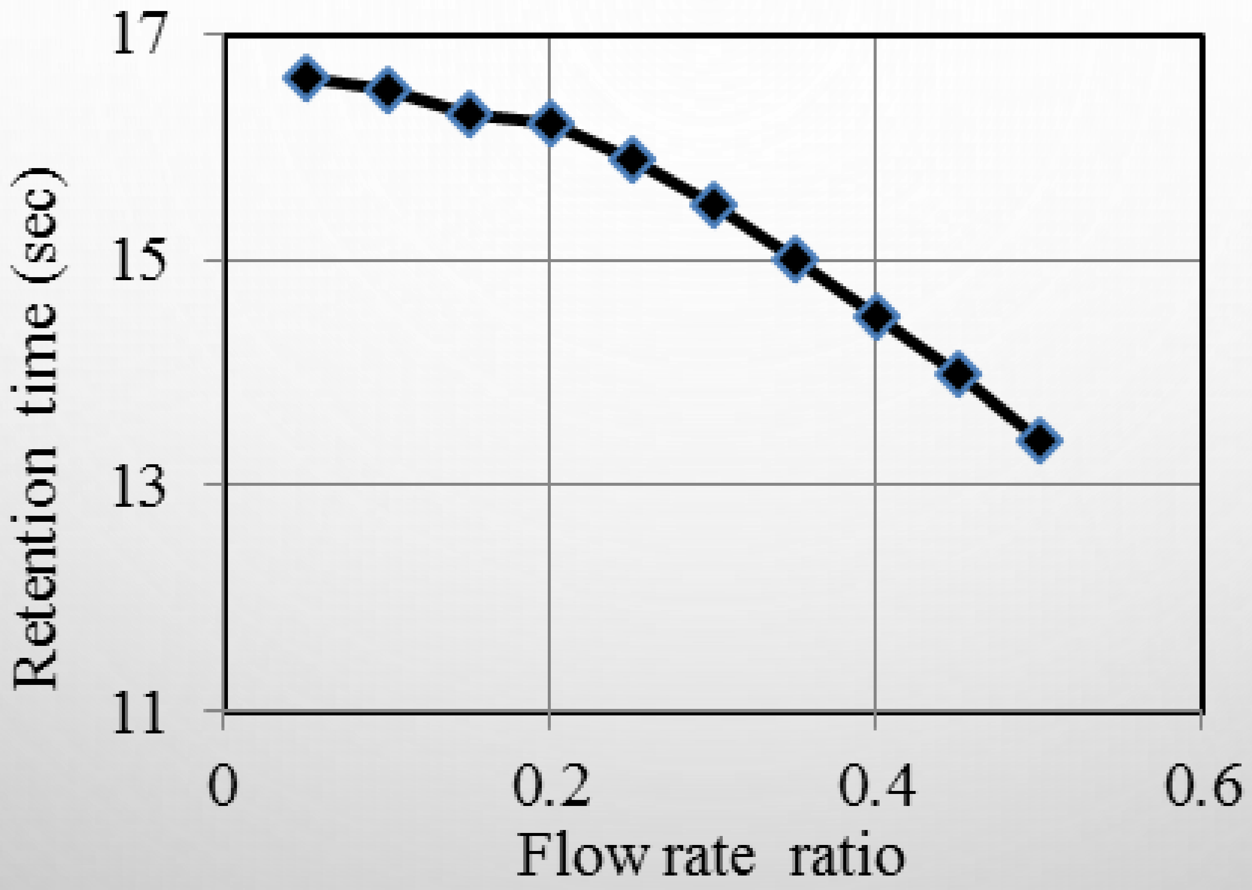

Fig. 9. Flow rate ratio effect upon the bubble retention time in the water

CONCLUSIONS

- The results of experimental investigations of jet pumps situated in a tank are presented.
- The experiments were performed in a laboratory using different jet pumps.
- The influence of the flow rate ratio in the jet pump on the size of the air bubbles is discussed.
- This work demonstrates the possibility of using physical models to study very complicated effects in a jet pump, for creation of different sized air bubbles in the water, and their retention time.