

The potential for bagasse pulping in Australia

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ABSTRACT

Despite the large quantity of sugar cane grown in Australia, no bagasse is pulped in the country. This is largely because of an established pulp industry based on the abundant native hardwood resources. However, increasing demand for fibre and the limited availability of additional forest areas make bagasse pulping attractive.

Technical issues relating to manufacture, infrastructure and pulp quality are discussed and scenarios of acceptable risk identified. It is shown that there should be scope for the production of market bleached bagasse pulp in Australia.

INTRODUCTION

Australia is perhaps unique among countries which are both major cane sugar producers and which have a significant paper industry in that it does not produce bagasse pulps. This paper will discuss the reasons for this situation, whether the situation is likely to change, and what new circumstances will be required to make a bagasse pulp industry attractive.

The early paper industry in Australia was largely based around Victoria and Sydney, as these were the areas where there was a demand and the necessary infrastructure. The early industry was based around rags and later wheat straw which was grown in the southern states. This helped secure these regions as the centres of the paper industry.

In the early parts of the twentieth century the demand for pulp grew and created the need for additional fibre sources. At that time no viable technology existed for bagasse pulping, and most of the cane growing areas were remote from the major paper mills and from the major paper consuming areas. Conversely, in the south-east, near where the existing paper mills and markets were, there were relatively abundant supplies of native hardwoods. Although there were considerable difficulties in developing the technology to pulp these woods, the resultant pulp was of good quality, which was not the case for bagasse pulps at that time.

Three new eucalyptus based pulp and paper mills were built in Victoria and Tasmania in the late 1930's and

the centre of the Australian industry was firmly established in the South East.

Since that time there have remained two peculiarly local impediments to the development of an Australian bagasse pulp industry: the abundant supply of native hardwood and the isolation of the cane crushers from the paper mills (this is important as the potential for selling market bagasse pulp has been limited).

However, despite these historical difficulties, there are some circumstances that may now make the production of bagasse pulp in Australia more attractive:

- It has become difficult to gain access to sufficient reserves of natural forest to support significant increases in wood pulp capacity. The alternative has been to establish plantations, but the increasing minimum economic size for new pulp mills and the long establishment times for plantations makes this unattractive in many cases.
- The technology for pulping bagasse has developed so that satisfactory quality pulps of various types are now being produced in many countries.
- Imbalance between supply and demand for fibre in the region is making acceptance of non-traditional pulp sources more attractive.
- Compared with establishing timber plantations, bagasse fibre can be available with a very short lead-time and with the cost of collection already covered.

PULP DEMAND

World wide demand for pulp continues to grow at a steady rate. The explosion of Chinese paper manufacture in recent years shows no signs of abating. In absolute terms demand for fibre is predicted to outstrip the availability of pulp from increasingly restricted forest areas. Whilst improved recovery rates for recycled fibre will assist to bridge the gap, nonwood fibres may provide the additional resource required over available wood resources. Jaakko Poyry (1) data shows that of a total global fibre demand of 325 million tonnes in the year 2000, pulp satisfied approximately 180 million tonnes of the demand. By 2015 Jaakko Poyry predict that global fibre demand will exceed 460 million tonnes per annum of which pulp will provide 215 million tonnes per annum.

In Australia in 2000 an estimated 1.158 million tonnes of pulp was transformed into paper grades and this had increased to 1.45 million tonnes by 2003, of which

357,000 tonnes was imported (2). Whilst a large market pulp mill is under consideration in Tasmania and a redevelopment of Maryvale pulp mill is mooted, active proposals also exist for additional paper capacity (eg Swanbank), which will translate into continuing pressure on pulp supply. A mill based on bagasse could be developed relatively quickly, without the constraints and lead times imposed by a wood based mill.

PROPERTIES OF BAGASSE

Bagasse is the residue after crushing and processing of sugar cane to remove the sugar juice. Bagasse fibres are of 1.0-1.5mm length and ca20 micron diameter, which is similar to hardwoods such as eucalyptus (0.7-1.3mm by 20-30 micron). Accordingly, with appropriate manufacturing processes, bagasse pulps can be produced of similar quality to pulp from hardwoods.

