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Performance Evaluation of Venturi Aerator for different Throat Hole Parameters

Amit Kumar Dam[1*] and Sudipto Sarkar[2]

[1,2]Dept. of Agricultural Engineering, Assam University Silchar-788011
E-mail: [1]amitdam1985@gmail.com, [2]sudiptoiit@gmail.com

Abstract—*Aeration is the process by which the area of contact between water and air is increased, either by natural methods or by mechanical devices. Proper aeration can make considerable improvements in a pond ecosystem. This paper investigates pond aeration by two phase flow systems such as high head gated conduit flow systems and two phase pipe flow systems using venturi tubes. The dissolution of oxygen into the water results from the air suction downstream of high head gated conduit and venturi tube, and the rising air bubbles into pond. The concentration of dissolved oxygen is an important indicator of water quality because aquatic life lives on the dissolved oxygen in the water. Aeration can increase dissolved oxygen when levels become deficient. Hydraulic structures can significantly improve dissolved oxygen levels by creating turbulent conditions where small air bubbles are carried into the bulk of the flow. The present paper shows applications of venturi principle to water aeration systems. . The maximum DO concentration achieved by using different rpm at different throat hole i.e 1mm, 2mm and 3 mm respectively. The maximum and quick values are reached in a time span of 480 seconds incase of 1800 rpm of hole 3 of 1mm diameter throat hole. The maximum DO concentration achieved by using the various different sieves at discharge of 0.55 lps, 0.75 lps, 0.80 lps, 1.05 lps and 1.105 lps are for 1 mm throat hole are 6.93 mg/l ,6.955 mg/l , 6.965 mg/l , 6.863 mg/l and 6.905 mg/l respectively. The results indicate that venturi aeration might contribute significantly to air entrainment and aeration efficiency. Therefore, venturi device can be used as highly effective aerator in aeration processes.*

Keywords: *Conduit, Venturi, Oxygen transfer, Aeration, Pond.*

1. INTRODUCTION

1.1 General Overview

Aeration is the intimate exposure of water and air. It is a way of thoroughly mixing the air and water so that various reactions can occur between the components of the air and the components of the water during water exchange. Dissolved oxygen (DO) is probably the single most important environmental factor in aquaculture. If DO concentrations are low fish will not eat well, they will not grow well, and they will be susceptible to disease. In order to have good feed conversion efficiency, high survival, and adequate profits, fish farmers must maintain plenty of DO in waters of culture systems. Aeration is necessary to supplement natural sources of DO. When DO concentrations are below saturation, aerators can put oxygen into water. The amount of oxygen from aeration depends upon the type and number of aerators and upon the concentration of DO in the water. Aeration is an important source of oxygen when DO concentrations are low. Aerators are the device which increases the rate at which oxygen enters water. Hence it increases the dissolved oxygen concentration in the tank.

The purpose of aeration is generally to increase the oxygen content of water used to house animals, such as aquarium fish or fish farm. Production of aerated water for drinking purposes. It helps to dispel other dissolved gases such as carbon dioxide or chlorine. Secondary treatment of sewage or industrial wastewater. To increase oxygen content of wart (unfermented beer) or must (unfermented wine) to allow yeast to propagate and being fermented. It is essential due to rise in atmosphere temperature that causes increase rate in degradation of organic matters and subsequent depletion in dissolved O_2 concentration in water. In chemistry to oxidize a compound dissolved or suspended in water.

1.2 Objective

Keeping in mind the above mention points the present study entitled "Performance evaluation of venture aerator for different throat hole parameters" was carried out with the following objectives.

To evaluate the SOTR and SAE for different placement of holes in throat section.

2. MATERIALS AND METHOD

The project is started off with the fabrication of venture of different sizes of hole at throat. Length of converging portion is 10 cm, throat portion 4 cm and diverging portion of 10 cm. Diameter at inlet of venture is 2.54 cm, 1.25 cm at throat and 2.54 cm at outlet.5 hole each of 1 mm, 2mm dia and 3 mm dia done at 5mm c/c of throat respectively. The schematic diagram for venturi is shown in Fig. 4.

