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# Heat Conservation in Pulp & Paper Industry

*Increasingly, Industries all over the world are facing energy crisis of considerable magnitude. The world energy consumption is increasing at the annual rate of 5 percent and the prices of fuel are sky rocketing. The position is bad for all fossil energy sources but the fuel oil position is especially critical The known oil resources may last for hardly forty years at the present level of consumption and its price has multiplied several fold in the last few months. More-over, the world industries depend more on oil. At present nearly 54 per cent of the total fossil based energy is derived from oil and in the next five years this figure will move up to 60 per cent. In India itself oil is supplying nearly 35 per cent of the total fossil energy used and the figure will rise to 38 per cent by 1980.*

*The energy crisis has forced both the existing and developing units all over the world to adopt a low profile. It must be stressed that this crisis is not a passing phase but has come to stay. Industry cannot afford to be complacent about this but has to take immediate steps to combat this crisis. This paper attempts to come to grips with the problem, with particular relevance to Indian Pulp & Paper Industry.*

Till the recent orders of the Government of India lifting the restriction on furnace oil, the Pulp and Paper Industry (and of course all other industries as well) had faced considerable trouble in getting its oil requirements. Some mills had in fact programmed for introduction of producer gas units or for switch over to coal, so as to reduce furnace oil consumption. But even coal cost has gone up and there are the difficulties of transportation, getting sanction from the Coal Mines Authority in time etc. The overall situation has not only affected existing units but has made getting sanction for new projects also, more difficult. Thus it has become very necessary for the Pulp & Paper Industry also, to review the status of heat conservation and to take steps to reduce heat energy consumption. It must be emphasised that the practice of heat conservation has attractive returns as well. For instance a typical Paper-Grade Pulp Mill of 100 TPD capacity may use thermal energy equivalent to about 25,000 tonnes of furnace oil every year, in the form of oil or coal or both. (At the rate of energy consumption equivalent to 700 Kgs. of oil per tonne of paper-pulp). Even a five per cent saving in this heat input would mean a reduction of Rs. 30 in the production cost of one tonne of pulp. And investment in new equipment or modification of existing equipment to achieve this heat saving could be realised in six months.

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### Steam Consumption in Pulp & Paper Mills

It is worthwhile to have a look at the steam consumption of normal Indian mills. A typical 100 TPD integrated pulp and paper mill may use an average of 11.0 tonnes of steam per tonne of paper. A 100 TPD paper-grade pulp mill may require between 8 to 9 tonnes of steam per tonne of pulp. A 100 TPD Rayon-Grade pulp Mill may require between 10 to 11 tonnes of steam per tonne of pulp. Typical steam consumption data in each of the three types of mills is presented in Table I. These are typical figures only. The variation (in practice) from mill to mill is found to be quite high, depending upon the thermal efficiency achieved in each section of the mill. The following points may be of interest in this connection.

i) Cooking steam consumption

Table 1

Steam Consumption Pattern in Typical Indian Mills.

Figures indicate tonnes of steam per tonne of pulp/paper.

| Section Detail | Paper-Grade Pulp Mill | Integrated Pulp and Paper Mill | Rayon-Grade Pulp Mill |
|---|---|---|---|
| 1. Digester House : | 1.80 | 2.00 | 4.30 |
| 2. Bleaching : | 0.50 | 0.20 | 1.05 |
| 3. Evaporator : | 1.72 | 1.72 | 1.85 |
| 4. Causticizing : | 0.62 | 0.62 | 0.50 |
| 5. Feed water heating : | 0.84 | 1.15 | 0.95 |
| 6. Auxiliaries : | 1.43 | 1.43 | 0.70 |
| 7. Flash Drier | 0.45 | — | 0.79 |
| 8. Paper Section : | — | 4.00 | — |
| 9. Miscellaneous : | 0.50 | 0.40 | 0.30 |
| Total : | 7.86 | 11.52 | 10.44 |
| 1. Steam from Black Liquor Solids : | 4.50 | 4.50 | 7.00 |
| 2. Steam from Auxiliary Fuel : | 3.36 | 7.02 | 3.44 |
| Total : | 7.86 | 11.52 | 10.44 |

appears to vary as much as much as between 1.5 to 3.0 tonnes of steam per tonne of of pulp. This again indicates the considerable scope for reducing steam consunption in this section. More attention may be given to uniformity in size of chips, accept percentage of chips etc., which may be possible with regular, scheduled maintenance of chipper knives, proper selection of chippers and angle of knives etc. Moreover, better circulation system of liquor, proper bath ratio are all important criterion.

