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A Study of the Suction Height Effect on Turbidity Removal Efficiency of Water in Pulsator

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Abstract - In water treatment plants in most countries around the world to achieve the desired standard of water quality, some units such as grid chamber, coagulation, sedimentation, clarification, filtration and disinfection are required. Among these units, the process of sedimentation is of prime importance, because nearly 70% of water turbidity is removed in this unit. Clarifiers help turbidity removal, so different types of which are frequently used in water treatment plants; among these the most famous one is Pulsator Clarifiers. This paper is aimed at studying the suction height effect on turbidity removal efficiency of water in Pulsator. This method is investigated experimentally by using a pilot scale model. This pilot has a scale of 1:25 and is modeled on an actual Pulsator with the capacity of 0.5 cubic meters per second. It was made of plexi glass and to produce vacuum, a vacuum pump are used and for suction contact sensors are used. The result of experiment shows that changes in suction height from 4 to 2 centimeter result in reduction of turbidity removal efficiency from 63/7 to 54/7. The main reason of reduction or increase in turbidity removal efficiency is mostly due to the formation of coarse and fine sedimentary floc.

Keywords : Pulsator- pulse clarification- turbidity removal efficiency - contact sensors - suction height.

I. Introduction

From past water resources have been an important factor in the formation of communities .Thus people in small and large groups gathered around them to settle. Factors such as population growth, higher demand for food, the necessity for improvement for the health care and social welfare, industrial development and protecting ecosystems, greatly contributed to the increase in water demand day by day. Nonetheless, today considering population boom and its subsequent consequences, naming, inadequate facilities, poverty and above all water shortage has created an insurmountable problem for the societies. So, one of the most important sectors in infrastructure development is the management of water resources. Water supply and distribution in developing countries, created major problems and have made governments invest huge sums of money in it. Therefore, doing research project and focusing attention on the new solution to this problem is inevitable. In most projects of water treatment plant, grid chamber units, primary sedimentation, rapid mixing, coagulation, sedimentation-filtration and disinfection are frequently used.

Pilot that is made in this study was different from that of in Mahidol University and the target is to study the effect of suction height on turbidity removal efficiency in Pulsator. After constructing the pilot, the rate of turbidity in input and output of Pulsator was sampled and tested according to standard method.

Grid chamber unit is a basin with suitable design for the deposition of material sediments in water. In water treatment plants with high capacity usually various compound settling pools are used, which are functionally different [1-3]. In these pools usually three operations: coagulation, flocculation and sedimentation take place in one space and again contact of sludge is used to increase the settlement of suspended solids in the water [4-9]. Pulsator is one of the water treatment plant units that are in the compound settling pool section with sludge blanket. In the pulsator coagulation and sedimentation occur simultaneously in one container [5]. The only research on this topic was conducted by Surat Intrto in 2005 at Mahidol University in Thailand. Although, Deremont -a French company- has been manufacturing Patent Pulsator for many years, little is known about the effects of variables on the efficiency of water turbidity removal. Therefore more research on the impact of using Pulsator on turbidity removal efficiency needs to be undertaken.

II. Materials and Methods

In this experimental study, by changing the desired variables that is the suction height, the turbidity removal efficiency rate of samples , taken from Pulsator input raw water and pure output water were measured based on TSS and samples' turbidity according to 2005 standard model. Then, the results of these measurements were used in final analysis. This research was conducted in Tehran Science and Research Branch of Islamic Azad University.

Since the main objective of this study was to reveal that how the efficiency rate changes with the increase or decrease in suction height, to determine the suction height in vacuum chamber contact method was used. In this method, water level can be measured

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through contacting a sensor with water surface. In this study three different sensors were used: one as reference, one for measuring maximum and another for measuring minimum height. Sensors were placed in 3 different heights and each time sampling was conducted from the output and input of pulsator and removal efficiency was calculated for each sample.

a) Design of Pulsator pilot

For designing the pilot model paying attention to geometric or physical similarity, and dynamic similarity is essential [14-12]. Considering geometric or physical similarities, the model is made with the scale of 1.25 to the dimensions of a real 0.5 cubic meter per hour Pulsator. Primary dimensions for simulation, are mass (M), length (L), and time (T). In the physical similarity two strategies were considered that the first is the similarity of particle settling movement in Pulsator pool and the second is the similarity of Pulsator pipe flow.

