Parallel column models were first proposed in the 1950s for investigating the sensitivity of a packed column to maldistribution. The parallel column model in ChemSep, although created for modelling Dividing Wall Columns, is also suitable for this kind of assessment as shown in this flowsheet.

On the left we have recreated the PCM of Billingham and Lockett; on the right is an exactly equivalent model built with a single ChemSep Unit Operation.

Billingham and Lockett wrote:
...it is not obvious to a column designer how to incorporate the output from a conventional column simulation design program into the models.

In other words, how can we extract from the results of a standard simulation of a column (presumably done with a commercial simulator) the extent to which a packed bed is sensitive to maldistribution.

To help address this need Billingham and Lockett used a parallel column model similar to the one shown at left in the flowsheet. They used a stage-to-stage calculation with a constant relative volatility to model the column sections. (The components selected in this flowsheet – argon and oxygen – act as surrogates only; they are renamed *A* and *B*.)

The ChemSep PCM at right in the flowsheet is exactly equivalent to the multi-unit model of Billingham and Lockett at left. The ChemSep PCM has a liquid distributor tray above the two parallel sections and a gas distributor tray below the parallel section. These distributor trays are modelled with a stage efficiency of close to zero (a very small number such as 10^{-6} is used in order to avoid numerical issues in the simulation). A particular advantage of using the ChemSep PCM for these calculations is that any thermodynamic model can be used (including a constant relative volatility model as was used by Billingham and Lockett and here).

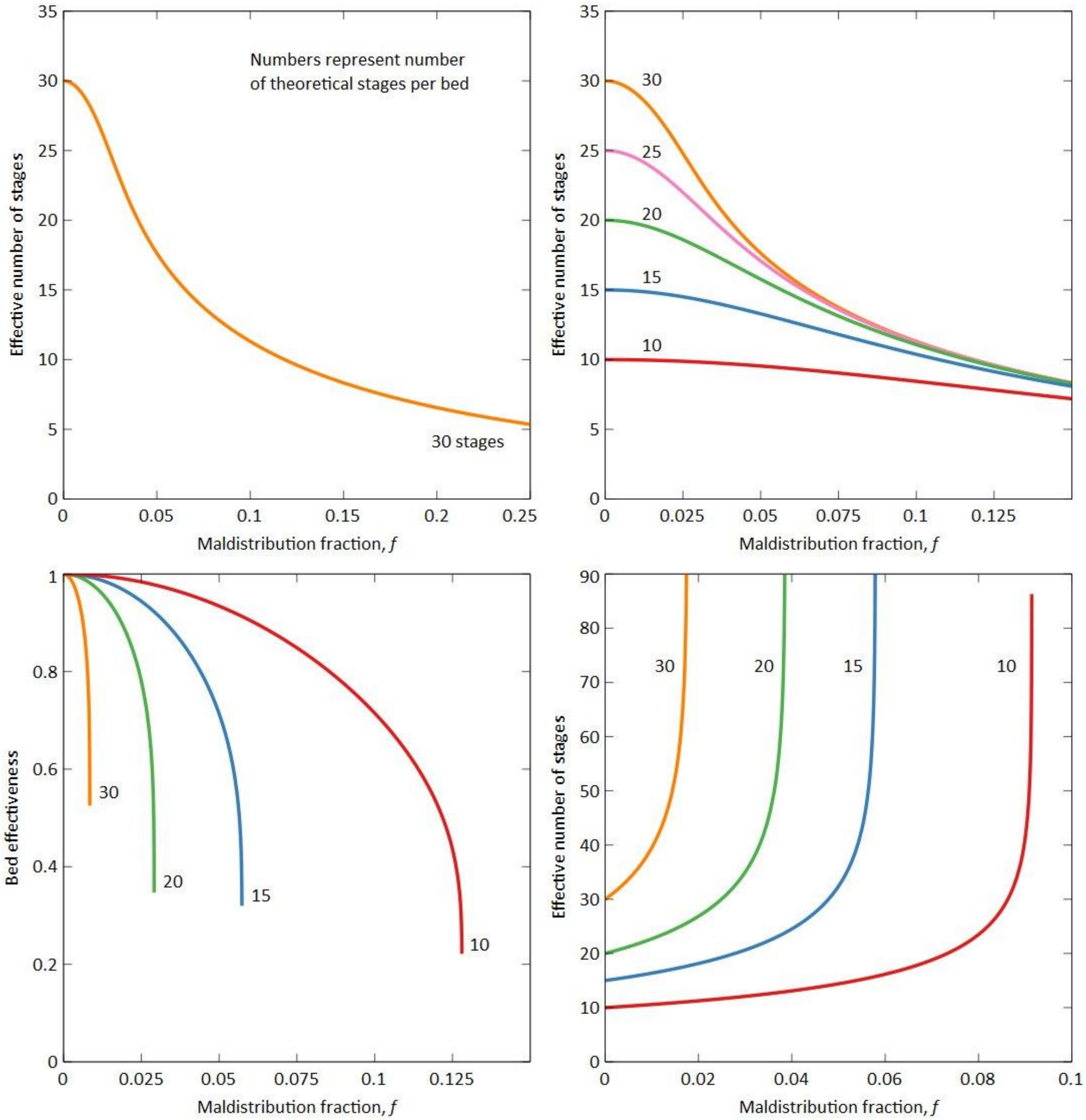
Maldistribution is modelled by splitting the liquid flow so that the flow to the left differs from the flow to the right as shown on the flowsheet. One small difference between our model and theirs is that they did not split the vapor flow as shown in Fig. 11; rather they assumed the gas flow to the base of each column to be the same. We can obtain the same result by specifying a gas flow to the stream splitter that is twice that needed and a split ratio of 50%.

The figures shown below are our recreation of Figs. 3-6 in Billingham and Lockett. f denotes the maldistribution fraction such that:

$$L_{Left} = (1 - f)L/2 \qquad L_{Right} = (1 + f)L/2$$

The bed effectiveness is

$$E = N_{f=0}/N_{f\neq 0}$$



Note the vertical asymptotes; these correspond to the maximum value of f above which no increase in the number of stages can provide the required separation.

For more about maldistribution in general and a review of parallel column models see the paper by Kooijman et al.

References

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