ii) Swedish Paper Mills attach great importance to heat recovery. A typical Swedish pulp mill is self sufficient in steam, i.e., the steam generated from the recovery boiler is sufficient to meet the entire steam demand of the pulp mill. Only the demand for paper machine is met by auxiliary fuel, in case of paper mills. This is achieved by efficient operation of recovery boiler and efficient use of steam in all sections, proper insulation, properly laid out and well maintained steam traps, minimisation of all flash losses and complete recycling of all condensates. It may be mentioned here that a normal Swedish krafte pulp mill with a flash drier would normally consume around 5.5 tonnes of steam per tonne of pulp which is wholly met by the recovery boiler. Naturally, this depends on the design of the recovery boiler and this point is considered later. Table 2 shows a section-wise chart of steam consumption in a typical Swedish pulp mill.

**Design Criteria for Recovery Boiler vis-a-vis Heat Recovery**

The various points to be considered are:—

i) Whether boiler is to be designed for maximum heat recovery in the form of steam, with provision for chemical recovery through an electrostatic precipitator. This would be a typical Scandinavian approach.

ii) Whether boiler is to be designed with a direct contact evaporator to recover part of the heat by concentrating black liquor. This is a typical American approach. With this arrangement the maximum evaporation in the direct contact evaporator would be only one lb of water per lb of steam. However, if the same heat is recovered in the boiler in the form of steam and then used in multiple-effect evaporators then a steam economy of as much as 4 to 4.8 lb. of water evaporation per pound of steam can be obtained. However, this would require a higher capital investment. Thus it is seen that a balance has to be struck between capital and heat economics.

A typical flowsheet of a Scandinavian and a North American practice of Recovery Boiler design is given in Figure I. Both are designed for 500 TPD and both have flue gas exiting at 125°C.

Thus we can see that the Seandinavian system extracts more heat than the American system, equivalent to 16,300 lbs/hr of high grade steam. (0.57 tonnes/hour of oil or 1.48 tonnes per hour of coal considering 1 tonne of oil=13 tonnes of steam and 1 tonne of coal=5 tonnes of steam). Thus it can be seen that in view of the fuel crisis, a good economics would be to adopt a Scandinavian pattern, in case the neceassary capital is available. For instance, in the above example the heat saved is equivalent to 27 Kgs. of oil per tonne of pulp or 71 Kgs. of coal per tonne of pulp.

**High-Yield Pulping Vs. Heat Economy**

Generally, a mill producing unbleached pulp may find it economical to resort to high yield pulping for raw material conservation, though of course this means a sacrifice in heat

**Table 2**

**Steam Consumption in a Typical Swedish Kraft Paper Pulp Mill With Batch Digesters**

| Section Details | | Steam Per Tonne of Pulp |
|---|---|---|
| 1. Cooking | ... | 1.7 |
| 2. Evaporator | ... | 1.4 |
| 3. Causticizing | ... | 0.4 |
| 4. Flash Drier | ... | 2.0 |
| Total | ... | 5.5 |
| 1. Steam from Black Liquor solids | | 5.5 |
| 2. Steam from Auxiliary fuel | ... | 0.0 |
| | | 5.5 |

Note—

Brown-stock washing plant and Bleach Plant are always using recovered heat from Digester Blow Heat Recovery and Evaporator Condensate.

**Heat economy comparison is as follows :**

**Scandinavian System**

| | | All heat exprersed in terms of steam at 840 psi and 842° F. |
|---|---|---|
| a) Heat regained in the economiser | = | 48.700 lbs/hr |
| b) Heat used in evaporator plant for evaporation from 50% to 60% dry solids content. | = | 4,400 lbs/hr |
| c) Heat used up in furnace for direct evaporation of liquor from 60% dry solids content. | = | 6,600 lbs/hr |
| Thus nett heat recovered | = | 48,700-(4400+6600) |
| | = | 37,700 lb/hr of steam. |

