ABSTRACT

A new concept for sea water desalination, where warm ocean water from the upper strata of the ocean in the ambient temperature is injected (sprayed) into a flash evaporator at a low pressure and the resulting water vapour is condensed in a condenser, using the cold ocean water taken from the depth of the ocean. The low pressure in the vaporizer and condenser is maintained by means of vacuum pumping system and barometric seals. The barometric seal, provided by the long duct connecting the vaporizer to the ocean enables to maintain the vacuum in vaporizer and also to discharge large volume of water which is not vaporized in the vaporizer without any pump. Similarly the barometric seal provided by another duct connecting the condensate side of the condenser to the fresh water collection reservoir enables to maintain the vacuum in condenser and also to discharge all condensed fresh water from the condenser without any pump.

The feasibility of desalination by low pressure vaporization of sea water at temperatures between 26°C and 32°C is demonstrated in two different experimental facilities by spray flash evaporation method. The plant operated at vacuum pressures between 10 mm of Hg and 18 mm of Hg (abs). The selected temperatures are corresponding to the warm temperatures of the ocean surface in the tropics and the pressures are taken based on the temperature of available cold water.
A parametric study conducted and the result gives a valuable output for developing technology for desalination. The temperature of the water droplet, the pressure in the vaporizer, the resident time of the injected water inside the vaporizer and the size of the droplet are identified as parameters influencing vaporization at low pressures. The vaporization time for a vacuum level is proportional to the square of the diameter of the particle and increases with the feed temperature due to larger temperature difference between the feed temperature and the final temperature at which vaporization ceases.

The rate of vaporization found out based on energy balance at the droplet surface shows that, rate of vaporization increases as the temperature of feed water and decreases in the pressure of the vaporizer increases the rate of vaporization. A vapour diffusion model is also developed, which takes into account the reduction of droplet temperature during the evaporation process, when the saline water was injected as fine droplets in a low-pressure vaporizer. The values obtained from the two models are almost identical. The predictions from the model were verified by a large number of experiments in two different experimental facilities (low flow and high flow facility).

First set of experiments are conducted in a low flow facility (nominal flow rate of 1000 kg/hr). Typical time required for evaporation of the droplets was found to be few hundred milliseconds and this was less than the resident time of droplet in the vaporizer. Changes in the height of water injection in the vaporizer did not significantly influence the yield of fresh
water. The resident times in excess of vaporization times are obtained in the experimental facility for the three values of injection heights used. Hence the resident time provided appears to be adequate. Small values of water injection pressures of about 0.5 bar (gauge) were found to be adequate when a swirl injector, used for garden sprays, was employed. The yield of fresh water increases as the temperature of feed water increases and in the pressure of the vaporizer decreases as predicted by theory and it was upto 3.6 %. A correlation is proposed for the coefficient of evaporation rate ($K_e$), which is independent of time for three vaporizer pressures.

Second set of experiments conducted in a flash evaporator [1000 mm height x 1200 mm diameter] for the same pressure and temperature conditions for high flow rate (nominal flow rate of 5400 kg/hr.per jet), where the saline water is injected in to the evaporator through a pair of high flow swirl injector. The influences of the different thermal, hydrodynamic and geometric parameters on the evaporator performances were investigated. The distance between injection planes of impinging water jets is varied between 100 mm and 400 mm and thereby the droplet sizes and the distributions of injected feed water are modified to study the impact on rate of vaporization. Higher fresh water yield is seen when the distance between the injectors is 200 mm. Also the influence of vaporizer volume on the rate of vaporization by varying the vaporizer diameter is studied. The vaporizer volume is indirectly a function of the residence time. The volume of vaporizer has large
influence on the rate of vaporization, higher yield is seen when the volume of the vaporizer was 1200 mm.

Experiments were conducted using the artificially prepared seawater adequate to demonstrate the technical feasibility of the process for the application of desalination. The fresh water obtained in the experiments meet the requirement of Indian Standards of potable water.