Recent Trends In Waste Heat Recovery

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SUMMARY

The paper describes different methods of blow heat recovery in soda and sulphate pulp mills. Blow heat recovery is an economic solution to meet the demand of hot water or energy for pre-evaporation of black liquor. Three recovery systems have been discussed and a case study given.

INTRODUCTION

Blow heat recovery offers an economic solution to meet the demand of hot water or energy for pre-evaporation of black liquor in sulphate and soda mills. This paper discusses features of blow heat recovery schemes and the innovations made in the equipment used. The possibilities of heat recovery from digester blow can be seen by assuming a mill having digesters of 76 M^3 capacity and 7 tonnes of air dry pulp per charge. In a day there are 42 blows with an output of 294 tonnes pulp.

A material balance around the digester will give—
UNITS—kgs/blow

	Liquor	Pulp	Total
BD pulp	—	6300	6300
Black/white liquor (40.5 M^3)	44550	—	44550
Water and soluble solids in wood (Yield — 44%, Moisture 40%)	17563	—	17563
Steam injection	1625	—	1625
	63738	6300	70038

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The heat released in blow vapours—Kcals/blow

Heat given by pulp—6300 (172.17 — 100) 0.35
= 159135

Heai given by liquor—63738 (172.17—100) 0.9
= 4139974

4299109

Average heat released/minute — $\frac{4299109}{8}$

during blow = 537389 Kcals/min

Average steam availability/hr = $\frac{537389 \times 42 \times 8}{539 \times 24}$

= 13958 kg/hr at 100°C

Three recovery schemes are now discussed with their specific advantages and limitations for optimum utilisation of the 13958 kg/hr blow vapours.

