# Improvements in Material Handling and Energy Systems with Reference to Small Paper Mills

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*There is a large number of small paper mills based on agricultural residues operating in India. Few of the problems of steam utilisation, material handling and power economy pertaining to the small paper mills are discussed in this paper.*

## 1. Introduction

Pulp and Paper Mills are generally based on conventional raw materials such as wood and bamboo. In view of rapid depletion of these conventional raw materials, some of these mills are going in for the use of mixed grasses, bagasse, cereal straw, rags, jute sticks, etc. which form the residues of agriculture, as a substitute to conventional raw materials. Further more, in India, the cost of installing a 100 TPD (the economically viable capacity) pulp and paper mill based on conventional raw materials is estimated at Rs. 300 to Rs. 400 millions thus making it a highly capital intensive industry.

It was reported that large quantities of agricultural residues were available in our country and were being wasted wittingly or unwittingly. As is well known, these raw materials are bulky in nature and available seasonally. Also procurement of these raw materials is rather cumbersome in as much as these sources are scattered. It is estimated that the maximum economic lead of procurement of these raw materials should be around 50 Kms radius from a factory. This puts a limitation on the quantum of available raw materials and hence the capacity of the plant. Keeping these in view Government of India encouraged the setting up of mini-paper plants of capacities varying from 15 to 30 TPD based on agricultural residues and other unconventional raw materials. Today a large number of small and medium paper mills are in operation and quite a few are in the process of being established.

These small paper mills have to work under certain inherent draw-backs such as no chemical recovery, no elaborate heat recovery system, no elaborate material handling systems etc. However, in order that, they be able to compete in the market, these mills have to improvise ways and means of improving the operational efficiencies of these mills.

It is our intention to identify a few of the points where there is scope for improvement of operation and effecting reduction in cost of production. The various aspects discussed in this paper (largely quantitatively) are not new to the paper industry, but these are not discussed at large. The purpose of this paper is to draw the attention of the paper mill Managers and arouse a constructive discussions in order to assess the practicability of implementing the same for the betterment of the industry.

## 2. Steam Efficiency

### 2.1 Insulation of Digester

Most of the small paper mills use Globe Digesters usually of 25M³ capacity each (3800 mm dia) for cooking the cellulosic raw materials. Cooking is done batch-wise at a pressure of about 5 Kg/cm²g and the actual cooking portion of the Digester cycle lasts about 5 to 7 hours.

Digesters are generally not insulated. The heat losses by combined radiation and convection from the Digester can be estimated by the following equation :

Steam consumption (at 7 Kg/cm²g) on account of these heat losses is estimated to be around 500 to 600 Kg/batch, and this is equivalent to Rs. 20 per batch. Assuming 3 batches per day per Digester, 3000 Kg BD straw charge per batch and 45% yield of pulp it works out to a reduction in cost of production, if

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these heat losses can be prevented by proper insulation of the Digester by Rs. 15/- per tonne of paper. Cost of insulation of each Digester (50 mm of Glass Wool, 4 mm of hard cement, hessian rapping, and 2 mm of bitumen coating for water proofing) should be about Rs. 8,000/- where as the annual saving can be as much as Rs. 18,000/- per Digester in year.

$$Q = A \times 0.173 \frac{(TS)^4}{(100)} - \frac{(Tair)^4}{(100)} + 0.5\,(t_s - Tair)^{1.25}\,(D_o)^{-025}$$

Where : Q = Heat losses B T U/Hr.

A = Surface Area ft²

$T_s$ = Surface Temp. °R

$t_s$ = " " °F

Tair = Ambient Temp. °R

tari = " " °F

$D_o$ = Dia of Digester inches.

### 2.2 Blow off Steam

Prior to discharging the pulp, the general practice is to release the pressure in the Digester. The flash steam generated during this pressure release amounts to as much as 2200 Kg per batch and in the present practice this is lost in the atmosphere. This is not only a waste of precious steam but also causes air polution. This can be recovered by condensation of this vent steam and reusing in the process. We estimate that the heat recovery equipment would cost less than one lakh rupees. The economics of the system are dependent on the capacity of the plant and are indicated in the following table :

TABLE

**Flash steam Recovery from Globe Digester**

*Basis:* Digester Volume 25 M³

Working Pressure 5 Kg/cm²g

Charge per batch 3000 Kg BD Straw
16000 Kg liquor

Contents of the Digester at the end of cooking. 1350 Kg pulp.
22650 Kg back liquor.

| | *CAPACITY ON PAPER PLANT* | | |
|---|---|---|---|
| | *10 TPD* | *15 TPD* | *20 TPD* |
| No. of Digesters | 3 | 4 | 5 |
| No. of batches/day | 8 | 12 | 15 |
| Heat in flash steam per batch | 1,250,000 K. Cals. 1,930 Kg of HP Steam 386 Kg of Coal. | | |
| Cost of coal at the rate of Rs. 200/- tonne | Rs. 77/- per batch | | |
| Daily expenditure on coal on account of steam loss | Rs. 616/- | Rs. 924/- | Rs. 1,155/- |
| Annual revenue if this heat is recovered | Rs. 184,800/- | Rs. 277,200/- | Rs. 346,500/- |
| Less : Operating expenses, interest, etc. | Rs. 40,000/- | Rs. 40,000/- | Rs. 40,000/- |
| Net annual revenue | Rs. 144,000/- | Rs. 237,200/- | Rs. 306,000/- |

It can be seen from the above table that even at the minimum plant capacity of 10 TPD the investment on the flash steam recovery can be recovered in one year or at the worst in two years. The reduction in production cost amounts to about Rs. 50/- per tonne.