For achieving the first, Froude number is fixed both in model and prototype and for achieving similar flow in pipes Reynolds number is fixed both in model and prototype [10]. Table 1 shows required parameters of the kinematics similarity in Froude model law [11].

Table 1 : Required parameters of the kinematics simulation in Froude model law [11]

Quantity	unit	Relations	Proportions
(Length) L	m	$L_m / L_P = \alpha$	$\frac{1}{25}$
(Width) W	m	$W_m / W_P = \alpha$	$\frac{1}{25}$
(Depth) D	m	$D_m / D_P = \alpha$	$\frac{1}{25}$
(Area) A	m	$A_m / A_P = \alpha^{۲}$	$\frac{1}{625}$
(Volume) V	$m^{۳}$	$V_m / V_P = \alpha^{۳}$	$\frac{1}{15625}$
(Ideal retention time) T	min	$T_m / T_P = \alpha^{۰/۵}$	$\frac{1}{5}$
(Input flow) Q_i	$m^{۳} / d$	$Q_{im} / Q_{iP} = \alpha^{۲/۵}$	$\frac{1}{3125}$
(Output flow) Q	$m^{۳} / d$	$Q_m / Q_P = \alpha^{۲/۵}$	$\frac{1}{3125}$
(Recycle Flow) Q_r	$m^{۳} / d$	$Q_{rm} / Q_{rP} = \alpha^{۲/۵}$	$\frac{1}{3125}$
(Surface over flow) SOR	m/d	$OFR_m / OFR_P = \alpha^{۰/۵}$	$\frac{1}{5}$
(Average velocity) U	m/d	$U_m / U_P = \alpha^{۰/۵}$	$\frac{1}{5}$
(Reynolds number) Re		$Re_m / Re_P = \alpha^{۱/۵}$	$\frac{1}{5}$
(Froude number) Fr		$Fr_m / Fr_P = \alpha^{۰}$	۱

b) Pilot construction

For the construction of the pilot, the plate of Plexi glass sheet with the thickness of 6, 8, and 10 mm is used. Total number of parts is 538, that are as follows:

- 35,10mm-thick sheets;
- 76, 8mm-thick sheets;
- 50, 6mm-thick sheets;
- 88, 3mm-thick sheets;
- one input water pipe to Pulstator (horizontal section);
- One input water pipe to Pulstor (vertical section);
- One input water siphon to Pulastor(vertical section)

- one 3-meter, bottom drain sludge pipe;
- 12, bottom drain sludge siphon;
- 7, bottom drain sludge valve and other parts.

Figure 1 shows the schematic diagram of experimental apparatus and figure 2 illustrates the testing pilot.