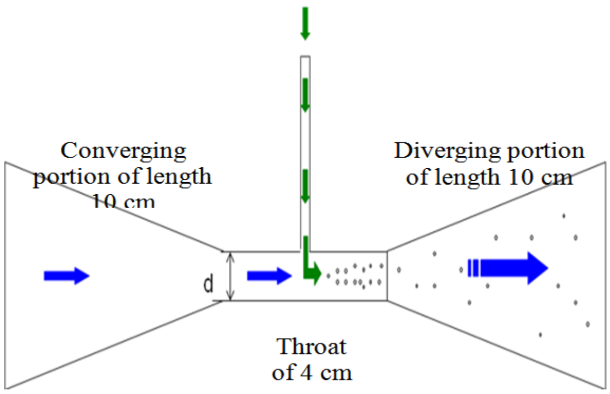


Fig. 1: Schematic diagram of Venturi Aerator

2.1 Experimental set up

A 150 L storage tank supplied water to a 90 cm long, 55 cm wide and 49 cm deep (water depth). The dimensions of the downstream water tank is 60.5 cm x 35 cm x 47 cm (length x breadth x depth) with water depth of 10 cm. The downstream water surface is disturbed by a venturi of throat hole diameter of 1mm, 2mm and 3 mm respectively. Each experiment was commenced by filling the storage tank and adding Na_2SO3 and $CoCl_2$ to increase the upstream DO deficit (Cs - Cu) to 0mg/l. During the experiments, DO and temperature measurements upstream and downstream of the venture were taken using a calibrated portable HYDRAS3 LT, oxygen meter.. The effectiveness of the aerator increases when a minimal amount of differential pressure exists between the inlet and outlet sides of the venturi tube, a vacuum occurs at suction holes of the venturi tube. Oxygen injection rates of venturi tubes are analyzed by DO meter having HYDRA S3 LT software. These analyses are carried out by means of the instrument DO Meter. The following materials and chemicals are used in the construction of the Venturi Aeration System: Water source (raw water),Lower tank, Upper tank, Motor, Distribution pipes, Centrifugal pump,3 numbers venturi with hole diameter 1 mm, 2 mm & 3mm , Do meter. Sodium Sulphite & Cobalt Chloride (Sodium sulfite and cobalt chloride in the ratio of 100:1).

2.2 DO (Dissolved Oxygen) meter

The DO meter offers the following features: Accurate dissolve oxygen measurements over long periods without recalibration. Low power consumption. Windows based communication software. Minimal service requirement. The software used is HYDRAS3 LT which is supplied with the custom designed window based communication software program. This software enables the user to communicate the DO meter (Hydra LT) via a computer. It has a data logging function that enables data collected by the DO meter to be logged directly to the computer. This is used when a continuous burst measurement is required. After every 15 seconds of measurement is made the values are returned to the data logger. In this study two data values are required to be returned from the DO meter- Temperature and DO

Fig. 2: Plate Fabricated venturi

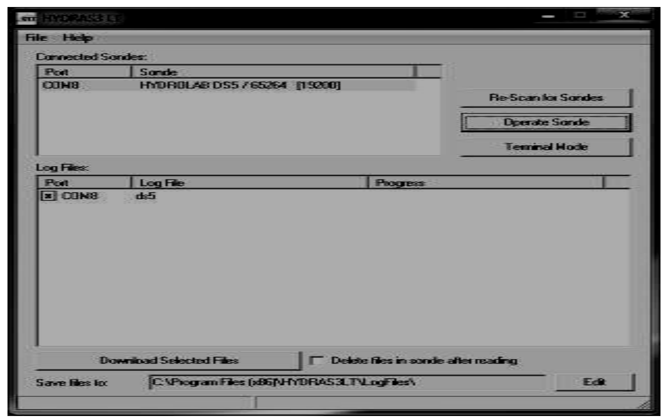


Fig. 3: Screen shots of DO reading

2.2.1 Chemicals Used in the Experiment

In the experiment, two types of chemicals were used to deoxygenize the water, the chemicals are, sodium sulphite and cobalt chloride. Sodium sulphite used 10mg per litre volume of water and 0.1 mg cobalt chloride used per litre of water. Cobalt chloride is act as a catalyst in the experiment.

