Bagasse and Straw ; Comparative study in pulping and paper making with some major design parameters

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ABSTRACT

Bagasse and straw as raw material to Pulp and Paper industry. differ considerably with respect to their conversion to bleached pulp and paper. Conversion plant and mechineries require substantial modifications in design and sizing of various sections to suit the requirement when using high proportion of these short fibers in the furnishes.

World's growing population and increased demand of paper and paper products has created shortage of traditional raw materials all over. This problem of shortage of paper making fibres has been felt more acute in developing countries where forest resources are limited in comparison to the need. Paper experts all over the world being fully aware of the situation are already in the process of making vigorous efforts both in the field of technology and engineering to find out ways and means for commercially viable and economical processes as well as machineries for making pulp and paper out of various types of agricultural residues.

In India, our traditional raw material Bamboo and also hard wood forests are depleting very fast for so many reasons and as a result the pulp and paper industry with its expansion plans both in private and public sectors faced with serious problem of shortage of paper making raw material supply.

We in India, have agriculatural residues such as straws, stalks and sugar cane bagasse produced in large quantities and if even about 20–25% of potentially available agricultural residues can be made available to the paper industry, it can definitely meet the growing demand to a sizeable extent. This paper discusses such factors which are necessary to consider for designing process equipments as well as developing process technology mainly for bagasse and straws with a view to share experience and knowledge with others in the field.

BAGASSE AND STRAW : AVAILABILITY IN INDIA AND THEIR STRUCTURAL COMPOSITION.

Before we discuss the design parameters of the machineries and process technology required for pulping and paper making of bagasse and straw, let us see what are these residues and their potential availability for paper making in various parts in India.

Sugar cane—Saccharun officinarum—is a typical grass grown in most of the tropical and sub-tropical countries. Bagasse is the fibrous portion of Sugar cane juice. India is one of the leading sugar producing countries in the world, producing not less than 4 million tonnes of bagasse every year. Major portion of this is used as fuel by the sugar mills. Bagasse is available in plenty in Andhra Pradesh, Maharashtra, Karnataka, Bihar, U.P. Sugar cane grows to a height of 2–4m and has a diameter of 4–6 cms and it contains around 12% sugar in the pith cells. Bagasse after extraction of sugar juice contains about 50% water and 1-2%sugar. It contains about 25% of parenchyma cells, 20% of central vascular bundles and 55% of rind vascular bundles by weight. Fibre constitute only about 40% of the dry bagasse, parenchyma cells 40% and vessel segments 20%.

Wheat straw and paddy straw constitute the major part of cereals and millets residue and it is available in plenty in Punjab, Haryana, U.P., West Bengal, Bihar

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Orissa, Maharashtra, Andhra Pradesh, M.P. Tamilnadu, Karnataka. A sizeable portion of 90 million tonnes of of paddy straw and 60 million tonnes of wheat straw products in India, can be made available to the Industry. The straw is used by the poor farmers as fuel, roofing materials and possibly the only source of fodder of livestock. Cereal straws consist of leafy sheath and bast cells between the nodes which form major part of a straw pulp. Straws have an average 50% bast fibre, 45% pareachyma cells and 5% vessles. In comparison, the softwoods have about 93% fibre content, 7% parencyma cells where as hard woods have 50% fibre content, 20% parenchyma and 30% vessle cells.

The average length of straw cells is only 0.3-0.5mm compared to 1-1.5 mm. of hard wood and 2.5-3.5 mm of soft wood cells. Bagasse fibres are about 1.6 mm in length but its average length is brought down to 1 mm due to large amount of short cells. The Chemical composition of straws and bagasse is little different from woods. Straws are richer in pentosans as compared to wood. Agro-residues contain higher ash compared to wood which arises due to high silica content.

PULPING :

Despite both bagasse and straw are of open type in structure, straws offer greater resistance to chemical penetration and also consumes more chemicals for delignification as compared to bagasse. A moisture free-well depithed bagasse may require 10% active alkali as Na_2O to produce 10K—No. pulp, whereas straw will require 14.5% Na_2O as active alkali to produce the same K—no. pulp. The gap of chemical consumption further increases when chemical requirements are reported in the form of unbleached pulp production basis, due to different yield percentages. 52-55% yield is obtained in the case of bagasse and maximum 46-48% yield can be obtained in the case of straw. As far as cooking time is concerned, comparatively less time is required for pulping bagasse. There is almost no difference in the cooking temp and liquor to solid ratio in both the cases. Steam consumption per ton of pulp production does not vary widely, despite the fact that wet depithed bagasse carries more water to the digestion zone as opposed to dry—cleaned straw, because of higher yield advantages in the case of bagasse.

Identical equipments can be used for washing, screening and cleaning operation in case of both bagasse and straw pulp in removing the spent liquor for chemical recovery as well as to have cleaned product. However straw pulp demands greater surface area for washing system due to relatively slower drainage property of straw pulp compared to bagasse pulp. Crude bagasse pulp has the freeness value of 20-22° SR and straw pulp has a freeness value of 28-30° SR. It is preferable to have three stages brown stock washing system in the case of straw pulp, wereas 2 stage washing may prove adequate in the case of bagasse pulp. On many occasions, this point is overlooked at the design and planning stage resulting in operating limitations until the unit is expanded to correct these short comings. 2—stage or 3—stage centrifugal screening system can be adequate for both pulps to get suitable clean pulp. Flat screens followed by fine rotary screens with plates of smaller perforations are an ideal set up for both pulps. A tailing screen will handle all the rejects from the coarse and fine screens. While bagasse pulp can be well screened in the conventional standard screening set up, straw pulp requires sufficiently elaborate layout to derive well screened pulp.

