

# Improved Chemical Recovery Efficiency in Kraft Pulp Mills

CHOWDHARY, L. N.,\* SAKSENA, U. L.,\* SUBHASH CHANDRA\*

## SUMMARY

The chemical balance in a kraft recovery cycle is discussed and the points of sodium and sulphur losses are identified. The ways and means to control the chemical losses and improve chemical recovery efficiency, have been discussed in the light of our experiences at Star Paper Mills. A scheme for regular monitoring of chemical losses to the effluent, as being followed by us, has been presented and its various aspects are discussed.

## INTRODUCITON

The kraft process is the largest contributor to the pulp production of the world, mainly because of its suitability to pulp different kinds of cellulosic raw materials and having a versatile established system for the recovery of pulping chemicals. In India, the kraft process accounts for more than 90% of the pulp production in the country. The efficiency of chemical and heat recovery systems, plays a vital role in the overall profitability of any kraft mill, and its importance need not be over emphasized.

In kraft process, the cellulosic raw material is treated with alkaline cooking liquor, called white liquor, at a temperature of 155–175°C. Most of the lignin of the raw-material is dissolved during the cook and the cellulosic fibers are left free. The spent liquor, with most of the inorganic cooking chemicals and dissolved wood constituents, known as black liquor, is concentrated by evaporation and burnt in a recovery furnace. The inorganic cooking chemicals are recovered from the furnace in the molten form, dissolved in weak wash and regenerated in the causticising section.

## CHEMICAL BALANCE IN KRAFT CYCLE

The main constituents of the cooking liquor are NaOH and Na<sub>2</sub>S besides Na<sub>2</sub>CO<sub>3</sub> and Na<sub>2</sub>SO<sub>4</sub> and other sodium compounds which are present in smaller quantities. The sodium and sulphur balance of one kraft mill, may vary considerably from other, depending upon the make up chemical and process conditions. A typical kraft recovery cycle, showing the points for sodium and sulphur losses, is shown in Fig. 1. The losses of chemical, take place mainly in three ways, viz.;

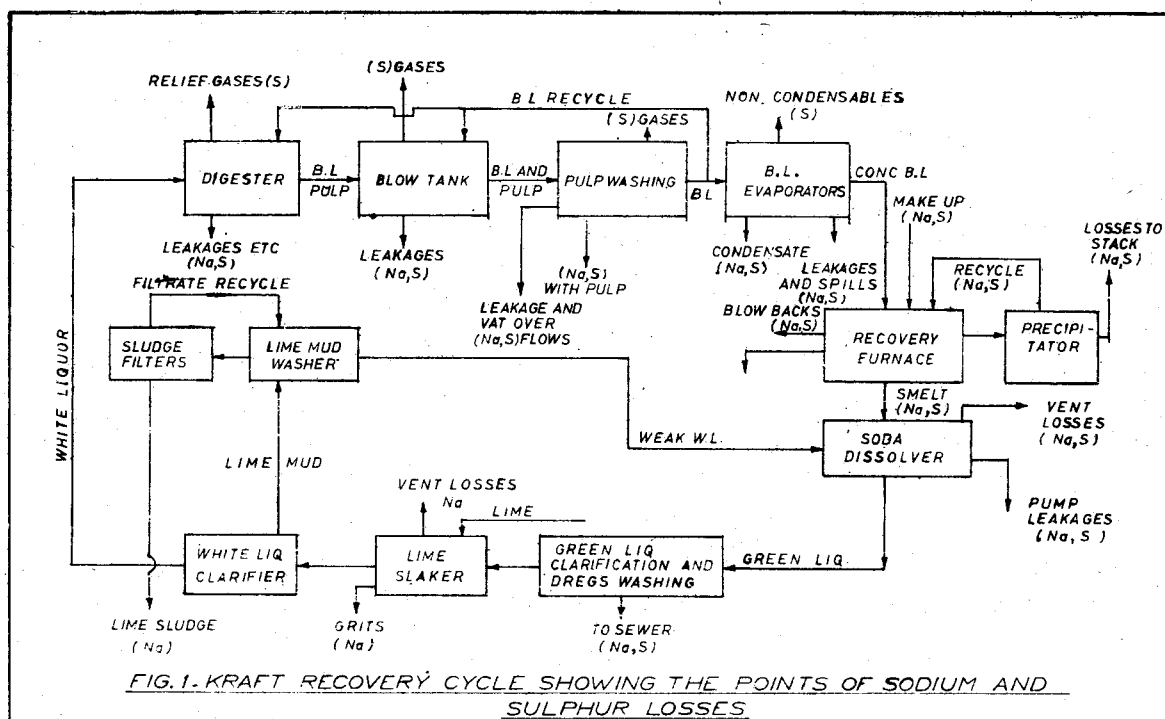
i) **EMISSIONS TO ATMOSPHERE**—Such emissions mostly result in the loss of sulphur in the form of gases like H<sub>2</sub>S, CH<sub>3</sub>SH, CH<sub>3</sub>-S-CH<sub>3</sub> and CH<sub>3</sub>-S-S-CH<sub>3</sub>. Emissions to atmosphere also include loss in the form of particulate matter like Na<sub>2</sub>SO<sub>4</sub> and Na<sub>2</sub>CO<sub>3</sub> etc. In case of the mills with a lime sludge reburning kiln, the particulate matter may include the lime as well.