Fig. 4: Cobalt Chloride and sodium sulphite

2.2.2 Supporting Structure

Fig. 5: Supporting Structures

2.2.3 Supporting software

In this experiment, a supporting software named as HYDRA S3 LT is used to operate the hydro meter. This software connects the hydro meter with the computer. This gives the readings of the different parameters such as temperature, level of oxygen (LDO), percentage of saturation level of oxygen (LDOs).

2.3 Methods

In general the methodology for determination of oxygenation capacity of venture aerator consists of assessment of dissolved oxygen at various position of the aerator using a simple modified method. An assessment of time of exposure is separately carried out with to flow. The performance of this type of aerator would certainly depend on the time of exposure. The time of exposure in the aeration system is the time taken by water to flow from the upstream to downstream position of the system.

It is to develop an aerator system using venturi and hole at throat of different diameter of tap water to gain pure aerated water. Venturi aerators pass water through air in small streams of orifice. A Venturi aerator is comprised of a converging portion having throat portion with end of diverging portion and a collecting tank. A lower tank is filled with water where the dissolved oxygen (DO) is set zero. This is done by addition of sodium sulfite and cobalt chloride in the ratio 100:1. Cobalt chloride was used as a catalyst for the sodium sulfite to remove oxygen from the water. For each test 0.1mg of cobalt chloride were weighed and dissolved in the tank. The cobalt chloride was allowed to mix for a minimum of 15 minutes prior to adding the sulfite solution. Sodium sulfite was the deoxygenating chemical used in each test. Sulfite binds with dissolved oxygen to form sulfate, thereby removing the oxygen from the water. For each test 9 mg of sodium sulfite was weighed and dissolved in the tank.

The pump was temporarily shut off when the sodium solution was poured into the tank. When the DO concentration drops to below 0 mg/L, the operation is carried on. The distributing pipe breaks the water up into small streams or drops. As the water moves through the venturi aerator, small streams of water flow through the converging portion to throat and throat to diverging portion upto tank. The water is collected and given further treatment if necessary. This water is measured by a DO meter placed at the lower or measuring tank and then the water is measured continuously and the same water is pumped to the upper tank for further test.

$$\boldsymbol{LDOs = \frac{last\ value\ average\ of\ LDO}{\%\ saturation\ level}}$$

We have to calculate the ln(LDOs – LDO) i.e.

$$\ln(\boldsymbol{LDOs - LDO})$$

Plot the graph between $\ln(LDOs - LDO)$ vs. time (15 sec interval).From the graph we get a linear equation

$$\boldsymbol{y = mx + c}$$

We have taken the value of m as oxygen transfer coefficient at temperature T^0C (K_La_T), here K_La_T in min^{-1}, we convert it in $hour^{-1}$ by multiplying it by 60. We have to determine standard oxygen transfer coefficient at temperature 20^0C (K_La_{20}) by following equation

$$\boldsymbol{K_La_{20} = K_La_T \times (1.024)^{(20-T)}}$$

K_La_{20} = Standard oxygen transfer coefficient at temperature 20^0C (h^{-1})

K_La_T = Oxygen transfer coefficient at temperature T^0C

Then standard oxygen rate transfer (SOTR) and standard aeration efficiency (SAE) can be calculated by

$$\boldsymbol{SOTR = K_La_{20} \times 0.9 \times V \times 10^{-3} \times 9.07}$$

Where

SOTR=standard oxygen rate transfer (Kg O_2/ h)

V= volume of water (m^3)

$$\boldsymbol{SAE = \frac{SOTR}{P}}$$

Where,

SAE= Standard aeration efficiency (Kg O_2/ KW h)

P= input power (KW)

2.3.1 Procedure to evaluate the performance of venturi aerator .

To evaluate the performance we have to plot the graph between SOTR and RPM, and compare in which condition we get maximum efficiency. Same as above we have to plot the graph between SAE and RPM and compare the condition of maximum efficiency.

