Modernisation and optimum utilisation of evaporators for hardwood black liquors-mill experience

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SUMMARY

The modifications carried out on the battery of evaporaptors to achieve optimum utilisation for handling the black liquors of increasing proportion of hardwoods (from 20 to 80%) are presented. Steps taken for maintaining adequate velocities for higher heat transfer coefficients overcoming the problems of higher viscosities are described. Operational changes introduced and energy savings obtained from closing of vapour circuit through cross-connection of two streets of evaporators are detailed. The important role played by the black liquor of certain species (like Erythrina suberosa-Dadup) as diluent in decreasing the viscosities of black liquors of mixed hardwoods containing large percentage of Eucalyptus tereticornis is explained.

SPB commenced production of cultural and industrial grade papers with bamboo and bagasse as raw materials in 1962. Due to the increasing difficulties in the procurement of bagasse and the economical unviability as a consequence of continuous rise in fuel oil prices, the Mill had to depend entirely upon bamboo for pulping. However, the dwindling supply of bamboo from the forests over the years forced the Mills to use the tropical hardwoods in gradually increasing proportion which is to the extent of 80% as on today. This forced situation of raw materials, from originally planned bamboo to available tropical hardwoods, had brought in a number of problems in the operation necessitating modifications in process as well as equipment. This article describes the attempts made to get over the operating difficulties through modification and improvisation to achieve optimum utilisation of existing evaporator units.

HARDWOOD BLACK LIQUORS

When the necessity to use tropical hardwoods had become obvious, the Mill had evaluated about 35 species of hardwoods in the laboratory to find out their suitability for pulping as well as the handling of the resultant black liquors. Out of the total of 35 species, about 12 species were selected for pulping, the major component being Eucalyptus tereticornis The black liquor from the mixture of raw materials possessed high viscosity posing problems not only at Evaporators but also affecting the working of recovery furnace The rise in viscosity with concentration of solids in black liquor could not be established exactly even in laboratories due to the sudden surge in viscosity which could not be attributed to any of the factors investigated.

Though the silica content had come down considerably in weak black liquor due to the reduced proportion of bamboo, the presence of fibre fines, gelatinous nature of black liquors and the free alkali drop across evaporator effects had posed serious problems in operation. Since the increase in percentage of hardwoods, the Mills experienced higher residual alkali drop across the effect than in the case of bamboo black liquors. This had resulted in partial plugging of tubes especially at concentration effects. To cope up with this situation, dilute caustic was added to the weak black liquor to

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higher residual alkali. This improved the running of evaporators. Fibre fines in black liquor seemed to have contributed substantially for the scale formation forming a nucleus for further growth. This becomes evident from the examination of analytical data given in Table 1 for evaporator scales. This could be successfully avoided by filtering the fibre fines through installation of suitable sidehill screens over weak black liquor receiving tanks.

It was also experienced that the black liquors of certain species, like Erythrina suberosa (local name-Dadup) helped in maintaining viscosity at lower levels working as diluents. The presence of these species in the chips digested contributed considerably to the ease of handling subsequent black liquors in the evaporators.

As expected, the frequency of water boil-outs of evaporator tubes increased with the increased use of hardwoods. During these boil-outs emergence of gelatinous black lumps from the bottom of the tubes along with the drainings was observed. The analysis of these lumps is given in Table 2. This may be attributed to the higher extractives like polyphenols and resinous matter in the wood species.

TABLE—1
ANALYSIS OF SCALE FROM THE TUBES OF CONCENTRATION EFFECT

	I While using 80% bamboo & 20% hardwood	II While using 30% bamboo and 70% hardwood
Loss on ignition	20.49%	28.90%
Acid insolubles	52.60%	39.07%
CaO	12.50%	28.24%
MgO	8 30%	0.40%
R_2O_3	2 80%	3.60%

TABLE—2
ANALYSIS OF LUMPS COLLECTED FROM CONCENTRATION EFFECT

I	ORGANICS	46.10%
	INORGANICS	53.90%
II	Acid insolubles	4 86%
	NaOH	1.76%
	Na_2S	3.96%
	Na_2CO_3	79.97%
	NaCl	4.78%
	R_2O_3	0.94
	CaO	1.48
	MgO	Traces
III	Alcohol benzene solubility — 9.61%	

