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Roosevelt Fountain Wind-Driven VFD Pump Control

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BROOKFIELD ZOO
Chicago Zoological Society

① Introduction

The Roosevelt Fountain is a centerpiece of the Brookfield Zoo. The largest jet can send water vertically up to 18.3m. On windy days, water from the main jet blows mist outside the boundaries of the fountain and onto the civilian walkway. This affects the visitors of the zoo. The present countermeasure to this complication requires a manual valve adjustment or temporary pump shutdown. This causes the zoo staff to have to divert from their usual tasks, wasting time. This countermeasure also wastes energy, causing the zoo to overspend on electricity.

② Purpose/Scope

The purpose of the project was to design an automatic system to control the height of the Roosevelt Fountain. Its implementation will save the zoo staff time and money. To do so, the project team not only designed the system to be implemented by the zoo, but also constructed a proof-of-concept model to easily demonstrate its functionality before the full-scale implementation is possible.

Figure 1: Roosevelt Fountain [Picture taken from the south entrance of the Brookfield Zoo. The fountain is shown at about 3/4 of its full height.]

③ Design Implementation

Figure 2: Anemometer [The anemometer is used to measure the wind speed and direction. It sends this data to the Arduino.]

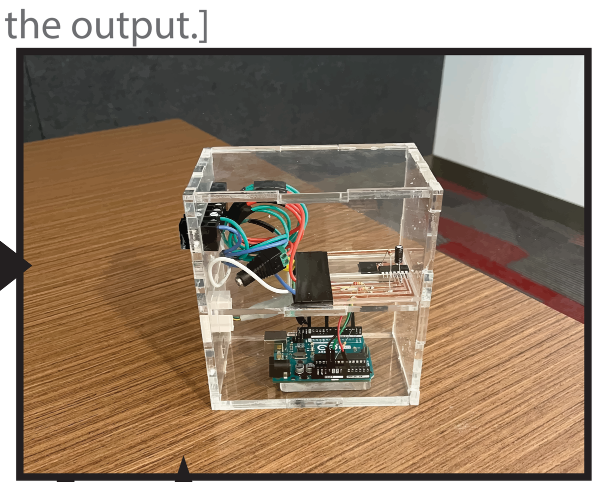

Figure 6: Acrylic Case [The Arduino processes the wind data, and the external circuit scales the output.]

Figure 3: Solenoid Valve [The solenoid valve receives the voltage from the Arduino and adjusts its state accordingly.]

Figure 5: Pump [This is the submersible pump placed in the pool for the proof-of-concept. (See Figure 7)]

Figure 4: Fountain Nozzle [This brass nozzle is used to mimic the full-scale system at the zoo.]

④ Results

Figure 7: Proof-of-concept in action. [This model shows that our system will function correctly once implemented as a full scale solution for the Brookfield Zoo. Jackson (right) is spinning the anemometer to imitate wind. Here, the fountain is at about 12 ft tall. This corresponds to a wind speed of about 8 mph, which is in line with the calculations shown in Figure 8. The maximum height of our model is 18 ft, so the results are proportional to what they should be for the full scale solution.]

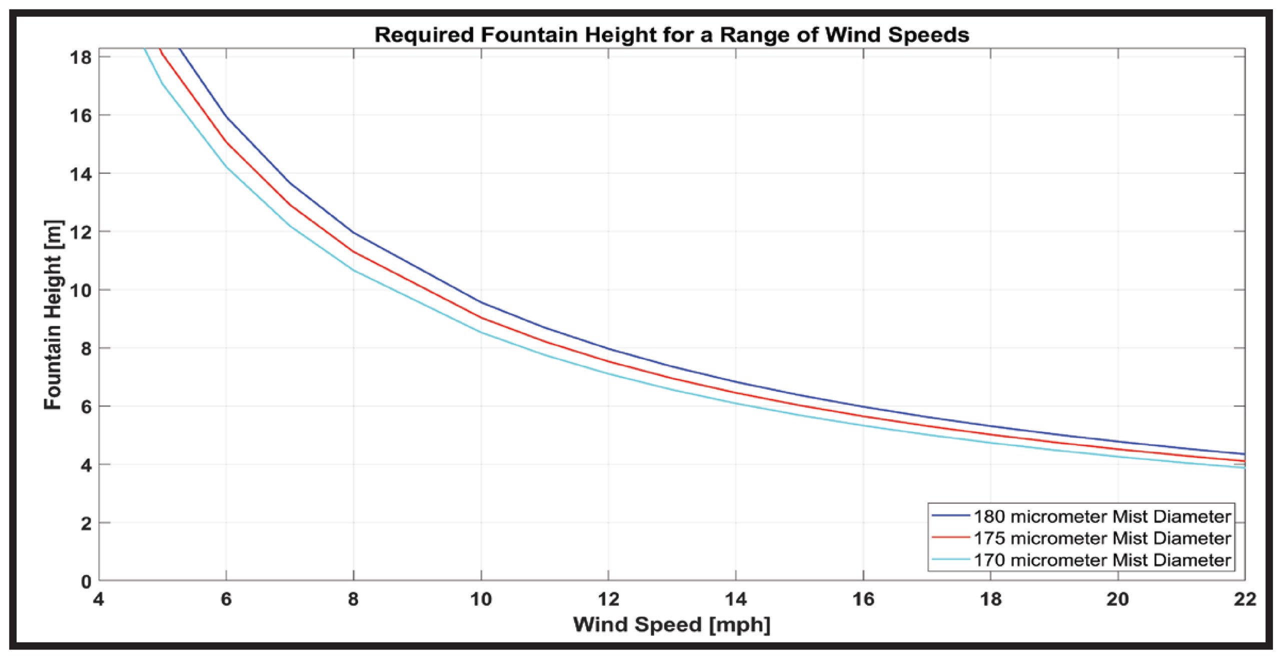

Figure 8: MATLAB fountain height and wind speed correlation [Shows the ideal height of the Roosevelt Fountain for wind speeds between 4 and 22 mph. The three mist particle diameters - 180, 175, and 170 micrometers - were deemed to be the most relevant since smaller particles are prone to evaporation before reaching the border of the fountain.]

⑤ Discussion

In our design, the wind velocity and direction data from the anemometer are sent as to the Arduino as digital and analog signals, respectively. The velocity value determines the voltage to be sent to a variable frequency drive that controls the pump. Each voltage is assigned to a specific frequency. When there are high wind speeds, the frequency of the drive and the fountain height decrease.

There are a few key differences between the model and the full-scale system. The anemometer (Figure 2), wiring and software are all the same; however, a solenoid valve (Figure 3) is used in place of the variable frequency drive (VFD), the piping is PVC, and the nozzle is a brass fountain nozzle (Figure 4).

Power, Cost, and Savings Calculations

	Seasonal Use (No VFD)	Seasonal Use (VFD)	Savings
Power (kWhrs)	9.96	2.211059788	7.748940212
Hourly Value	$ 0.58	$ 0.13	$ 0.45
Total Seasonal Value	$ 800.09	$ 177.61	$ 622.47

Table 1: Seasonal energy and cost savings of full-scale solution [This table shows an estimate for the seasonal savings based on some initial VFD frequency assumptions made by the team. The true values will vary slightly depending on the initial system setup made by the Brookfield Zoo staff once it is ready to be implemented. These numbers do not account for the time that will be saved during implementation. The team has estimated that about 15 minutes will be saved per day that the fountain is functional.]

⑥ References/ Acknowledgements

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