Art of high solids evaporation-Opportunities for improved co-generation

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ABSTRACT

Recently the chemical recovery installations in developed countries have made remarkable achievements in evaporation techniques and have been able to fire the black liquor at 80% solids. Central Pulp & Paper Research Institute has done extensive research on black liquors from different raw materials. With increased understanding of black liquor properties, it is now evident that high viscosity of the black liquors is the single most responsible factor for low evaporator outlet concentration, CPPRI has evolved a technique to reduce the viscosities & obtain high solids concentration black liquor. With this technique, It is possible to take the concentration of highly viscous bagasse black liquor to the extent of 70%. The technique involves thermal depolymerization of high molecular weight organic residues, which results in tremendous reduction in viscosity. The present paper describes the technique developed by CPPRI and its enormous potential for commercial application.

Introduction :

In the past the recovery units have been paid limited attention as compared to that of pulp & paper production. Particularly in India R & D was concentrated on the recovery boiler & causticization. Little work was done on evaporation. Even today the recovery installations have not made any serious efforts in achieving the required concentration targets from the evaporators and we are still depending on direct contact evaporators to raise the concentration to disired level. Industrialized countries considering the environmental impacts, increased cost of energy and recovery boiler safety have made remarkable progress in evaporation techniques. Today the black liquors are concentrated to a solids levels of 80% and eliminating the direct contact evaporators, a source of malodoious compounds.

Central Pulp & Paper Research Institute is actively engaged in improving the cogeneration opportunities in Indian paper Industry. Encouraged by the findings in work during the year 1983--84, that the black liquor viscosity is reduced at elevated, temperature, institute is actively engaged to develop this concept in to a commerical reality & has come out with a technique of high solids evaporation.

The paper highlights the thermal treatment process which is found to be an attractive solution for all types of black liquors. The function of the evaporator plant has been for now only to concentrate black liquors to the dry solids level high enough to burn black liquor safely. Increased energy costs, increased capital investment costs and the strict discharge limits in to the environment have caused chemical recovery experts to play a much more important role in the pulp mill industry.

In most of the Indian Integrated paper mills employing wood/bamboo as a raw material, the black liquor solids firing range is around 60% w/w with steam generation of only 2.4—2.6 t/tp as against 3 2--3 4t steam/tp in developed countries where the black liquor solids firing range is above 70% w/w.

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In the recent years, firing of black liquor in to the recovery furnace, at higher dry solids concentration is an area of considerable interest in soda recovery process as there is large incentives to remove as much of water as possible from the black liquor before firing it into the recovery furnace but the limitation is basically the handling of the product i.e., thick black liquor.

Results & Discussion :

High solids evaporation technique :

CPPRI has developed technique which involves depolymerization of high molar mass organic residues at elevated temperature more than that of normal pulping temperatures. Black liquor is concentrated to a concentration of about 30%—40% solids depending upon the raw material in multiple effect evaporator, thereafter subjected to thermal treatment for specified time thermally treated black liquor with low viscosity is subsequently evaporated in remaining bodies of multiple effect evaporators.

Effect of thermal depolymerization on viscosity :

Thermal treatment of bagasse & wood kraft black liquor procured from mills resulted in appreciable reduction in viscosities. The reduction in viscosity upon thermal treatment in case of bagasse reflects from the cleavage of linkages between polysaccharides & lignin, conversion of higher molar mass polysaccharides in to lower molar mass component as evident from the determination of degree of polymerization (DP) value of isolated hemicelluloses from the treated & untreated black liquor, where DP was reduced to 88 from 125. like wise reduction in viscosity in case of mill's kraft wood black liquor was due to decrease in the concentration of large molecular mass lignin components which are degraded to low molecular mass components.

Black liquor combustibility :

Results of combustion behaviour of black liquor before & after thermal treatment are reported in Table-1. Results clearly indicate that combustibility of black liquors is highly influenced by the thermoplasticity of organic residues which is again related to molecular size. Reduction in molecular size increases the thermoplasticity due to well dispersed homogenous organic mass. Thus, combustibility of the black liquors upon thermal treatment has improved remarkably as there is decrease in IPDT, & Tig values and also the activation energy (Ea) for pyrolysis stage is reduced from 113 KJ/mol to 58 KJ/mol and 121 KJ/mol, to 68 KJ/mol for bagasse & wood black liquors respectively. The swelling behaviour showed remarkable improvement as evidenced from swelling volume ratio which has increased from 7 ml/gm to 13ml/gm & 16ml/gm to 22ml/gm for bagasse & wood respectively.

Table—I

Results of combustion behaviour of spent pulping liquors before & after thermal treatment

particulars	Bagasse Black Liquor		Wood Black Liquor (Mill)	
	Original	Thermally treated	Original	Thermally treated
Cal. Value, Cal/g	3420	3310	3420	3380
IFDT,°C	454	414	327	312
Tig,°C	763	730	718	671
Ea, KJ/mol	113	58	121	68
SVR, ml/g	7	13	16	22

IPDT-Integral Proceedural Decomposition Temp. Tig.-Temp. of Ignition

Improved Energy Generation & Economics :

The energy economics of high dry solids firing is calculated for 125 t/day solids generated from soda bagasse pulp mill as shown below. This clearly shows that overall energy balance in recovery section is increased to about 12% as shown in Table-II.

