Practices and experiences in black liquor evaporation, recovery boiler operation and causticising– Optimization of operating parameters

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Introduction

The manufacture of pulp by alkaline method can mainly be done by two processes i.e. Soda Process and most commonly used Kraft or Sulphate process. The manufacture of pulp by sulphate process is economical only if the chemicals used in processing or cooking of raw material can be recovered for further use. Hence chemical recovery section is a must in the paper industry adopting sulphate pulping process.

The main objectives of the chemical recovery process are :

— To recover the chemicals used in processing of raw materials i.e. wood or other fibrous raw material for pulp production, and

— To beneficially use thermal energy generated during combustion of black liquor solids in the furnace. Looking to the high capital cost of the paper industry coupled with the rising cost of raw material and other inputs, it has become need of the hour to optimize all the operating parameters to mke the unit more economically viable.

In this paper, an attempt has been made to high light possible measures that can be taken to improve overall performance of the chemical recovery plant. The chemical recovery plant comprises of three main sections :

1. Multiple Effect Evaporator unit
2. Recovery furnace including waste heat recovery boiler and other connected equipments.
3. Causticising plant including lime kiln.

I Evaporator Section :

Black liquor evaporation is basically a heat transfer process. There are various factors which affect the preformance of multiple effect evaporator unit, e g.

— Temperature of feed liquor.

— Concentration of feed liquor.

— Operating steam pressure.

— Concentration of outlet liquor.

— Liquor flow sequence.

— Vapour flow sequence.

— Quality of cellulosic raw material.

Out of these, concentration of feed liquor, outlet liquor and liquor flow sequence can easily be optimised with minimum effort and time.

Feed Liquor Concentration—An overall economics has to be worked out by striking a balance between chemical losses in washed pulp and quantity of fresh water addition on brown stock washers. More quantity of fresh water will increase the volume of black liquor to be processed in evaporator section resulting in increased steam consumption per tonne of black liquor solids for evaporation. Hence the utilization of fresh water should be optimised in such a way that chemical losses in pulp are within acceptable limit with less fresh water consumption resulting in overall monetary gain.

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With various trials it has been observed in our case at The West Coast Paper Mills Ltd., Dandeli, that an inlet concentration of 17 to 18% solids to quintuple effect short tube evaporator unit with a chemical loss of 25 30 kgs. as Na_2SO_4 per tonne of pulp is optimum considering cost benefit analysis between chemical losses at Brown S tock Washers and steam consumption at evaporators.

Concentration of Outlet Liquor—It plays an important role in steam economy and steam generation in chemical recovery boiler. Outlet liquor concentration varies from installation to installation but normally depends upon the firing liquor concentration, steam generation and flue gas outlet temperature in recovery boiler. For our Tomlinson Furnace with direct contact evaporator a concentration of 46-47% total solids in outlet liquor has been found to be most optimum.

Increase in outlet liquor concentration causes more scaling and thus increase in frequency of water boil out. But it is still economical considering the increase in steam generation and quantity of steam required for extra water boil out.

Liquor Flow Sequence—It is also the principal factor governing capacity, steam economy and energy consumption. In general, not much attention is given in this area. Our experience reveals that it is practicable to improve evaporator's performace and to increase steam economy by optimising liquor flow sequence with the study of operating parameters of individual evaporator bodies.

Vacuum Pump—Installation of vacuum pumps in place of steam ejectors is a step towards energy conservation but mainly depends upon the location of the mills.

Scaling in Evaporators—Scaling in evaporators is a principal cause of reduction in evaporator productivity in paper mills and severe scaling may cause frequent interruptions in black liquor processing requiring water boil-out to remove the soluble scales. This becomes a serious bottleneck to increase pulp production where evaporation capacity is a limiting factor. The nature and intensity of scale formation also depends upon the quality of fibrous raw material used for pulping.

At west Coast Paper Mills a short plant trial with antiscalant has been tried and results so far have been encouraging. The frequency in water boil-out has decreased thereby increasing the availability of evaporator by 10-15%.However,further studies are still in progress to establish the results.

II. RECOVERY FURNACE :

There are two factors which affect the performance of chemical recovery furnace—

— Thermal efficiency

— Chemical recovery

Operating variables play a key role for the improved performance of chemical recovery furnace. Over the years, the Kraft Recovery Boiler has gone through series of changes and modifications attributing to disposal of black liquor to optimising chemical recovery, maximising steam generation, minimising chemical losses and environmental problems. Since optimisation of various operating variables differ from mill to mill, the common factors which affect the performance are air consumption, firing liquor concentration, heating media for firing liquor and liquor spray. Operation of the recovery furnace should be such that the thermal energy generated during combustion is beneficially utilized for steam generation and recovery of chemicals should be maximum.

Firing Liquor Concentration—It is an established fact that higher the liquor concentration, better the operational efficiency of recovery boiler and therefore it is very much essential to maximise the firing liquor concentration. There appears to be a scope in increasing the firing liquor concentration by increasing concentration of multiple effect evaporator outlet liquor, maximising heat transfer across direct contact evaporator, raising the temperature of firing liquor by indirect heating etc. From our experience it is seen that increasing firing liquor concentration helps in increasing unit steam generation, better chemical recovery and less fouling of boiler passes.

