Plant heat transfer coefficients from RC1 experiments

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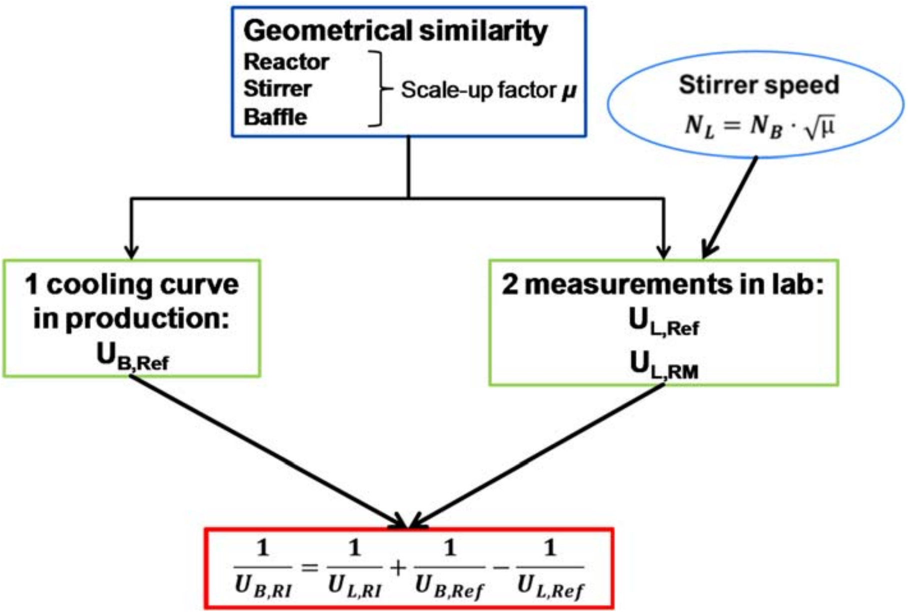
In order to thermally control a chemical reaction it is important to know the overall heat transfer coefficient U of the vessel. However, in multipurpose plants of the pharmaceutical or fine chemicals industry reaction mixtures change constantly and this information is mostly missing. Based on rough estimates which require large safety margins the cooling system must then be operated well overdimensioned, i.e. the reactions must be slowed down or diluted with corresponding loss in space-time yield.

The aim of the presented work is to determine the cooling capacity based on only one cooling curve in the plant reactor and additional calorimetric measurements in the laboratory. This procedure is based on the Wilson method as explained in [1]. A prerequisite of this procedure is the principle of similarity, i.e. geometrical similarity of reactor, stirrer and baffles.



The applicability and accuracy of this procedure was evaluated by comparing 4 different liquids, i.e. solvents (Butylene glycol, Fabrication oil, Isoparaffine, Mineral oil) with water as reference liquid in the temperature range between 40°C and 90°C. The calorimetric laboratory measurements were done with the Mettler-Toledo RC1 in a 1.5 ltr. steel reactor. The plant reactor was a 13 m^3 glass lined reactor with double jacket and oblique blade agitator.

The relative deviations between extrapolated and measured U values were always in the range of +8 to -11%, which is surprisingly low, taking the large scale-up factor of about 8000 into account.

In order to evaluate the limitations of geometrical similarity for scale-up, the lab measurements were also performed with different stirrer types, i.e. impeller and flat blade stirrer. The relative deviations between extrapolated and measured U values were also in the range of ±10%, except for the more viscous mineral oil (109 mPa·s @ 40°C), measured with an impeller stirrer of larger relative diameter. These results suggest that for the lab measurements a similar stirrer with identical relative diameter might be used instead of an absolutely identical setup.

Above all, the presented work indicates that the overall heat transfer coefficient of a plant reactor can reliably be extrapolated based on calorimetric data from the lab and may replaces time consuming cooling curve experiments in plant scale.

[1] S. Choudhury, L. Utiger, R. Riesen, Chem. Ing. Technik 62 (1990) Nr. 2, 154-155; or Mettler-Toledo Publications 00724218, Heat Transport in Agitated Vessels: Scale-up methods