

# Factors to be considered in the designing of equipment to suit indigenous raw materials in developing countries-rice straw

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## 1. Introduction

Coniferous woods have been traditionally used as a basic raw material in the paper industry. The equipment manufacturer has therefore considerable experience in the designing of equipment based on these conventional raw materials. Non-conventional materials, both woody and non-woody, such as tropical hardwoods, agricultural residues and bamboo are gaining importance particularly in developing countries. The design that has been hitherto followed by manufacturers of equipment for the processing of these non-conventional raw materials is based purely on the experience and technology associated with coniferous species. However, there is a need to specially design equipment suited for indigenous raw materials to obtain quality and performance standards equivalent to that of traditional materials.

Besides incorporating design features to suit the characteristics of the grade of paper to be produced, the equipment should be simple enough

to match the skill of the operating and maintenance crew. Another factor to be taken into consideration is the difficulty of obtaining spares due to foreign exchange restrictions. On account of the insufficient demand for different grades of paper the equipment should be versatile enough to cover a wider range of paper grades compared to similar operations in advanced countries. The equipment manufacturer has therefore a vital function to perform in meeting the requirements of the paper industry in developing countries.

This paper has been written based on the operating experience in the use of rice straw. Some of the problems connected with the use of this indigenous raw material are discussed to indicate areas where improvements in equipment design are necessary.

## 2. Pulp Mill

### 2.1 Raw Material Preparation

Most of the mills using rice straw have cutters that are basically designed for working with wheat straw. Structurally wheat straw is stiffer than rice straw and consequently there are problems such as frequent jamming and non-uniform-

ity in the length of the chopped rice straw. To eliminate some of these problems certain changes are necessary in equipment design. The poor life obtained from the straw cutter knives and the short intervals at which knives have to be changed for sharpening requires study to develop the right grade of steel.

### 2.2 Straw Cleaning and Dusting Equipment

Rice straw contains a lot of fines and dust, which during the conveying and cutting operation of the straw, freely escapes into the air making the operating area uncomfortable for the workmen besides affecting the machinery on account of the abrasive character of the fine dust particles.

The efficient removal of the dust is also very important to effect economy in the use of cooking chemicals as well as to maintain the required quality standards of the paper produced.

Straw is a difficult material to process on account of the high content of leafy materials, dust, etc. Rice straw is more difficult to pulp as it contains 50% of leafy material and other contraries, compared with wheat straw which contains only 20% to 25%. The cleaning of rice

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straw therefore needs special attention. Most of the Mills favour a wet cleaning method for rice straw to meet quality standards. This method of cleaning straw is expensive due to the use of heavy equipment such as pulpers, presses and de-watering drums. In order to reduce the cost of capital equipment as well as to reduce operating costs, it may be necessary to develop a less complicated equipment to clean the straw efficiently.

### 2.3 Problems in Processing Moist Straw

Since rice is grown in areas of heavy rainfall there are wide fluctuations in the moisture content of the straw. Air dry straw contains 15% moisture. It has been noticed when the moisture content exceeds 25% there are difficulties in handling this material through the cutter, dust separators, conveyors, etc., and the cutter itself does not cut the straw to the required length needed for cooking.

### 2.4 Conveying of Raw Material from Cutter to Digester

Even though straw appears structurally to be a soft and weak material compared with wood it has been noticed that the conveying of straw in chopped form to digesters located at an elevation of 12 to 15 meters from the cutter floor is a major problem. In most of the cases the equipment manufacturer designs and supplies pneumatic handling equipment for this purpose. Experience has shown that this is not the best method of conveying this raw material. The disadvantages of pneumatic handling equipment are:-

2.4.1 The use of high capacity blowers for the handling of straw gives rise to problems associated with dust.

2.4.2 The abrasive nature of the raw material results in heavy replacement costs of the blow pipes and blow fans used for conveying the straw to the digester floor.

2.4.3 The blow lines get jammed due to a slight increase in the moisture content of the straw and therefore frequent interruptions to production are experienced during the rainy season.

2.4.4 When high pressure blowers are used for conveying and filling the digesters the entrapping of air causes poor packing.

In certain cases the equipment manufacturer employs screw conveyors to convey the chopped rice straw to digesters, after mixing with the chemicals. It has been found that screw conveyors cause heavy interruptions to production due to the screw getting jammed because of the tendency of rice straw to "rope". Wherever screw conveyors have been used they have been successfully replaced by belt conveyors.

### 2.5 Digesters

The digesters needed for the cooking of straw should be of the rotary type. In the rotary type both the spherical and cylindrical type of digesters have been used for rice straw. The cylindrical type is preferred to obtain clean blows and to avoid formation of "balls" due to the rotation of the digester.