ii) **EFFLUENT DISCHARGES**—The losses in the liquid form, result in the loss of sodium and sulphur both, from the system.

iii) **SLUDGE DISPOSAL**—This includes the discharges of inorganic sludge, from green liquor clarification stage and sludge filters. This results mainly in the soda losses.

The loss of chemicals, is made up by addition of various make up chemicals. The make up chemical requirements vary widely not only from one mill to another but also for a particular mill over a long period. The usual make up chemical is sodium sulphate, which contains sodium and sulphur in the ratio of 2:1. For the losses to effluent system, in liquid form, the Na : S ratio is greater than this, but this is compensated by the fact that emissions to the atmosphere, result mostly in the sulphur loss, in the form of SO<sub>2</sub> and H<sub>2</sub>S. The sulphidity, in the system, largely depends upon the equilibrium of sodium and sulphur losses. In case the soda losses increase, and more sodium sulphate is added to make up for them, there will be an excess of sulphur in the system and sulphidity will increase. This would result in increased sulphur losses from the system, till a new equilibrium is achieved. Similarly, a reduction in sulphur losses, would imply the reduced use of sodium sulphate make up, increased use of sulphur freemake up like sodium hydroxide or sodium carbonate of same level of sulphidity is to be maintained.

\*Star Paper Mills Limited, Saharanpur (U.P.)



With the use of latest techniques\* and available modern equipment, most of the kraft mills in advanced countries have a total chemical loss of 30-50 Kg. of  $\text{Na}_2\text{SO}_4$ /tonne of pulp. In certain cases the figure may be even lower. In India, however, we do not have the advantage of sophisticated technology of that level and the total losses generally range from 50 to 150 kg. of  $\text{Na}_2\text{SO}_4$ /tonne of pulp. Table-1 gives the typical values of chemicals lost from various points of kraft cycle under Indian conditions.

**TABLE-I**  
**SODA AND SULPHUR LOSSES FROM VARIOUS POINTS IN KRAFT CYCLE.**

S.No. Item	Losses per tonne of pulp	
	Soda loss as $\text{Na}_2\text{O}$ , Kg.	Sulphur loss as S, Kg.
1. Digesters	1.00	2.00
2. Brown Stock Washers	12-20	0-25
3. Black Liq. Evaporators	10-15	6-14
4. Recovery Furnace	4-6	5-10
5. Soda Dissolver	2-4	0.1-0.2
6. Causticising	10-14	Negligible
7. Miscellaneous*	5-10	—
<b>Total :</b>	<b>44-70</b>	<b>13.35-26.45</b>

\*Miscellaneous losses include the losses due to leakages, spills etc.

## VARIOUS POINTS OF CHEMICAL LOSSES

For the sake of discussions, the chemical losses have been divided into two categories.

1. Regular process losses, and
2. Leakages, overflows and accidental discharges. These are being discussed sectionwise in the following paragraphs:

### REGULAR PROCESS LOSSES

**DIGESTERS**—Kraft cooking can be performed by either a batch process or continuous process. In batch cooking, during steaming of the chips, the enclosed air, within and between the chips, is expelled. Just before blowing also, the gases are allowed to escape to atmosphere. Alongwith the small quantities of entrained black liquor, these gases mainly contain non-condensables like  $\text{N}_2$ ,  $\text{CO}_2$ ,  $\text{H}_2\text{S}$ ,  $\text{CH}_3\text{SH}$  etc. and small quantities of dimethyl sulphide, dimethyl-disulphide, methanol and formic acid etc. In continuous cooking, the quantity of gases released is smaller, and the flow is uniform, unlike the fluctuating flow of batch digesters.