3. RESULTS AND DISCUSSION

3.1 Effect of Discharge on do Diffusion

In order to study the effect of discharge on DO diffusion, the first set of experiments were carried out by varying the discharge with same throat hole. The initial value of DO was brought down to zero by adding suitable amount of sodium sulphite and cobalt chloride as has been discussed earlier. Potable water was allowed to flow through the venturi of 1 mm, 2mm & 3mm throat hole and the change of DO was monitored at an interval of 15 seconds. The experiment was carried out until the DO reached 80% of the saturation value at the particular temperature of the experiment. The results obtained in these experiments are illustrated in the Fig. 3.1.1 to Fig. 3.1.15. It can be observed from the Fig. 3.1.1 to Fig. 3.1.15 that the DO concentration increases with time. The maximum DO concentration achieved by using different rpm at different throat hole i.e 1mm, 2mm and 3 mm respectively. The maximum and quick values are reached in a time span of 480 seconds incase of 1800 rpm of hole 3 of 1mm diameter throat hole.

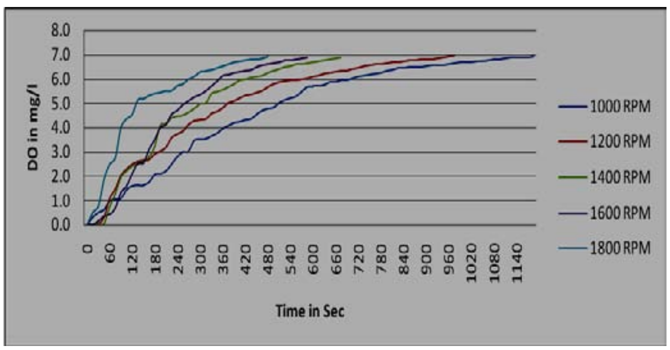
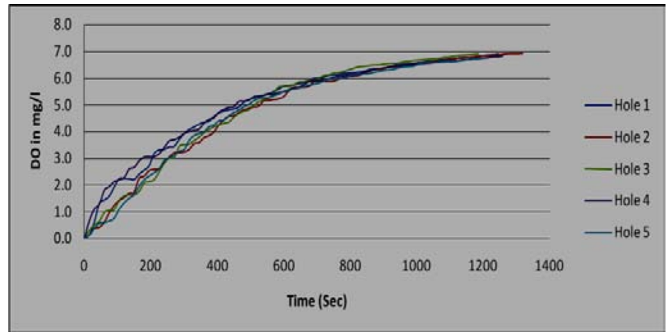


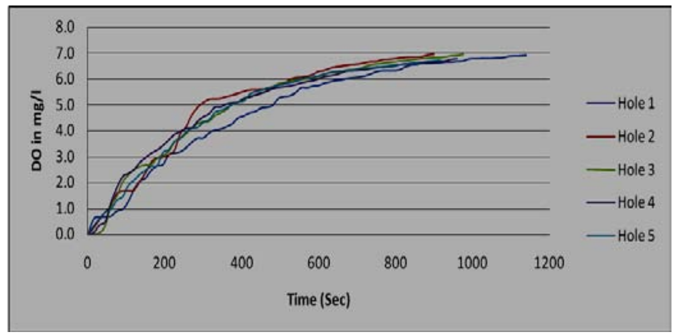
Fig. 3.1.3: Variation of DO with respect to time for hole 3 of 1mm diameter