There are a number of features of bagasse which require different treatment from the processing of wood chips. Some particularly important considerations are as follows:

- Storage – sugar cane is a seasonal crop and the crushing mills operate for only about half the year, so it is usually necessary to store large quantities of bagasse for long periods. Unfortunately, the as received bagasse is prone to biological action that can rapidly lead to severe colour degradation (particularly detrimental if mechanical pulps are to be made), yield loss and degradation fibre properties. Therefore special methods of storage are required.
- Pith - bagasse typically contains 30-35% pith cells. These are fine, thin walled, low cellulose content cells which do not produce paper-making fibre. However, they consume large quantities of chemicals, result in a poor draining pulp and reduce scattering power in mechanical pulps. Therefore, effective de-pithing is an essential requirement.
- Silica – compared with most other non-wood fibre sources, bagasse is quite low in silica, but at 0.5% it is at least twenty times higher than in eucalyptus, and removal or other compensatory methods are essential to a practical mill.
- Chemical recovery – silica is a major issue, but the high viscosity of the liquor and the small scale of most bagasse mills also present significant problems

Bagasse is used commercially to produce chemical, semi-chemical and various types of mechanical pulp in

both bleached and unbleached forms. It is most commonly used in countries where other fibre sources are limited and often (but by no means always) in situations where imported pulps are too expensive. Various factors must be considered when planning its use:

- Pulp strength – the pulps produced are not generally of high strength. They are similar or slightly deficient to hardwood pulp and generally a long fibre component must be added where high tear strength or high machine speed are required (however, one small mill in Peru uses bagasse to make multi-wall bags for cement⁴).
- Pulp properties – bagasse pulps are generally smooth, and soft. However, chemical pulps have poor opacity. It does not produce ‘universally applicable pulps’ under open market conditions. Therefore it is important to consider the final use very carefully when planning a mill.

Bagasse has been used in many grades where local factors limit the availability of alternative pulps, but grades in which bagasse has proved particularly suitable include: printings and writings, tissue grades, corrugating medium and newsprint. Some of these can be made from 100% bagasse, but in most cases bagasse pulp is most competitive when a moderate proportion of another pulp is added, usually to give better runnability. Hurter (3) has summarised the suitability of bagasse in a range of paper products as shown in Table 1. In general, bagasse is particularly suitable for many grades, with some limitations in those grades where tensile properties are predominant.

TECHNICAL PARAMETERS

Storage of bagasse

The problems of inappropriate storage of bagasse have been described by many authors (4, 5, 6, 7, 8, 9, 10). If bagasse is not stored properly, it will undergo microbial attack leading to severe colour loss, loss of yield and loss of pulp strength. The problem is particularly severe if the bagasse is stored partly wetted. One approach has been to form the bagasse into large bales and allow these to dry out by a natural heating action. This method is very effective, but is impractical for large-scale storage such as for pulp mills.

Table 1 Suitability of bagasse pulps in various products

Bagasse Pulp and Long Fiber Virgin Woodpulp			
Type of Paper	Bagasse (%)	Long Fiber Pulp (%)	Quality
Bond papers	80 - 90	10 - 20	excellent
Bristol boards	100	0	excellent
"B" grade wrapping papers	60 - 70	30 - 40	acceptable
Corrugating medium	90	10	excellent
Glassine	80 - 90	10 - 20	very good
Greaseproof	75 - 85	15 - 25	excellent
Lightweight MG wrapping ⁽¹⁾	65 - 75	25 - 35	good
Linerboard	60 - 70	30 - 40	acceptable
Newsprint ⁽²⁾	80 - 100	0 - 20	very good
Sack kraft papers ⁽³⁾	50 - 60	40 - 50	acceptable
Sanitary tissue & toweling	80 - 85	15 - 20	very good
Test liner ⁽⁴⁾	75 - 85	15 - 25	good
Waxing papers	50 - 60	40 - 50	good
Wood-content printing papers	80 - 90 ⁽⁵⁾	10 - 20	very good
Wood-content writing papers	80 - 90 ⁽⁵⁾	10 - 20	very good
Woodfree printing papers	0 - 100	0 - 10	very good
Woodfree writing papers	0 - 100	0 - 10	very good

Notes: (1) Bleached or unbleached.
(2) Typically includes combination of chemical and chemimechanical bagasse pulps.
(3) Clupak required on paper machine.
(4) Select kraft wastepaper could replace a portion of the long fiber virgin woodpulp.
(5) Bleached chemimechanical or high-yield chemical pulp used for part of bagasse furnish.