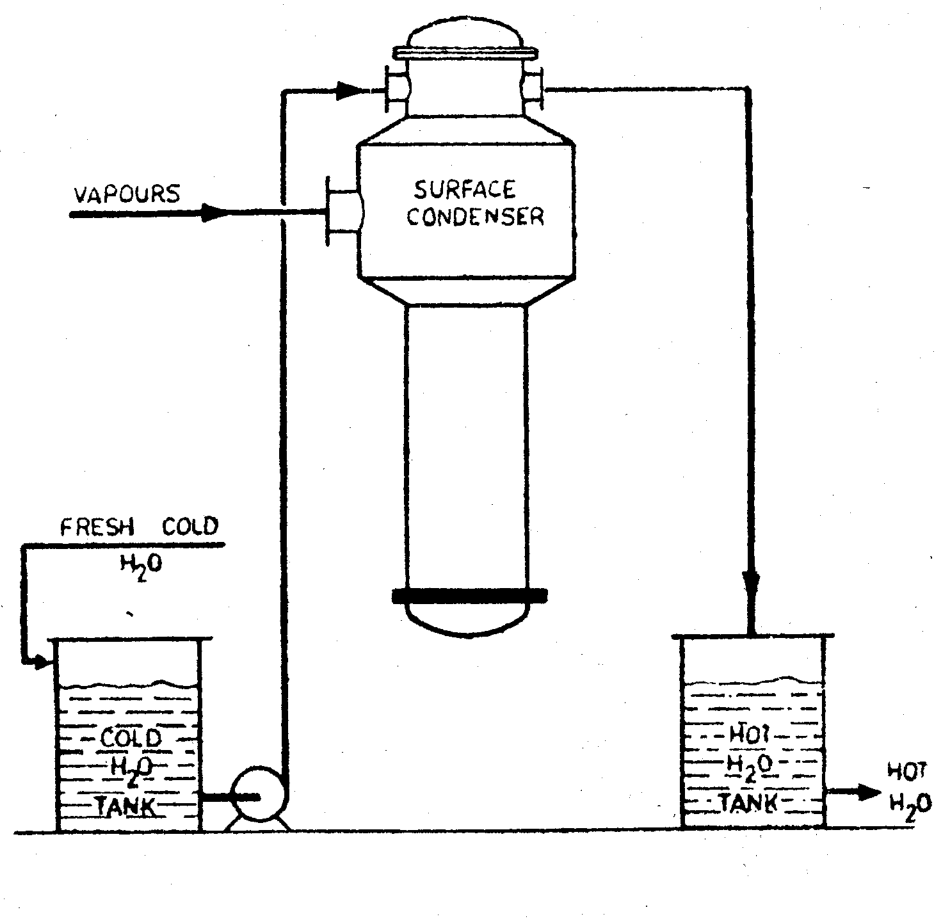
RECOVERY SYSTEMS

(1) SURFACE BLOW CONDENSER SYSTEM (EXHIBIT 1)

Consists of a shell and tube condenser with sufficient surface to condense the peak release of steam, a water circulating pump, hot and cold water storage tanks and water regulating valves. Thə surface condenser is of a special design (Exhibit 2) with a wrap around entrainment separator to recover fiber and liquid carried over from the blow tank. Cone bottom catchalls are also provided if necessary before the condenser and the separated pulp/liquor from either the cone separator or the wrap around catchall on the condenser is drained to a small receiving tank. The separator is provided with flashing connections. The cold and hot water tanks are normally sized to hold sufficient water to accommodate two consecutive digester blows.

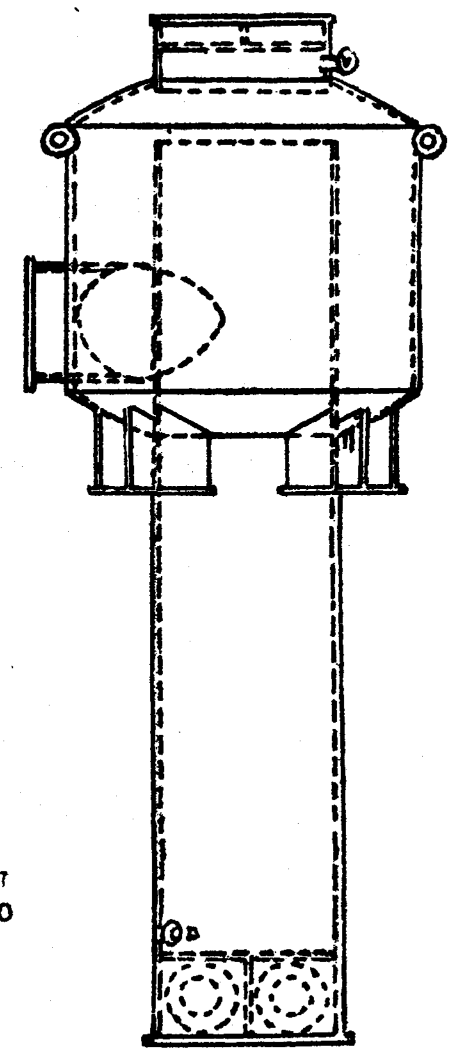
release at the start of a blow. On a batch digester system the maximum flow rate is 1.75 times the average. The control valve is automatically opened and held constant for an adjustable time to include the high flow rate period. An adjustments timer establishes this period and at its end switches the control of the water valve over to the temperature control instrument. For the remainder of the blow the water flow is controlled by the temperature controller. When a low level cold water tank is used the initial energising of the system also starts the water pump.

