M.Tech (OE1) OE 5020 Design Project

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# Design of Fluidic Diode for an Oscillating Water Column.

First Review April 2021

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# Scope and Objectives

- **Objective**

Design the Fluidic Diode for an Oscillating Water Column type wave energy converter.

- **Scope**
  - Improve the performance of the twin turbine
  - Designing a fluidic diode for targeted output of the twin turbine
  - Verify the different shapes for a potential fluidic diode application
  - Determine the dimensions of potential fluidic diode shape.
  - CAD model of the designed fluidic diode.

# Design Methodology

- Obtain the performance characteristics of the twin turbine.
- Calculate operating range of pressure drop of twin turbine through curve fitting technique.
- Match the working pressure of diode and flow rate with the pressure drop and flow rate of twin turbine.
- Choose the optimum dimensions of the diode so that maximum efficiency is obtained from system.

# Work done so far…

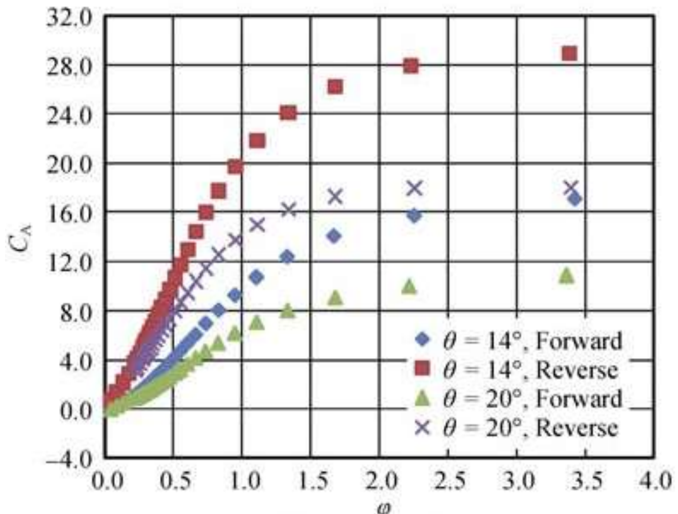
- Literature Review
- To obtain the performance characteristics of the twin turbine.
- Initial Parameter Assumption (guide vane angle, hub ratio, flow rate and inner diameter).
- To use the curve fitting technique to calculate the pressure drop in forward and reverse direction of the twin turbine
- To plot the performance curves on basis of above calculated data

- The details of above will be presented in the subsequent slides

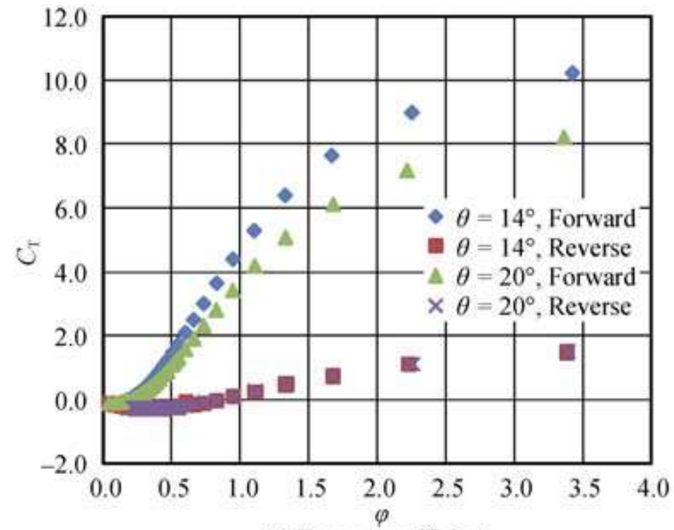
# Performance Curves

$$C_t = \frac{2To}{\rho(u^2+v^2)Ar} \qquad C_a = \frac{2\Delta PQ}{\rho(u^2+v^2)Av} \qquad \Phi = \frac{v}{u}$$

Obtain the curves and Digitize the plots to calibrate it → Export data to excel sheet and Fit the polynomial of order n → Check Regression Prediction coefficient and obtain the equation of curve