A more practical and highly effective method is true wet storage with biological inoculation. The method was developed in South Africa by Ritter (4) and an advanced form is described by Rangamannar et al (9). The technique is to keep the bagasse saturated with circulating water. This water is inoculated with suitable micro-organisms to ferment the residual sugars in the bagasse (in some cases additional sugars are added to assist this process). This fairly rapid biological process creates an environment in which the cellulose degrading biological processes are unlikely to proceed. In addition to these biological aspects, it is also necessary to build storage piles that will remain properly saturated, and from which reclaim is relatively easy, and means of doing this have been described in the literature (9, 10).

Depithing

Adequate removal of pith is essential to produce a satisfactory pulp and to avoid wastage of chemicals. Depithing is possible with dry, moist (ca50% moisture) or wet bagasse (4, 6, 7, 10, 11). The objective is to remove pith so that it is reduced from constituting about 30% to about 5% of the bagasse. Typically bagasse is moist depithed, wet cleaned, stored and then wet cleaned again before pulping.

Dry and moist depithing remove large quantities of pith and are performed by hammer-milling and screening to remove the pith as fines, but dry working is not widely used because of fire and health problems associated with the dust it generates.

Wet depithing is performed in centrifugal separators at about 10% consistency. It is effective in removing pith remaining after moist processing, but is too expensive to use alone.

Depithing has been practiced for many years, and although there is certainly room for improvement, the only real risk associated with it is of installing an inadequate system as a misguided economy measure.

Desilication

Bagasse contains a moderate amount of silica, and it is usually desirable to remove this at some point in the process. If this is not done, then there will be excessive equipment wear (and possibly paper machine wear) when mechanical pulps are made, and build-up in the chemical system when chemical pulps are made. With mechanical pulps the main concern will be with sand and grit adhering to the bagasse, and washing and riffling can remove this. However, with chemical pulps even quite small phytoliths within the cane mass are also of concern.

Over the years numerous solutions to the silica removal problem have been proposed and many of them operated at various levels. In general, it would seem that the chemistry of removing the silica is not particularly difficult; it is the technology of controlling the process so as to get physical separation of the silica rich stream without too much contamination that has presented problems.

Silica removal methods for chemical pulping have concentrated on treating the raw material, the black liquor or the green liquor.

Gupta et al (12) describe a method whereby about 75% of the silica could be extracted from bagasse with 2% sodium hydroxide at 75°C. There was a commensurate reduction in the alkali required for subsequent pulping and it said that 'the presence of lignin in the extracted liquor is negligible'. The method looks very attractive (especially if it could be integrated with wet depithing so that little new equipment is required) but it does not appear to have progressed beyond the laboratory stage.

The most successful approach to silica removal so far seems to be by precipitation from black liquor by partial acidification with carbon dioxide from flue gases, or by addition of lime. The acidification approach has been most used.

A substantial pilot plant was operated on rice straw liquor at Ratka for some years (13, 14). Although it achieved good silica removal, the settling rate of the silica was very low and centrifugation was required. The plant was said to be fairly successful, but there

does not appear to have been any further commercial use.

A Unido led program in India led to a full scale plant at Hindustan Newsprint Mills (15, 16). The plant worked by three-stage carbonation to give large precipitate particles that could be separated by filtration, and it was applied to a range of non-wood materials. About 90% removal of silica was achieved, but foaming and adequate control of pH remained as issues.

Myreen (17, 18) has suggested a proposal whereby the silica is precipitated using substantially pure carbon dioxide which is generated by burning the black liquor in oxygen. The method presents a number of advantages, but has only been tested in the laboratory and represents a substantial technical risk at this stage.

Various methods have been proposed for precipitation of silica from green liquor. Rao et al (19) proposed two stage causticizing, whereby silica was selectively precipitated in the first stage and the mud discarded so that relatively clean mud was generated in the second stage. However, the selectivity of the process was not particularly good, and it does not seem to have been developed further. Bohmer (20) proposed the addition of sodium aluminate or bauxite to precipitate the silica as zeolite. A high silica removal efficiency was claimed, but the process does not seem to have been developed.