Air Consumption—Too little air or high excess air disturbs the furnace operations. Hence its control to the optimum value is a must. Requirement of air can be controlled with the help of oxygen analysers showing quantity of oxygen present in flue gases. A figure of around 2% oxygen in flue gas has been found to maximise steam generation and better furnace control with increased reduction efficiency in the furnace.

Liquor Heaters—Firing liquor having concentration ranging from 60-65% requires a firing temperature of 116 to 118°C for better combustion and furnace control. Lower temperature than this causes cooling of the charbed and thereby black out problems at air ports affecting furnace operation. The above temperature can be achieved either by direct injection of steam in firing liquor or indirect heating by means of steam jacket vessels or tubular heaters. The direct injection of steam causes dilution and hence decreasing the steam generation since more heat will be utilised for extra water addition.

Based on our practical experience, it has been observed that indirect heating with steam jacketed vessels is the best solution. This does not require any water boil-out and is very easy to operate maintaining steam generation.

In tubular heaters, frequency of tubes plugging is much more due to high concentrated liquor being handled and hence requires frequent water boil-out causing unnecessary energy consumption and interruptions in liquor heating operations.

Firing Liquor Spray—The liquor must be fired in a furnace in such a way as to produce coarse particles that will flash dry with minimum carry over and no wet liquor reaches the bed. The finer particles remain suspended in gas stream and burn in flight rather than on bed and causes increased carry over and rapid plugging of boiler. A firing liquor pressure of 1.8 kg/cm^2 (g) for to 2.4 kg/cm^2 (g) splash plate nozzles has been observed to be the most optimum.

Direct Contact Evporator—During running of recovery boiler, scaling in direct contact evaporator occurs and requires a water wash for about 8-10 hours in every 3 to 4 weeks. During this water washing of direct contact evaporator either the unit has to be run on oil firing only or lower concentrated liquor directly obtained from multiple effect evaporator with substantial oil firing support.

It has been tried and observed to be successful that if the liquor obtained from evaporator section is preconcentrated and stored in a separate tank by processing more quantity of black liquor than required for normal firing in direct contact evaporator, the normal liquor firing can be done with very little support of oil firing or completely avoiding it during washing of direct contact evaporator.

III. CAUSTICISING PLANT :

The performance of causticising can be evaluated by :

1. Degree of conversion of sodium carbonate to sodium hydroxide in green liquor.
2. Utilization of lime during causticising reaction.
3. Chemical losses and free calcium oxide content in lime mud.
4. Dead load in white liquor.

The conversion of sodium carbonate to sodium hydroxide depends upon chemical concentration and temperature of green liquor, supply and quality of lime, etc. Hence fundamental knowledge about the principles governing causticising reaction is a must to understand the factors affecting the rate of reaction and this facilitates the better control of causticising process. The slaking reaction to form calcium hydroxide from calcium oxide is an exothermic reaction and causticising reaction to produce sodium hydroxide is an endothermic reaction.

Temperature of Green Liquor — The better causticising conditions can be obtained at around 103-105°C temperature. Slaking of lime at higher temperature is faster and surface area obtained of lime particles at higher temperature is higher facilitating better utilization of lime for the causticising reaction. Since slaking reaction is exothermic, it is quite advantageous to carry out the slaking by keeping the green liquor temperature at around 100°C. The temperature of causticising reaction then can be maintained at around 103-105°C.

The increase in temperature of green liquor from 85° to 95-100°C has resulted in better causticising control, reduction in lime consumption, improved settling characteristics of lime mud generated and reduction in chemical losses. The chemical losses and calcium oxide losses have gone down by 40%. The higher recausticising efficiency has subsequently reduced dead load in the system which has got other inherent advantages.

Utilization of Lime—Equilibrium conditions of causticising reaction are to be established which depends upon quality/concentration of green liquor, varying from mill to mill. Our practical experience shows that causticising reaction can be operated at around 5% below equilibrium condition to avoid consumption of excess lime causing poor settling and filtering conditions resulting because of unreacted calcium oxide present.

Rotary Lime Kiln—Majority of paper mills in the country have conventional vertical kilns and quality of lime produced from such kilns is far from satisfactory. Lime purity is around 70%. Poor quality lime is nuisance for efficient operation of causticising plant. It generates more waste lime mud causing higher chemical losses and overloading of equipments. The above problems are solved to great extent by installing a rotary kiln. At our mills the quality of lime produced from rotary kiln is comparatively very good and purity of lime is as high as 80 to 82%. Rotary lime kiln also fully solves the problem of lime sludge waste disposal as it is possible to use lime sludge discharged from causticising section as a feed to produce good quality lime.

From plant experience, it is seen that uniform good quality lime can be produced if the drying is completed in chain section only, and keeping a constant flue gas temperature leaving the kiln.

Fuel oil is used in rotary kiln to raise the temperature at desired level in the kiln. Fuel consumption can be brought down by reducing moisture content in raw material feed, control of exit gas temperature, better operation of lime cooler, reduction in radiation losses etc.

Conclusion

It is concluded that in order to improve the performance of the chemical recovery plant, the operating parameters and process variables are to be optimised which varies from installation to installation and optimization mostly depends upon practical experience.

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