EXHIBIT-1



SURFACE BLOW CONDENSER SYSTEM

EXHIBIT-2



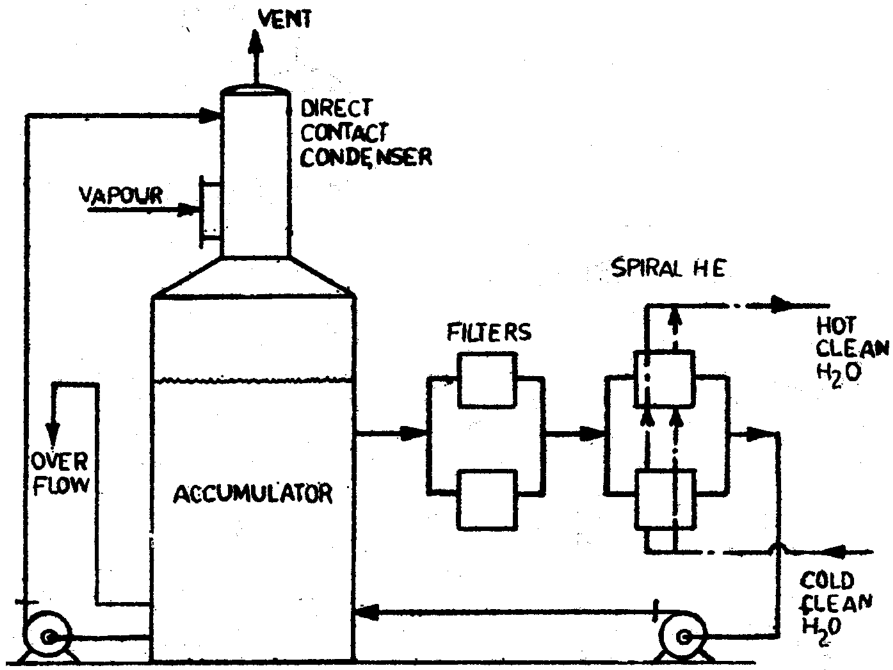
SURFACE CONDENSER

The instrument schemes used today eliminate the lags inherent in earlier cooling water flow sensing systems. Positive starting of the control system at the start of blow is now achieved. Adjustment is made to take care of the higher than average vapour

(II) DIRECT/INDIRECT BLOW CONDENSER SYSTEM (EXHIBIT 3)

Consists of a direct contact condenser, a water circulating pump, accumulator tank, condenser water

EXHIBIT-3



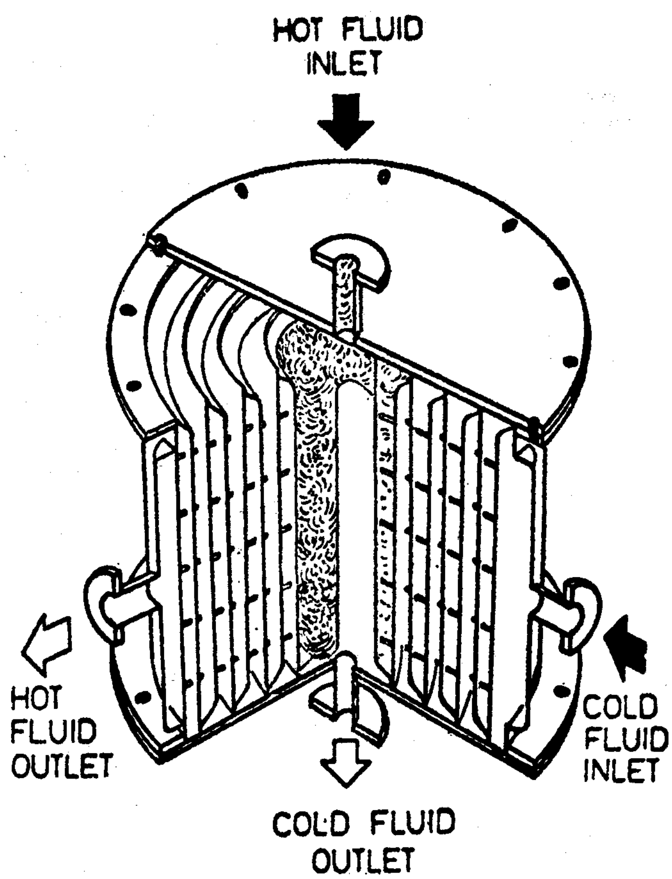
DIRECT/INDIRECT BLOW CONDENSER SYSTEM-II

