Transient Analysis of Fluid Flow Through a Fluidic Diode Used in a Wave Energy Converter

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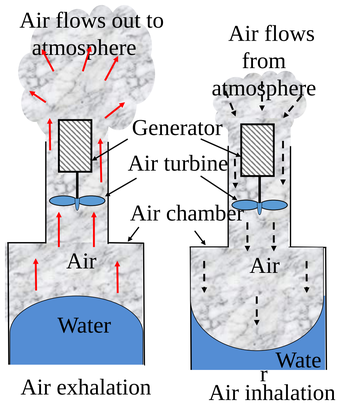
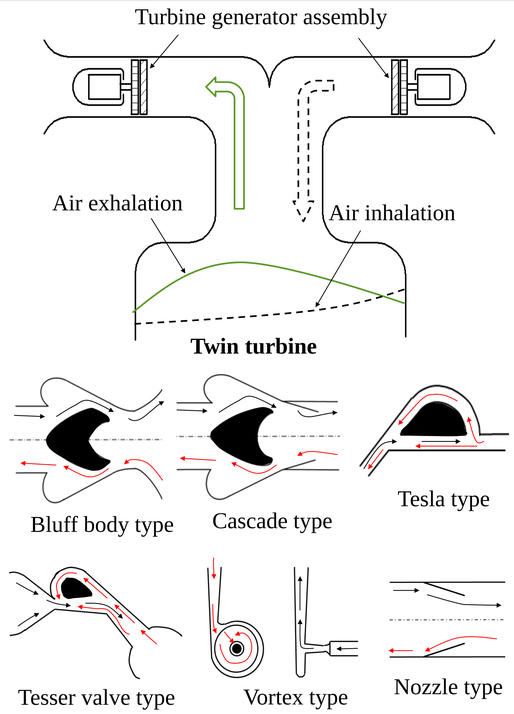
Introduction

- Ocean waves are produced from the energy transfer from the wind over the ocean surface.
- The oscillating water column device is extensively studied among the various wave energy harvesting devices because of its simplicity in operation and maintenance [1].



Working of oscillating water column

- Pneumatic energy of the oscillating water column can be harnessed by arranging the pair of conventional air turbines (Twin turbine) to eliminate the requirement of flow rectification [2].
- Twin turbine performance is less than individual turbine because the turbine alone unable to block the airflow in the opposite cycle completely [3].
- A fluidic diode that offers variable resistance to fluid flow can be used to improve the flow blockage. Its performance is given by diodicity.

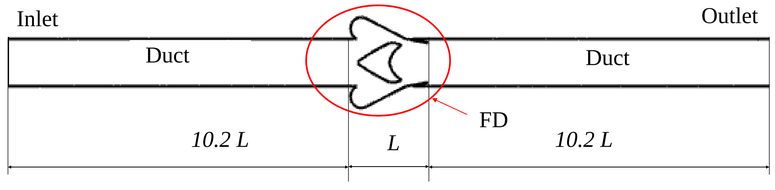


Some of the fluidic diode model in literature

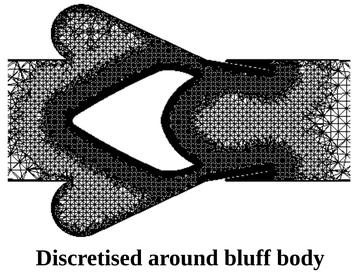
- Studying the performance of these device for oscillating flow condition is important because mimics the real sea state which is the intended operation of these device

$$Diodicity\ (\Psi) = \frac{Pressure\ drop\ (\Delta p)\ for\ reverse\ flow}{Pressure\ drop\ (\Delta p)\ for\ \ forward\ flow}$$

Numerical methodology



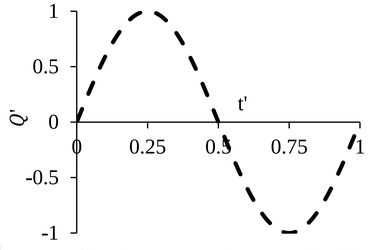
Computational domain



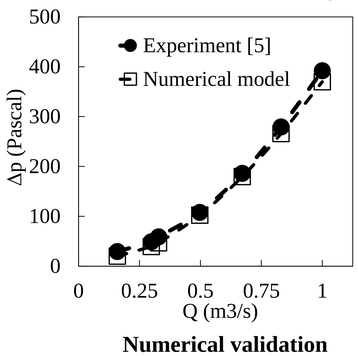
Discretised around bluff body

Numerical setup

Parameter	Description
Analysis type	Steady flow
Mesh	Unstructured/Tetrahedral
Fluid	Incompressible air
Residual convergence value	1 x 10^{-6}
No. of iterations	5500
Turbulence model	Realizable k-ε
Near wall treatment	Scalable wall function