(b) Input coefficient



(a) Torque coefficient

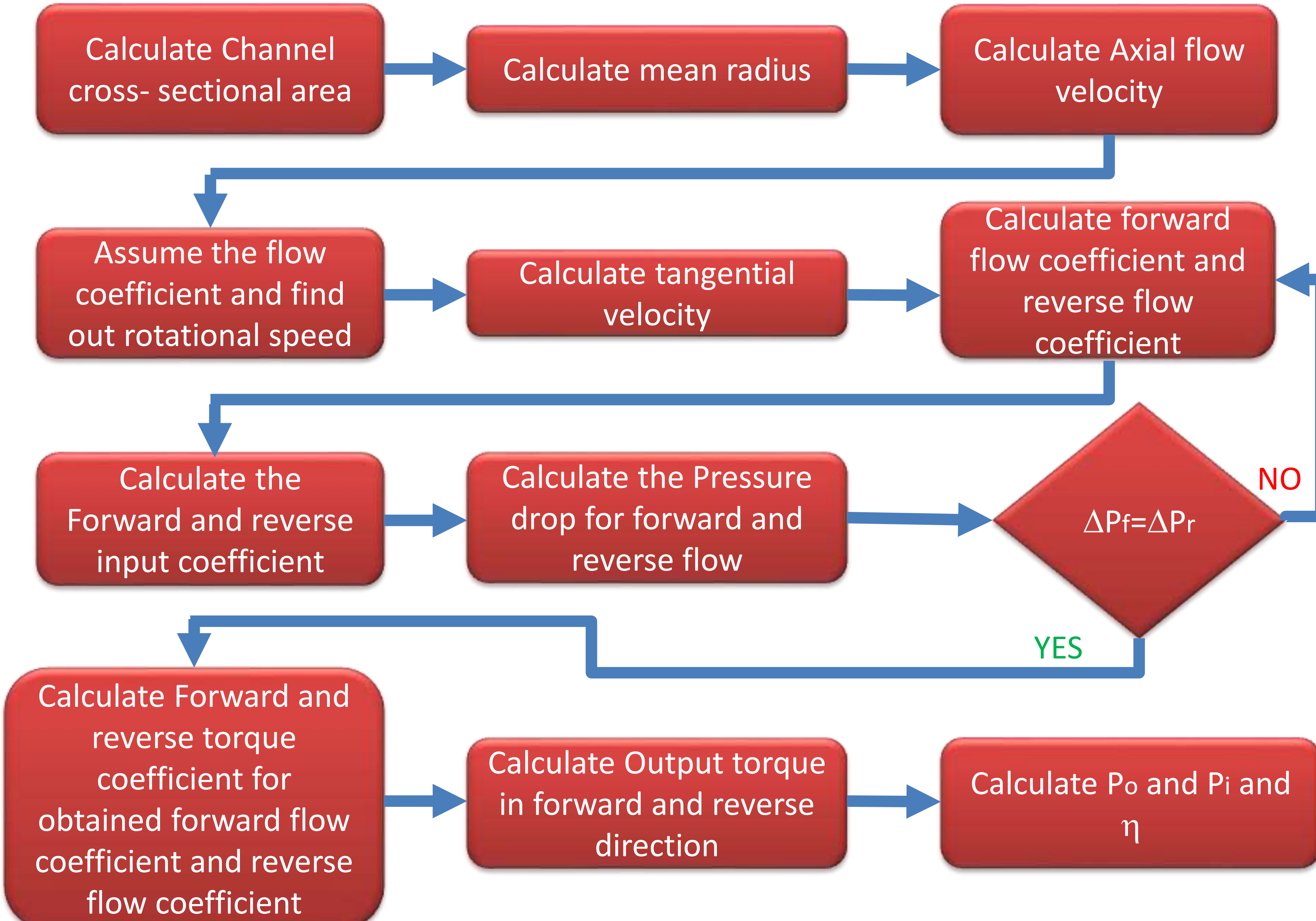
Caf = -0.3078x6 + 2.2651x5 - 4.751x4 + 0.2832x3 + 5.9876x2 + 3.6672x - 0.2951

Car = 0.9808x6 - 9.1296x5 + 32.097x4 - 52.719x3 + 35.366x2 + 6.8355x + 0.7557

Ctf = -0.266x6 + 1.8555x5 - 3.4393x4 - 1.4822x3 + 8.492x2 - 1.321x - 0.0869

Ctr = -0.129x6 + 1.0756x5 - 3.0752x4 + 3.1771x3 + 0.0649x2 - 0.7917x - 0.1795

# Process chart



# Parameter Assumption

- Guide vane angle – 20 degrees
- Hub ratio – 0.7
- Inner Diameter – 0.24m
- Flow coefficient and rotational speed are varying parameters
- Sinusoidal flow is assumed