A rather different approach is to precipitate the silica onto the pulp (21). This gives effective fixing of the silica, but reduces pulp strength (which is already marginal) and there would be issues of market acceptance.

Well researched plans were developed in Australia by Arisa Limited to build a straw pulp mill at Horsham, including a comprehensive process to deal with silica, incorporating some of the forgoing approaches. Initially it was proposed that the straw would receive an initial charge of sodium hydroxide, which not only dissolved some of the straw structure but also reduced silica by about half in the process. Lime was also to be added to the green liquor to precipitate silica as calcium silicate. Combined with an innovative approach to water treatment to preferentially purge silica Arisa was confident that silica could be effectively be managed (22).

In summary, with the possible exception of black liquor carbonation, there is no universally commercially proven method for selective removal of silica. However, a quite effective method (particularly for moderate silica content raw materials such as bagasse)

is simply to continuously purge a portion of the lime mud - which can be used as agricultural lime.

Pulping

Compared with other issues, pulping presents relatively few uncertainties. It is well established that good quality chemical and semi-chemical pulps can be made using soda or soda-AQ in Pandia type digesters with a very short residence time.

Unlike wood pulping, kraft pulping does not offer significant quality advantages over soda, and has the problems associated with odour and often with more difficult bleaching. Other pulping methods such as using solvents are at various stages of development and steam explosion technology has been promoted, but none has been demonstrated to offer sufficient advantages to warrant the technical risk to apply them in Australia at this stage.

It is possible to recover lignin and some other chemicals from black liquor from various pulping methods, but to be economically viable a project should not rely on by-products, so these factors will not be discussed here.

After some initial difficulties, mechanical pulping of bagasse is now well established, particularly in India (5, 8, 9, 10). The pulp is suitable for tissue products and can form a major portion of the furnish for newsprint, but some reinforcing pulp would be required to meet Australian requirements.

In summary, pulping presents no particular problem, and the pulp can be used in a wide range of paper applications dependent on the pulping process and the end use of the paper product.

Chemical recovery

Compared with black liquor from wood pulping, bagasse (and other non-wood liquors) are very viscous, high in silica and often have a somewhat lower heat of combustion. Further, the quantity of liquor to be handled is rather small for conventional smelting furnaces and the pulping methods employed often result in a more dilute liquor to the evaporators.

Despite these difficulties, the actual combustion of the liquors is not particularly difficult and there are multiple successful installations of both smelter type furnaces (e.g. Orizaba in Mexico, Varinder Agro (23) and Shree Vindhya in India (24)) and of fluid bed incinerators (25) (e.g. Orizaba, Stanger in South Africa (26), Shreyans and Shree Rishab in India (27)).

Issues to be faced in the recovery include:

- Low inlet concentration to evaporators – requiring extra capacity and care to avoid the foaming region.
- Viscosity and fouling limits in evaporators – requiring spare evaporator bodies to allow cleaning, and/or transfer to forced-circulation or direct-contact evaporators at a lower concentration than for wood based mills.
- Smelt viscosity issues in smelting furnace – may need supplementary firing to maintain adequate bed temperature.
- With fluidised beds, emissions of combustibles may be high because of the low combustion temperature (however, the high melting point of sodium silicates means that bed sintering is less likely to be an issue than with wood based fluidised beds).
- Poor mud settling and poor lime kiln thermal efficiency – largely a matter of how well the silica level in the chemical circuit is controlled either by selective removal or by purging of lime mud.

There are other less conventional recovery systems which might be used (e.g. DARS with a modified chemistry) but these would require further development before they would present a satisfactory technical risk.

THE ECONOMIC ADVANTAGES OF BAGASSE PULP

Technical solutions exist to address the challenges of using bagasse to manufacture pulp. There are many mills in operation that employ aspects of available technology but often these mills are in third world developing countries where the economic and environmental realities of Australia do not apply. For a mill in Australia suitable scale and environmental factors must be addressed.

Factors to be considered in determining the viability of a bagasse mill include:

Availability of bagasse

World-wide significant quantities of bagasse are potentially available, estimated to be in excess of 100 million tonnes (28). The reality is that of this only about 4+ million tonnes of bagasse pulp is produced annually (extrapolation of 1998 estimates reported by Atchison (29)).

