5.9. Special Considerations

As the boil up rate is very sensitive to the ΔT it is necessary to determine the range of the ΔT to provide for the anticipated boil up range under both clean and fouled conditions. This ΔT range should be within the controllable limits of the heating media. The boil up is basically controlled by varying the heating medium temperatures. For a condensing media a pressure control is used and for a sensible heat source media a by-pass control is used but here both temperature difference and heat transfer coefficient of the heating medium changes.

For a condensing media, a problem arises when boiling at low loads with a clean vaporizer that the required pressure may be so low (or a vacuum) that condensate removal becomes difficult. For a sensible heat source, the amount of by-pass may so reduce the flow in the vaporizer that problems in distribution or accelerated fouling may occur.

The vaporizer should have liquid in it and be started up at the lowest ΔT possible. It is possible in those cases of large fouling allowances, excessive conservatism in design, or underestimated coefficients that the design ΔT can be large enough for a clean reboiler to get into the film boiling regime. The design flux may also be low enough so that it can be met in the transition or film boiling modes. Under these conditions the effect of ΔT is reversed from that of nucleate boiling thus the controls will be ineffective and the rate of fouling may be increased.

If a condensing medium pressure becomes too low at low loads or clean condition, then a partial flooding of the surface should allow increasing the pressure into a controllable range. The surface should be flooded a fixed amount. Trying to control the boil up by varying the amount of flooding is difficult due to the slow response. With partial flooding consider the effect of stresses especially in horizontal units where the stresses are different in the flooded and unflooded tubes.

Wide boiling range mixtures, where the boiling point of the heavy component exceeds the heating medium temperature, require reboilers in which circulation occurs even in the convective heat transfer region otherwise the light component will be stripped out and stagnation will occur.

Operation near the critical pressure have several problems. The density difference between vapor and liquid is low so the driving head for circulation is low. The maximum heat flux and the critical ΔT are also low. Operating under film boiling conditions might be considered as a possible solution.

Low pressure (vacuum) operation requires careful analysis of the effect of static head on the boiling point and the possible temperature pinch thus caused at the top of the liquid zone. This boiling point elevation also results in much greater liquid preheat lengths and also reduces the available head for circulation. The large density differences cause higher acceleration pressure losses which result in reduced circulation. Low pressures require larger cavities for nucleation thus suppressing nucleate boiling coefficients, but the use of enhanced surfaces can be effective.

Low ΔT operation (8°F) may sometimes be necessary because of process economics. Here the problem is nucleation and the use of enhanced surfaces is required. However, prediction of heat transfer coefficients is very uncertain and experimental tests on the specific surface liquid combination are recommended. Boiling curves developed from a small single tube pool boiling apparatus will provide a guide to the basic heat transfer coefficients which can be modified as necessary from the above discussed methods.

Very high ΔT is often encountered when vaporizing a low boiling point liquid; e.g., ammonia, with low pressure steam and here another problem of potential freezing of the heating medium must be considered. An available high temperature medium is another cause for high ΔT. At high ΔT the three limitations of film boiling, mist flow, and instability must be evaluated by the methods given above. Instability can be controlled within limits by throttling of the recirculation line or can be avoided by a shellside reboiler. Mist flow only represents a low heat transfer coefficient. Film boiling is a possible mode of operation if the potential for transition boiling is avoided where the control criteria are reversed. A possible solution to transition and fihn boiling is the use of medium- to high-finned tubes where the temperature drop along the fins is such that nucleate boiling occurs near the fin tips. Boiling on fins has been tested in the laboratory but no publication of a commercial application has been found.

5.9.1. Examples of Design Problems

To design a heat exchanger requires that one first specify essentially all the dimensions of an exchanger and then one can proceed with the heat transfer calculations to determine whether the assumed design will give the desired performance and, if not, then the initial design is modified and the calculations repeated until an acceptable match of design and performance is obtained. A design problem is, therefore, a series of rating problems. In the rating of an exchanger its dimensions are known and only the heat transfer calculations are required; however, for vaporizers these calculations still involve considerable iterative trials to converge on an answer. It is obvious that the better the initial guess matches the final design the less the amount of calculation; hence, here is where experience is beneficial to the designer. In an attempt to aid a novice designer each of the examples below show in the initial steps one way of getting an initial design. In the second example, 5 steps are also used, however, in step 4 the guess of fraction vaporized is based on experience or as in this case prior knowledge of the experimental value.