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Thermal desalination process - Design perspectives

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Urban areas, although better served than rural areas, are struggling to keep up with the population growth. Population increase on Earth, is directly related to the global food and energy demand. Expansion of the agricultural sector and the energy sector considerably increase the competition for water. Population growth is directly proportional to the demand of fresh water. Decision for using new water resources is always challenged by the factor of cost. Thermal water desalination process is so far less efficient but very close to the natural water cycle. This study is based on designing a thermal desalination plant, which is suitable for desalinating sea water. The paper discusses the important factors that are required to be considered, while designing a thermal desalination plant.

The plant is designed to run with a small scale experimental solar pond which is located in the University of Kelaniya, Sri Lanka (Latitude 6^{o} 58' 23.17524 N, Longitude 79^{o} 54' 54.91315 E). The plant has two major tanks known as the evaporator and the condenser and each tank has a volume of 0.085 m^3. Boiler and pressure vessel international codes published by the American Society of Mechanical Engineers (ASME) and equations published in the Coulson & Richardson's Chemical Engineering Design book were used to estimate the necessary thickness of tank walls and pipes. Steam flash nozzles were installed inside the evaporator for efficient flash evaporation and fresh water spray nozzles were installed inside the condenser for direct steam condensation. Due to the low thermal storage in the small scale solar pond, the plant is designed to deliver 1 liter of fresh water per hour. However, this design is constructed with two steam pipes instead of one to obtain maximum desalination rate of the plant.

Size of the steam pipes between condenser and evaporator depends on steam generation rate and condenser temperature of the plant. Inappropriate designs may cause explosions in the tubes. The evaporator and condenser liquid temperatures of this design are 60^{o}C and 55^{o}C respectively. The pressure required to evaporate 60^{o}C water can be found from the standard steam tables and it was found to be 20 kpa. Specific volume of steam at this pressure and temperature is nearly 7.667 m^3/kg and this value changes to 9.600 m^3/kg when the steam transfers to the condenser side of the plant. A steam velocity of 2.06 m/s between evaporator and the condenser is required to provide one litre per hour fresh water output. Considering the specific volume and the mass flow rate of the steam, the diameter of the steam pipe should be at least 4 cm. The ASME guidelines provide the required thickness for steam pipes. However, it is important to separate small water droplets in the steam before entering to the condenser. To achieve this goal, a locally made plate demister is installed between the evaporator and condenser. Water droplets separated by the demister are again fed back to the evaporator of the plant. Water level inside the condenser and evaporator must be maintained at a certain level to conserve the efficiency of the system. Increasing water level inside the condenser and evaporator tanks cause to increase the pressure inside the plant will hence decrease the efficiency