Agricultural Residues—A Neglected Raw Material

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Analysing the problems of the under-developed countries of the world, the writer feels that fullest and in all ways utilization of the agricultural resources is one of the solutions. Agricultural residues or waste—straw, bagasse, grass, jute sticks, etc., have high potentials in pulp industry. Due to selective action in pulping, the neutral sulphite process with bases sodium, magnesium and ammonium for pulping of these agricultural residues are discussed and advantages of ammonium base process are mentioned. A flow sheet of a pulp plant based on ammonium neutral sulphite process which evaporates and dries the liquor is presented. Equipment cost, manufacturing and financial return for a 50 tpd unit is given. Bagasse pulping by pre-hydrolysing before sulphate cooking and its economic aspects have been dealt with. For the production of newsprint and other cheap grade papers from jute sticks, preservation of natural colour of the raw material have been discussed.

INTRODUCTION

Analyses of the problems which confront the underdeveloped countries of the world reveal the following as common denominators:

They are :

1) How to increase the agricultural production to feed the growing population?
2) How to industrialize the country using indigenous resources and raw material?
3) How to find alternative employment (to agriculture) for rural population?

Consequently, any solution to the stagnant, often declining economic situation of these countries must aim to attack most of the above problems.

In order to find a solution which takes into account the above-mentioned problems, one can set up a hypothetical industrial project which serves the following conditions:

1) It produces something which agriculture can use to increase its yield.
2) It uses agricultural waste as raw material, thus contributing towards higher income for agriculture.
3) It is situated in an agricultural district and brings jobs to unemployed or underemployed rural population, and doing so effectively reduces the uncontrolled movement of population to towns and cities.

In an attempt to find out such an industry which fulfils the conditions mentioned above, many process industries have been studied. Investigations show that pulp industry, which normally uses wood as the main raw material, has many of the potentials and can, after some modification, claim to satisfy most of the conditions.

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The pulp and paper industry in the developed countries are operating large and integrated units for bulk production of commodities. This is possible for the high market demand for papers like newsprint, kraftliner, corrugating, etc., and also high paper consumption of each special grade of paper. For the developing countries the problems posed are rather different.

1) The market for one particular type is not big.

2) A mill unit must be geared to produce as many types of paper as demanded by the market.

3) Raw material collection and transport is difficult and ineffective due to undeveloped infrastructure.

4) Capital, organisation, and technical skill are not readily available.

5) Transplantation of advanced technology from the developed countries has shown that their potential capacities cannot be utilized fully viz capital tends to be higher in undeveloped countries.

6) High capital cost makes financing difficult, and tends to set high productive capacity for feasible economic unit.

7) Costs of all chemicals are high, compared to industrially developed countries.

AGRICULTURAL WASTE AS A SOURCE OF PULP

Pulping of straw, bagasse, grasses etc. is well known. Holland is the foremost country in pulping straw. The most common processes in Holland are Kraft, Soda, and Neutral Sulphite.

Bagasse is used in the U. S. A., Mexico, Cuba and India as source of pulp. Process used is mostly soda or kraft. Esparto has been pulped in England, France and Spain by soda process.

FAO's book "Raw Material for More Paper" adequately points out the suitability of straw and bagasse as a pulping raw material and also indicates the various uses of pulp.

Numerous discussions with regard to bagasse utilization have shown that main problems of releasing the bagasse is tied up with guaranteed supply of alternative fuel (coal or fuel oil) to the sugar mill. The latest view, adopted by the industry, is to bypass this simple transport and organizational obstacle by switching over to other raw material like eucalyptus etc.

But this is no solution. Extraction of wood from forest, transport to mill, debarking, etc., cost money and place additional strain on transport and organization. From national standpoint impetus to utilisation of bagasse and jute sticks is urgently needed, as it will give additional support to sugar industry and jute cultivators. It is undoubtedly a shear wastage to continue to burn bagasse and the jute sticks, and at the same time to plant eucalyptus for paper production. Amount of bagasse available is 3 million tons per year and jute sticks 3-4 million tons per year.