RECOVERY BOILERS AND REQUIRED LIQUOR SOLIDS

1. No. I Recovery Boiler (B & W)	Equipped with venturi scrubber cyclone separator for secondary evaporation. The feed to the secondary evaporator is 200 m^3 of black liquor per day at 36-38% total solids (equivalent to 90 tons of solids per day).
2. No. II Recovery Boiler (Gotaverken)	Equipped with cascade evaporator for secondary evaporation. The feed for the secondary evaporation is 240-250 m^3 of black liquor per day at 42% total solids (equivalent to 135 solids per day).

ORIGINAL EVAPORATOR UNITS

A short description of original evaporation units is given below :

Type	5 effects LTV
Tube length	24′ × 2″ (7.31 m × 5 cm)
Material of construction of tubes	MS for IA, IV & V effects SS for I, II & III
Sequence of flow	IV-V-III II-I
Reheaters	V, IV, III & II effects
Demister pads	V, IV, III & II effects
I effect is having two passes	
Heating area	204.4 sq. m.
Water evaporation capacity	28 t/hr
Steam economy	4.2
Inlet concentration	13-14%
Feed	45 359 kg/hr
Product	13 610 kg/hr
No. of units	2
New unit is the mirror image of the old unit.	
Runnability :	
I effect	30 days
II & III effects	60 days
IV & V effects	90-120 days for checkup & cleaning
Cleaning	By pneumatic cutters Mild acid Boiling with inhibitor

The original flow sheet for processing black liquors is given in Figure 1.

The evaporator unit, though could be run as quintuple effect while handling bamboo black liquors at designed steam economy of 4.2, the introduction of higher percentages of hardwoods had reduced the handling capacity of 5 effects leaving only 4 effects for operation while two bodies were

regularly under cleaning. Thus, the steam economy had to be sacrificed for handling black liquors of higher percentages of hardwoods.

INSTALLATION OF A PUMP IN BETWEEN FIRST PASS AND SECOND PASS OF CONCENTRATION EFFECTS OF BOTH UNITS :

Due to the high viscosity of black liquors, it was felt hat the velocity of the liquor flowing from first pass of the concentration effect to the second pass was not sufficient to have adequate capacity utilisation. A separate pump connection was provided to achieve forced circulation from first pass to second pass. This arrangement had considerably improved the runnability of the concentration effect The schematic diagrams showing the flows before and after installation of pump are given in Figure 2.