Straw being a bulky material there are difficulties experienced in the packing of straw. The packing density in the digester using rice straw averages to about 130-140 kg. BD/cubic meter. This is low compared with other materials. In order to effect maximum utilization of digester capacity and to reduce operation costs, better packing methods in the digesters have to be devised. During the past few years there has been a tendency to go in for continuous digesters wherever it could be efficiently used. However, not many mills using rice straw have gone in for the use of continuous digesters mainly because the mills using rice straw are not large enough to consider the application of such an equipment for a small output. There are few mills working with wheat straw using continuous digesters but due to the peculiarities of rice straw the application of this equipment needs careful study.

### 2.6 Brown Stock Washer

Slow drainage is one of the problems experienced with rice straw pulp, therefore the selection of the right type of washer is of considerable importance. It has been found by experience that a higher filtering area has to be allowed in the case of rice straw as against woody raw materials. The specific load on the washer is as high as 1.59 tons/sq. meter/24 hours.

Due to the problems experienced by the formation of scales and deposits the washers should be fitted with proper cleaning showers to keep the filter cloth in a clean condition. For working with rice straw pulp,

synthetic filter cloth is preferable as it does not easily get clogged. The cleaning of synthetic cloth is also comparatively easy. In view of these advantages, the washer drums should have facilities to install synthetic filter cloth in place of metal wire cloth.

### 2.7 Screening

The screens used for handling the pulp should be fitted with fine screen plates in view of the fibre characteristics of straw pulp and the presence of heavy contraries. On account of the heavy rejects that result from using such screen plates there is need to have a primary and secondary arrangement in the screening of rice straw pulp. The screening equipment should also have powerful sprays to clean the screen plates for efficient operation.

### 2.8 Centri-Cleaners

To obtain high quality pulp for the manufacture of bleached grades the centri-cleaners that have to be designed for straw pulp should be of the high pressure type. The number of centri cleaning units needed in the case of rice straw is high compared with wood pulp due to the heavy impurities and fines present in the pulp. For efficient centri-cleaning it may be advantageous to have a 4 stage cleaning system in place of a 3 stage cleaning system. The cleaners on the last stage should be fitted with "stock savers" on account of the fibre loss experienced through these cleaners. The inter stage pumps on the centri-cleaner units should be made with a special type of material or composition to

withstand the wear caused by contraries present in the straw pulp.

### 2.9 Bleaching

The bleaching of straw pulp should be based on a three stage system i. e. chlorination, caustic extraction and hypo-chlorite in order to obtain high brightness with good strength properties. The interstage washers for working with straw pulp should be carefully selected. On account of the slow drainage characteristics of the pulp, the filtering area required should be considerably higher compared with wood pulp. For a satisfactory performance of the washers the filtering area should be 1.8 ton B. D. pulp per sq. meter/24 hours. It has been found washers connected to vacuum pumps give better results in washing compared with the valveless type of washers.

### 2.10 Problems connected with the Recovery of Chemicals

Chemical recovery plants have not been so far designed for pulp mills operating on rice straw because it has a high content of silica which makes it difficult to recover chemicals from the black liquor. Attempts have been made to reduce the silica content from the black liquor. Although these methods have shown that silica could be partly reduced there is still much work to be done in designing equipment suitable for the complete desilication so that it could be performed on a commercial scale to make the pulping of rice straw more economical.

### 3. Stock Preparation Equipment

Straw pulp, in view of its characteristics, requires little or no refining

or beating. In order to obtain adequate strength properties the straw pulp should be blended with long fibre pulp. The type of equipment that has to be selected for refining the long fibre pulp is dependent on the quality of the long fibre pulp and the grade of paper that has to be produced. The type of the tackles used on the refiners and the refiner speed have to be carefully chosen to obtain optimum properties that would meet the quality requirements of the different grades of paper using a high percentage of straw pulp in the fibre furnish.

### 4. Paper Machine

The following design features have to be considered in the designing of the paper machine and ancillary equipment on account of the special characteristics of rice straw pulp.

#### 4.1 Approach Flow System

In comparison with other grades of pulp, straw pulp has heavy contraries and dirt, and the paper normally made from straw pulp is heavy in specks. To make clean paper "free from specks" the use of proper centri-cleaners is essential. Heavy slime formation is another problem experienced with straw pulp. The approach flow system, both for stock and water, should therefore be carefully designed to reduce slime growth.