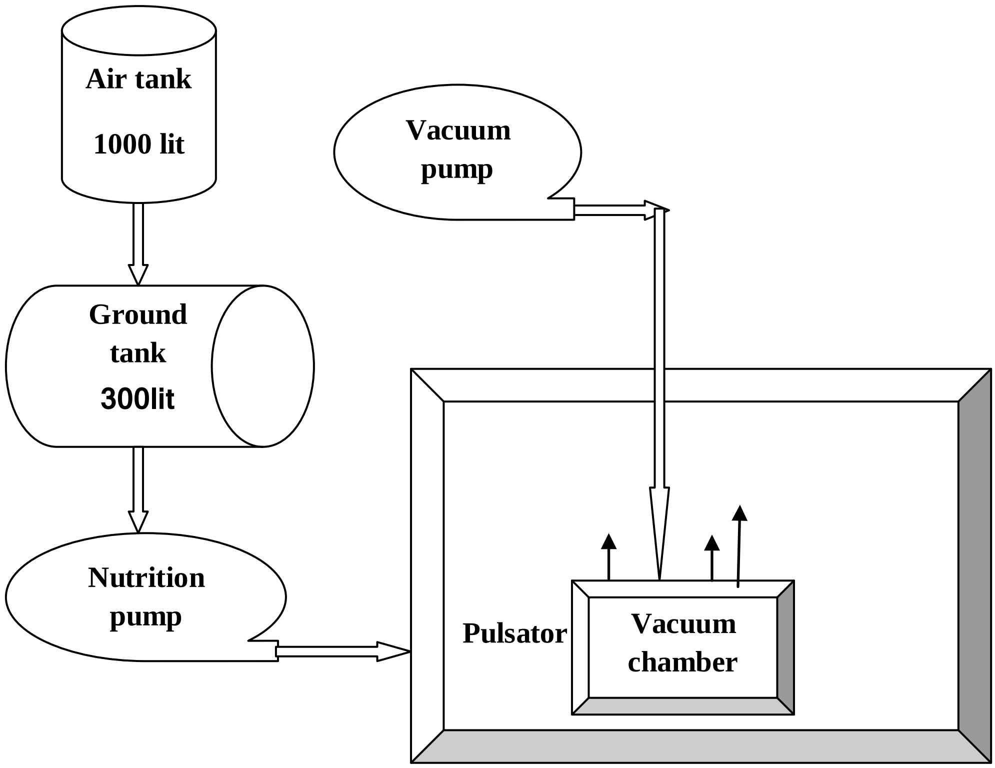

Figure 1 : The Schematic Diagram of Experimental Apparatus

Figure 2 : Test Pilot

c) Electro-mechanical equipment

The following pieces of equipment were added to complete the pilot.

- A one-inch raw water input pipe.
- Water flow control needle valve to Pulsator.
- A 1000-litre, raw water supply reservoir with mechanical stirring added.
- Vacuum pump
- Solenoid valve to cut off and connect vacuum pump
- Needle valve to regulate air flow to vacuum breaker pump.
- 3Proximity sensors for setting the water level, in a vacuum chamber
- 24-volt feed source for supplying electric solenoid valve
- pinch valve to drain Hoper sludge
- electrical control systems including relays, timers, and other equipment

d) Nephlometry device

For measuring turbidity, Nephlometry device with the following characteristics is used.

1. A Lovibond Neplometry device.
2. A two -Range Nephlometry device: 20 NTU and 200 NTU
3. A standard solution of 0.02 NTU

e) Determination of water level inside the vacuum chamber

To determine the water level inside the vacuum chamber there are various methods that include:

i. *The contact methods*

In the contact methods from contacting sensor to water, the height can be measured and sensors can be permanently installed at different heights. However, since the heights of the sensors used in this experiment are adjustable many fewer sensors were needed. In this study, three different sensors are used one as reference, another to measure maximum and the last one to measure the minimum height.

One of the disadvantages of using contact sensors is that they become dirty and consequently defunct. However, since they are economically priced, comparing with non-contact sensors, they were preferred in this study.

ii. *The non-contact sensors*

Non-contact sensors usually work with radiation and through sending a wave and measuring the return time they measure the height and length of the object aimed at. These sensors are more accurate than contact sensors and their reaction is much better.

III. Result

The results of experiment show that suction removal efficiency increases with the increase in suction height. That is because, at heights with lower suction, the pulse created is lower so particles have a minimal chance to collide with each other and subsequently the formation of large floc at lower suction height is not likely. In conclusion the removal efficiency in this case is less. The changes are illustrated in chart 1. In tables 2, 3, 4, as described in previous section, the changes in turbidity removal efficiency were measured in samples taken at three different heights.

As can be seen in the chart at the suction height of 2 centimeter the efficiency was 54.7%, at 3 centimeter it was 62.8% and at 4 centimeter, it was 63.7%.