Air Density – 1.2 kg/m^3

Flow rate- 0.15 m^3/s

$$\eta = \frac{\Delta PQ}{\omega \Sigma T_o}$$

$$v = \frac{Q}{A_{channel}}$$

$$A_{channel} = \frac{\pi}{4}(D_o^2 - D_i^2)$$

$$r_{mean} = \frac{1}{2}(r_o + r_i)$$

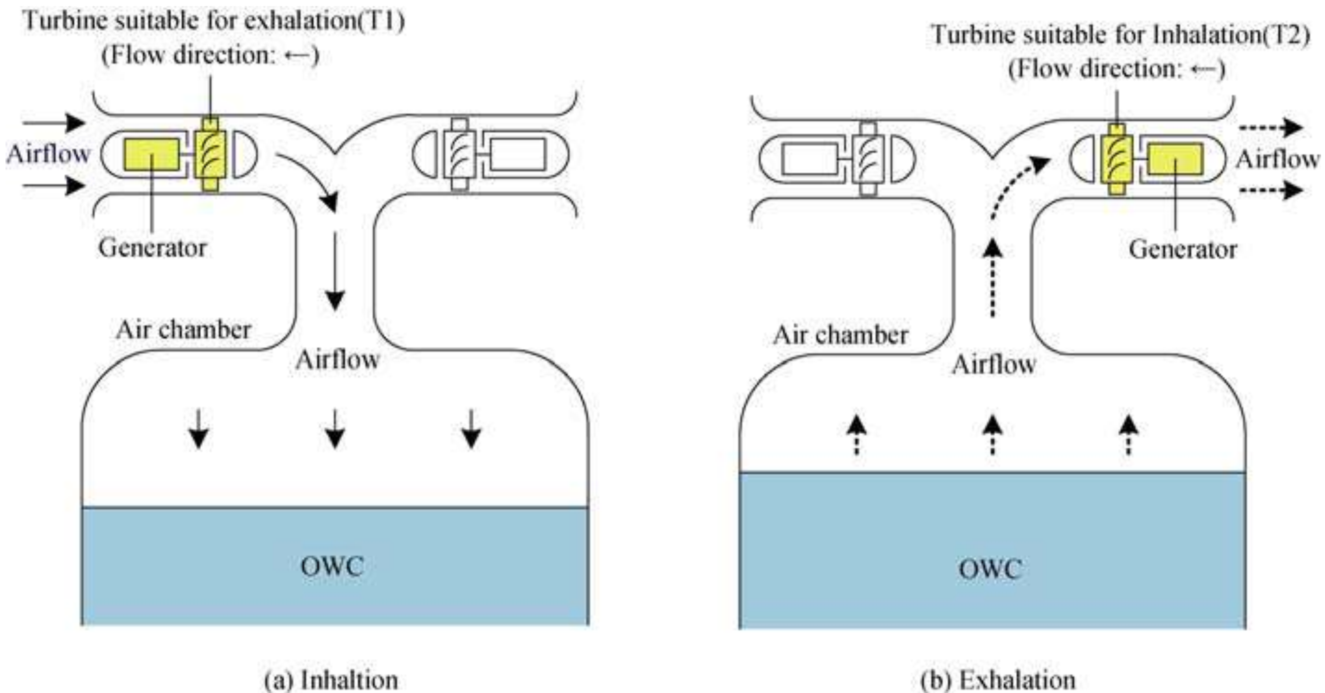



Fig1 : Basic arrangement of twin unidirectional Impulse turbine topology

Ref: A Twin Unidirectional Impulse Turbine for Wave Energy Conversion Manabu Takao et al