#### 4.2 Selectifier Screen

The use of selectifier screens gives better results in producing a clean paper free from specks. Vertical screens of the selectifier type operate efficiently on low consistencies on the paper machine as compared with the open rotary type screens.

### 4.3 Flow Box

It has been noticed, that stock containing a high percentage of straw pulp has a tendency to entrain air in the stock. In the designing of the flow box special attention has to be given to prevent the cascading effect of the stock both in the approach flow system and the flow box.

### 4.4 Wire Part

Due to the slow drainage characteristics of the pulp, the paper machine designed for straw pulp should have the wire part suitably built to meet the requirements for this pulp. It has been found, the drainage through the wire could be improved by the use of 'hydro foils' as against the conventional table rolls. In the running of coloured grades where the two sided effect is more pronounced with straw pulp, the water removal should be very gentle and gradual as it is possible to control drainage with the use of foils.

### Size of the Wire

Considering the characteristics of straw pulp it is necessary to have an increased wire length to provide adequate drainage through the wire. In determining the width of the machine in relation to the trimmed width of the finished sheet, it has been found necessary to provide a shrinkage allowance of about 6.5% to 7% in the manufacture of writings and printings using straw pulp.

### 4.6 Dandy Roll

The function of the dandy roll is to consolidate and smooth down the surface of the sheet while it is being formed. The dandy roll can be a source of problem on account of

'pick-ups' or 'lick-ups'. When operating with straw pulp the picking-up of the sheet is not a serious problem. The main problem is in keeping the dandy roll clean as it gets filled up with fines from the straw pulp and in consequence, operating difficulties develop on the machine. An open dandy roll is generally considered preferable to a closed dandy roll as it is easier to clean. In the 'open Trunnion' type, steam showers and high pressure water showers for cleaning are fitted inside the dandy roll. The location of the cleaning showers with water jets directed from inside to outside makes it possible to remove the fines that build up on the face of the dandy roll.

### 4.7 Shake

Shake generally helps in distributing the fibre more evenly thus reducing the tendency of the fibres to orient in the machine direction. While working with a high percentage of straw pulp in the furnish the function of the shake is not so important as the straw pulp being short fibred gets distributed evenly without the help of the shaking mechanism.

### 4.8 Web Transfer

Paper Machines are specified either 'open' machines or 'Closed' machines. On an open machine the web is unsupported between the couch roll and the first press felt. On closed machines the web transfer takes place from the wire to the press on the underside of a top felt. It has been found on open machines that at least 30% of the fibrous composition should be long fibre pulp for a basis weight of 60 gsm. to obtain runnability conditions on the machine. Due to the poor web strength

properties of paper made from agricultural residues, there is a need to use a 'pick-up' arrangement on low basis weights in the transfer of the web from the couch to the press. Here again, there is a need to concentrate on the development of the press design, so as to enable paper made with 100% straw pulp to run satisfactorily at speeds comparable to conventional raw materials.

### 4.9 Wet Suction Boxes

The paper machine operation could be improved in the case of straw pulp by using wet suction boxes as these boxes have a high drainage capacity independent of machine speeds. The advantages in using wet suction boxes in the manufacture of grades where a high percentage of straw pulp is used are :

- 4.9.1 A gentle vacuum can be applied to the sheet thereby reducing the heavy drainage of fines and loading materials through the sheet.
- 4.9.2 Suction boxes prevent the 'stock jump' which is normally experienced at high speeds.
- 4.9.3 The vacuum and the drainage flow could be controlled to meet the requirements of a wide range of basis weights and machine speeds.

### 4.10 Suction Boxes

The suction boxes play an important role in removing at least one third of the total water of the entire paper making operation. However, suction boxes also cause heavy wear on the wire. It is estimated, the drag on the suction boxes are responsible

for at least 50% to 70% of the total load required to drive the Four-drinier section of the machine. The life of the wire is comparatively short, working with straw pulp, on account of the heavy suction that has to be used on the suction boxes and due to the high percentage of fines present in the stock. The high silica content present in the straw pulp also reduces the life of the wire. The use of synthetic "Plastic Tops" for the suction boxes, has contributed to the improvement in the life of the wire.

#### 4.11 Press Part

In using a high percentage of straw pulp in the fibre furnish there are problems on the press due to sticking. To get a satisfactory operation it may be necessary to use press rolls of a certain material composition that would prevent the tendency of the web to stick to the press. Some mills have found the use of granite rolls better than Stonite rolls in dealing with the problem. Certain mills have found the use of self-skinning rolls advantageous for the press section, particularly for the first press.