regulating valves, spiral plate heat exchangers, hot water circulating pump and temperature control valves. Two separate cycles are involved. The digester blow steam is condensed intermittently in the direct contact condenser. The water flow is regulated so that the water leaving the condenser is at a temperature of about 96°C. The heated water passes into the top of the accumulator tank, and the cold water is pumped to the condenser from the bottom. The heated contaminated water, withdrawn continuously from the top of the accumulator, is pumped through a series of spiral plate heat exchangers (Exhibit 4) which are particularly efficient for contaminated water service. Fresh water is heated in the other channel of the spiral heat exchanger to about 70°C. This temperature is maintained constant by controlling the contaminated and fresh water flow rates. The contaminated hot water is cooled to 46°C and returned to the bottom of the accumulator tank where it is stored for condensing the next digester blow. A bleed is provided from the accumulator tank.

(III) DIRECT/INDIRECT BLOW CONDENSER SYSTEM (EXHIBIT 5)

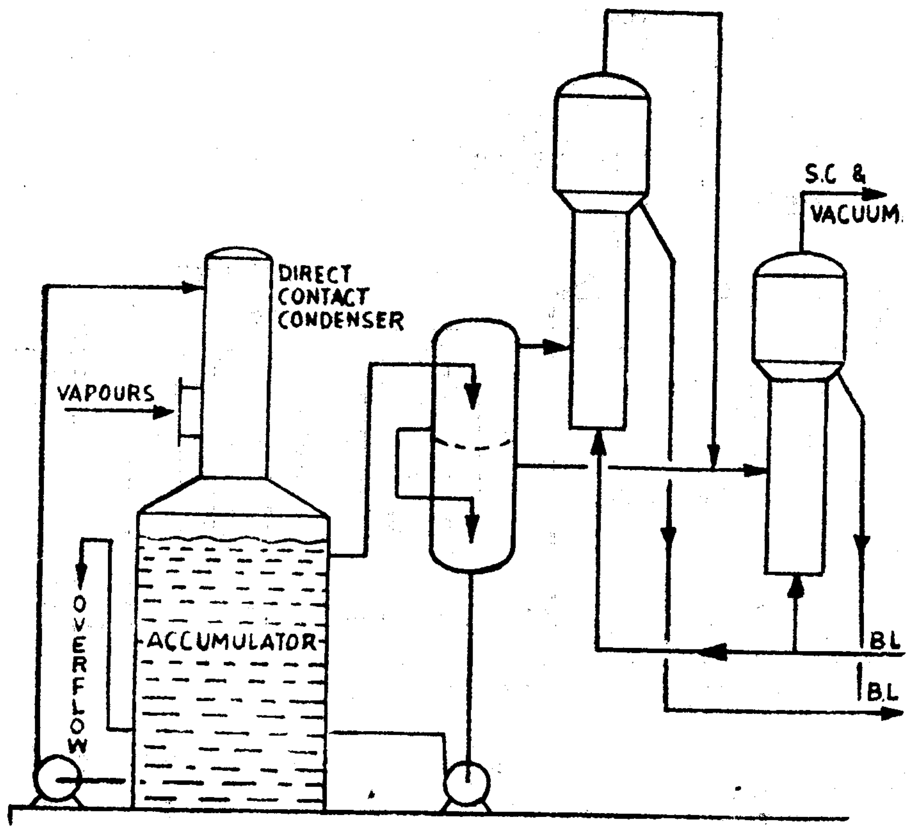
Is similar to system II upto the accumulator stage. The hot water at 96°C from top of the accumulator is flashed in a two stage flash vessel and the flash vapours at 76°C and 60°C respectively are used as heating vapours on the shell side of two pre-evaporator calandria bodies. The condensate from the evaporator and flash vessels is returned to the accumulator at 60°C. An ejector system is used to maintain the required vacuum to the second stage of the pre-

EXHIBIT-4



SPIRAL HEAT EXCHANGER

EXHIBIT-5



DIRECT / INDRECT BLOW CONDENSER SYSTEM-III

evaporator system and the vapours from the second stage pre-evaporator are condensed in a surface condenser. A bleed is provided from the accumulator tank.

