A GUIDE FOR SELECTING THE OPTIMUM EVAPORATIVE SYSTEM FOR CONCENTRATING ALUMINATE LIQUOR

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Abstract

In an alumina refinery the spent liquor from the precipitation stage has to be re-concentrated before it can be recycled to the bauxite digestion. Different evaporative techniques are utilised for this concentration, whereby each system has its own advantages as well as limitations.

Today, the choice is essentially between multiple effect flash or falling film evaporator systems. Rising film evaporators, which found ready acceptance in the past, have been essentially discontinued due to their lack of operating flexibility, whilst forced circulation evaporators are normally only used when salts precipitate during the concentration process.

The aim of this presentation is to examine the flash and falling film systems based upon a spent liquor feed concentration of Na_2O total 185 g/l (equivalent Na_2CO_3 316 g/l), which is typical for the spent liquor feed to many evaporation plants and then analyse the heat transfer areas required in order to achieve a range of green liquor concentrations in the above mentioned range.

This article looks at the most important differences between the flash and falling film systems and the highlights the advantages and disadvantages on the basis of the main operating characteristics, which are can be summarised under the following main headings, heat transfer area required, steam economy achievable, concentration gain needed and electrical power consumption.

1 Introduction

In order that a realistic basis is provided for comparing the systems the same feedstock and same evaporation rate is taken. The concentration of the green liquor, which has to be returned from the evaporators to the refinery, is dependent upon the type of digestive system that is being used. Typically the concentration in the green liquor is from Na_2O total 217 g/l (equivalent to Na_2CO_3 371 g/l) to Na_2O 264 g/l (equivalent to Na_2CO_3 451 g/l).

To provide a realistic basis for the comparison the following configurations have been chosen. For the flash plant a system has been selected which consists of 9 + 3 effects (9 effects vent to heat exchangers and 3 effects vent to the barometric condenser). For the falling film plant a 6 effect system has been selected. These arrangements are typical for modern plants.

To provide a realistic basis for comparing the systems the following points have been considered:

- The same spent and green liquor conditions are taken for both plant types
- The heat and mass balances as well as the heat transfer area have been iterated in order that each system has the same steam economy
- The plants have been based upon a typical evaporation capacity of 150 t/h.

The systems have then been evaluated by comparing heat transfer area required through the range of concentration factors between spent and green liquor. Furthermore the requirement for recirculation of liquor has been examined.

The results of the investigations are presented as four cases:

Case 1. Concentration Factor 13%

The spent liquor feed to the plant is 1000 m^3/h and the green liquor concentration is Na_2O total 217 g/l (Na_2CO_3 371 g/l). The steam economy is 3.6 kg/kg.

The flash plant requires 34% less heat transfer area than the falling film system. At this concentration factor the flash system is more competitive than the falling film system.

Case 2. Concentration Factor 17%

In order to increase the concentration factor whilst maintaining the evaporation rate the spent liquor feed is reduced to 834 m^3/h and the green liquor concentration increases to Na_2O total 225 g/l (Na_2CO_3 385 g/l). The steam economy is 3.85 kg/kg.

The heat transfer area for the flash plant is now only 6% less than that of the falling film plant. Under these circumstances the flash and falling film system are more or less in balance.

The reason why the heat transfer area of the flash plant increases relative to the falling film plant is that the quantity of spent liquor feed is not sufficient to carry sufficient heat to provide the required evaporation rate through preheating alone.

In order to compensate for this shortfall green liquor product has to be recycled to the spent liquor. In practice this means that part of the green liquor product leaving heat exchanger HE-06 is directed to HE-05. The quantity of recycle, which is equivalent to 16% of the spent liquor feed, has the negative effect of increasing the boiling point rise of the liquor in the system and hence the temperature difference available for heat transfer is less and this has to be compensated for by increasing the heat transfer area.

The improvement in the steam economy between case 2 and case 1 is due to the fact that more sodic condensate is discharged to the battery limits at a lower temperature and hence more heat is recovered. This results in less heat loss to the cooling water. This trend becomes more marked at higher concentration factors.

Case 3. Concentration Factor 22%

The spent liquor feed is reduced to 666 m^3/h and the green liquor concentration is Na_2O total 243 g/l (Na_2CO_3 415 g/l). The steam economy is 4.05 kg/kg.

The situation is reversed and now the flash evaporator requires 18% more area than the falling film system. The quantity of green liquor recycle has now increased to 48% of the spent liquor feed.

Under these circumstances the flash system not only has the disadvantage that it requires more heat transfer area but in addition the power requirements for pumping the liquor will increase significantly.

Case 4. Concentration Factor 32%

The spent liquor feed is reduced to 500 m3/h and the green liquor concentration is Na_2O total 264 g/l (Na_2CO_3 451 g/l). The steam economy is 4.29 kg/kg.

The flash evaporator now requires 275% more heat transfer area than the falling film system and the quantity of recycle liquor is higher than the spent liquor feed, namely 112%. Under these circumstances the falling film system is the only option.

2 Conclusions

1. At low concentration factors the heat transfer area required by a flash plant is lower than that of a falling film plant however this advantage is progressively lost as the concentration factor increases. As the maximum desirable liquor temperature is limited (to avoid excessive scaling) the amount of heat that can be taken up by the spent liquor for preheating is limited and hence recycling of the green liquor product is the only option.

   Recycling has two disadvantages, firstly the boiling point rise of the liquor increases, which means that less temperature difference is available for heat transfer, therefore more heat transfer area has to be provided.

   Secondly the quantity of liquor which has to be pumped through the system increases, which increases the electrical power consumption increases.

   It can be concluded that if the concentration factor is less than 15% the flash system needs significantly less area and is the preferred option. From 15% to 20% both systems are approximately in balance. Above 20% the falling film system becomes progressively more attractive and above 25% the only option.
2. As the concentration factor increases the steam economy improves because more sodic condensate is recovered at lower temperatures (hence more heat is recovered from the condensate) and therefore less vapour condenses in the cooling water.
3. It was also observed that the flash system is less sensitive to the cooling water supply temperature than the falling film system because a higher supply temperature can be at least partially compensated for by using a multi-stage barometric condenser which enables the temperature of the coldest effect to be reduced.