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Development of Decentralized Simple Multiple-Effect Evaporator for Liquid Concentration and Distillation

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Summary

The multiple-effect vapor-diffusion still can be used to concentrate various kinds of solution as well as to produce pure water. Because of its simple structure and high energy-efficiency, it has a great potential to be introduced into many factories and workshops, and to reduce CO_2 emission drastically. With the aim to put the still to practical use, we constructed stills of this type and a numerical simulation program to investigate their performance in various conditions. The experimental and numerical results show that there are five difficulties in putting the still to practical use. We worked out several measures to each of them and experimentally and numerically examined how the measures work. These examinations improved the prospects of putting the still to practical use. Our finds are summarized as follows.

①Vapor-diffusion resistance between an evaporating surface and a condensing one decreases the evaporation rate in every effect. We reduced the distance between the surfaces from 10mm to 5mm, and this increased the total evaporation of the still by 45%. We are planning to reduce the distance to 3mm for the higher performance of the still

②Concentrate and condensate carry some heat out of the still, and the heat greatly decreases the ratio of the total amount of evaporation to the steam spent in heating the still. The simplest measure is to decrease the flow rate of the solution flowing into every effect to increase the ratio of the effluent concentration to the influent one. This decreases the heat carried out by the concentrate and the condensate.

③Uneven flow rate of solution in the evaporating wicks might cause deposition and/or dryout which decrease the evaporation from the wicks. We constructed a simple device to feed every wick with the solution evenly.

④The evaporating wick became less wettable after gluing it onto the metal plate, and it caused dryout on the wick. Without gluing, many bubbles appeared between the metal plate and the wick soaking solution with the progress of the evaporation. Then we used double-sided tape to stick the wick onto the plate and found that the wick was wettable enough not to bring about dryout. To achieve the higher concentration ratio, we need a new double-sided tape which keeps the wick wettable more highly.

⑤The condensate is partly mixed with the concentrate in the effects. We constructed a new collecting device at the end of the still, and found that it worked well. There are the spacers between the evaporating wick and the metal plate in every effect, and we need to change the hydrophilic surfaces of the spacers into hydrophobic ones to prevent the mixing completely.

Prospects of the development of the still

The multiple-effect vapor-diffusion still will be put to practical use in the near future, but the produced water will not be used for drinking since the water might contain slight chemicals from the double-sided tape. A high-performance still will be constructed, which has 10 effects with 3mm diffusion distances and with the effluent concentration three times as large as the influent one, and achieve the total evaporation 4.8 times as much as the consumed steam.