The difference in bleachability characteristic between these two pulps lies in the relative lignin content in the unbleached pulp as well as the resistance of the colouring materials offer towards bleaching agents. Both medium and high density bleaching are in practice in modern mills. There is almost no presence of colouring bodies in case of bagasse. Bagasse pulp is easier to bleach by employing 3-stage bleaching sequence (C-E-H) in a continuous system, as compared to straw pulp. Older mills employ single stage boeaching with hypochlorite treatment in beaters. However, pulp of any brightness above 75/76% produced by this process will result in serious loss in strength properties. Straw pulp on the other hand, is comparatively bleach resistant and require more expanded stages of bleaching to attain high brightness level and three stage bleaching as in the case of bagasse pulp may not be sufficient for high level of brightness. Chlorine dioxide bleaching as a final stage, following the C – E – H sequence, to obtain high level of brightness may be found very useful and also economic. While designing the layout of the plants and equipments in the bleaching section, it is very important to give due attention to the fact that there is considerable difference in the dwelling time and the reaction temp. during chlorination, caustic extraction and hypostage in cases of the two pulps under

discussion. The dwelling time is in general longer in case of straw pulp as compared to bagasse pulp. Washing of pulp after each stage of bleaching is an important step and filters of adequately large size should be provided to compensate the slow drainage properties. Sulphurous acid treatment in case of straw pulp is a very desirable step in bleaching to avoid colour reversion and to stabilize brightness.

PAPER MAKING :

Straw pulp has better bursting strength and bulk whereas bagasse pulp is possessing higher breaking length and tearing resistance and both pulps are on the whole equally suitable for paper making purposes. Better machine runnability can be established with about 85% bagasse pulp in the furnish where as above 75% straw pulp in the fibre furnish is quite difficult to maintain to achieve similar results under idential machine operations and speed.

Straw pulp needs little refining to prepare the pulp for the paper machine due to high hydration and slow drainage characteristics developed during the pulping and bleaching process. Bagasse pulp, however, require mild refining and this is required mainly to break the hetrogenous fibre bundle than to developing hydration. Electrical energy consumption for stock refining will also vary accordingly.

For most grades of writing and printing papers straw pulp may not require any seperate refining except the treatment through the finishing refiners where the blended refined long fibre pulp and straw pulp get a final brushing to provide the required good sheet formation. The long fibre pulp has to be refined seperately and blended together with straw or bagasse pulp prior to final refining/jordaning, screening and cleaning operations.

Rosin size requirement for both the pulps has been reported to be much less to produce hard sized paper as compared to the papers made from conventional fibres. However, Alum requirement is on higher side than used in conventional paper making. This is mainly due to low pH conditions required to avoid press picking. Both pulps can be used for production of cultural grade of papers. However, much limitations are put on the paper machine speed because of the slow drainage properties of both the pulps. This may prove even the production most uneconomical due to reduced machine capacity. That is the reason why the machine needs considerable change in the design and operation to maintain high machine speed, as the proportion of bagasse or straw pulp increases and approaches 80% or above.

With the uses of high percentage of straw or bagasse pulp, the Fourdrinier part of the paper machine should be better designed with a pressurized head box for achieving correct pond height and good formation at all machine speeds and with a longer wire part compared to conventional design to provide adequate forming and dewatering zone. Multiblade foil system has been reported to be very useful for maintaining slow and uniform drainage. Since the paper web with high percentage of straw and bagasse pulp in the fibre furnish has low strength, it may be suggested to have suction pick-up or similar system for transfering the web to the press section from the wirepart. The water holding capacities of these fibres of straw and bagasse pulp are somewhat different, compared to that of the conventional pulp and therefore, to achieve better dryness the press section is unlikely to yield appreciable results. Ideal press part design should consist of three sets of presses to achieve dryness of paper to the tune 38-40% followed by a smoothing press. However, this area of the wet part of the paper machine having a lot of scope for improvement, has already developed several press designs in the recent years. With the typical fibre characteristics of these two pulps, it is essential to go for relatively more open type wet felts with enough porosity. This will help in uniform and adequate drainage at the press section. Special attention is also required to be given for proper cleaning of felts and suction roll holes, since due to excessive fines and debris they tend to clog up very rapidly.

These two pulps behave differently during the process compared to conventional fibres. Due to more water carryover with the paper web and the stock being more hydrated in nature, the evaporation has to be at uniform temperature over an extended number of dryers. Smaller dryer groups are also preferred to maintain better control in drying rates since, as the drying proceeds the web shrinks at a much faster rate than conventional fibre.

Straw and bagasse pulp generally produce rough surfaced paper and it is preferable to have 2 calender stacks in the MF grades of papers,

CONCLUSION :

Papers with both straw and bagasse pulp possess satisfactory strength properties. Normally, mills use around 20% long fibre in the fibre furnish which greatly improves the paper machine performance and also the strength properties of the final product. Rattle and stiffness are the inherent properties of these pulps and therefore, paper rich in these pulps show these characteristics very prominently.

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