At STAR, we have the arrangement to arrest the entrained black liquor in a M.S. trap and then the gases are led to a condenser. The greater part of dimethylsulphide and dimethyl-di-sulphide condenses in the condenser. The condensate is used in the process while the noncondensables escape to the atmosphere. It may be mentioned here that these gases are burnt in lime kiln or sent to black liquor oxidation plant in western countries, to minimise the odour problem and reduce sulphur losses. we do not have any such facility at our mills.

**BROWN STOCK WASHING**—The washing of pulp is carried out to remove the dissolved organic and inorganic compounds. These are recovered as weak black liquor containing 10–18% dissolved solids. The common equipment used for pulp washing is rotary drum vacuum washer, and generally the washing is carried out in a counter current manner using 2–4 washers. In case of continuous Kamyr digesters, the high heat diffusion washing is also practiced, while some mills use the pressure filters as well. The recent development includes the wash presses and continuous diffusor washer. The inventors of continuous diffusor washer claim (2) that, with the technique, the power consumption is reduced by 90%, building requirements are substantially less, and the less maintenance and supervision requirements further out down the washing costs.

In India, most of the mills in larger sector, use multistage counter current vacuum washers. The chemical losses from such units, for the same type of pulp, mainly depend upon No. of washing stages and dilution factor, employed. Other process variables like temperature of wash water, vat consistency, vacuum etc. are also important. The washing losses in our country generally range from 20–25 Kg. of  $\text{Na}_2\text{SO}_4$  per tonne of pulp.

At STAR, our wood pulp washing street, was designed to handle 65 tonnes of pulp/day and was provided with two Nos. (8' x 10') kamyr washers. In order to cope up with the increased pulp production and increased use of hardwoods, they were replaced by two Nos. (10' x 12') Eimco washers each having two washing stages. With these washers, the losses with pulp ranged from 40–50 kgs.  $\text{Na}_2\text{SO}_4$  per tonne of pulp. In order to reduce the losses further, we installed one more Eimco washer which has been commissioned 8 months back. The average soda losses now, are around 30 kg.  $\text{Na}_2\text{SO}_4$ /tonne of pulp. We feel that it is desirable to use single stage washers for ease of operation and better efficiency. Two stages on a single drum, some times cause the intermingling of the filtrates.

The economics of increasing the number of stages or dilution factor, to recover more chemicals, depends upon the cost of steam, chemicals and operating variables which vary from one mill to another. If fuel is cheap and extra evaporator capacity exists, it might be advisable to increase the dilution factor. If the steam cost and evaporator capacity do not permit it, the same objective can be achieved by adding one more washing stage to the existing street. The addition of one washer could be economic even if the alkali loss is reduced by 8–10 kg of  $\text{Na}_2\text{SO}_4$ /tonne of pulp, as revealed by the following calculations:

Let us say, daily pulp production	= 100 tonnes/day
No. of working days/yr.	= 330
Saving/tonne of pulp	= 10 kg. $\text{Na}_2\text{SO}_4$
Annual Saving	= 330 tonnes $\text{Na}_2\text{SO}_4$

Taking the cost of  $\text{Na}_2\text{SO}_4$  as Rs 900/tonne,  
Annual Savings = Rs. 2.97 lakhs.

On the basis of above it is apparent that an additional washer can pay back for itself in 3–5 years time. These calculations also show, that a saving of 1 kg  $\text{Na}_2\text{SO}_4$  tonne of pulp, apparently a very small figure, means a saving of Rs. 3000/-per annum for a 100 Tonnes pulp mill. The addition of one washer, besides saving in chemical, would also reduce the pollution load on effluent. In such circumstances, as shown by the above calculations, it may be worth while to go for a 4th washer in case of the mills having 3 stages. Of course, the conditions of individual mills differ considerably, but this will certainly prove to be a profitable proposition in some cases. Of course, the importance of operational variables, which is very well discussed in the literature, should not be ignored in achieving the goal of higher efficiency.

**BLACK LIQUOR EVAPORATION**—The thin black liquor from brown stock washers at 12–18% dissolved solids, is concentrated to about 60% solids in evaporators. This may be done in multiple effect evaporators alone or partly in multiple effect evaporators (to 40–45%) and then in direct contact evaporators, depending upon the recovery furnace design. The oxidation of black liquor is also practiced, in order to combat with the problem of malodorous gases and to reduce the sulphur losses.

