Design of a Saltwater Swimming Pool with Renewable Off-Grid Solar Heating

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Abstract -- **The half Olympic sized pool, to be located in parking lot P12, has been designed to meet the client's specifications. To disinfect the pool, a saltwater cholrine generator has been incorporated into the pool system. The salt concentration in the water will not harm a human being and will need to be replenished only when there is fresh water added to the pool. The renewable energy heating system consists of a number of solar collectors and pumps to transport the pool water to and from the heating system. The pumps will be supplied with electricity from photovoltaic cells, thus allowing for an entirely renewable heating system. The capital cost of the system is estimated at $221,400 excluding installation, design costs and taxes. The seasonal operation and maintenance cost is estimated at $53,300 per season.**

Index Terms -- **Solar heating, Saltwater, Swimming pool, Renewable Energy**

I. Background And Problem Statement

Recent studies have shown a correlation between the use of chlorinated swimming pools and respiratory health [1]. Thus there is a great need for a treatment system that does not use the harmful chemical chlorine. This paper details the design process and outcome of a non traditional salt water swimming pool utilizing an off-grid renewable heating source.

II. Technical Analysis And Synthesis

A. Criteria and Constraints

The outdoor pool is 12.5m wide x 25m long x 2m deep (half Olympic size) with a sun deck. The pool will be located on the current University of Soeville parking lot P12 and must utilize an off-grid renewable source of heating energy. The requirements of O. Reg. 565/90 Amended to O. Reg. 179/02 for Public Outdoor Swimming Pools were met in the design. The pool was sustainably designed to maximize the use of renewable energy and minimize capital, operation and maintenance costs without compromising health, safety and environmental impacts.

B. Renewable Energy Heating

Solar energy was chosen to be the most reliable heating option for the pool. Solar water heating panels will ultimately be used along with photovoltaic cells to power the pumps required to transport the water to and from the heating system.

C. Assumptions

The pool was designed with a flow rate of 29 L/s and a maximum capacity of 125 persons. It was assumed that the grid will provide sufficient power to run the treatment system and the pool components, excluding the heating system.

D. Milestone

The project milestone is a technical engineering drawing of the components of the pool treatment system.

III. Methodology

A. Salination

The process of salination utilizes a chlorine generator which transforms common salt into chlorine gas through electrolysis. The gas is instantly dissolved in the water to form chemical chlorine, which disinfects the pool water. The process by which saltwater is converted to chlorine through electrolysis is given by the following equation,

$$2NaCl + 2H_2O \rightarrow Cl_2 + H_2 + 2NaOH \quad [1]$$

The salt dissolves in the water to form sodium and chlorine ions. The water is then passed through oppositely charged electric plates in the generator. The ions are able to migrate to the plates of corresponding opposite charges. The chlorine ions migrate to the positive plates, give up electrons, and are converted to chlorine gas. This process is shown in Fig 1.

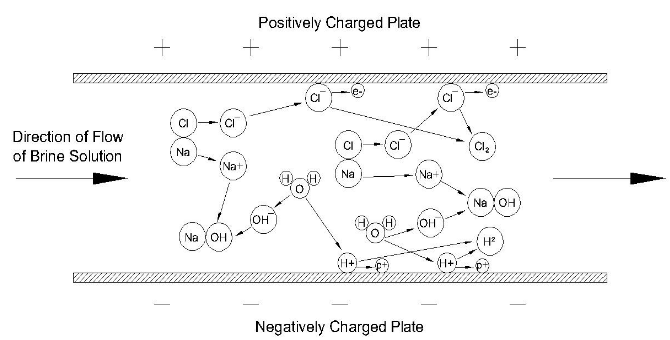

Figure 1: Chlorine Generator: Theory of Operation.

When the chorine completes the task of disinfection, it reverts back to salt. This creates a safe and effective means of pool water treatment.

B. Cost Analysis

The capital cost including the pool, the chlorine generator, and the solar heating system is estimated at $221,400 excluding installation, design costs and taxes. The seasonal (mid-June to mid-September) operation and maintenance cost associated with landscape maintenance, utilities and personnel is estimated at $53,300 per season.

IV. Detailed Design

A. Energy Requirements

The pool will be heated using a solar water heating system located in the southeast corner of parking lot P12. The system consists of 56 solar collectors occupying 156.25m2. Pool water will continually flow through the solar fins within the collectors to absorb the heat radiated from the sun [2]. The pool water will be pumped to the heating system via four pumps, each being powered by a 60W photovoltaic cell [3]. To ensure maximum heating efficiency a pool cover will be utilized when the pool is not in use and there will be no shading around the solar heating collectors or photovoltaic cells. A pool temperature of $25.5^{o}C$ to $26.7^{o}C$ is expected to be maintained [4]. Due to the location of the pool within southern Ontario and the fact that it will only operate during the summer and spring, no auxiliary heating system will be required.

B. Environmental Impact and Sustainability

One of the largest environmental impacts of a saltwater pool is the disposal of the saltwater before winter. The saltwater in the pool must not be disposed of in sanitary drains or released to the land surface.

One method for disposing saltwater is by desalinization. This will eliminate the environmental impact of salt on the land surface. Solar desalination evaporation systems, which make use of environmentally friendly energy rather than electrical power, may be used to recover the salt and water. The salt recovered from the pool can be used as road salt during winter maintenance on campus. Alternatively, the brine may be used in the cooling system below the ice rink surface in the Gryphon Rink.

This pool design seeks to minimize the amount of electricity used from the grid through solar heating and by choosing energy efficient pumps and chlorine generators.

The use of salination for pool water disinfection minimizes the use and exposure of the chemical chlorine. Thus reducing the environmental and health risks associated increased ozone formation and ground level ozone.

The portion of parking lot P12 located directly behind the Gryphon Rink will be converted into a green space.

C. Safety

Salt (NaCl) is a colourless or white, odourless solid with a stable reactivity that may cause irritation to skin, eyes and the respiratory tract. Gloves and safety glasses with side shields are to be utilized when handling NaCl. The storage facility for NaCl on site is equipped with an eyewash station and a safety shower and has good ventilation.

Although the solar plate collectors are impact resistant, if a break event takes place, the plate should be removed and immediately replaced. Personal protective equipment must be worn to eliminate risks of cuts. Further, solar collecting panels will be located in a fenced off area away from the pool deck so to limit access to only trained personnel.

To reduce the risk of electrocution as a result of contact between water and electricity all equipment will be housed in a locked enclosure in the pool area.

To prevent access after hours that may result in a safety incident, a fence will enclose the pool area.

V. Discussion

The total energy required to run the solar heating system is 240W, which is provided by four photovoltaic panels. Multiple pumps in the solar heating system incorporate redundancy, meaning that if one pump were to break down the system would still maintain the temperature at 75% the desired temperature

Integration of the treatment system with other pool components (filters, pumps, etc.) was achieved by ensuring the various components of the pool system were compatible. This includes pipe fitting adapters for each pump, tees, and adapters for the various pool parts such as skimmers. Regular maintenance is required for the saltwater generators as precipitate buildup is common in the production of chlorine.

VI. Conclusion

It is recommended the water quality of this design be simulated to ensure that the standards for a public pool are being met in accordance with O. Reg. 565 Amended to O. Reg. 179/02. A similar simulation should also be performed with the heating system to ensure an adequate pool temperature of $25.5^{o}C$ to $26.7^{o}C$ is maintained throughout the swimming season.

Acknowledgement

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