Productivity on Small Paper Mills—An Alternative Approach to pulping

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ABSTRACT

Capacity utilization and productivity of paper and board industry is on the decline. This is mainly attributed to the inefficient operations of the small units which constitute a sizable portion of the gross national installed capacity. Major technical problems of the small mills could be resolved and productivity increased by way of new pulping methods. Organsolv acetic acid pulping of agricultural residues appears to be an alternative having advantages of low cost of production, less costly chemical recovery and cleaner environment over conventional pulping methods. Advantages of organsolv acetic acid pulping is discussed in this paper.

INTRODUCTION

The total installed capacity of paper & board in India is about 2.3 million tonnes comprising the large, medium and small paper mills. The overall capacity utilization reached its peak in 1976 at 77.4% but since then it has drastically declined to about 60% in 1984. The reasons of lower capacity utilization are many but mainly due to scarcity of suitable raw material, obsolete technology, high cost of chemicals and non-availability of power and coal. To be entirely accurate, raw materials in general are not in short supply, but conventional ones definitely are. There are plentiful suppliers of fibers but they are not suitable for economical pulping with today's available technology

The small paper mills alone contribute to about 40% of the total gross national production of paper & board. Unhindered production of these units can greatly help alleviating the prevailing paper famine in the country and have proved so in the past. Unfortunately due to various reasons many of the small paper mills are either closed or on the verge of closure and this has resulted in drastic reduction in overall capacity utilization. Functional improvement of these units would go a long way in improving the overall productivity of the industry in the country. The problem of small paper mills are more acute and it is hige time that these mills make all out efforts to eliminate existing bottle necks to save it from a greater disaster. The task is up-hill but nevertheless technological developments hold promise for the future.

An understanding of the plight of small paper mills reveals that some of the major problems faced by these units are :

a) Availability of suitable fibrous raw material.

b) Old machineries and obsolete technology,

c) Limited financial resources and lack of infrastural facilities,

d) Lower production rate and higher cost of production due to higher cost of chemicals, power and utilities.

e) Increased production cost due to lack of chemical recovery, and

f) Liabilities of environmental protection.

Conventional forest based raw materials are costly, being short in supply. The small paper mills with limited resources cannot afford uninterrupted procurement of such items. Suitable and cheaper substitutes are therefore essential. Cost of conventional cooking chemicals, power and utilities have gone up so high that it has become almost impossible for the small paper mills to manufacture suitable quality pulp economically and stand in the competition with large

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mills. The smaller size of these units does not permit economically viable chemical recovery plant which adds to higher production cost. Further the cost of effluent treatment is comparatively higher for small paper mills due to higher BOD and COD load in absence of chemical recovery.

ALTERNATE RAW MATERIAL

India is one of the largest producers of sugar cane growing around 140 million tonnes of sugar cane every year which if utilised fully would yield around 42 million tonnes of bagasse or capable of supporting a production of 7-8 million tonnes of paper annually an amount more than five times the annual consumption. India also produces vast amount of cereal straws which is at present partially used by the paper industry. The raw material crisis of the small paper mills can be overcome through utilisation of cereal straws and bagasse in greater proportions. The problem of using these agricultural residues lies in the fact of the inferior quality of the products. Therefore the challenge ahead is development aud commercialization of new pulping technology so as to improve the pulp quality. Profitability of small paper mills is another burning problem. One alternative as regards profitability improvement is adaptation of alternative pulping process having the following features :

a) Use of unconventional and cheaper cooking chemicals,

b) Less energy intensive process,

c) Less chemical recovery cost,

d) Less polluting process.

ALTERNATE PULPING APPROACH

Development of alternative pulping technology has been pursued for a long time and some of the recent developments look promising. Organosolv pulping is an option that was proposed several decades ago[1]. Most of the pulished work of organosolv pulping are based on wood and little work has been reported on agricultural residues. However, the same is applicable to agricultural residues & grasses.

A number of alcohol : water mixtures as pulping agents[2] were tried and it was found that n-butyl and n-amyl alcohol produced a pulp of lower lignin content and higher yield that did ethyl or methyl alcohol. Addition of smaller amount of mineral acid increased the rate of delignification. Improvement in carbohydrate yield can be obtained by using magnesium salts [3] as a catalyst in ethanol-water pulping. Organosolv pulping has also been studied in alkaline conditions. The major drawback of alkaline organosolv pulping is that a chemical recovery system is required for the alkali. The alcohol pulping and recovery (APR) process, which was patented [4] is one of the few organosolv pulping technologies that has advanced the issue of alcohol recovery and by-products handling. In addition to environmental advantage of being sulfur free, the APR process has a cost advantage over conventional pulping mainly as a result of a much less costly recovery system. The significant advantages[5] over kraft pulping are :

a) 45% lower capital cost.

b) 35% lower manufacturing cost

c) Minimal pollution and opportunity to make more valuable use of by-products.

Although the a queous ethanol pulping is being considered for commercial exploitation[6] in developed countries, energy requirements for ethanol recovery and the need for by-product utilization may limit its development in our country.

