A SMALL SCALE MULTIPLE EFFECT DISTILLATION (MED) SYSTEM FOR RURAL DRINKING WATER SUPPLY

BY

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Dedicated to the

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CERTIFICATE

This is to certify that the thesis entitled "**A Small Scale Multiple Effect Distillation (MED) System for Rural Drinking Water Supply**" being submitted by **Shiv Kumar Vyas** (1996 RAM 004) for the award of the degree of **Doctor of Philosophy**, to the **Indian Institute of Technology, Delhi** is a record of the original bonafide research work carried out by him under our guidance and supervision and that the material embodied in this thesis has not been submitted in part or full to any other University or Institute for the award of any other Degree or Diploma.

We further certify that such help and source of information, as has been availed of during the course of investigation have been duly acknowledged by him.

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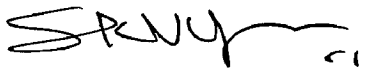

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ABSTRACT

A small scale multiple effect water distillation (MEWD) system for rural areas was designed and fabricated using locally available materials. In this unit, which operates at supra-atmospheric pressure, falling-film vertical tube evaporators are employed. For the ease of operation on a small scale, steam is condensed in the tube side and brine evaporated on the shell side, which is generally not the case in the reported large scale plants in literature. Parallel feed configuration was used to feed brine into the evaporators. Design of a mixed feed system, employing part parallel and part forward is also briefly discussed. Small sized orifices are used to withdraw distillate and brine. The triple effect MEWD unit is rugged and can be operated and maintained by rural artisans. The system has been tested for its operation and performance. The unit produces about 60 litres per hour of distilled water for an input of 20 kg/h steam.

Literature reports many large scale MEWD units or multi-stage flash (MSF) units capable of producing 4000 m^3, and above, per day of distilled water. However a small scale MEWD unit, for the rural sector capable of producing 1-3 m^3 per day of distilled water is not reported anywhere. This work therefore is a unique venture.

Experimental studies were made and simulation studies were carried out. The performance of the unit was evaluated in terms of total distillate produced, and the overall cost per unit distillate. The gained output ratio (GOR), which is defined as the ratio of the amount of distillate produced to the amount of steam supplied to the first effect, was also calculated.

Influence of various parameters such as the temperature difference ΔT across the tube and shell sides of the evaporator, feedwater rate, steam flow rate, and steam temperature, on OHTC was examined. OHTC was very much enhanced on using wire-mesh inserts placed inside the tubes where steam condenses. Based on heat and mass balance analysis scope for further improvement in system configuration has been worked out.

A computer simulation programme was developed to predict performance characteristics of MEWD systems, at our scales and configurations, to project the effect of varying input parameters such as primary steam temperature, feedwater rate to an effect, distillate and brine withdrawal orifice sizes, OHTC, and other parameters on the output distillate. The simulated predictions compare well with the experimental results for the triple effect MEWD unit. For a given set of input variables, the GOR of the system, using parallel feedwater configuration, decreases with increase in number of effects from three to six to ten effects, on account of increased primary steam temperature and the resultant feedwater preheating requirements. The simulation study predicted a possible GOR of 1.8 for the triple effect system under certain given conditions. Predictions for a ten-effect system, with mixed parallel and forward feed, indicate the GOR to be around 2.6. Since distilled water is not used to raise steam in the baby boiler, therefore, the GOR figures effectively may be increased by one. Techno-economic viability of the MEWD system was examined and it is seen that the unit would be viable for supplying drinking water to small rural communities by treating water contaminated by any kind of dissolved impurities at varying concentrations.

The triple effect MEWD system can produce about 1.2 m^3 of distilled water over a sixteen hour period of operation per day. Currently liquefied petroleum gas (LPG) was used as a fuel in the boiler. However, a predicted cost of Rs. 161/m^3 was arrived at using biomass based fuels (US$ 1 = Rs. 46 approx.). Similarly, a ten effect system can produce 3.25 m^3 of distilled water over the same period, at Rs.116/m^3. Considering a basic need of 5 litres per capita per day (lpcd), for drinking and cooking water, it is seen that 1.2 m^3 satisfies the needs of 240 persons, or, 48 families of 5 members each. A ten-effect plant can take care of 130 families or 650 persons. Thus, feasibility of operating such small-scale plants in rural areas is well established.

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