**OXIDATION OF BLACK LIQUOR**—This offers great potential for air pollution abatement by stabilising the volatile sulphur in black liquor. It helps in reducing the sulphur losses from the system, corrosion of equipment, and results in improved quality of condensate, thereby reducing the pollution load. The estimated savings of sulphur due to black liquor oxidation vary from 5–10 kg/tonne of pulp depending upon the plant operation and the nature of black liquor. The oxidation of black liquor has been successfully attempted in some Indian Mills, but the doubtful economics of the proposition coupled with certain operational problems, has dissuaded other mills from embarking upon such a venture. With Air Pollution Control Law already in the process of being enacted, it is high time to seriously examine the application of the technique to Indian conditions. Vital information about black liquor oxidation is available in the literature (2,3), but the technology and equipment may have to be modified to suit indigenous requirements.

**MULTIPLE EFFECT EVAPORATION**—Chemical losses in multiple effect evaporators are mainly due to entrainment of black liquor, alongwith the vapours, and due to formation of sulphurous gases during evaporation. The use of catchalls, demisters, cyclone separators and other designs of entrainment separators is common and during normal running of the plant the losses due to entrainment are not substantial. However,

due to scale forming nature of black liquor, it is necessary to resort to water boil outs and mechanical/chemical cleaning of heat transfer surfaces, at frequent intervals. The chemical losses, during water boil outs could be very substantial, and it is desirable,

- (i) to minimise the scale forming tendency of liquor, and
- (ii) to avoid unplanned water boilings.

The problem of scale formation in evaporator, has been analysed in details in literature (<sup>4,5,6</sup>) and only some salient points have been mentioned here. In order to minimise the risk of scale formation in evaporator tubes, it is necessary to maintain a high degree of sulphate reduction, and causticising efficiency, as the inorganic salts like sodium sulphate and carbonate precipitate readily on the tubes, especially at high solid content and temperatures. Lignin and silica may also precipitate if the pH of the liquor is low. It is desirable to maintain a residual active alkali of 6-8 gpl as  $\text{Na}_2\text{O}$  in black liquor to avoid precipitation of lignin and silica. Scale formation is also accelerated due to presence of fibres in the liquor, and installation of a fiber filter prior to evaporators is desirable.

At STAR, we have a quintuple effect L.T.V. evaporator unit which was designed to handle the black liquor from pine. With the increased use of hardwoods the problem of scale formation became increasingly difficult and frequent water boiling and cleaning by mechanical means became necessary. To tackle this problem we reduced the outlet concentration from evaporators, increased the feed rate for higher liquor velocities, and made time schedules for water boiling and mechanical cleaning of the bodies. This also avoided unplanned stoppages and helped in reducing the soda losses from the system. For water boiling, we use combined condensate from the plant to avoid the use of fresh water which is hard. A connection from the combined condensate pumps, to the weak black liquor storage, has been provided, and, in case of excessive entrainment during water boiling, the entrained liquor is diverted to weak black liquor tanks.

In addition to the soda losses discussed above, sulphur is also lost from the system in the form of  $\text{H}_2\text{S}$ ,  $\text{CH}_3\text{SH}$  etc. liberated during evaporation. The gases which are condensed come out with the foul condensate and the non-condensables escape to the atmosphere causing foul smell and atmospheric pollution. In advanced countries, some mills practice the stripping of combined condensate by steam. The expelled gases are generally lead to a lime kiln or a separate furnace, for burning.

The use of Venemark apparatus for cutting down the sulphur losses from multiple effect evaporators, is also mentioned (<sup>7</sup>). In this apparatus,  $\text{H}_2\text{S}$  is recovered by spraying weak white liquor on the gases from last effect of multiple effect evaporator system, prior to its going to condenser. A sulphur recovery

to the extent of 4 Kg/tonne of pulp may be expected. we have no knowledge if any of these techniques have been tried in our country, but they certainly deserve the attention in the prevailing circumstances.