# Analytical Calculations

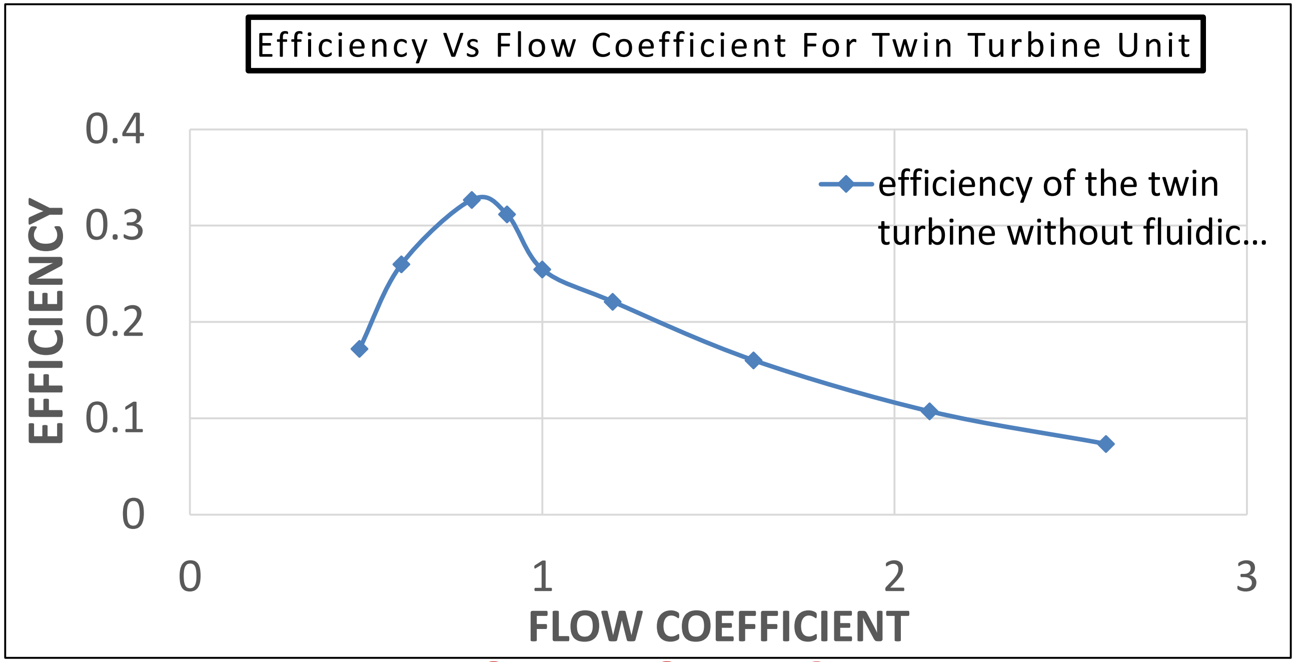
| Parameter | Value | Unit | Parameter | Value | Unit | Parameter | Value |
|---|---|---|---|---|---|---|---|
| Guide vane angle | 20 | deg | Inner diameter | 0.24 | m | Tof | 0.1119 |
| Air Density | 1.2 | kg/m^3 | Rotational Speed | 1400 | rpm | Tor | -0.0216 |
| Hub ratio | 0.7 | | Cross sectional area | 0.0231 | m^2 | Po | 7.1858 |
| Flow rate | 0.15 | m^3/sec | Axial flow velo v | 6.4935 | m/s | Pi | 22.043265 |
| Flow coeff | 0.8 | | tangential velo u | 8.1169 | m/s | **effi** | **0.326** |
| mean radius | 0.102 | m | w | 79.5775 | rad/sec | | |

| | | | |
|---|---|---|---|
| Caf | $y = -0.3692x^5 + 3.2334x^4 - 9.9211x^3 + 11.101x^2 + 2.5501x - 0.4597$ | Car | $y = -1.2126x^5 + 9.7809x^4 - 26.612x^3 + 24.413x^2 + 7.4154x + 0.3595$ |
| Caf | 2.8734 | Car | 3.4673 |

| Flow coeff | tangential velo | Forward Input coeff | Flow coeff forward | pressure drop | Backward Input coeff | Flow coeff reverse | pressure drop | |
|---|---|---|---|---|---|---|---|---|
| Φ | u | Caf | Φf | ▲pf | Car | Φr | ▲pr | ▲p |
| 0.8 | 8.1268 | 0.42 | 0.2 | 17.309 | 9.0225 | 0.6 | 486.2462 | -468.9372 |
| 0.8 | 8.1268 | 3.3141 | 0.6 | 178.6055 | 2.6215 | 0.2 | 108.0373 | 70.5682 |
| 0.8 | 8.1268 | 2.541 | 0.5 | 125.865 | 4.139 | 0.3 | 178.7773 | -52.9123 |
| 0.8 | 8.1268 | 2.9276 | 0.55 | 151.1054 | 3.3604 | 0.25 | 141.485 | 9.6204 |
| 0.8 | 8.1268 | 2.8502 | 0.54 | 145.8793 | 3.5133 | 0.26 | 148.6326 | -2.7533 |
| 0.8 | 8.1268 | 2.8734 | 0.543 | 147.4367 | 3.4673 | 0.257 | 146.4735 | 0.9632 |

| | | | |
|---|---|---|---|
| Ctf | y= -0.3357x5 + 3.0338x4 - 9.8999x3 + 13.149x2 - 2.1762x - 0.1569 | Ctr | $y = 0.0849x^4 - 0.7271x^3 + 1.9264x^2 - 1.0196x - 0.0848$ |
| Ctf | 1.2013 | Ctr | -0.2316 |

# Plot obtained by Analytical Calculations




# Work to be done

- Match the working pressure of diode and flow rate with the pressure drop and flow rate of twin turbine.
- Choose the optimum dimensions of the diode so that maximum efficiency is obtained from system.
- Cad model of the fluidic diode

# Work Schedule

| Activity | March | April | May | June | 1-15 July |
|---|---|---|---|---|---|
| Literature Review | | | | | |
| Obtain the performance characteristics of turbine | | | | | |
| Analytical Calculations | | | | | |
| CAD Modelling | | | | | |
| Report | | | | | |

**Thanks**