

## **290a Membrane Extraction through Double-Pass Cross-Flow Flat-Plate Modules with External Recycle**

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The recycling operation applications to a membrane extractor produce two conflicting effects: the desirable effect of increasing the fluid velocity and decreasing the mass-transfer resistance, resulting in an increase in the mass transfer coefficient. The undesirable effect of lowering the concentration difference due to inlet fluid mixing with the recycling stream, resulting in a decrease in the mass transfer driving force. At a small inlet volume rate  $Q_a$  the fluid velocity  $V_a$  is very small, therefore, the increase in fluid velocity created by applying the recycling with reflux rate  $R$  which is not large enough, can only slightly compensate for decrease in the mass transfer driving force in the membrane extractor. Thus, the mass transfer in a recycling system with small  $Q_a$  and low  $R$  is scarcely greater than that in a membrane extractor the same size without recycling. This is especially true for lower solute concentration. Nevertheless, the reflux introduction really has a substantial effect on membrane extraction for larger inlet volume rate. This is because the recycling operation increasing the fluid velocity has greater influence than decreasing concentration difference (the driving force of mass transfer) in a device the same size with recycling, resulting in an increased mass transfer rate  $W$ . However, the improvement in performance  $I$  decreases as the inlet volume rate further increase. This is because at a higher inlet volume rate, the fluid velocity is large enough with recycling. Therefore, by applying the recycling operation, the mass-transfer resistance is reduced, while the mass transfer driving force rapidly decreases.