3.2 Effect of throat hole on DO diffusion

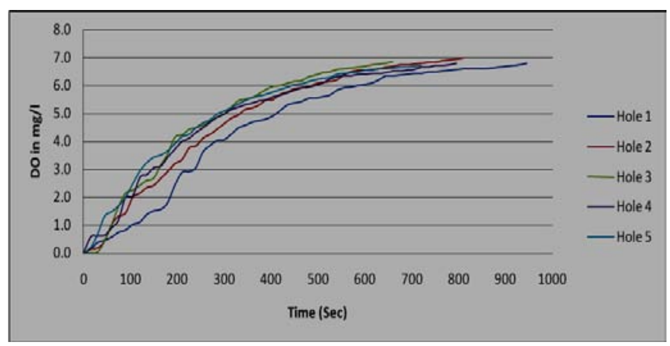
In order to study the effect of throat hole on DO diffusion, the first set of experiments were carried out by keeping the discharge constant and varying the throat hole. The initial value of DO was brought down to zero by adding suitable amount of sodium sulphite and cobalt chloride as has been discussed in chapter 3. Potable water was allowed to flow through the venturi and the change of DO was monitored at an interval of 15 secs. The experiment was carried out until the DO reached 80% of the saturation value at the particular temperature of the experiment. The results obtained in these experiments are illustrated in the Fig. 4.3.1 to Fig. 4.3.15. It can be observed from the Fig. 4.3.1 to Fig. 4.3.15 that the DO concentration increases with time. The maximum DO concentration achieved by using the various different sieves at discharge of 0.55 lps, 0.75 lps, 0.80 lps, 1.05 lps and 1.105 lps are for 1 mm throat hole are 6.93 mg/l ,6.955 mg/l , 6.965 mg/l , 6.863 mg/l and 6.905 mg/l respectively.



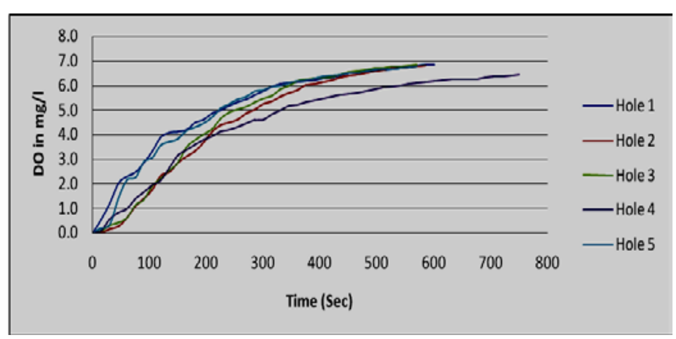
3.2.1 Variation of DO with respect to time for 1000 rpm of 1mm diameter and discharge of 0.55 lps.



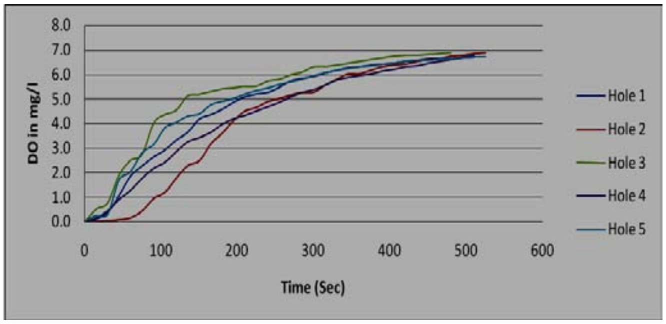
3.2.2 Variation of DO with respect to time for 1200 rpm of 1mm diameter and discharge of 0.75 lps.



3.2.3 Variation of DO with respect to time for 1400 rpm of 1mm diameter and discharge of 0.8 lps.



3.2.4 Variation of DO with respect to time for 1600 rpm of 1mm diameter and discharge of 1.05 lps.



3.2.5 Variation of DO with respect to time for 1800 rpm of 1mm diameter and discharge of 1.105 lps.

3.3 Standard Oxygen Transfer Rate (SOTR)

The variation of SOTR for the different Discharge, RPM and Holes are plotted as shown in the figures below Tables. It can be observed from the tables that the SOTR keeps on increasing with increase in RPM.

