Pico – power Production from a Squirrel – cage Darrieus VAMCT

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Introduction

Hydrokinetic energy has a huge potential in harnessing natural energy from marine currents found naturally in oceans, rivers, and streams; Artificially in pipes for irrigation, hydration, and recology. Hydrokinetic turbines are characterized for its low capital investments and modularity. This thesis looks at confirming "impedance matching" results and exploring efficiency parameters of a pico-scale squirrel-cage darrieus Vertical-Axis Marine Current Turbine.

Theory

Hydrokinetic Energy

- Energy transfer of linear marine current flow into rotational energy to induce work from rotating magnet interacting with a stationary electromagnetic induction coils.
- Three-phase rectifier receives electric pulse from magnetic induction and converted to digital oscilloscope data, shown in Figure. 1.
- Rectifier circuit is used to convert AC to DC.
- *Lenz's Law* : As a magnet is moving towards a conducting ring, an induced electromotive current is caused to flow opposite the direction of moving flux.
- Power produced from turbine, Eq. 1

$$P_{turbine} = \frac{V^2}{R} \tag{1}$$

where, V is average voltage generated within a given period (volts), R is load resistance (Ω).

Impedance Matching

- The load resistor labeled in Fig. 1 (Left) and represented by resistor symbol in Fig. 1 (Right).
- This load is used to match the internal resistance from induction to rectifier. This acts to maximize the power output of the turbine. [1]

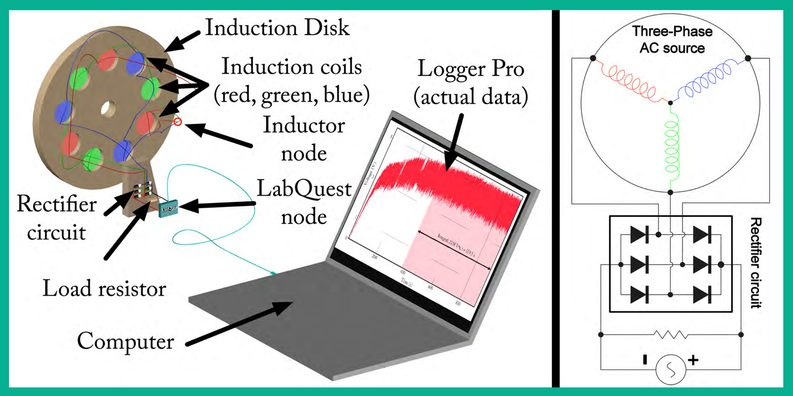

Figure 1: (Left) Three-phase rectifier circuit shown in 3D as applied to the generator. (Right) Three-phase rectifier circuit attached to a load and Digital oscilloscope.

Goals ⇝ Methods

- Increase structural integrity to reduce shaking. ⇝ Redevelopment of the generator base structure and securing to a sturdy support structure (Milling Bench, Fig. 3).
- Explore a champion style turbine head. ⇝ A Three–bladed Squirrel–cage Darrieus turbine VAMCT. [2, 3, 4, 5]
- Confirm impedance matching resistance results. ⇝ Sampling an array of different resistances and cross-referencing with Carleson. [1]
- Improve upon sources of driving force. ⇝ Applying the easily accessible resource of air pressure attached to a fixed retort stand.
- Develop a system for stopping the turbine. ⇝ A red shop cloth, Fig. 2 manually pushed into the front center axis of the turbine head.

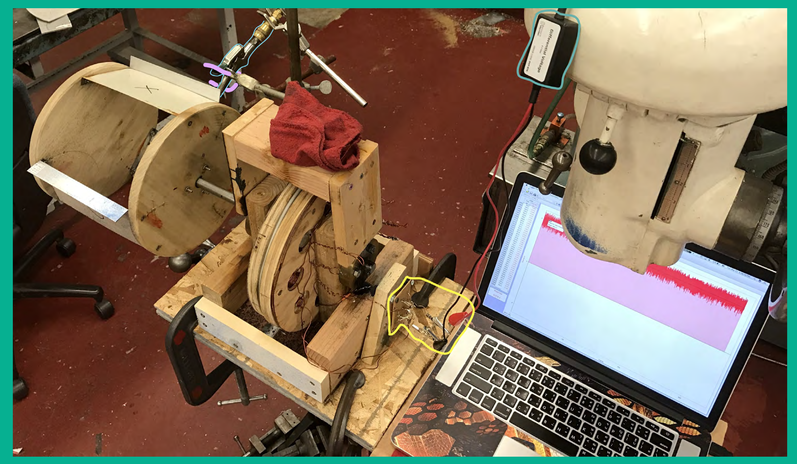

Figure 2: A photo of the setup, shown and labeled in Fig. 3

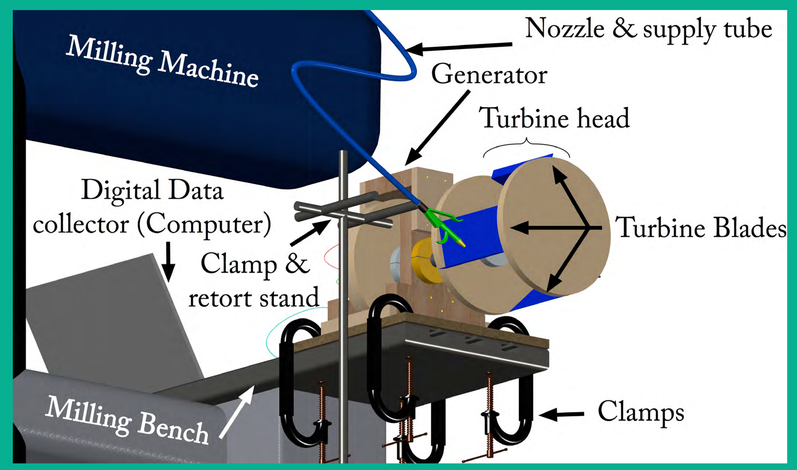

Figure 3: A diagram of a 3D model showing the entire setup with labels.

Results

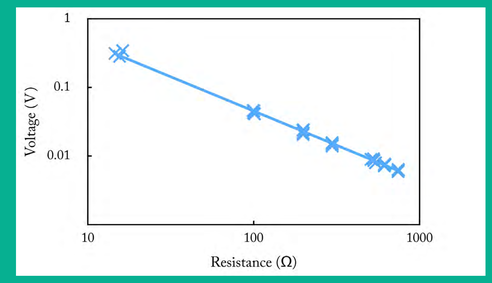

Figure 4: Testing impedance matching resistances of 15, 100, 200, 300, 510, 600, and 750 Ω. Comparable to [1]

Table 1: Sample data collected and calculated down to power generated shown in the last column. Load remains constant based on Fig. 4, where power is maximized.

Test	Area ($V \cdot s$)	Time period (s)	Load (Ω)	Volts (V)	Power (W)
1	2204	425.1	15.1	5.1844	1.78
2	1303	288.2	15.1	4.5212	1.35
3	2081	451.5	15.1	4.6091	1.41
4	1590	330.4	15.1	4.8123	1.53

Conclusion

- Output power had a range of 1-2 Watts. Capable for small LED circuits in class instruction. Can be used to convert air pressure into electricity.
- For future prospects, getting this turbine field–tested would be a great step forward. Also, optimizing the turbine and generator for VAMCT field–testing.

Credits

- Linfield Physics and Theater Departments
- Special thanks to Professor Xie Tianbao
- Matthew Carleson '15 [1], and the Harger family

References

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