**DIRECT CONTACT EVAPORATION**— The main chemical losses at direct contact evaporators are due to loss of sulphur compounds in the waste gases leaving the unit. Hydrogen sulphide is liberated due to hydrolysis of sodium sulphide present in the black liquor. We donot have the first hand experience of the system, but the sulphur losses from these units very much depend upon inlet liquor and flue gas conditions. Murray and Rayner (<sup>8</sup>) found that a direct contact evaporator may emit  $\text{H}_2\text{S}$  or may absorb  $\text{H}_2\text{S}$  depending upon the process conditions. According to them, the emission of  $\text{H}_2\text{S}$  is favoured by high concentration of  $\text{Na}_2\text{S}$  and low pH level of liquor, and low concentration of  $\text{H}_2\text{S}$  in the incoming flue gas. Black liquor, after ordidation, with zero  $\text{Na}_2\text{S}$  may result in absorption of  $\text{H}_2\text{S}$  from the flue gas.

The entrainment of black liquor droplets with flue gases, also results in soda losses from the system. To minimise this it is necessary that various process variables like flue gas velocity, black liquor level etc., be maintained at optimum level.

**RECOVERY FURNACE & BOILER**—The losses from the furnace and boiler section can be discussed under the two headings viz. (a) stack losses and (b) soda dissolver vent losses.

(a) **STACK LOSSES**—The losses from the stack are in the form of particulate matter, mainly consisting of  $\text{Na}_2\text{SO}_4$  and  $\text{Na}_2\text{CO}_3$ , and sulphur bearing bases like  $\text{H}_2\text{S}$  and  $\text{SO}_2$ . Sulphur is emitted chiefly as hydrogen sulphide, most of which is converted in the upper part of the furnace. The sodium is emitted mainly as a gas in the elemental form and as  $\text{NaOH}$ , this then reacts with  $\text{SO}_2$  to form sodium sulphate. The emission of sodium increases with the increase in furnace temperature. The emission of sulphur is a complex function of temperature, air volume and liquor solids level. The sulphur emission is lowest at about  $1100^\circ\text{C}$  and hence a strict temperature control between  $1000$  to  $1100^\circ\text{C}$  is desirable for furnace zone.

Theon and others (<sup>9</sup>) report that the emission of  $\text{H}_2\text{S}$  and  $\text{SO}_2$  can be reduced to undetectable limits if high turbulence is maintained in the combustion zone and sufficient excess oxygen is available. In a series of experiments performed, on a Combustion Engineering recovery furnace, with direct contact evaporators, burning black liquor from pine and fir, it was observed that secondary air above 35% and an air velocity of 150-180 feet per second at secondary air ports, could reduce the sulphur emission to negligible level.

Thus, the chemical losses from the furnace, can be minimised by careful control of liquor burning, air supply, furnace draft, smelting and combustion

zone temperature, etc. Operating variable should be controlled to achieve the highest possible reduction of salt cake, in order to reduce the dead load in the system and scale forming tendencies in evaporators and liquor preheaters.

At STAR, we have a JMW unit, designed to handle black liquor from a pulp production of 90 tonnes per day. The unit has an economiser and SF precipitator of matching capacity. The performance of the unit has been satisfactory and is currently handling black liquor from a pulp production of about 110 tonnes/day, after some modifications. The increased use of hardwoods, resulted in problems with the viscosity of liquor and we had to reduce the firing concentration to about 55% dissolved solids. Based on our experience with this unit, we feel that following important points should be borne in mind, to reduce the chemical losses from furnace.

(1) It is important to add salt cake to the thick liquor as steadily as possible. The fluctuations in the salt cake supply result in fluctuations of the furnace temperature and thereby the emission of sodium and sulphur increase. The ash collected in the hoppers and precipitators should also be added judiciously at a regulated rate.

(2) The unit should be fired at a constant rate, as far as possible. This may be achieved by providing higher capacity for thick liquor storage, to take care of disturbances and water boiling etc. in evaporator.

(3) Too much of excess air should be avoided because it results in formation of sticky dust (possibly due to formation of sodium bisulphate) which adheres to the surface of tubes and lowers the heat transfer.

(4) A proper schedule for preventive maintenance and cleaning is highly desirable. This includes the cleaning of boiler passes, salt cake mixing tank, black liquor spray pumps, green liquor pumps, I.D. fan, and maintenance of soot blowing equipment, precipitator etc. in efficient condition.

(5) The black liquor should have high enough free alkali to avoid precipitation of lignin, which might cause trouble in B.L. injection system. High free alkali also helps in maintaining the fluidity of smelt.