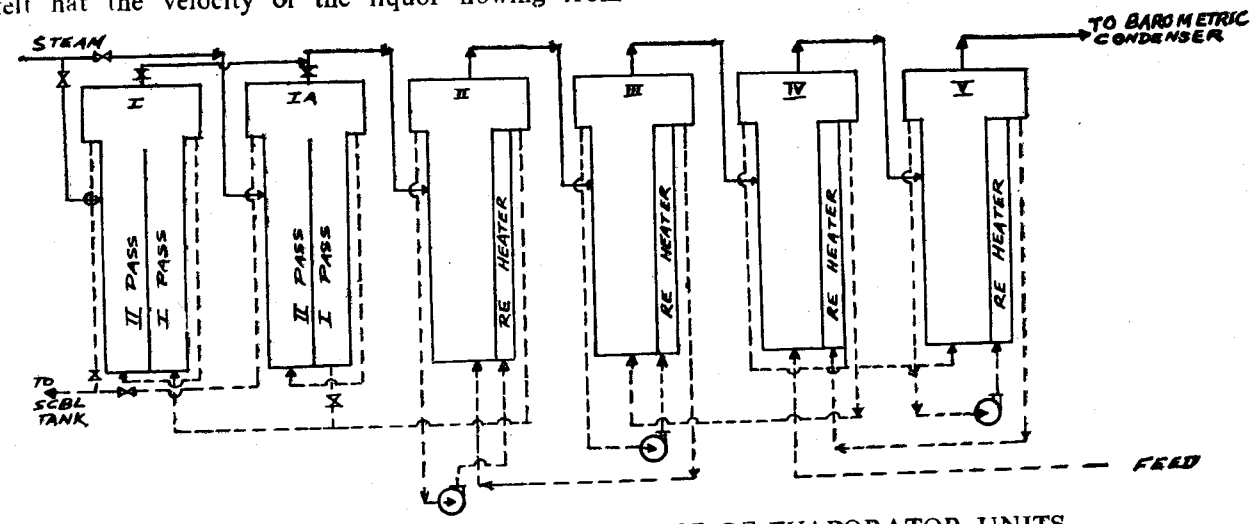

FIG. 1 ORIGINAL ARRANGEMENT OF EVAPORATOR UNITS

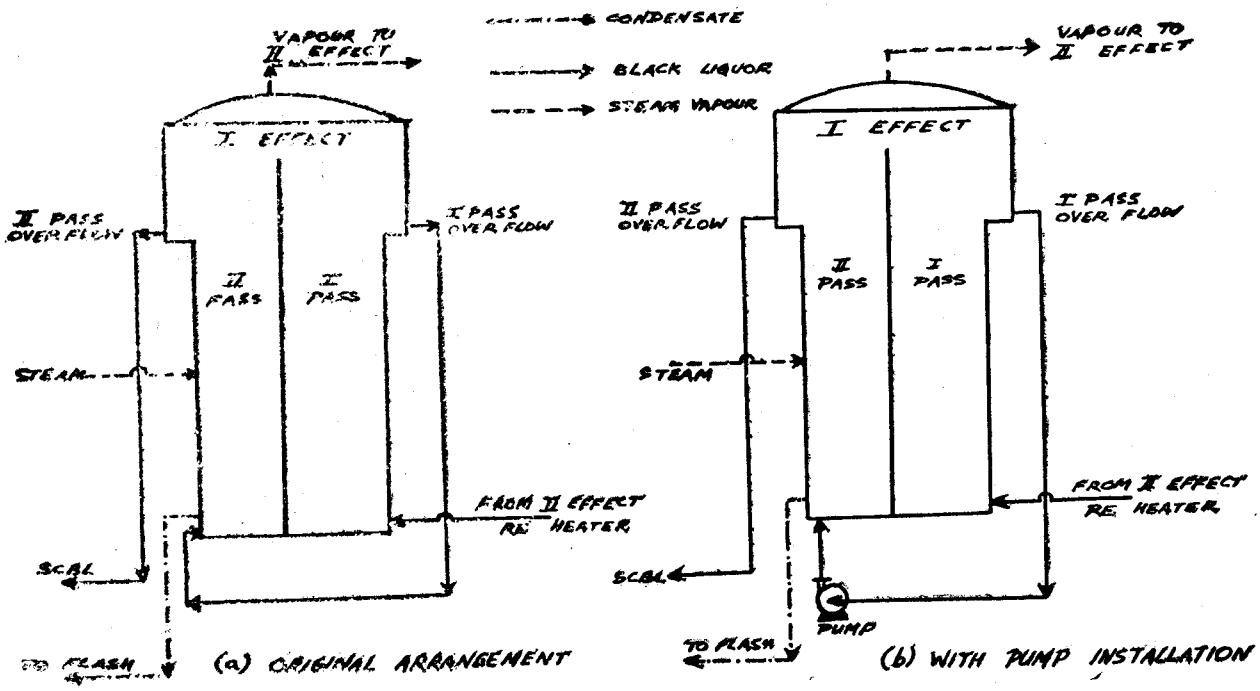

FIG. 2—INSTALLATION OF PUMP BETWEEN FIRST AND SECOND PASSES OF I EFFECT

CONVERSION OF CONCENTRATION EFFECT OF FIRST (OLD) UNIT TO A FINISHER

In view of the granulating tendency of black liquors from hardwoods at lower concentrations, it was difficult to handle black liquors above 36% total solids at the concentration stage. Further, it was also experienced that the capacity of the unit was getting reduced to 50-60% after concentration effect was put back in service after a thorough cleaning. This had resulted in under supply of concentrated black liquor at 42% total solids to the second recovery furnace and the first recovery furnace had to be overloaded feeding the black liquor at 36% total solids taking advantage of the thermal efficiency of venturi scrubber and cyclone separator. To get over this problem, concentration effect from the old set of evaporators was taken out of stream by converting it as improvised finisher to concentrate liquor from 36 to 42% total solids. This arrangement had given some relief and worked satisfactorily. The only disadvantage of this arrangement was the venting out of about 1360 to 18 0 kg. of vapour per hour into the atmosphere when first effect was used as improvised finisher. Effects 1A and II were alternatively run as first effect for four effect unit.

