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Water Current Velocity Intensification by Momentum Diffusion Method

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Abstract:
Investigations on methods to intensify flow velocity have been conducted. The results show that flow velocity can be improved using momentum diffusion method by installing non porous channel in the flow. In this work, the investigated flow velocity increased 1.6 times using a 100 mm semicircular channel on a flowing shallow river.
The implication of the work could be that renewable energy from low velocity flowing sources can now be used to generate more power than would have been possible in low velocity flow conditions. However, it is noted that further testing will be required to investigate the implications of increasing the width of the channel. It is also noted that method of design and installation of the technique into flow system for such power generation improvement will need to be examined.

1. Background

Water current is common in open rivers, seas and oceans. Water current generators have received attention in recent times because water current is relatively available daily compared to solar energy and wind [1]. Due to space requirement and ecological reasons, the preferred installation for water current generation could be in the open ocean and seas [2].
Reference [3] studied the East coast of Asia and the result suggested ocean current generators for twelve (12) sites. The key parameters in the study were:

1. Near coast
2. Shallow seabed
3. Stable flow velocity
4. High flow speed

The minimum flow speed as selected by [3] is 1.0 ms^{-1}. Related studies have been conducted elsewhere [1]. Reference [2] believed that approach used by [3] provides a sustainable, practical and economical approach to ocean current power production, power evacuation and transmission to the final user.
In general sense, nearness to coast and shallow seabed will mean low flow velocities except in certain rivers of the world. Meeting the [3] criteria could be a challenge. In West Africa for instance, it is noted that the Guinea current, attains mean speed of about 0.3 ms^{-1} ([2], [4] and [5]).
The emphasis on renewable energy generation implies searching for opportunities to increase the potential of renewable sources of energy at our disposal. In this paper, a momentum diffusion methodology is investigated as a technique for intensification of low velocity water current for power generation to satisfy the requirement of [3].

2. Introduction

Consider a flow of fluid in a given direction as shown in Figure 1. When the flow is guided by a smooth faced plate, a fairly organized flow is made within the guided channel. In this open system as we have in an open ocean, shear stresses and pressure variations within the flow will generate momentum change within the affected fluid. This momentum is often a higher momentum and will diffuse into the lower momentum in the direction of flow. As the flow is nearly unidirectional, the team’s investigation showed increased velocity, V2 in the direction fluid flow (Figure 1).