**American System**

| | | |
|---|---|---|
| a) Total heat regained from flue gases | = | 47,400 lb/hr |
| b) Heat used up in direct contact evaporator for evaporating black liquor from 50% to 65% dry solids | = | 26,000 lb/hr |
| c) Net heat gained in economiser | = | 47,400-26,000 |
| | = | 21,400 lb/hr |
| Diff. in nett heat regained in | = | 37,700-21,400 |
| Scandinavian & American System | = | 16,300 lb/hr. |

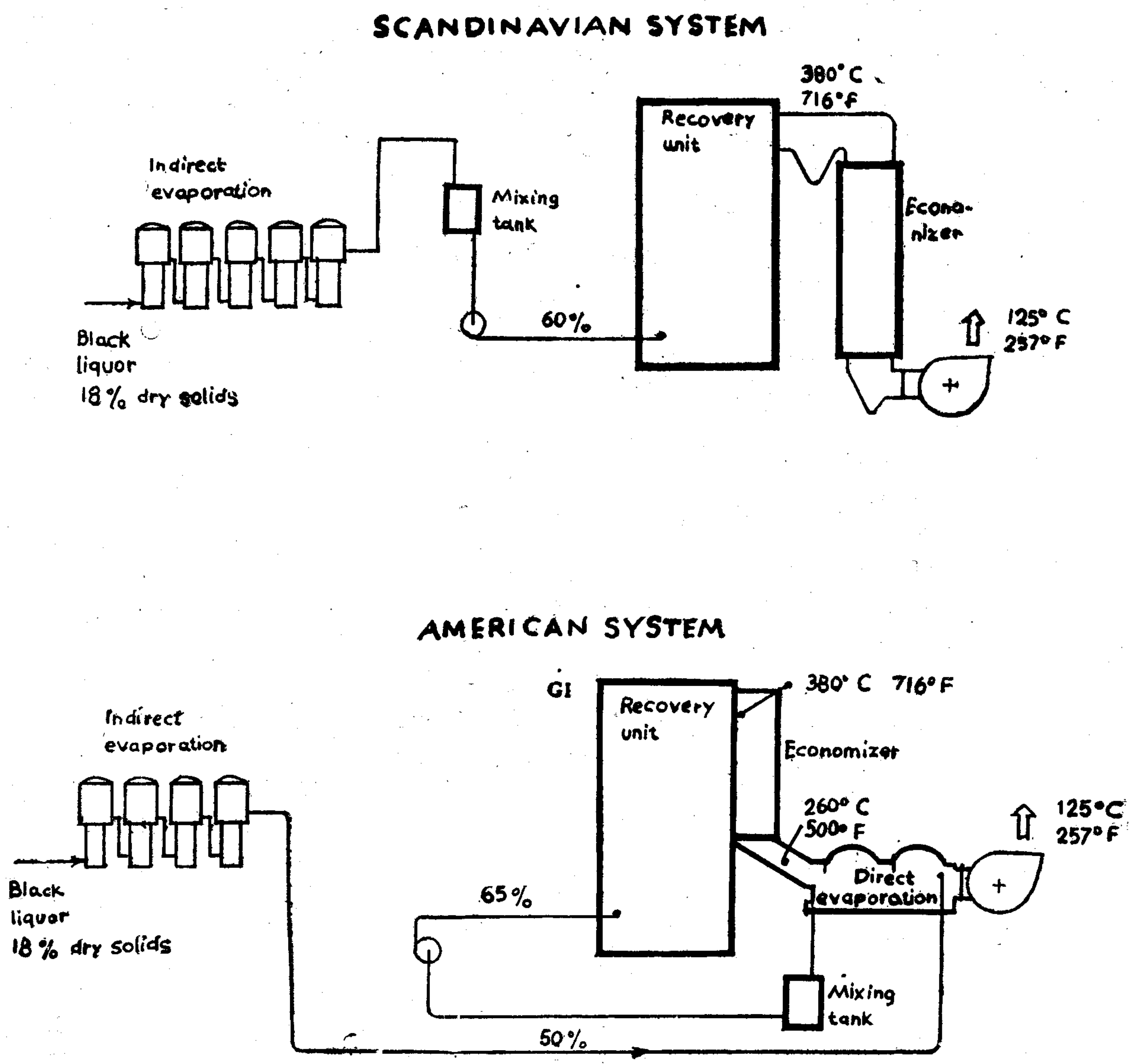
SCANDINAVIAN SYSTEM
380° C
716°F
Recovery unit
Indirect evaporation
Mixing tank
Econo-nizer
60%
125° C
257° F
Black liquor
18 % dry solids
AMERICAN SYSTEM
380° C 716°F
Recovery unit
Indirect evaporation
Economizer
260° C
500° F
125°C
257°F
Direct evaporation
65 %
Black liquor
18 % dry solids
Mixing tank
50 %