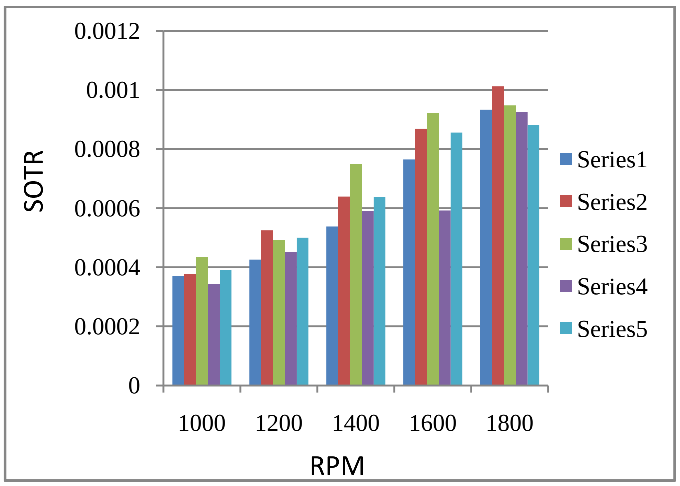


Fig. 3.3.1: Variation of SOTR with respect to RPM for different orientation of hole of 1mm diameter.

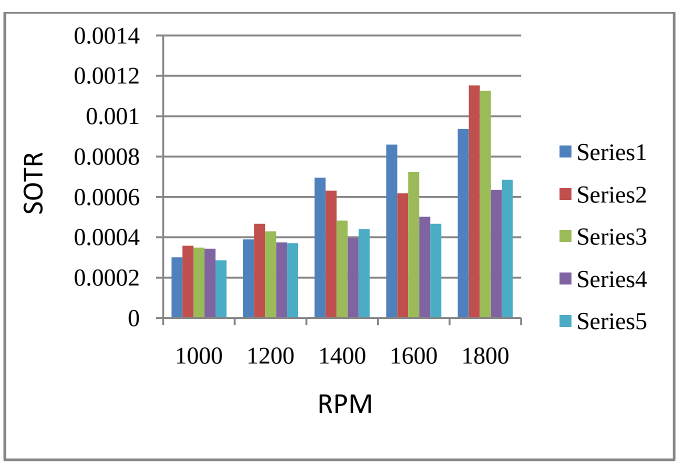


Fig. 3.3.2 Variation of SOTR with respect to RPM for different orientation of hole of 2mm diameter.

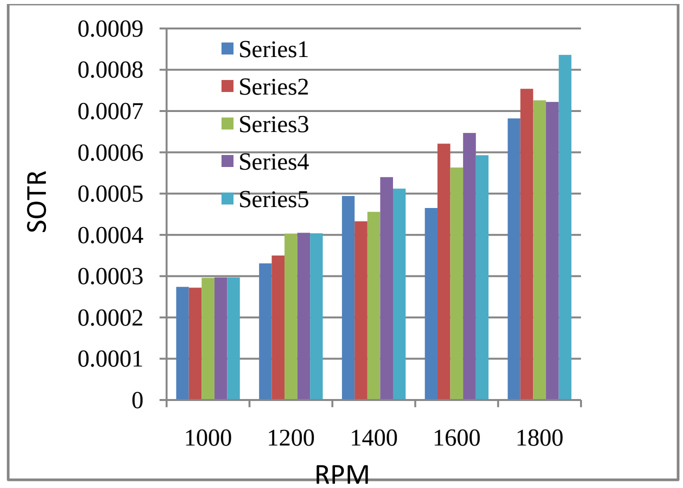


Fig. 3.3.3: Variation of SOTR with respect to RPM for different orientation of hole of 3mm diameter.