ACETIC ACID PULPING

Acetic acid offers a good promise as a pulping agent It has been known for a long time to be a good lignin solvent, however few published data is available on it. 72% of the lignin can be extracted from wood chips after 30 hours of cooking. Delignification is much more effective and the time can be reduced to 2-5 hours when wood chips or cereal straws are continuously extracted with 95% acetic acid containing 0.1% HCl at 110°C[7].Pine wood needs the highest and cereal straws the lowest amount of acetic acid. The spent liquor can be evaporated in vacuum and the residual syrups poured in water.. Thereafter the precipitated lignin can be easily filtered off, while the hemicelluloses remain in filtrate. Pulps with good strength properties from hardwoods and softwoods were obtained by using a solution of 85–96% acetic acid at a temperature in the range 150–205°C for 2–5 hours[8]. Water content in excess of 15% of cooking liquor reduces pulp yield as a result of polysaccharide hydrolysis and slowed delignification process. For every reaction temperature and liquor composition, there exists a optimum cooking time. Aqueous acetic acid pulping of softwoods prove characteristically difficult. The process may prove economical for pulping of agricultural residues particularly bagasse and cereal straws as they need low amout of acetic acid for pulping. The acetosolv lignin obtained in pure form as a byproduct is convenient adhesive material. Similarly the hemicellulose fraction which is rich in pentosan can be used to provide furfural in large quantities. In the recent past pulping with acetic acid is gaining importance for pulping hardwoods and annual plants.

For any economically viable pulping process it is important to recover the cooking chemicals. A number of possible methods are available for recovery of acetic acid e.g. distillation and liquid/liquid extraction liquids/liquid extraction with ethyl acetate offers a most viable method to recover acetic acid from aqueous solutions. It has a hign distribution coefficient and will thus strip acetic acid with ease. It can also be produced at the mill site from acetic acid and ethanol. A computer model for acetic acid pulping and recovery is under develapment at the University of Wisconsin. Other obvious advantages [8] of this process are :

- The pulping chemical, acetic acid can be recovered by distillation or extraction.
- Loss of acetic acid is compensated by the acetyl groups in wood.
- The evaporation energy of acetic acid is one fifth that of water.
- No pressure vessels are needed.
- Lignin and hemicelluloses can be recovered in pure form.
- Washing of agricultural residue pulp is easy.
- Satisfactory pulp in the yield 50–60% can be obtained.

Pulping of Agricultural residues : Preliminary studies were carried out on acetic acid pulping of rice straw and whole bagasse using 95% acetic acid. Straw to liquor ratio was 1:6 and it was cooked at 140°, 150° and 160°C respectively. Yields obtained range from 45–55%. Bagasse gave pulps with higher yields and high kappa number, showing that it is characteristically more difficult to delignify bagasse than rice straw.

TABLE-I

Species	Tamp. °C	Yield (%)	Kappa No.	Screen rejects, % %	Tear Index (m N. m²/g)	Tensile Index (N.m/g)	Burst Index (kPam²/g)
Rice straw	140	43.5	53.9	2 25			
	150	46.5	53.0	0.5	2.0	35 0	1.2
	160	47 0	—	0.9			
Bagasse	140	53.5	80 0	0.6			
	150	54.7	82 0	0.4	2 5	36.0	1.4
	160	46.5	45.0	0.4			

Cooked with Acetic acid (95%) for 2.5 hrs.
Strength Properties at 180 ml CSF.

Rice straw pulp yield does not change appreciably with temperature, however kappa number decrease with temperature increase. Strength properties obtained for both rice straw and bagasse is satisfactory. The initial freeness of the pulps are high which can facilitate their easy washability and the pulp can be refined to desireble strength properties. No foaming tendency was encountered during washing as observed in soda pulping of agricultural residues.

In another set of experiments, pulping of rice straw was carried out under milder conditions of time, temp. and acetic acid concentration (50%). Results obtained are compared with chemical pulp prepared by usiug 8% sodium hydroxide at 150° C. Pulp yield obtained is 45% which is about the same as obtained with high acetic acid concentration, kappa number is marginally higher.

TABLE—II

Rice straw	Temp °C	Yield (%)	Kappa No.	Viscosity cm^3/g	Tear Index ($mN. m^2/g$)	Tensile Index (N.m/g)	Burst Index ($K.Pam^2/g$)
Chemical pulp	150	47.0	65.0	712	4.9	32.0	1.6
Acetic acid pulp	130	47.3	64.0	808	3.5	31 0	1,1

Chemical pulp — 8% NaOH,
Acetic acid — 50%
Strength properties — at 150 ml CSF.

Pulp viscosity and strength properties are satisfactory and comparable with the chemical pulp.

Bleaching : Acetic acid pulps respond favourably to bleaching and application of two stage hypochlorite (15%) give a brightness of 68% at less than 5% bleach loss.

CONCLUSION

Acetic acid pulping of agricultural residues offers a good promise as an alternate pulping method. Pulps with satisfactory strength properties in the yield 47–55% are obtained from bagasse and rice straw, and the bleaching response is good. A number of possible routes are available for easy recovery of acetic acid from waste streams. By-products like lignin and hemicellulose are obtained in pure form and can be used as a useful source of chemical feed stock.

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