**(b) SODA DISSOLVER VENT LOSSES**—The losses from dissolver vent may be as high as 6-8 Kg  $\text{Na}_2\text{SO}_4$ /tonne of pulp. The process variables which influence these losses are rate of smelt flow and level of the dissolver tank. The design of steam spurting nozzle and situation of agitator in the tank also affects the gas velocities in the vent and consequently the carry over and soda losses.

One way of minimising the loss could be the installation of stainless steel mist eliminator pad of knitted construction. The efficiency of this pad

depends upon the velocity of air-vapour mixture which should be maintained below 5 meter/sec. for maximum recovery. The draft loss across the pad should be 2-3 mm WC. The washing of the demister installation by a water shower mounted above it, to prevent alkali build up is also necessary. The shower can be operated intermittently at a predetermined interval with the help of a time switch. This avoids the unnecessary dilution of the green liquor.

**CAUSTICISING SECTION**—The chemical losses from continuous recausticising plant are mainly taking place with lime sludge and the grits being rejected from the plant or from the green liquor clarification stage.

The efficiency of the causticising plays a vital role and it is important to maintain it as high as possible with minimum excess lime used. Other process variables like temperature concentration of green liquor, quality and quantity of lime, reaction time etc., need careful control at optimum level to achieve the best result.

At STAR, we have a Dorr-Oliver continuous recausticising plant consisting of drum slaker, double arm rake classifier, white liquor clarifier, mud washer and two lime sludge filters. The plant was designed to handle green liquor at rate of 25  $\text{m}^3$  per hour. The plant has been giving satisfactory performance except that the soda losses, with outgoing filter sludge, could not be below 1-1.2%  $\text{Na}_2\text{O}$  on the basis of dry sludge, despite of our best efforts. We planned to instal an additional lime mud washer which was commissioned 8 months back. With this addition, our soda losses with sludge, have come down to 0.4-0.5%  $\text{Na}_2\text{O}$  on dry basis. This has resulted in a saving of nearly Rs. 1.50 lakh/annum.

We feel that quality of lime is a major single variable which controls the causticising losses to a great extent. The poor quality of lime not only affects the causticising efficiency and lime mud settling characteristics, but it also results in large quantity of rejects in the form of grits and sludge, thereby increasing the chemical losses/tonne of pulp substantially. We have also experienced that forced outages due to plugging of lines, short life of slaker and clarifier, result in unscheduled stoppages and loss of chemicals. A close control of lime feed to maintain a minimum excess lime, and good quality of lime, can help in reducing such stoppages greatly.

In operation of white liquor clarifier and lime mud washer, the quantity and density of underflows is vital for maximum chemical recovery. According to our experience, the underflow should have a solid content of 35 to 40% for efficient recovery and the withdrawal rate of underflow should be as uniform as possible. Higher solids in underflow of lime mud washer, also help in maintaining the desired consistency of slurry in the filters for efficient filter operation.

## LEAKAGES, OVERFLOW AND ACCIDENTAL DISCHARGES

Temporary discharge of this type could be mainly attributed to :

- (i) **Equipment failure:** like leaking of a filter cloth, leakages from glands etc.
- (ii) **Cleaning of equipments :** like pipe lines, tanks vats, traps etc.
- (iii) **Regulatory errors:** failure of control and measuring instruments or lack of communication between the departments.
- (iv) **Human Factors :** including negligenced and forgetfulness etc.

It is not possible to completely eliminate such temporary discharges but they can be certainly minimised to a great extent. At STAR we have provided the sump facilities for collection of spills, overflow and leakages from pumps etc., in case of furnace and evaporator plants. The collections are pumped back to the process periodically.

The spills and overflows losses can also be reduced by providing overflow lines in tanks and vats etc. and connecting them to the suitable points in the process, where necessary.

Losses due to equipment and instrument failure can be reduced by adequate preventive maintenance programme and regular check up of controls and measuring devices. Continuous monitoring of drains for detecting temporary discharges, as being followed by us, also helps in reducing the incidents of carelessness.

## SCHEME FOR MONITORING THE SODA LOSSES

At STAR, we are following a scheme for monitoring soda losses to the drain and with washed pulp regularly. The samples of effluent from 4 drains are collected round the clock at an interval of 2 hrs. starting from 7.00 A.M. in the morning. The drains from which the effluent is collected are:

- (i) **Pulp Mill Drain** — covering the pulp mill area including digesters, washing plant, blow tank and blow heat recovery.
- (ii) **Soda Recovery Drain I** — covering multiple effect evaporators.
- (iii) **Soda Recovery Drain II** — covering JMW boiler area, intertank, condenser seal tank, combined condensate tanks etc.

