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MODERN BLACK LIQUOR EVAPORATORS

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Summary

Black liquor Evaporators should be capable of giving maximum steam economy while reaching high end concentrations. Condensates produced should be of low odor and low B.O.D. Rosenblad Free Flow Falling Film evaporator has met with these requirements and same is described here in this paper.

At present in our country most of the evaporator installations in pulp mills are L.T.V. climbing film type. These evaporators are simple to operate were very effective for non fouling or low-fouling liquors. Most of the installations are quintuple effect which give a steam economy in the region of 4. Ever since we started using hardwood alongwith bamboo as raw material, trouble started in evaporators and most of the time in steaming effect 1 or 2 there was a build up of scaling. Additional effect was added in some of the installations soas to keep a spare body always clean for switching over. This also did not solve the problem as there was a heavy down time in the system and in addition there was blockage of investment. In some of the mills it became necessary to increase the quantity of hardwood to 40-50% and in some mills to 60%. It became practically impossible to concentrate the liquor beyond 40-42%. Steps were taken to install Forced Circulation Finishers to increase the concentration to 50-55% depending upon the extent of using hardwoods. These Concentrators could solve the operating problems to some extent but these are heavy in power and steam consumption which completely upsets the economies of concentrating the blackliquor.

Moreover even with the use of a F. C. Finisher it was still necessary to use direct contact evaporator in the recovery boiler to further concentrate the liquor to 60-62% so that it could be fired in the furnace. This not only aggravates the pollution problem but also affects the efficiency of boiler. Keeping in view above problems in L. T. V., Rosenblad Corporation of Princeton, New Jersey, U. S. A. came out with entirely a new design of Free Flow Falling Film evaporators wherein dimple-plate type of heat exchangers are used instead of tubes.

Present indications are that most liquors can go to an end concentration of about 68% and easier liquors are capable of going to concentration in excess of 80% TDS. With introduction of Rosenblad's plate type falling film free flow evaporators achieving these high end concentrations has become possible nd there no apparent problems with evaporator operation.

To reach maximum end cncentrations the temperatures must be kept sufficiently high so that viscosity is manageable and satisfactory heat transfer coefficients can be obtained. However, higher temperatures also lead to higher scaling rates so the usual engineering compromise must be reached. Alternatively, the concentrator must be arranged so that it can cope with the deposits. In such cases the falling film plate type evaporator has many advantages over any other evaporator where the liquor is inside a tube. This is illustrated in Fig. 1 and Fig. 2.

Fig. 1 shows the scale build up on the outside of plate type heating surface as compared to a similar build up inside a tube. The deposits are on theoutside of the convex surface that forms the plate. These are easy to remove and often remove themselves. Scale build up inside a tube is quite different and is build up in annular rings well contained within the tube walls. Here much more severe washing is required and in extreme cases mechanical cleaning becomes a must thus resulting in longer down time.

Fig. 2 shows the actual scale on the heating surface, how it tends to break up, and the ease with which it is washed off.

Latest trend is to install one large evaporator instead of number of streets. One of the reasons that this has become a practical arrangement is the turn down that can be obtained. A plate type falling film evaporator will have stable operation anywhere from 25-100% of the designed capacity.

These evaporators can be made with provisions for adding additional effects in future. With falling film evaporators this is specially advantageous as generally there is a capacity increase when future effect is added. This is because the heat transfer coefficients actually go up with a decrease in temperature differential and this outweighs additional losses due to pressure drops and boiling point rise. Thus it can be safely said that all falling film plate type evaporators will increase in capacity in direct proportion to the number of effects i. e. a five effect evaporatr when converted to six effect will increase in capacity by 20% with no increase in steam or cooling water consumption. Of course some of the transfer pumps and valves may have to be modified.

Maximum Steam Economy

In falling film evaporator the heat transfer coefficient increases with decrease in specific loading (pounds of evaporation per hour and square foot) The opposite is true of the rising film evaporator which also requires a minimum temperature differential in order to be able to boil. This makes it possible to have falling film multiple effect system with many more effects than are possible with LTV evaporators.

The Concentrator is always the first effect of the evaporator plant because of the performance of the falling film evaporator. This increases the steam economy and simplifies the systems. L. T. V. systems install the Concentrator in parallel with multiple effect evaporator because of the minimum tepmerature differential required. As a result fve bodyfive effectfalling film evaporator with the first effect producing liquor at full end concentration i. e. 65%–70% uses approximately the same amount of steam as a conventional eight body six effect LTV evaporator.