The corresponding SOTR values for different throat hole are also given as in fig.3.3.1, fig.3.3.2, fig.3.3.3. It can be observed from the table, that the SOTR keeps on increasing as the discharge increases. Also it can be seen that as there is increase in SOTR as the throat hole size of the increases. Hence it can be stated that in order to attain maximum SOTR it is important to take bigger throat hole size with a higher discharge of flow.

3.4 Variation in Standard Aeration Efficiency (SAE)

In order to calculate SAE the power consumed by the pump assembly is calculated by measuring the voltage and current. The product of voltage and current gives us the power consumed by the pump in kilowatts. It can be observed from the table that as the discharge increase the power consumption also increases. It can be observed from the fig.3.4.1, fig.3.4.2, fig.3.4.3 that the maximum value of SAE is high for 1800 rpm of hole 2 of 2mm diameter and the minimum value of SAE is low for 1000 rpm of hole 2 of 3mm diameter.

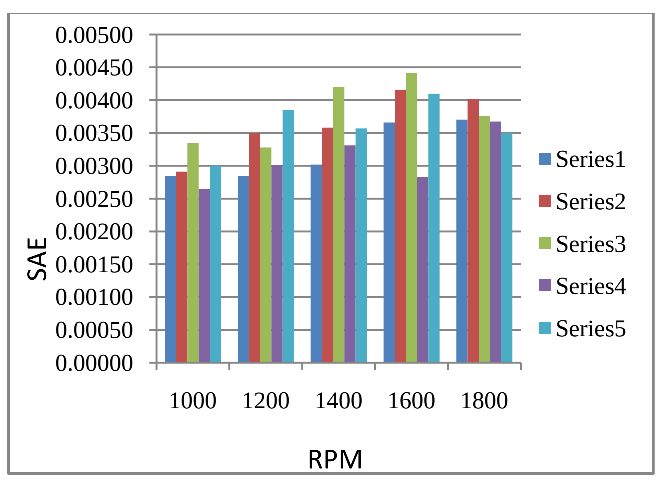


Fig. 3.4.1 Variation of SAE with respect to RPM for different orientation of hole of 1mm diameter

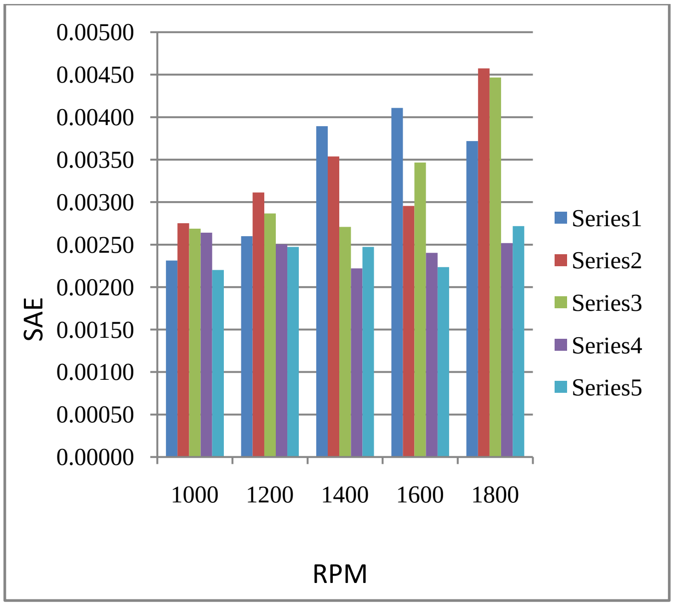


Fig. 3.4.2: Variation of SAE with respect to RPM for different orientation of hole of 2mm diameter.