#### Smoothening Press

The main function of a smoothening press is to improve the finish of the sheet particularly of the underside before it enters the drier group. It is normally unfelted and is not designed for water extraction. On account of its location the sheet is plastic and able to be gently worked. Although the smoothening press has been found to give satisfactory performance on conventional raw materials, there are difficulties in working this press with a high per-

centage of straw pulp. To provide better runability conditions through the smoothening press improvements may have to be effected.

#### 4.13 Dryer Part

Fluff formation is one of the problems experienced with straw pulp due to the sticking action of the web to the drying cylinder. In order to prevent this sticking action, specially to the first and second cylinders following the press section, it will be advantageous to have these cylinders covered with a non-sticking material such as 'Teflon'.

#### 4.14 Limitations on Machine Speed

It is not possible to operate the machine with 100% straw pulp, on account of the weak structure of the paper web. Most of the mills using straw pulp use at least 30% long fibre pulp to provide runability conditions on the machine. Even in this case, the satisfactory operating speed obtained is only up to 200 meters per minute. For higher operating speeds with straw pulp and for higher utilization of straw pulp in the furnish considerable work is needed, particularly in the press section to avoid web breaks.

#### 4.15 Machine Clothing and Cleaning Devices

The behaviour of straw pulp and the problems connected with felts and wires are peculiar. There is a need for more work to determine the right type of felts to suit the characteristics of straw pulp.

The felt cleaning devices should be carefully designed to deal with difficulties associated with heavy fines present in pulp that have a

tendency to blind the felts, resulting in poor drainage through the felt. To keep the felt in good condition proper cleaning devices should be designed to get both good life from the felt as well as to avoid operational problems due to felt crushing etc.

The performance of synthetic machine cloth is considered to be better than phosphor bronze wires for straw pulp furnishes.

### 5. The Conservation of Water

Mills that are designed to work on straw pulp have problems associated with the use of water. These are, on account of constructing mills close to agricultural areas, where farmers as well as the paper industry have a common source of water supply such as a river or a lake. Consequently, there is a need for the paper industry based on rice straw to have an efficient management in the use of water within the mills. Equipment designers have therefore to find ways and means to conserve the water that is used in the paper mills by choosing the right type of showers, recycling methods, etc. which will cut down on the use of fresh water to obtain a closed water system. Recycling water has also its limits on account of the slime build-up within the stock and white water system of the paper machine.

### 6. Effluent Disposal

In view of the location of the pulp and paper mills in predominantly agricultural areas there will be problems connected with discharge of effluent through areas which are under cultivation. Some progress has been made recently in the use of the Ammonium base natural sul-

phite process for pulping. For mills that are using straw pulp, a process of this type would be of great interest as it is possible to supply the farmer with the fertilizer produced from the waste liquor.

### 7. Instrumentation

Instrumentation in a paper mill covers process controls, measuring instruments, drive controls of both constant and variable speed motors and valve controls on the stock and water flow system. In advanced countries the basic concept in instrumentation is to utilize as far as possible less man hours due to labour costs being high in relation to the total cost of the product. As a result pulp and paper making is based on the principle of making the product at high operating speed with high efficiency so as to reduce man-power requirements. In the case of developing countries, however, where the cost of labour is comparatively low the process instrumentation required for the paper industry should be viewed differently. With a high degree of automation in the paper industry, instrumentation has become so complicated even for advanced countries. It is therefore advantageous for developing countries to reduce instrumentation to the barest minimum and wherever man-power could be used for process control work, it is far better to use skilled operators and supervisory

staff. This would keep the equipment design simple, capital investment low and provide more employment opportunities to the numerous unemployed educated youth.

### 8. Spares

An equipment manufacturer in an industrially developed country does not normally view the problem of spares seriously. In consequence the equipment supplied is fitted with a wide range of components that could be obtained at quick notice, an example of this would be all types of rollers and ball bearings.

In a developing country where these facilities are not available interchangeability of spares is an important factor to be considered. It is advantageous from this point of view to standardize as far as possible most of the equipments such as pumps, agitators and certain machine components so as to provide maximum interchangeability of spares.

### 9. Conclusion

Equipment for pulp and paper manufacture has been hitherto designed primarily on the technological experience gained in the use of conventional raw materials.

This paper has dealt with some of the problems that equipment manufacturers have to consider when supplying pulp and paper machinery based on non-conventional materials.

Each developing country has its own specific problems related to the type of raw material, grade of paper to be manufactured, the technical skill available, foreign exchange problems and the degree of heavy engineering industry development in the country. The writer hopes that the general ideas outlined in the use of this non-conventional raw material would prove useful for the further development of the pulp and paper equipment manufacture in India.

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