Condensate Quality

Traditional evaporator guarantees call for 0.1% of the liquor solids losses per evaporator effect. For this performance a standard LTV evaporator with a cyclone separator will be quite sufficient provided the vapour body is adequately sized. Condensate quality can be further improved by installing more sophisticated vanu type entrainment separators.

Key to entrainment is not togenerate any small particles. Most entrainment separators have a lower limit to particle size below which they are not efficient. In this respect free flow falling film evaporator has resulted in a big improvement. The liquor and vapour are separated directly on the heating surface and visually it is difficult to sy whether liquor is boiling or not. Plate spacing in such evaporators is such that boiled off vapour will have no influence on the liquor film. In conventional LTV evaporator which may be rising film, falling film or forced circulation, the liquor and vapour exit together at substantial velocities. Existence of these high velocities can cause the formation of small particles which may be difficult to separate. A free flow evaporator operating on weak black liquor normally produces less than 1 PPM of Na^2O in the combined condensates.

Segretation of Condensate

Segregation of condensate is better in Rosenblad dimpled plate heating than tubulr evaporators. Rosenblad evaporators use a bottom steam inlet and steam flows vertical upwards and is in continuous counter current contact with stem condensate flowing by gravity downwards in the element. Thus the quantity of volatile contaminants in the steam fraction is continuously enriched by volatiles distilled from the condensate into the steam. Since approximately 80% of the total B O D and maladorous compounds come off with the first 30% of the total evaporation (which is normally generated in the last two effects) only the last effect and surface consdenser require divided heating surface for condensate segregation. The 10% steam vented from the top of the main condensing surface which is passed into the second pass section contains 65-70% of the BOD and maladorous compounds. As a result the condensate in main (first) section is effectively steam stripped and no further treatment is required. Condensate segregation within a Rosenblad five effect evaporator is illus trated in Fig. 3 which shows that 94% of the total evaporator condensates will be clean while 3-6% of the total condensate will be foul. In tubular evaporators such is not the case and stripping is required to be done for whole of the segregated condensate. Primary advantage of condensate segregation in Rosenblad evaporators is that it minimses the amount of foul condensate produced and which is only 3-6% and steam requirement for stripping same is almost negligible.

Thus the energy and pollution demands placed upon black liquor evaporators have been successfully met by the free flow evaporators. Main advantages can be summerized as follows :

1. High end Concentration

The free flow evaporator is capable of operating to concen trations in excess of 80% of TDS depending upon the liquor. Main advantage of this type of evaporator is that the liquor side is always available for inspection.

2. Maximum Steam Economy

Except for the capital cost there is no limit to the steam economy of this type of evaporator. Smooth operation is possible with any reasonable number of evaporator effects. The Concentrator i. e. the first effect operates at the same steam economy as the balance of the evaporator plant.

3. Condensate Quality

The general configuration and the choice of entrainment separators produce condensates which rarely have more than 1 PPM of Na^2O.

4. Segregation of Condensate

As appx. 80% of the total BOD and malodorous compounds come off with the first 30% of the total evaporation and which normally takes place in the last two effects, heating surfaces can be easily divided for segregation of condensate. This results only in 3-6% of condensate produced which is foul and balance 94% condensate is produce as clean condensate.

