## ABSTRACT

The uncertainty of fouling behaviour in plate heat exchangers is one of the main reasons (if not the main reason), why this heat exchanger type is not more widely installed in the chemical and process industry, despite the obvious potential for cost and energy savings. Recent investigations by Bansal (1994), have shown that similar heat exchanger plates with different corrugation patterns near the fluid inlet and outlet regions, fouled at very different rates under identical process conditions. As different corrugation patterns give rise to different flow patterns, the differences observed by Bansal (1994) are attributed to the effects of flow distribution on fouling rates in the plate channels. Consequently, in the present investigation, the effects of flow distribution on the precipitation fouling of calcium sulphate were studied experimentally using Alfa Laval P01 plates (diagonal flow), Alfa Laval M3 plates (diagonal and side flow), and 2-mm-thick stainless-steel flat plates (diagonal flow).

Effects of solution flow velocity, temperature, concentration, port position, plate surface roughness and distributor design on fouling were investigated. For corrugated diagonal flow plates (P01 and M3), the fouling rate was found to increase with decreasing solution flow velocity, and increasing solution temperature and concentration. Not only is the initial solution concentration an important factor in the fouling process, but also the amount of solution concentration being topped up so as to maintain the initial concentration during a run, and the time of doing so, have been shown to have a dramatic effect on the fouling process. When compared with their side flow counterparts, diagonal flow plates exhibit slightly lower fouling resistance and pressure drop values.

For the custom-made flat plates, increased fouling was observed with increasing solution concentration and plate surface roughness. In order to obtain a more even distribution of flow within the plate channel, low-flow-velocity and stagnant zones were avoided by using different distributor designs to channel fluid from the high-velocity regions to the low-velocity ones. In doing so however, all the 5 distributor designs examined created additional regions of low flow velocity in their wake.

Visual observation of flow distribution and fouling deposition in corrugated and flat plate channels were performed using a corrugated and a flat transparent polycarbonate plate respectively. From these observations, it became obvious that the two conditions necessary for precipitation fouling of calcium sulphate to occur, are high temperature and low flow velocity.

A few fouling mitigation methods were investigated. It was found that the addition of $NaNO_3$ to calcium sulphate solution reduced $CaSO_4$ fouling significantly. Velocity surges and the injection of air at a high flow rate for a short time period into the flowing solution, proved capable of removing an existing fouling layer. However, continuous air injection into the solution line, and the use of ion-sputtered plates and a magnetic device all failed to achieve any significant decrease in fouling.

Different ways of incorporating excess heat transfer area in plate heat exchangers for fouling provision were evaluated. In the presence of adhesion-controlled fouling, the traditional method of adding extra parallel plates proved to be inferior when compared with the incorporation of larger plates with different aspect ratios and additional plates in a second pass. On the other hand, if no flow control is possible, a two pass arrangement and plates with half the standard plate width should be avoided for reaction fouling.

Flow simulations were performed using the commercial Computational Fluid Dynamics (CFD) package, CFX. A flow passing through a 2-D channel with a single corrugation, and with multiple corrugations, has been modelled and interesting results have been obtained. Special emphasis was placed on the local flow distribution in a plate channel. This information was essential to improve the design of heat exchanger plates to guarantee longer operational cycles. Simulations were performed for different distributor designs and different plate shapes. Computational results compared well with those obtained experimentally.