FIG. 1

economy because the total solids in Black Liquor would naturally be reduced due to milder cooking conditions. For example, in a mill a bleached pulp yield of 40 per cent and an unbleached yield of 45 to 47 per cent could be obtained by cooking to a permanganate number of 15 to 16. By adopting high-yield pulping (i. e. by cooking to a P. No. of 23-25) a bleached yield of 41 per cent and an unbleached yield of 50 per cent could be obtained. This indicates that the bleached yield gain is hardly 1 to 2 per cent (due to bleaching losses) although the unbleached yield gain is 3 to 5 per cent. Compared to this the Black Liquor solids would go down from about 1.9 to 1.3 tonnes of solids per tonne of pulp. Thus the heat sacrifice is considerable, especially in the context of the present fuel crisis. Thus a careful balance needs to be struck between raw material conservation and heat conservation, according to the needs and economics of the mill concerned.

**Efficient use of steam in paper machines.**

The consistency of pulp to the paper machine may range anywhere from 0.8 per cent to 1 per cent depending upon the quality and gram weight of paper to be manufactured. If the consistency of initial pulp is 0.8 per cent and moisture in the final paper is 5 per cent, then for a 100 TPD paper production, nearly 12,400 tonnes of water is to be removed per day. This is in two stages, first mechanically and then by evaporation with steam.

It is obvious that the first step towards reduction in steam consumption is to see that the maximum water removal is achieved in the wire part and the press part before the paper enters the dry end of the machine. (One can easily judge the importance of the moisture entering in the dryers by the fact that if moisture in paper increases at the drier entry point by 5 per cent then the extra steam for evaporation would be nearly 0.57 tonnes of steam per tonne of paper). For this following are the main factors to be considered.

i) Modern draining equipment like hydrofoils multi-blade foils and vacofoils should be effectively utilised.

ii) There have been many developments in the design of presses and press clothings to effect the maximum removal of water in this part, like shrink fabrics, felts like combitex (in which felt and fabric are combined in a single clothing) etc. to help in better removal of water in the press part.

iii) The formation of a uniform sheet with uniform moisture should be ensured.

For reduction of use of steam, the following points may be kept in mind.

i) The rotary steam joints and steam traps should be maintained in good condition and an efficient condensate removal system should be adopted. The condensate is to be collected in a flash tank and sent to boiler house. In a well maintained system 80 to 85% condensate recycling is possible.

ii) A closed machine hood with exhauster and hot air circulation will help in efficient removal of water vapours and resultant heat conservation.

In short, efficient condensate removal system, proper vapour removal, use of proper ventilation system and use of modern press clothing like combitex etc., will go a long way towards conservation of heat in this section of the mill.

**Current Programme of Heat Conservation at Harihar Polyfibers**

The first step taken was to establish the heat energy balance over the mill. Table 3 gives the energy balance so established. Heat output distribution is divided into seven convenient sections and we will take up each section as follows:—

**Section 1**

This consists of Vapour phase venting, sulphate venting, blow relief and digester preheater condensate.

a. Vapour phase venting has an heat equilent to 0.24 tonnes of steam per tonne of pulp. Because of corrosive nature

Table 3

Heat Energy Balance over the Mill

Basis : 1 A. D. Tonne of Rayon–Grade Pulp

Datum Temperature—30°C

Heat Input Distribution

| S. No. | Item | Energy Kcals. | Equivalent Tonnes of Steam | Equivalent Tonnes of Coal | Equivalent Tonnes of Oil |
|---|---|---|---|---|---|
| 1 | Package Boiler Furnace Oil | 2.6 | 4.94 | 0.988 | 0.380 |
| 2 | Recovery Boiler Furnace Oil | 0.1 | 0.19 | 0.038 | 0.015 |
| 3 | Flash Drier Furnace Oil | 0.9 | 1.71 | 0.342 | 0.132 |
| 4 | Lime Kiln Furnace Oil | 1.0 | 1.90 | 0.380 | 0.146 |
| 5 | Wood | 8.36 | 15.78 | 3.157 | 1.210 |
| | Total | 12 96 | 24.52 | 4.905 | 1.883 |