In Australia there is in excess of 3 million tonnes of bagasse potentially available for the manufacture of pulp. Presently, this bagasse is burned to produce steam

and electricity. At a current estimated value to the sugar mills typically around \$40 per dry tonne, bagasse represents a low cost raw-material when compared to wood, even after allowing for pith removal.

Bagasse availability is limited to north-eastern Australia, loosely divided into the following regions: NSW; Bundaberg; Mackay; the Herbert; the Burdekin; and the Northern mills as shown in figure 1

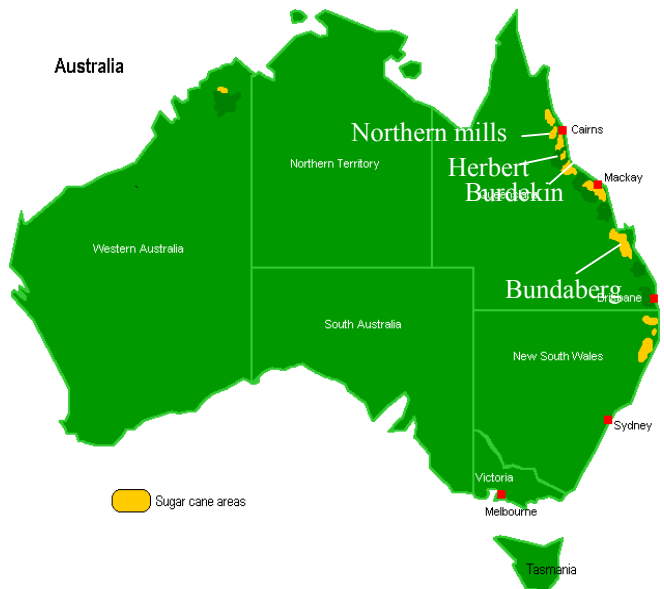


Figure 1 Sugar growing areas in Australia

Table 2 summarises the quantity of sugarcane crushed in each region and the potential available quantity of depithed bagasse. The data in table 1 assumes that all bagasse which is currently used to produce steam and electricity can be replaced by an alternative fuel source, the fibre content of the cane is 13%, and 35% of the bagasse is required to be removed as pith. Assuming 45% pulp yield and 350 operating days per year, a chemical bagasse pulp mill located in the Mackay region could produce as much as 1090 tonnes of pulp per day. Realistically, the optimum outcome may involve splitting the bagasse for both pulp production and to generate process steam for the sugar and pulp mills. For an integrated sugar mill/pulp mill, the separated pith would be returned to the sugar mill to generate energy or could be used for that purpose also in a non integrated mill.

Infrastructure Issues

Water resources

Water is a key issue in locating a mill. Paradoxically the Bundaberg and Mackay regions are the most water deficient regions. The New South Wales, the Burdekin,

the Herbert and the Northern mills all have adequate water supplies but are generally more remote from potential user markets. Attention to design and use of best practice technology in water treatment and reclamation will minimise net water consumption and water availability need not disqualify Bundaberg or Mackay as a site for a mill.

Table 2 Potential availability of bagasse by region

Region	Cane crushed (million t/a)	Depithed bagasse potential (odt/a)	Potential chemical pulp mill size (odt/d)
Northern Mills	7.8	659,000	850
Herbert Mills	4.0	338,000	430
Burdekin Mills	8.6	728,000	930
Mackay	10.0	845,000	1090
Bundaberg Mills	3.9	330,000	420
NSW Mills	2.3	194,000	250

Energy Resources

If a large proportion of bagasse produced in a region is used for pulping, an alternative fuel source must be burnt to supply process steam to both the sugar and pulp mills. Presently, coal is the most obvious choice of fuel but future construction on the proposed natural gas pipeline from New Guinea may eventually provide another option. Mackay, the Herbert, and the Burdekin all have access to abundant coal supplies and large ports. The Bundaberg region and Northern mills have access to ports, but have limited access to coal. The New South Wales mills do not have ready access to a port or to coal.

Transport

Although bagasse is bulky, transportation costs for bagasse can be relatively low when the bagasse pulp mill is integrated with a large sugar mill. This was a concept initially employed by a consortium lead by Multiplex Limited to develop a bagasse pulp mill at Bundaberg (Bundaberg 2K+). To achieve economic scale factors additional bagasse could be transported by truck to the integrated pulp mill from surrounding sugar

mills. In practical terms the Mackay, Bundaberg, the Herbert, and the Burdekin have a closer proximity of sugar mills than other regions and may therefore offer the best prospects for siting a bagasse mill.