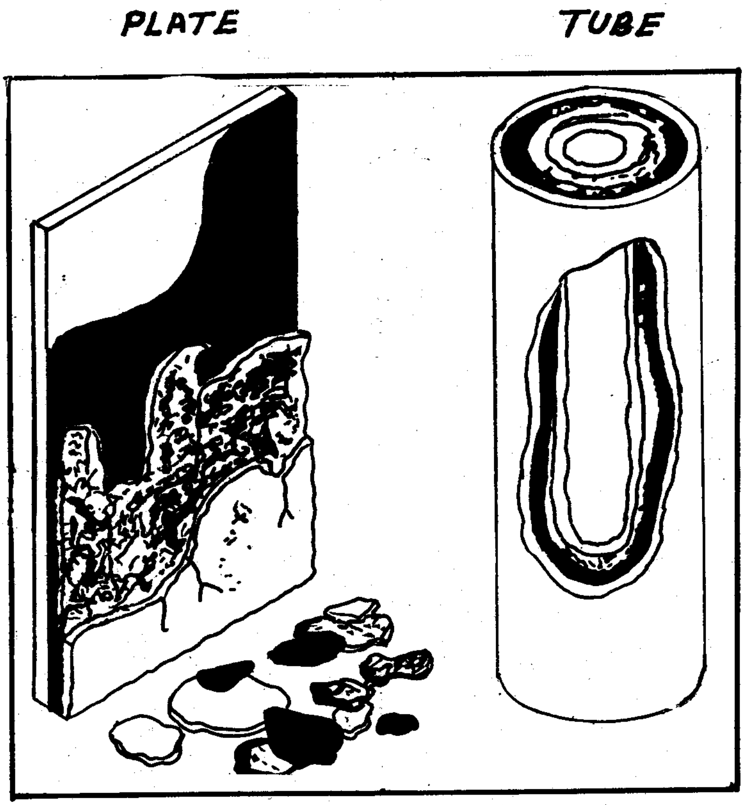
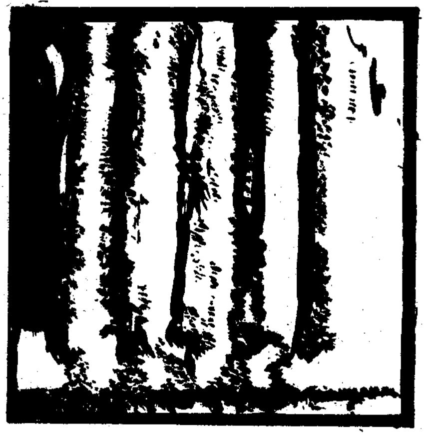


Figure 1
Comparison of Scale Build Up

BEFORE WASH



AFTER WASH

Figure 2
Actual Scale on Plate
Before and After Washing

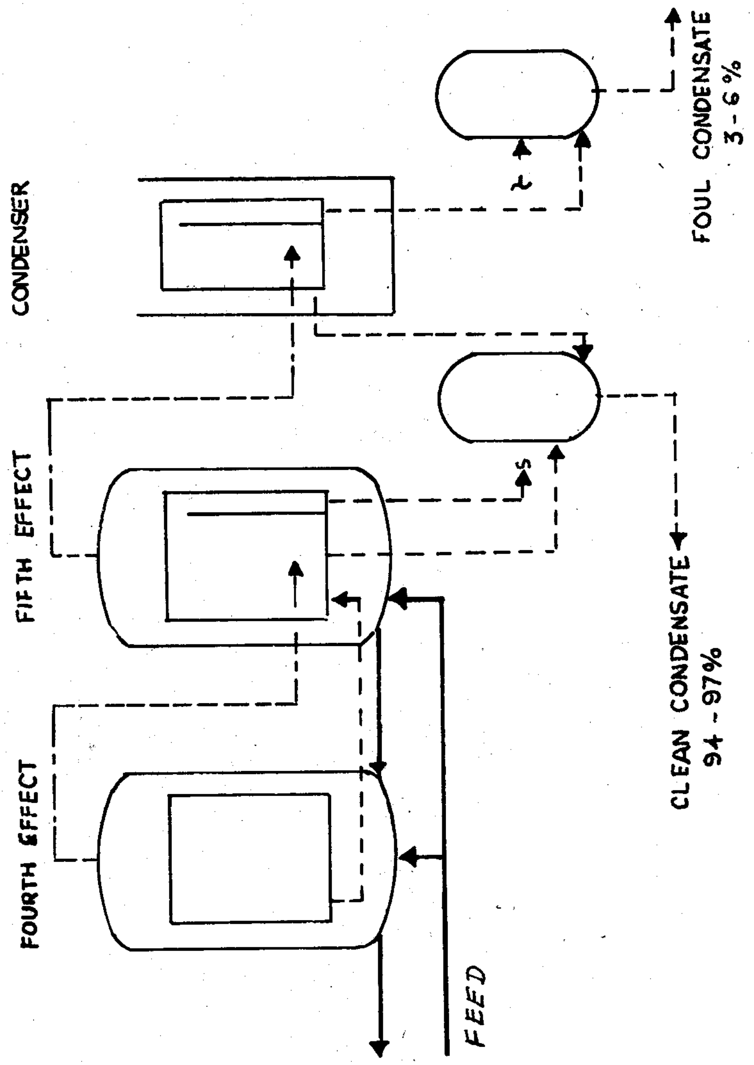


Figure - 3

Typical Arrangement for Condensate Splitting
in a Free Flow Evaporator