Heat Output Distribution

| Section | Nature of Stream | Millions Kcals | Tonnes of Steam | Tonnes of Coal | Tonnes of Oil |
|---|---|---|---|---|---|
| 1 | Vapour phase Venting | 0.134 | 0.24 | 0.048 | 0.020 |
| | Sulphate Venting | 0.193 | 0.36 | 0.072 | 0.030 |
| | Blow Vapour | 1.135 | 2.14 | 0.428 | 0.160 |
| | Preheater condensate | 0.220 | 0.41 | 0.082 | 0.032 |
| | Total | 1.682 | 3.15 | 0.630 | 0.242 |
| 2 | Dissolving tank vapour | 0.550 | 1.04 | 0.208 | 0.080 |
| | Evaporator Ejector | 0.019 | 0.04 | 0.008 | 0.003 |
| | Total | 0.569 | 1.08 | 0.216 | 0 083 |
| 3 | Digester House drain | 0.905 | 1.71 | 0.342 | 0.128 |
| | Bleaching drain | 1.700 | 3.23 | 0.646 | 0.250 |
| | Recovery drain | 0.880 | 1.67 | 0.334 | 0.128 |
| | Total | 3 485 | 6.61 | 1.322 | 0.506 |

of vent vapours, a stainless steel in-line heat exchanger is being considered.

b. Sulphate vent and blow vapours (equivalent to 2.50 tonnes of steam per tonne of pulp) are taken to a conventional Jet Condenser and the hot condensate is divided into two streams. One stream is directly going for use in washing and digestor sections. The other stream exchanges heat with clean water in a multi-stage shell and tube heat exchanger. Then the clean hot water thus produced is taken to bleaching. This arrangement is required because of quality considerations, ours being a Rayon-Grade Pulp Mill.

c. Digester preheater condensate being slightly contaminated cannot be directly taken to boilers. Hence this will exchange heat (in a plate heat exchanger) with demin water going to boilers. This will heat 60 Cu. Mtr. per hour of boiler water through 16.5 Deg. C. Thus heat savings are nearly to the tune of Rs. 3000 per day with the total installation cost being around Rs. 1,00,000. Thus the heat saving accounts for around Rs. 30 saved in production of one tonne of pulp, in terms of furnace oil. saved

**Section 2**

Presently no steps have been taken for recovering heat from dissolving tank vapours. The scheme of heating weak white liquor to dissolver, with this stream is being considered.

Non-condensibles from evaporator ejector, exchange heat in a heat exchanger with fresh water.

**Section 3**

Drains account for a heat equivalent to 6.61 tonnes of steam per tonne of pulp. We do not propose to disturb this stream, in as much as this is doing some effective work in our effluent lagoons where the desirable temperature would be 40 to 50 Deg. C., micro biological stabilisation.

**Section 4**

This section deals mainly with heat carried away by flue gases. The present approach with regard to recovery boiler flue gas is to design a multi-stage scrubber which will produce contaminated hot water with the demin water going to boiler deaerators, in an indirect heat exchanger. The other streams are not currently in active consideration for heat recovery.

**Section 5**

These represent the radiation losses. These losses are on higher side which is because of the very high wind speeds locally prevalent.

**Sections 6, 7**

Steam traps performance, blowdown of boilers etc. are being continuously watched for further

| | | | | | |
|---|---|---|---|---|---|
| 4 | Recovery Boiler Flue gas | 2.303 | 4.37 | 0.874 | 0.340 |
| | Package Boiler Flue gas | 0.200 | 0.38 | 0.076 | 0.030 |
| | Lime Kiln Flue gas | 0.560 | 1.C6 | 0.212 | 0.080 |
| | Flash Drier Primry flue gas | 0.216 | 0.41 | 0.082 | 0.032 |
| | Flash Drier cyclone Exhaust | 0.054 | 0.09 | 0.018 | 0.007 |
| | Total | 3.333 | 6.31 | 1.262 | 0.489 |
| 5 | Radiation losses in digesters | 0.045 | 0.07 | 0.014 | 0.005 |
| | Radiation losses in Recovery Boiler | 1.390 | 2.64 | 0.528 | 0.200 |
| | Radiation losses in Evaporator | 0.062 | 0.11 | 0.022 | 0.008 |
| | Radiation losses in Lime Kiln | 0.200 | 0.38 | 0.076 | 0.030 |
| | Radiation losses in flash drier | 0.190 | 0.36 | 0.072 | 0.027 |
| | Radiation losses in tankages | 0.650 | 1.23 | 0.246 | 0.095 |
| | Total | 2.537 | 4.79 | 0.958 | 0.365 |
| 6 | Steam Losses | 0.500 | 0.95 | 0.190 | 0.073 |
| 7 | Unaccounted | 0.858 | 1.63 | 0.326 | 0.125 |
| | Total | 1.358 | 2.58 | 0.516 | 0.198 |
| | Grand Total | 12.960 | 24.52 | 4.905 | 1.883 |