The overall infrastructure situation is summarised in Table 3

Table 3 Summary of infrastructure by sugar region

Region	Proximity of mills	Water	Coal supply	Ports
Northern Mills	Adequate	Excellent	Poor	Adequate
Herbert Mills	Good	Good	Good	Excellent
Burdekin Mills	Good	Excellent	Excellent	Good
Mackay	Excellent	Poor	Excellent	Excellent
Bundaberg Mills	Adequate	Poor	Adequate	Good
NSW Mills	Adequate	Excellent	Poor	Poor

In summary the Herbert and the Burdekin regions are presently well supported by infrastructure and have potentially very low transport costs. Mackay is very well supported by infrastructure and low transport costs but significant water saving measures would be required to build a pulp mill. The Bundaberg region has reasonable infrastructure and good proximity to Brisbane, however significant water saving measures would again be required to build a pulp mill. The quantity of bagasse potentially available at Bundaberg may also be marginal to support a viable pulp mill. The New South Wales region represents the least attractive location for a bagasse pulp mill since it has the smallest fibre supply, relatively poor transportation costs and may have some difficulty sourcing alternative fuels. Other infrastructure requirements for a pulp mill are generally satisfactory in these regions as for the most part they already exist to support the operating sugar mills.

TECHNOLOGY

Pulping

Although bagasse can be pulped by a variety of processes this paper has focussed on chemically pulped bagasse on the basis that potential markets in Australia

and for export will be predominantly for chemical pulp. Because there is minimal quality advantage associated with kraft pulping, soda or soda-AQ pulping is the preferred option as it offers fewer process or environmental challenges with consequent operating and capital cost advantages. Horizontal or semi-horizontal continuous tube digesters (eg Pandia or M&D) are well proven for bagasse pulping and would be the probable choice of pulping technology for a mill built in Australia. However this technology is mainly employed at mills having modest capacity and there is scope to develop alternatives for mills with larger capacity. According to information published on the Queensland Government State Development website and SKM website in support of the environmental approval process for the Bundaberg 2K+ project (May, 2000), the kraft process was to be employed and Kamyr type digester is understood to have been proposed for that mill. This choice of technology was probably dictated by plans, which evolved to include pulping of wood as well as bagasse.

Metso have supplied more than 50 horizontal digesters for nonwood pulping and have developed a standardised concept for non-wood pulping, washing, screening and bleaching (30) that provides a suitable template for a small to medium size mill. The slower draining nature of bagasse pulps requires critical attention to sizing of brown stock washers and bleach plant washers. A rule of thumb comparison predicts that a bagasse washer will process only about 1/3 of the throughput of wood pulp over a similar sized washer.

Bleaching

As with nonwood pulps in general, bagasse is responsive to bleaching and this enables shorter sequences to be employed and less bleaching chemicals to be used. Traditionally nonwood pulps have been bleached with CEH or CEHH sequences, both of which would no longer be acceptable for a new mill in Australia. These sequences can have environmentally detrimental consequences but also impact pulp strength. Strong claims are made for an OQ (PO) sequence for the standard Metso nonwood pulp mill and the following comparisons are reported (Table 4)(30)

Table 4 Comparison of bleaching processes

	C-E-H-H	ECF OD(EO)D	TCF OQ(PO)
Brightness, % ISO	84	84	84
Yield loss, %	7-8	4-5	4-5
Cost of chemicals, USD/odt	18,3	21,1	28,6
Power consumption fiberline, kWh/odt	130	150	160
Steam consumption, tons/odt	0,2	0,53	0,58
Estimated COD AOX kg in bleach plant			
- COD, kg/odt	60	35	30
- AOX, kg/odt	5,5	0,7	0
Water discharge, m ³ /odt	50-100	15-20	5-10
Relative installation cost, MUSD	34	39	30
Cost difference compared to TCF, %	12	23	

Whilst there are operating cost penalties associated with this sequence, there are capital cost advantages and significant downstream environmental advantages. Specifically for bagasse pulps, it is claimed that the tear index at tensile index 70 kNm/kg is from 20-50% higher than with a CEH or OD(EO)D sequence. Also, water re-use can be maximised and effluent discharges minimised with this sequence, which will make it particularly attractive in areas where water availability is limited.