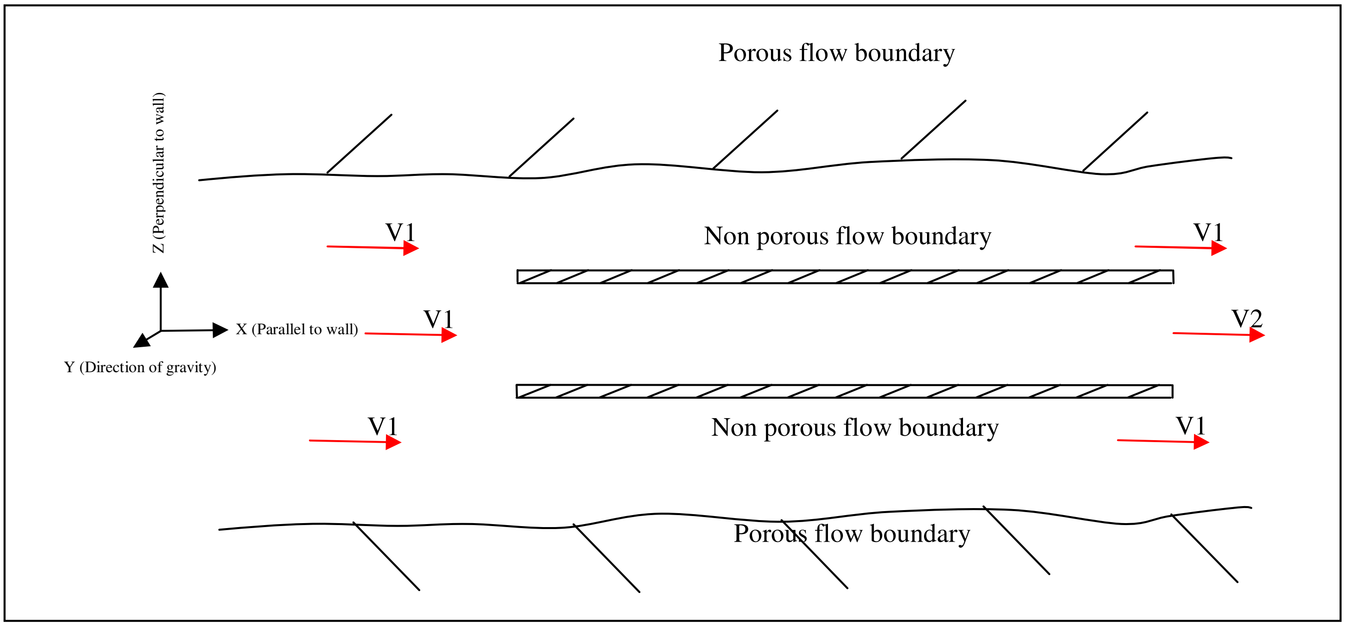

Figure 1: Porous and non-porous boundary flows

In an open river, the boundaries are porous to velocity of flow towards the wall. On another case, the boundary of the flow is a non porous solid structure enabling the flow to streamline better than if it were to be porous boundaries of the river. The consequence of the application of the non porous solid boundary within a homogenous water current flow system is investigated in a simple test and reported.

3. Test Materials

a) 0.1 x 2.3m semi-circular plastic pipe
b) Measuring meter rule
c) Stop watch
d) Table tennis ball
    a. Mass of Table Tennis ball is 2.70 gram
    b. Diameter of Table Tennis ball is 40.0 mm

4. Test Method and Procedure

Two of the 0.1 x 2.3 m semi-circular plastic pipes were made (Figure 2). One was designed to have a 90^o bend. The other was made as a straight (unbent) system. The purpose of making the two was for comparison only. The two of the 0.1 x 2.3 m semi-circular plastic pipes were then placed on a flowing river such that surface flows are allowed into them.

Figure 2: Indicating the semicircular plastic pipes on streaming river

The measuring rule is placed by the side and along the water exits of the plastic pipes. Two identical standard Table Tennis balls are placed, one at the exit end of the semi-circular pipe and the other at the streaming water surface and the velocities are computed from measured time of the clock and the distance travelled by the balls. The approximate positions of the two identical balls are shown in Figure 3. Three trials were made.

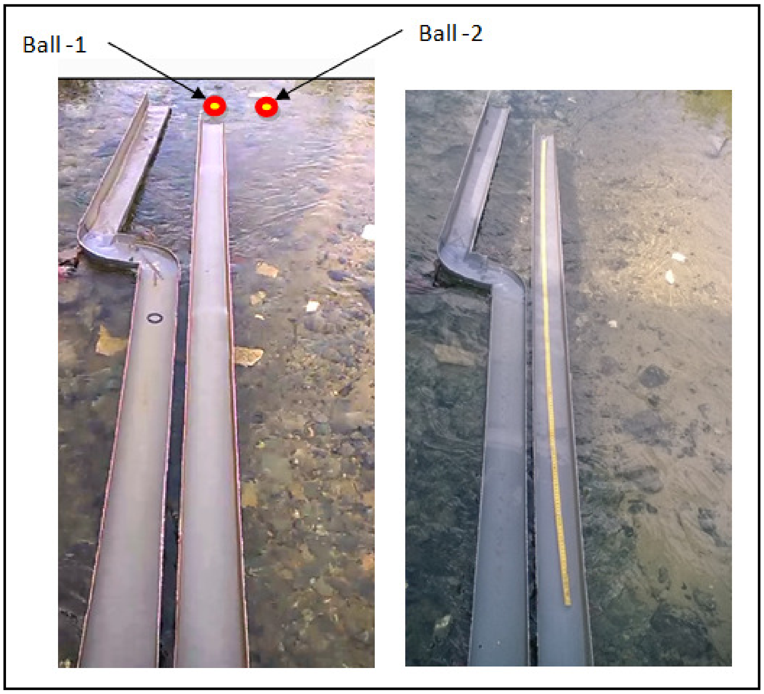

Figure 3: Two identical balls placed at pipe exit and the streaming water surface.