So it is clear that efficiency changes curve over suction height is upward, in other word with the increase in the suction height the efficiency goes up accordingly.

Table 2 : changes of the turbidity removal efficiency at 4 centimeter suction height

	Input NTU	Output NTU	Efficiency %
Sample1	45	16.3	63.8
Sample2	33.2	16.5	50
Sample3	30.9	16.8	45.6
Sample4	33.9	16.3	51.9
Sample5	38.9	17.5	54.5
Sample6	43.9	19.5	55.5

Table 3 : changes of the turbidity removal efficiency at 3 centimeter suction height

	Input NTU	Output NTU	Efficiency %
Sample1	56	18.4	67
Sample2	56.2	18.2	67
Sample3	55.2	18.3	66.8
Sample4	47.2	19.2	60
Sample5	42.3	18.1	57
Sample6	38.3	16.2	57.8

Table 4 : changes of the turbidity removal efficiency at 2 centimeter suction height

	Input NTU	Output NTU	Efficiency %
Sample1	38.4	15.4	59.8
Sample2	30.9	15.1	51
Sample3	26.2	13	50.4
Sample4	31.2	13.2	57.7
Sample5	31.2	13	58
Sample6	29.8	13.8	53.6

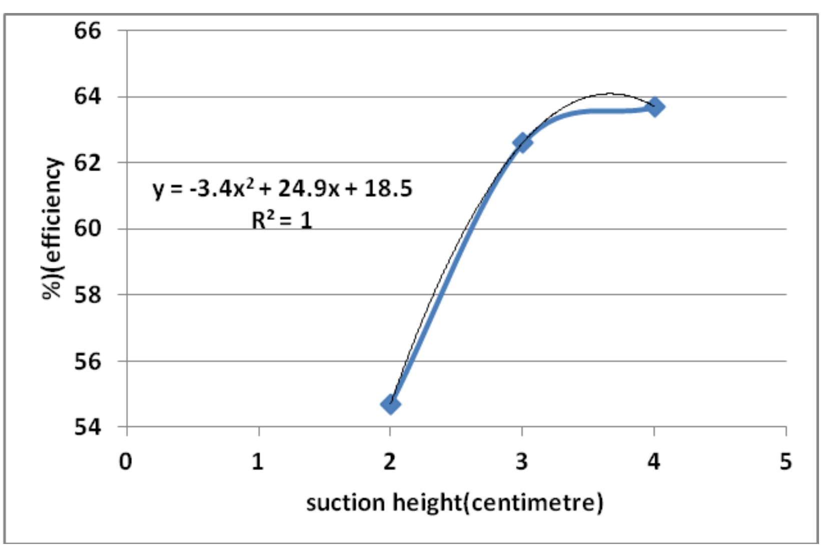

Chart1 : efficiency changes over time

IV. Conclusion and Recommendation

As can be seen in diagram 1; efficiency changing in relation to height-when the suction height increases so does the removal efficiency. Optimal suction height could be the subject of future research and it is possible that with the increase in suction height the formed flocs break down and result in the decrease in efficiency. This can be deduced from comparison of curves at Different heights. The slope of the curve at the height of 2 to 3 cms is much more than that of 3 to 4 cms. It seems that the graph has a maximum and exceeding that figure, with the increase in suction height, the efficiency decreases. Different optimal suction height can be the subject of Future research.

If the pilot scale can be bigger, around 1.5, more reliable results will be achieved. Similarly, if the test is conducted on real scale, it will yield more practical results. Moreover ultra sonic and gate valve sensors can replace touch sensors and needle valves respectively to increase the flexibility of the model. Furthermore, instead of creating artificial turbidity real muddy water can be used since this, in turn, can sustain constant flow of turbid water to enter the Pulsator.

One of the problems and difficulties of this study was the high cost and lack of high-tech equipment which inevitably limited the testing points. Therefore, experiments were performed in only three points.

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