The flash steam recovery is being practised in large mills. The system is far elaborate and consequently very expensive.

We are not aware if this thought of heat recovery is being practised in any existing smaller units. An attempt is being made to implement this in one of the units being engineered by us.

### 3. Material Handling

### 3.1 Digester Feeding

As mentioned earlier, the agricultural raw materials such as straw, are bulky in nature and handling of these raw materials is one of the major problems in these mills. Each Digester takes nearly 3400 Kg of air dry straw per batch. In terms of volume this is as high as 90 M³. Manual loading of this takes as much as 3 hours per batch which can be efficiently handled by semi-automatic handling system using pre-

impregnation method in under an hour, thus saving 2 hours per batchper Digester. Presuming a batch cycle of 8 hours, a Digester can increase its production by 25% per day of 24 hours. It is estimated that the straw handling system for a battery of three Digesters will cost approx. one lakh rupees. (This does not include the conveyeing of cut straw from the cutter to the Digester loft). Without going into the details of economics, it can be visualised that a plant employing three Digesters can increase the production by a minimum of two tonnes per day assuming that there is enough built in capacity in the down stream to process this pulp the turnover of the plant can be increased by about 20%.

### 3.2 Cut Straw Handling

The cut straw from the Cutter is generally conveyed by Pneumatic Conveying method which is highly sophisticated and its function is dependent on the condition of the straw. There are, however, other alternatives such as flight conveyors, drag conveyors etc. which can be judiciously employed, depending upon the plant layout and location. While pneumatic conveying is clean and require less capital investment, it suffers from high power consumption and limitations of the condition of the straw. Other systems are relatively capital intensive but cheaper to operate and highly flexible.

### 3.3 Discharging of Digester

At the end of cooking, the Digester is generally emptied by opening the man-hole and dumping the stuff on the floor under the Digester while rotating. This is not only a time consuming operation but entails loss of precious hot liquor. Of late blowing of Digesters into blow tank is being practised thus saving on the discharging time and messy operation of handling the cooked pulp. This improves the operational efficiencies and productivity of the Digesters.

### 4. Energy Efficiency

The energy requirements in industrial plants are mainly for the various drives and heating processes. The drive for driven equipment may be applied through I.C. Engines, electric motor or steam drives such as turbine or steam engine. In an industry, such as paper mill, requiring a large quantity of low pressure process steam, it is suggested to generate steam at a reasonable pressure temperature conditions and use a combination of extraction/condensing/back pressure turbines to match the power requirements in full or part with the total process demands of steam.

All small or medium sized paper mill cannot in practice adopt these cycles in view of the complicacies and investments involved in such systems. However, in plant sizes of 20 TPD and above some of these schemes can be adopted with a reasonably encouraging results both in economics and adaptibility.

In this paper, we are making an attempt to discuss one such possibility with reference to a 20 TPD paper plant. The steam requirements of such a plant are estimated in general as 10 TPH (12 tonnes per tonne of paper) with a split of about 4 TPH at 7 Kg/cm$^2$g and the balance at 3 Kg/cm$^2$g. A boiler designed for 10 TPH maxm. continuous demand operating at 10Kg/cm$^2$g. will generally do the job as far as process requirements are concerned. However, the L P process steam of 6 TPH of which about 5 TPH is a reasonably steady demand is a petential power generating source if a judicious selection of boiler is made. For example, one tonne of steam at 18 Kg/cm$^2$g and 300°C when expanded to 3 Kg/cm$^2$g in a back pressure turbine, can generate 50 KW power. Thus power generation of the order of 200 to 250 KW from LP process steam is a distinct possibility.

As one of the possibilities, we have examined the economics of using this turbine as the paper machine drive which is one single point of consumption of 200 KW. Our examination in a specific case shows that a saving of approximately Rs. 1.5 lakhs in a year can be effected.

The turbine can also be connected to a turbo-alternator and small HP motors can be connected to this turbine. These aspects, however, have to be examined specifically in each case. Where the power costs are as high as 30 paise per unit, this system should prove highly profitable.

This brings us to the selection of steam generating plant. In small paper mills, it is generally observed that boiler gets the least attention. For example most of the small mills opt for a second-hand Lancashire boilers which have minimum thermal efficiency among various types of boilers. Prospective Entrepreneurs should give a greater attention to the choice of boiler in order to effect best utilisation of the fuel energy.