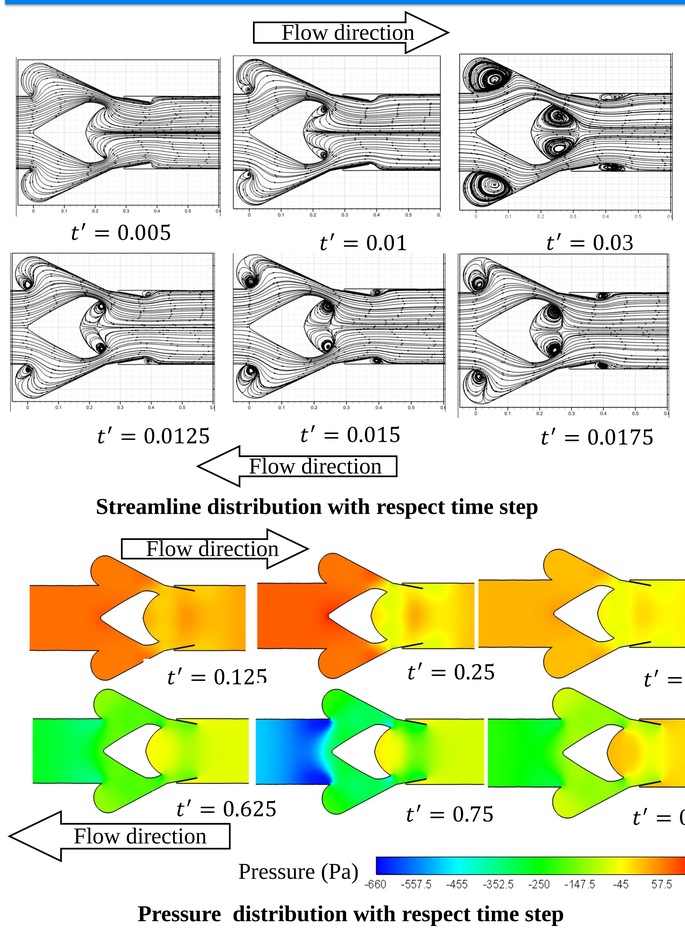
Oscillating air flow profile [4]



Numerical validation

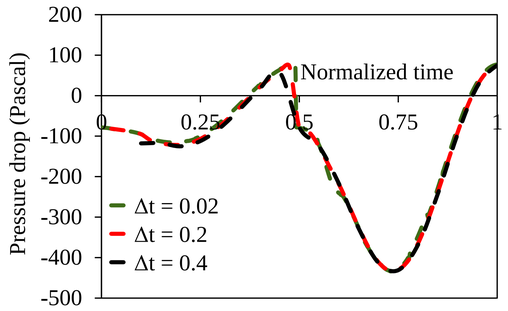
- Grid convergence index was used to arrive at the optimum no of mesh elements [6]
- Boundary condition for forward flow constant flow rate at the inlet and outlet is open to the atmosphere for reverse flow the boundary condition reverses.
- After numerical validation of the study state is performed the same model was used for oscillating flow condition.
- ANSYS FLUENT 16.2 was used for the simulations.

Results and discussion

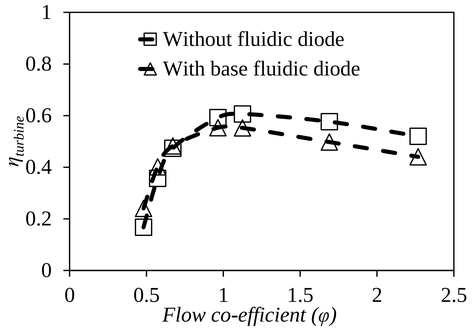


Streamline distribution with respect time step

Pressure distribution with respect time step



Time step validation



Overall efficiency of twin turbine

$$\eta_{overall} = \frac{\frac{1}{T}\int_0^T (T_f + T_r)\omega\, dt}{\frac{1}{T}\int_0^T \Delta p_T Q dt}$$

- As fluid flows over the bluff body it smoothly with time it start to separate.
- Pressure drop around the bluff body is higher compared to other section for the forward direction flow.
- For reverse flow the pressure drop is higher around the nozzle section.
- The overall efficiency of the turbine was found by taking the power out put from both the turbine and input power to the system

Conclusions

- The performance of the fluidic diode is greatly affected by its geometrical construction.
- The twin-turbine outperformed the twin-turbine coupled with fluidic diode at a higher flow coefficient (φ>1).
- The placement of the fluidic diode increases resistance across the turbine, Hence at higher flow co-efficient (φ>1), the performance of the turbine decline affecting the global efficiency of the twin turbine.

References

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