5. Results and Analysis

Measure time, t /sec	Distance/cm travelled by Ball-1 in time t	Distance/cm travelled by Ball- 2 in time t	Distance variation/cm	Velocity of Ball 1 relative to Ball 2, cm/s
3	98	60	38	12.6
3.5	92	52	40	11.4
2.9	93	58	35	12.0

It is obvious from the experiment that velocity of the ball is more on the guided channel than on the streaming river. The situation can be taken as a block of flow in a unidirectional traffic flow. Natural sources of flow variations will result in increased momentum within the flow. This may not be very obvious at the entering point (Figure 4). The little changes within the flow result into momentum diffusion growing into bigger values as seen obviously in Figure 3. Example of activities that could lead to the changes in flow is the event at the open air motion at the free surface. Other events are the shearing on the wall which is a continuous process and flow surges.

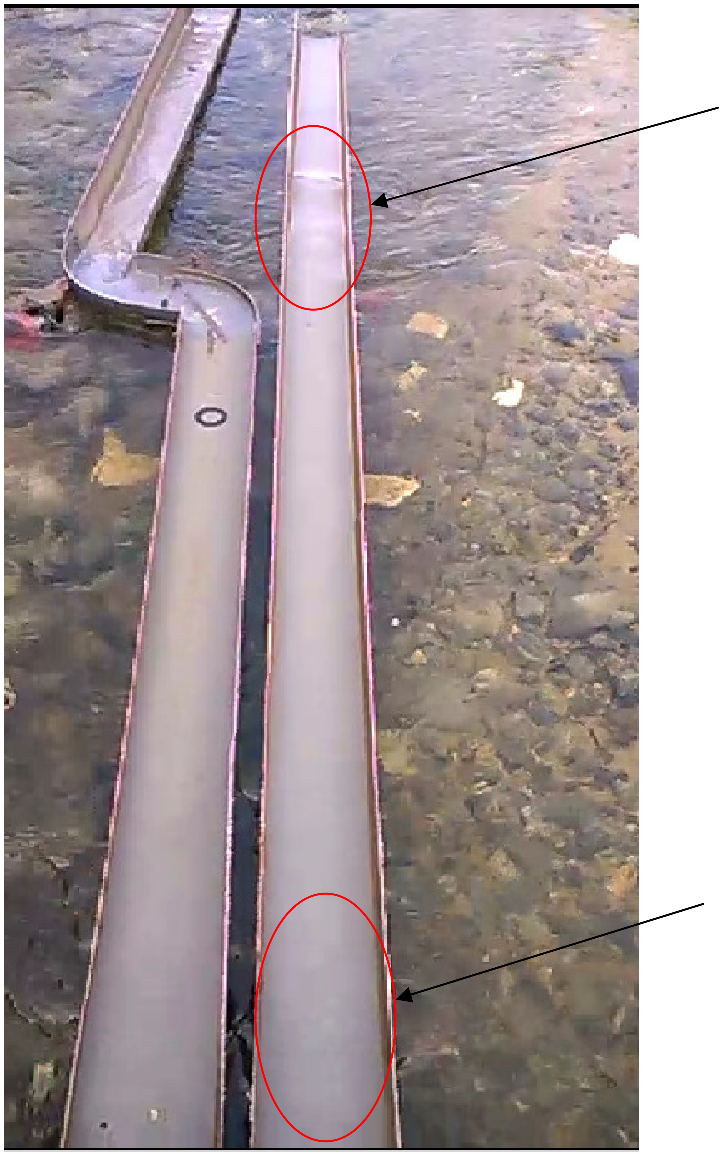

Figure 4: Momentum diffusion

6. Conclusion

Both the streaming river and the semicircular pipe are open channel flow systems. The relevance of the result is that non-porous channels can be constructed in low running currents of oceans and rivers to increase velocity and therefore energy within the flow. The method of design and installation will be investigated in another paper. It is believed that when design and installation is fully optimized, it will be possible to generate electricity from flowing water without much concern on flow velocities.

7. References

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