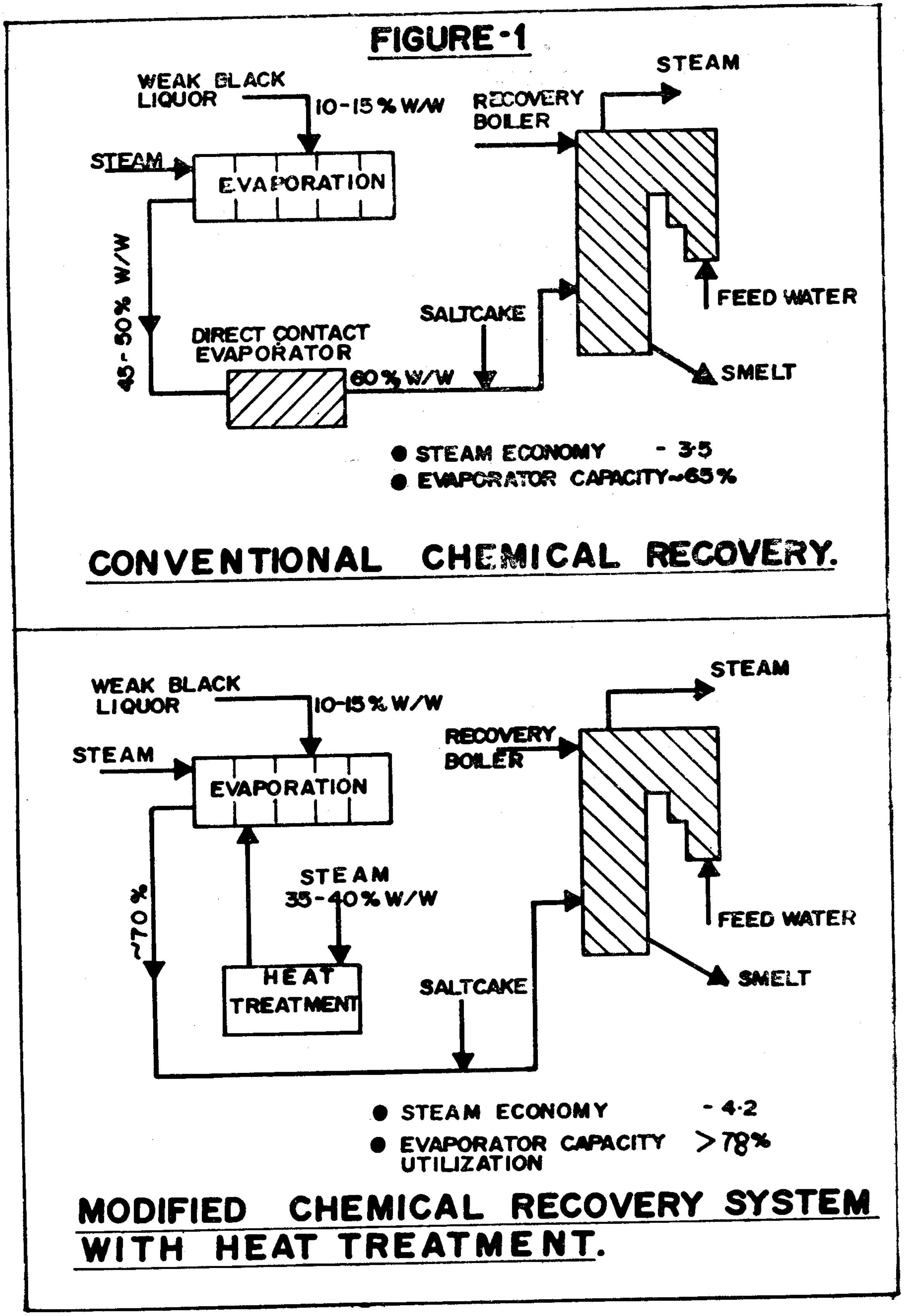
TABLE-II

HEAT BALANCE DURING COMBUSTION
(Basic-KJ/Kg Dry Black liquor solids)

Heat Input :

	Conventional process	With thermal treatment process
Gross heating value of B L. solids, KJ	12500+315 (BL) (OIL)	12330
Sensible heat in water		

FIGURE-1



CONVENTIONAL CHEMICAL RECOVERY.

MODIFIED CHEMICAL RECOVERY SYSTEM WITH HEAT TREATMENT.

in liquor, KJ	535	295
Heat in combustion air, KJ	425	505
Total	13775 KJ	13130 KJ

Heat Out put :

Sensible heat in smelt, KJ	600	600
Specific heat in water evaporated, KJ	3000	1200
Specific heat in moisture from hydrogen in B.L. solids, KJ	877	877
Sensible heat in flue gas, KJ (120°C)	450	450
Unburnt loss, KJ	50	50
Radiation losses & unaccounted, KJ	450	450
Total	5500 KJ	3500 KJ
Heat to steam	8275, KJ	9630,KJ
Steam generated t/t solids	2.6	3.1
Additional steam (of 40 kgs at 400°C) for 125 t solids/day,	—	63 tons.
Thermal efficiency, %	60	73

Thermal treatment-possibility of refrofitting:

From the data available, it has been experienced that the steam economy even in some of the sextupule evaporator installations is as low as 2.7 to 3.5 clearly indicating that full evaporation capacity of evaporator is not utilized. Introduction of thermal treatment in an intermediate stage of evaporation should help in maintaining the desired level of operations by increasing the rate of circulation due to reduced viscosity. Fig.-1 gives a typical illustration of retrofitting the existing evaporator system.

Reference :

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