TABLE I

	Performance Figures		System I Surface Cond	System II Dir Cond with spiral HE	System III Dir Cond with Flash Tank and Pre Evap
1.	Blow vap to system (avg.),	kg/hr	13958	13958	13958
		°C	100	100	100
2.	Condensate from system (avg.),	kg/hr	13958	13958) as over	13958) as over
		°C	100	46) flow	60) flow
3.	Percent total heat recovered from vap.,		84.33	92.8	90.6
4.	Clean hot water output from system,	kg/hr	250181	273967	
		°C	70	70	
5.	Clean water input to system,	kg/hr	250781	273967	
		°C	40	40	
6.	Black liquor input to pre-evap.,	kg/hr			10000
		TS%			10
		°C			80
7.	Black liquor output from pre-evap.,	kg/hr			73027
		TS%			13.7
		°C			59.3
8.	Evaporation in pre-evap	kg/hr			26973
9.	Steam economy pre-evap.				1.9
10.	Actual heat recovery	%—	84.33	92.80	149.0

$$\frac{\text{Heat output as hot water or as evap., kcals}}{\text{Heat avl. from blow vap, kcals.}} \times 100$$

CASE STUDY

Performance figures, Given in Table—I calculated for each of the three systems described. The basis is the availability of 13958 kg/hr blow vapours at 100°C.

CONCLUSION

Each of the three systems has advantages and drawbacks and the choice of a particular system will depend on the total energy balance and system requirements in the particular plant.

The vertical surface condenser system is superior from flexibility considerations. It is a straight batch meaning that mill capacity can be increased indefinitely without change to the blow condenser system as long as digester size does not increase and digesters blows do not come simultaneously. For example a mill making 20-twelve minute blows operates with 60 minutes between blows. This mill could expand to 40-twelve minute blows without change to their surface condenser system and still have 30 minutes between blows. The other systems do not have this flexibility. The only parts of these systems which are of batch design are the circulating pump and direct contact condenser. The large accumulator tank size is based on the water withdrawal rate and the spacing between blows. If the time between blows is cut in half the accumulator must be doubled in volume. The two stage flash vessel, pre-evaporators and the spiral plate heat exchangers are designed for continuous operation and doubling the rate will require doubling the equipment. The surface condenser system has low operating costs especially when using an elevated cold water storage tank. This system avoids the large circulating pump power, contaminated water return pump power and steam/ water requirement for the vacuum system for the pre-evaporator.

The direct contact system with spiral heat exchanger is thermally more efficient than the surface condenser system. The spiral plate heat exchangeis are compact and are well suited for service with contaminated water/suspended solids. The filters can often be dispensed with provided adequate control is maintained on blow tank level and operation.

The pre-evaporator system has the maximum heat recovery and offers an excellent total energy solution to the plant. The integration of the heat the plant. The integration of the heat and mass balances of the evaporation and blow heat recovery sections will enable an optimum energy balance to be worked out for the plant.

DATA REQUIRED FOR DESIGN

The digester feed conditions are required :

—number of tonnes of pulp produced per digester percent yield pulp to wood charged

—percent moisture in wood

—quantity of cooking liquor (white and/or black liquor)

—quantity of direct steam used

—digester pressure

In addition data needed are :

—blowing time in minutes

—maximum inlet water temperature

—desired outlet water temperature

—number of blows per day

A brief discussion on the hot water usage contemplated, present energy balance around the multiple effect evaporation system and flexibility requirements desired will enable an optimum design of blow heat recovery alternatives.