possible improvements in heat conservation.

**Conclusion**

General approach to heat savings would ideally consist of ensuring:

a) Maximum recovery of heat from the thermal energy available in the raw materials.

b) Maximum thermal efficiency of recovery boilers and auxiliary boiler.

c) Maximum conservation of heat by reducing the heat losses all over the mill.

d) Maximum recovery of the heat from waste outgoing heat-streams and transfer of heat thus recovered to in going streams of air, liquor, water, etc.

With the above objectives in mind, it will be very useful to draw up a thermal energy balance over the entire mill. This would lend perspective to the heat conservation programme adopted and the mill personnel would be able to evaluate the programme in a better way. Such a thermal balance magnifies the possibilities of efficient use of heat energy.

The following points may be borne in mind in this connection:

1) Most of the mills have an in-built standard heat recovery system which would normally include blow-heat recovery, reuse of foul and pure condensate, insulation, steam traps etc. However, it is a moot point whether all these systems are operating at the desired level of efficiency. In this connection, it may be mentioned that even after insulation and provision of traps the total losses incurred in this manner could amount to as much as 10 to 15% of the total heat input to the process. The first step in the direction of heat economy would be to achieve the optimum utilisation of these equipments and also to instal these where they are non-existent. Care must be taken to instal proper and well maintained steam traps. Flash losses must be avoided as far as possible.

2) A good blow-heat recovery system in a paper mill should be capable of recovering at least one tonne of steam per tonne of pulp. This heat is normally used in the bleaching section in the form of hot water. It is clear that inefficient running of blow heat recovery system would reflect on the cost of pulp production, being in the worst case as much as Rs. 70 per tonne in terms of furnace oil saved.

3) Apart from the above mentioned conventional methods of heat recovery, need exists (in view of the present energy crisis) to explore other ways of heat recovery. One such potentially important possibility is the recovery of heat from Recovery Boiler flue gases. These have a considerable potential in so far as heat recovery is concerned. At Harihar Polyfibers this stream contains a heat equivalent of about 4.3 tonnes of steam per tonne of pulp (Rayon-Grade). We have already indicated the attempts we visualise to recover this heat in our mill.

In this connection, mention may be made of the S.F. MoDo Scrubber system which has been developed by AB Svenska Flakt Fabriken and SF Products, Canada, by which clean hot water is produced in direct contact between the flue gas and water. The SF MoDo system has made the recovery of heat from flue gases more economic and attractive than before. A paper was presented at the annual meeting of the Technical Section, Canadian Pulp & Paper Association, January 1968, describing the system in detail.

Indian industries could consider developing a scrubber indigenously along these lines.

4) As regards steam generation per tonne of paper in recovery boilers, the range appears to be between 2 to 5.5 tonnes of steam per tonne of paper. Naturally this would relate to Block Liquor solids per tonne of pulp which again depends upon the permanganate number of pulp which the mill desires to maintain, Black Liquor losses in the pulp mill section, efficiency of washing etc. Without going into details (which will depend upon the optimum balance which will vary from mill to mill) it can be safely said that there appears to be much scope for heat conservation, in the form of more heat generation from Black Liquor solids.

5) The overall steam consumption in integrated pulp and paper mill in India appears to vary from 10 to 15 tonnes of steam per tonne of paper. For design calculations involved in the planning of a new mill the steam requirement is normally taken as 11 tonnes of steam per tonne of paper. This clearly indicates that mills consuming more than 11 tonnos of steam per tonne of paper have to give a serious thought to their heat losses.

**Acknowledgement**

We are extremely grateful to our General Manager, Shri V. P. Gohel for his valuable guidance in preparing this paper and his permission to present the paper.