INTRODUCTION OF A NEW FINISHER EFFECT

Since about 40 to 50 tons of vapour per day was to be vented into the atmosphere without recovering the thermal energy, a forced circulation finisher was connected in stream. The new finisher was designed and fabricated in the Mill workshop and commissioned in the later half of 1979, The finisher was connected in line with old street evaporators. The details of the finisher operation are given below :

Inlet solids	a) 34—36% b) 26—28%
Outlet solids	a) 41—43% b) 34—36%
Steam flow	2.41 t/hr at 3.5 kg/cm^2
Heating surface	71 m^2
Tubes	5.5 m × 5 cm SS 304 93 tubes
3 passes 32, 31 & 30 tubes for 150 tons solids/day	All other parts are MS designed
Flash chamber	1.22 × 1.83 m = (4′ × 6′)
Circulation pump	10 m^3/mt 24.4 m Centrifugal horizontal split casing 100-110 circulations/mt. with 2.75 m/sec velocity.

UTILISATION OF VENT VAPOUR FROM FINISHER

During the commissioning and trial run period of the finisher, there are initial problems for closing the vapour circuit to II or III effect as it was disturbing the vacuum. After a few trial runs, the

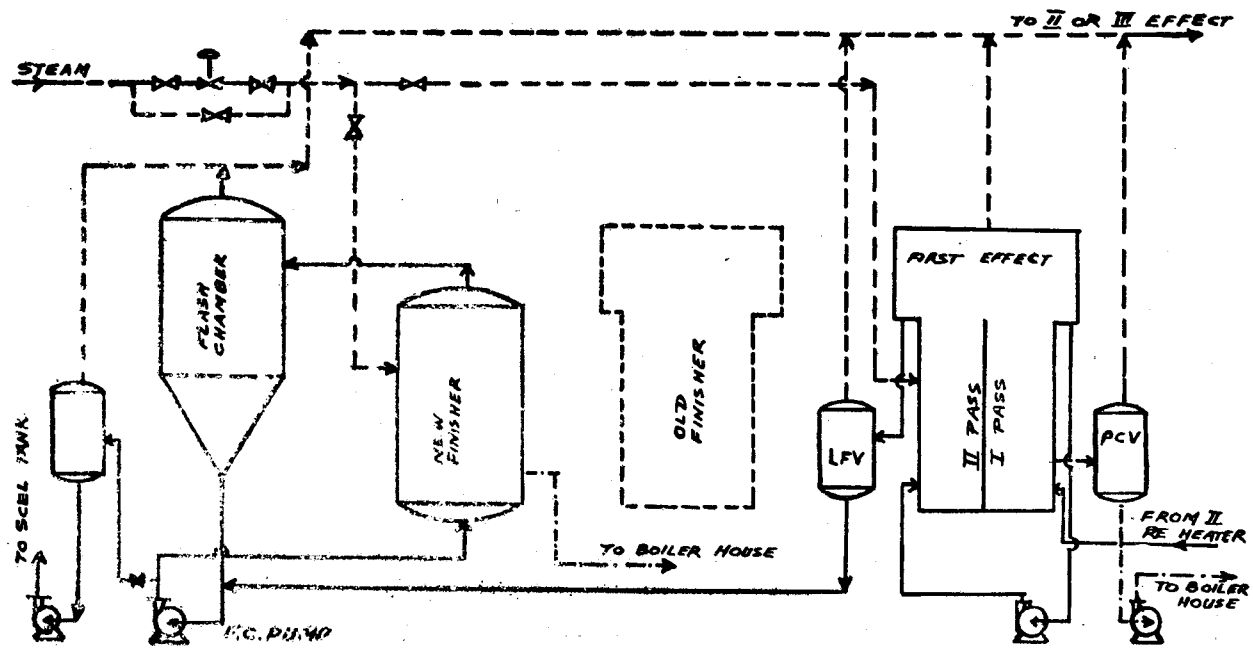

FIG. 3—CLOSING OF VAPOUR CIRCUIT

vapour circuit could be successfully closed either to second or third effect in service without upsetting the equlibrium of the unit. The schematic diagram of this arrangement is given in Figure 3.