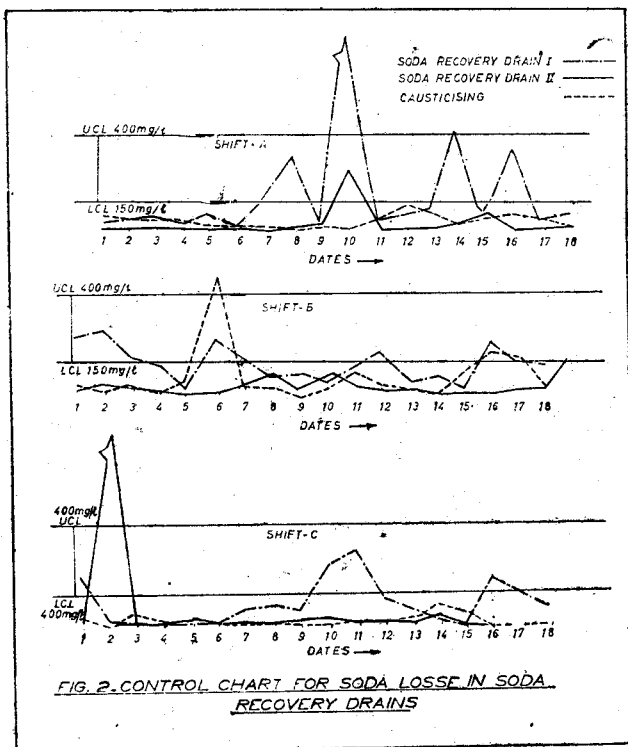
TABLE-II

### SODA LOSSES FROM PULP MILL AND RECOVERY DRAINS

S.No.	Time (hrs)	Pulp Mill drain	Soda Losses as Na in mg/lit		
			Soda Recovery drain I	Soda Recovery drain II	Causticiser drain
1.	0700	250	100	25	130
2.	0900	105	98	25	50
3.	1100	300	240	32	50
4.	1300	165	105	32	65
5.	1500	310	72	27	75
6.	1700	230	44	29	75
7.	1900	90	50	25	68
8.	2100	174	53	34	62
9.	2300	147	82	29	55
10.	0100	570	94	27	94
11.	0300	206	78	32	53
12.	0500	320	135	29	42

(iv) Causticiser drain— covering all the equipment in the continuous recausticising plant.

The drain samples are analysed for soda content with the help of a flame photometer and the results are communicated regularly to the concerned departments. This practice has helped in cutting down the losses due to accidental discharges and over flows. Table-I shows the losses from different drains on a normal working day. During water boiling in the evaporator the soda losses in Recovery Drain I could be as high as 3000–4000 mg Na/litre. Similarly in case of pulp mill the leakages from circulation pumps, may give a figure of 1000–1500 mg Na/litre.



The alkali losses with washed pulp are also monitored regularly. Samples of washed pulp from brown stock washers are collected 3 times in a shift and the composite sample of a shift is analysed for alkali losses. The losses in our case generally range between 25–35 kg  $\text{Na}_2\text{SO}_4$ /tonne of pulp.

The results of soda losses in drain and alkali losses with washed pulp, are depicted graphically as shown in Fig. 2. The graphs are kept in Soda

Recovery and Pulp Mill and the process staff is always aware of the losses in their respective shifts.

This scheme has been in use for some time now. The success of scheme depends upon proper sampling and quick feed back of the results. At present, the analysis of samples is carried out in day shift only but the cases of visibly dark samples are reported to the plant immediately.

## CONCLUSION

Continuous monitoring of the losses and strict process control can result in substantial improvement of chemical recovery efficiency. Under the present circumstances, with water pollution control law already in force and air pollution control law in offing, the importance of these controls needs no emphasis. These controls are now vital for existence of the unit itself. Further the increasing costs of chemicals, raw-material and fuels, make it imperative to maintain as high chemical and thermal efficiency as possible. It will not be out of place to mention that an increase of 1 % in chemical recovery efficiency, for a 150 Tonnes/day pulp mill, means a saving of roughly Rs. 3.0 lakhs/annum at present prices, which is quite substantial. This means that a regular evaluation of process and equipment and continuous monitoring of losses, is vital to achieve the goal of higher recovery efficiency.

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