A practical issue in bleach plant design for bagasse pulps is to avoid excessive mechanical action on the pulp, which will deteriorate in freeness under conditions of high shear.

Chemical Recovery

For many mills in developing countries the challenges of chemical recovery have been avoided by simply avoiding chemical recovery. Gupta et al (31) reported that in 2000 of the 111 registered agro-based mills in India only 6 had installed a chemical recovery system, of which 5 are conventional systems and one is a fluidised bed system. Suggested solutions to the various issues are outlined. Chaudhuri (32) has also summarised the range of negative operating issues to be addressed in the recovery circuit of a non-wood pulp mill, most of which are relevant to a bagasse pulp mill to some degree. A standard soda recovery/causticizing system is proven but capital and operating costs are relatively high due the complex equipment and the need to make up for disposal of silica contaminated lime sludge, or alternatively the carbonation of black liquor. Chaudhari compares the capital and operating costs of 4 potential recovery systems, including DARS, which while technically proven has not survived commercially due to equipment challenges. Conventional soda recovery has the highest operating and capital costs but is proven and reliable. As demonstrated at Sappi's Stranger Mill, capital costs can be minimised by using a Fluidised Bed type furnace

rather than a Tomlinson type and this is a viable option for a medium size mill, although energy recovery is inferior. Such a system at a paper mill in India, (Shreyans Papers), has been well reported (33).

Variner Agro at their pulp and paper mill at Dhaula, Punjab in India committed to conventional high pressure recovery technology in 1998 and set up a process employing available technology for dealing with nonwood pulps. Their average furnish is 67% wheat straw and 23% bagasse topped up with various other nonwood fibres. The straw and bagasse (after depithing) are cooked separately in spherical digesters. This is a small mill (28,000 tpa paper capacity) but a 165 tpd black liquor solids boiler of Ahlstrom design has been installed in anticipation of future expansion. Liquor is concentrated in an 8 body, 6 effect free falling film evaporator set of Rosenblad design.²³

A mill established in Australia to match the available fibre resource would be of a scale that would be likely to require a conventional recovery system. Accordingly a key requirement for a viable mill is to verify a suitable commercial system for desilication.

Capital & Operating Costs

The requirement for specialised equipment and generally smaller plant scale ostensibly puts a nonwood pulp mill at a disadvantage to a woodpulp mill on a unit capital cost of production comparison. The smaller scale impacts on unit labour costs and debt servicing costs. Specialised equipment is often more expensive with capacity outcomes less certain. Against these cost imposts there are some offsets including the lower raw material cost, the lower chemical costs for pulping and bleaching and the lower capital cost associated with smaller and less complex digester and chemical recovery equipment. Emerging opportunities for nonwood pulps and the availability of standardised plant designs such as offered by some suppliers will inevitably ensure greater capital cost competitiveness.

At the front end of the process, there are storage and process complications related to the depithing stage and the risks of biological degradation. However the expensive and high maintenance wood chipping and processing facilities required for wood pulping are avoided with the potential for a net capital cost advantage.

CONCLUSION

Bagasse is a renewable resource produced as a by-product of a cash crop. There are good environmental and economic reasons for encouraging its use for pulp making.

It appears technically and economically feasible to produce both bleached mechanical and bleached chemical pulps in Australia. The remoteness of the sugar growing areas from a newsprint mill and the limited scope for selling market mechanical pulp point to chemical pulp as offering the most commercially attractive option, particularly in view of the increasing demand for fibre and limited scope for exploiting additional forest areas.

TCF bleaching appears to offer capital cost and technical advantages with bagasse and would be useful in areas with limited water availability.

Several regions in Queensland have abundant supplies of bagasse, alternative energy sources and the necessary infrastructure to support an export pulp mill, particularly if the availability of bagasse is increased by using coal or natural gas to provide at least part of the energy needs for the crushing mills.

Although Australia will continue to feel predisposed to and more comfortable with wood pulping, future limitations on availability of wood fibre and the inherent economic advantages of significant available quantities of low cost of bagasse should be sufficient to encourage bagasse pulping.

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