CHANGING THE LIQUOR ENTRY FROM TANGENTIAL TO RADIAL AND MODIFICATION OF FLASH CHAMBER :

The closing of the circuit as mentioned above gave rise to problems regarding solids concentration. It was also observed that suction of the circulating pump was starving for liquor and vibration of pump was also experienced. The pump motor was taking only 60% of the rated load and black liquor solids could be increased only by 3 to 4%. This had prompted to modify the tangential entry of the liquor from the heater to the flash chamber to radial one. Subsequently, the flash chamber was also modified by increasing the height by 1 m. This modification had improved the performance of the finisher remarkably. The pump motor load had increased to about 85% and the solids percentage could be increased by 6 to 8%.

UTILISATION OF VAPOUR FROM IMPROVISED FINISHER OF OLD STREET

Since the vapour from improvised finisher could not be handled in old set of evaporators (as it was already handling the finisher vapour), a cross-connection was made to the new street of evaporators. By this arrangement, all vapour circuits were closed resulting in a saving of 50 t/day of steam at an overall steam economy of 3.6 to 3.8. The final arrangement of evaporator system at SPB is shown in Figure 4.

Forced circulation finisher and improvised finisher are utilised for increasing solids from 36 to 42% as required before firing in the two boilers. Though the evaporators could not be run as quintuple effect to gain the advantages of the steam economy of 4.3, the optimum and sustained utilisation of the unit was possible to cope up with the situation arising from the gradual increase of hardwoods to the extent of 80% in the raw material mixture.