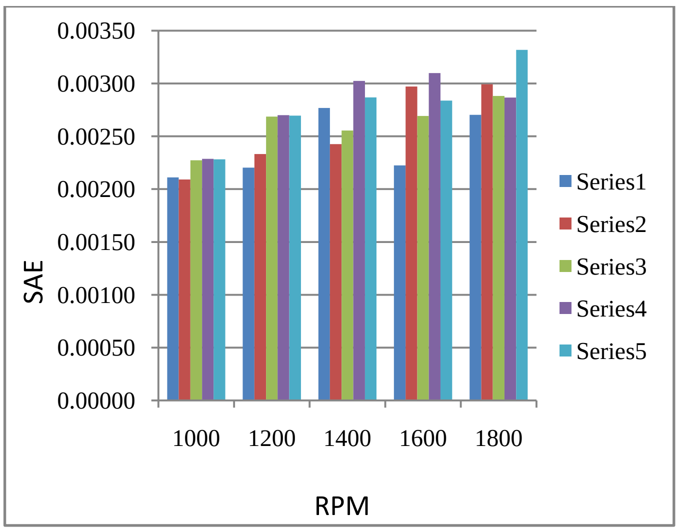


Fig. 3.4.3: Variation of SAE with respect to RPM for different orientation of hole of 3mm diameter.

4. CONCLUSION

Discharge rate was varied with different throat hole diameter for doing experiments for performance evaluation of aerator. Just as is the case in any aerator, the aerator fabricated for this study has been found to carry out aeration. It has been observed that the aerator performs best when the discharge rate is high. Also the aeration improves when the hole size of the sieves increases.

5. ACKNOWLEDGEMENTS

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REFERENCES

[1] Ahmet Baylar, M. Cihan Aydin, Mehmet Unsal and Fahri Ozkan,2009, Numerical Modeling Of Venturi Flows For Determining Air Injection Rates Using Fluent V6.2,Firat University, Civil Engineering Department, Elazig, Turkey,Vol 14.
[2] Ahmet Baylar, M. Emin Emiroglu And Mualla Ozturk , 2005.The Development Of Aeration Performance With Different Typed Nozzles In A Vertical Plunging Water Jet System
[3] Avinash Kumar, Sanjib Moulick, Basant K. Singha, Bimal C. Mal(2013) ,Design characteristics of pooled circular stepped cascade aeration system.
[4] AhmetBaylar, FahriOzkan, and Mehmet Unsal,Effect of Air Inlet Hole Diameter of Venturi Tube on Air Injection Rate
[5] Avinash Kumar, Sanjib Moulick, Bimal Chandra Mal (2013)
[6] Avinash Kumar, Sanjib Moulick, Bimal C. Mal(2010), Performance evaluation of propeller-aspirator-pump aerator
[7] Baylar, A., Bagatur, T. and Emiroglu M.E., 2006. Aeration efficiency with napes flow over stepped cascades. Proceedings of Institution Civil Engineering Water & Maritime Engineering. 160(WM1), 43-50.
[8] Baylar, A., Unsal, M. and Ozkan, F., 2011. The effect of flow patterns and energy dissipation
[9] Baylar, A., Bagatur, T. and Emiroglu, M.E., 2007. Aeration efficiency with napes flow over stepped cascades. Proc. Inst. Civil Eng Water Maritime Eng 160(WM1), 43-50.
[10] Boes, R.M.and Hager,W., 2003. Hydraulic design of stepped spillways. Journal of Hydraulic Engineering 129(9), 671-679.
[11] Chanson, H., 1994. Hydraulics of nape flow regime above stepped chutes and spillways. Australian Civil Engineering Transaction in Instrumentation Engineering. 36(1), 69-76.
[12] Chanson, H., 1996. Prediction of transition nappe skimming flow on a stepped channel. Journal of Hydraulic Research. 34(3), 421-429.
[13] Chanson, H., 1995. Hydraulic Design of Stepped Cascades, Channels, Weirs and Spillways. Pergamon, Oxford press, UK, Jan., pp 292.
[14] Chanson, H. and Toombe, L. 1997. Flow Aeration at Stepped Cascades. Research Report No. CE155, Dept. of Civil Engineering, University of Queensland, Australia, June, 110.