MULTIPLE EFFECT DISTILLATION (MED) OF WATER AS A RURAL MICROENTERPRISE

BY

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Submitted

in fulfilment of the requirements of the degree of

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Dedicated to my

Parents and Teachers

CERTIFICATE

This is to certify that the thesis entitled **"Multiple Effect Distillation (MED) of Water as a Rural Microenterprise"** being submitted by Anurag Mudgal (2006AMZ8181) 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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ABSTRACT

Increased water pollution due to industrial activities, growth of population and increasing requirement of water for the agricultural sector have led to a situation wherein access to safe drinking water in many parts of the country has become a problem. There are several areas in India where water is contaminated by toxic chemicals such as arsenic and fluoride. Removal of dissolved salts and toxic chemicals especially at part per million (ppm) levels is one of the most difficult problems. There are several methods used for water purification. The choice of the method depends mainly on the level of feed water salinity, source of energy and type of contaminants present. Distillation is an age old method which can get rid of all types of impurities including dissolved impurities but the challenge lies in designing for small scale operations and optimizing it. Multiple effect distillation (MED) is a method in which latent heat of once produced steam is recycled several times, which economizes the operation, and, produces many units of distilled water with one unit of primary steam input.

This technology is already in use for large scale production of distilled water especially in the Middle East, even from sea water (with ~ 30,000 ppm salts). These methods are already being used to treat water on a large scale (3000 – 30, 000 m^3 per day). Efficient small scale distillation systems for distilled water production for rural communities have not been developed and commercialized as known till date except for a triple effect unit that was fabricated at IIT, Delhi in 2003. This unit showed the

feasibility of operation at small scales but was not optimized in terms of design aspects and operational issues.

In the present work a MED unit with extendable number of effects has been designed and operationalised for optimum yield of product water in terms of total distillate produced. The unit can be operated with any number of effects varying from two to ten effects. The unit comprises a baby boiler integrated with pressurised feed water pre-heater (PFPH) and economizer, vertical tube evaporators (VTE-s), condenser, mist eliminators or feed entrainment separators, distillate withdrawal capillaries, parallel feed and brine transferring capillaries, pump and other peripherals. The unit is insulated to minimise heat loss to the surroundings. The baby boiler selected is capable of producing 30 kg/h steam continuously.

The present work is aimed at improving the performance and ease of handling of the system for varying number of effects (from three to nine), optimizing various design parameters, selecting appropriate feed water supply configuration and improved efficiency of heat input from the boiler. In depth performance studies have been conducted and aspects leading to improved design, operation, maintenance and better economic returns, were looked into.

Parametric studies were undertaken on the improved MED system so designed for optimising operational parameters. The unit was tested for 9 effects + condenser (9+C), 6+C and 3+C units. The optimum yield of total distillate produced was found to be 167± 1, 121± 1 and 91± 1 litres per hour respectively at 95% confidence level

for an input of 30 kg/h steam. The PFPH was integrated with the boiler assembly to give high top brine temperature. Controlled flow rate of feed water using calibrated capillaries, optimization of annular clearance for better feed water film formation over evaporator tubes, and mixed feed arrangements have been amongst the major contributions of the present work. Maximum overall heat transfer coefficient (OHTC) found in the first effect was around 20000 $W/m^2\ ^oC$. Such a high value of OHTC is the secret of success of the unit.

Long term maintenance, contingencies and economic issues were considered in terms of scaling and corrosion. Strategies to minimize these were also considered. In the Indian scenario economic feasibility of the unit has been looked into in the context of a rural micro enterprise.

The unit is capable of fulfilling the drinking water needs of forty families with 5-6 members in a family, by operating for 8-9 hours per day. If requirement is more, the unit may be run for a longer period. It can also be taken up as a self employment option and the product water may be sold directly to the battery markets, laboratories and other industries using distilled water for electroplating, pharmaceuticals and so forth.

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