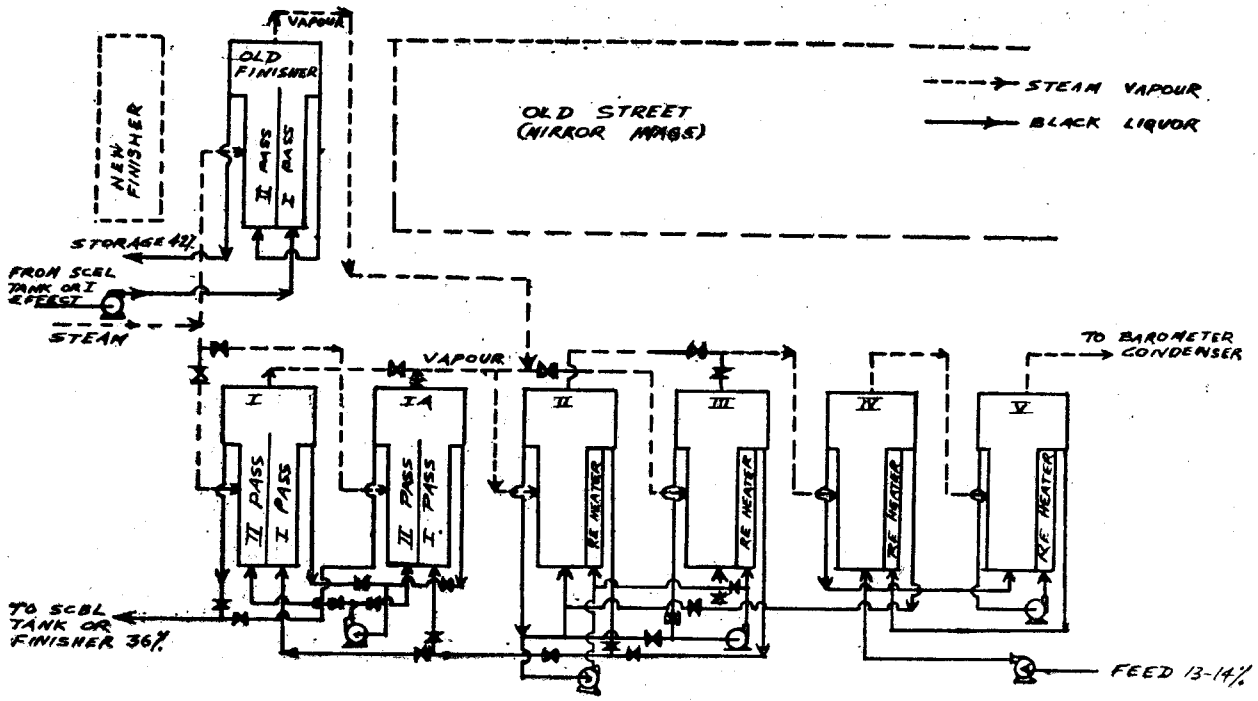

FIG 4 –FINAL ARRANGEMENT OF EVAPORATOR UNIT

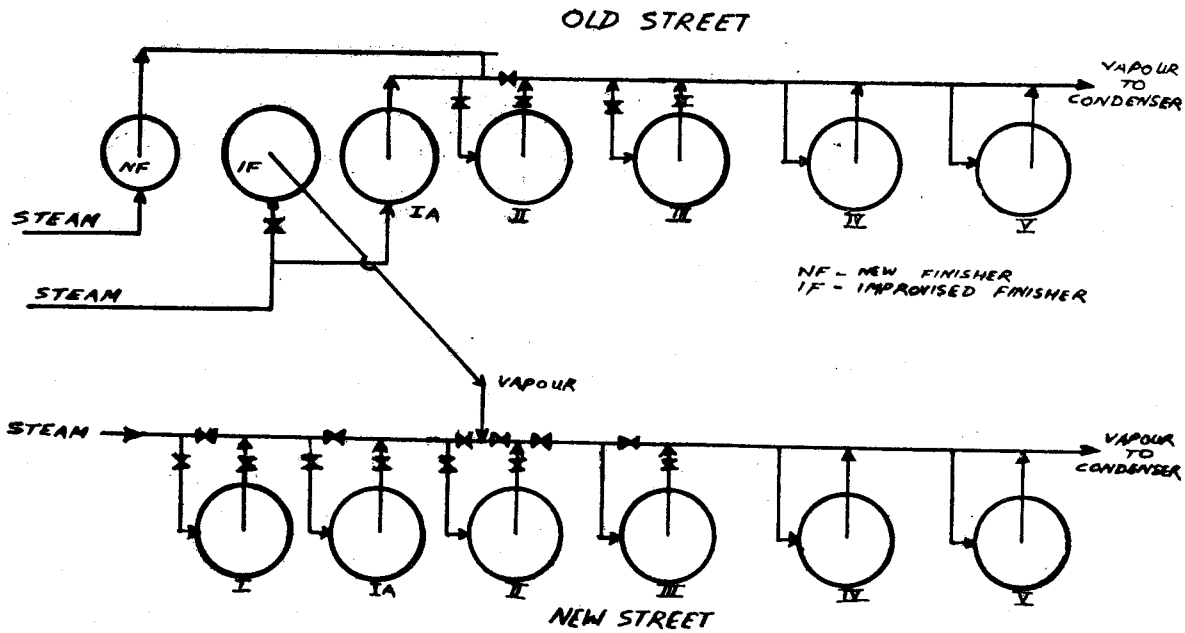

FIG. 5—VAPOUR CIRCUIT OF TWO EVAPORATOR UNITS

CONCLUSIONS

1. Dilute caustic dosing at inlet of evaporator effects improved the mobility of hardwood black liquors and maintained residual alkali across each effect which improved runnability.
2. Introduction of forced circulation in between the two passes of concentration effect has increased the velocity and improved heat transfer of hardwood black liquors and resultant capacity, runnability and efficiency of evaporator units.
3. With the modification of tangential entry to radial entry to the flash chamber, the concentration of solids improved in forced circulation finisher.
4. Single stage (effect) improvised finisher gave satisfactory performance to concentrate hardwood black liquor from 36 to 42% and closing of the vapour circuit resulted in considerable energy savings.