SUITABILITY OF NEUTRAL SULPHITE PROCESS

All fibrous raw materials respond to neutral sulphite pulping, but hardwoods, straw, grass and bagasse are preferred due to their low lignin content.

Neutral Sulphite process is particularly suitable for fibrous raw material with high hemicellulose and low lignin content. It therefore gives higher yield than Soda, Kraft, Sulphite and Bi-sulphite due to preferential dissolution of lignin. The hemicellulose left in the pulp is an advantage for paper making both in the bleached and unbleached state. The hemicellulose content also renders use of this pulp as raw material for glassine and grease proof.

Neutral sulphite pulping is a well established process. Most common method is to use buffered sodium sulphite and no recovery of chemicals. With increased restriction on discharge of polluting effluent new mills are built with recovery section or incineration plants or cross recovery.

The most common base is sodium However, the recovery system for sodium is extremely complicated, and the process requires elaborate machinery. Numerous pilot plants and other recovery systems have been built but success can be termed as limited.

One of the successful system of Neutral Sulphite waste liquor treatment is evaporation of the liquor followed by incineration (Copeland & Dorr System). The process converts the inorganic salts to sodium sulphate and burns off the organics. Generally the organic matter cannot support combustion and requires addition of fuel oil for complete combustion. Tampella recovery system is now established. The very reason why sodium base is so widely used is its cheapness and availability in large quantities as a by-product of other chemical industry.

Moreover, caustic soda is cheap chemical in the industrially developed countries, where caustic soda is sometimes regarded as a by-product, while chlorine is the main product in the electrolysis of salt. Power cost is considerably higher in industrially backward countries.

Magnesium can be used as a base, although the process is not yet practised in industrial scale. The recovery process is simpler than sodium, although equipment required is quite elaborate and expensive. The process is covered by patents, and considerable amount of license-fee and royalty is charged.

AMMONIA AS BASE IN NEUTRAL SULPHITE PROCESS

Ammonium base acid sulphite pulping is widely practised in Europe and North America. Total Sulphite Mill in Norway was the first mill, Alaska Pipe in the

USA. Jossefore in Sweden are only a few examples. Biggest fluting mill in Europe (Finland) uses ammonium base.

Ammonium neutral sulphite method is practised in limited number of plants and has been found satisfactory. The price of ammonia as base is less than that of sodium but a little more than magnesium on equivalent bases. For this reason, there is a growing interest in ammonium neutral sulphite pulping even in Europe and America. In a number of sulphite mills in the world it pays to use ammonia as base and burn the liquor (no recovery of ammonia) despite its moderately high chemical cost.

The ammonium base waste liquor can be used to produce valuable by-products. Toten Mill in Norway recovers its waste liquor and after de-hydration markets it as tanning chemical. Crown Zellerbach's mills in the U.S.A. sell the dehydrated ammonium sulphite liquor as fertilizer/soil conditioner under the trade name Orzan A. While India requires enormous quantities of fertilizer, use of evaporated ANS waste liquor would be an ideal solution.

Simplified flow diagram of Ammonium sulphite pulping is shown in **Fig. 1.**

The advantages of the Ammonium Base process are :

1) The waste liquor can be dried and sold to agriculture at the same price as that of ammonium sulphate per nitrogen equivalent.
2) Compared to conventional sulphate or soda process (which is the only process that can use all raw material) neutral sulphate has higher yield, lower chemical consumption and low capital cost.
3) The pulping plant is less complicated in absence of regeneration system.
4) From national economic point of view, the chemicals, i.e. ammonia and sulphur are used twice, as pulp mill only borrows it — does not consume it.
5) Ammonia-base with dehydration of waste liquor is cheaper when compared with magnesium base with regeneration.

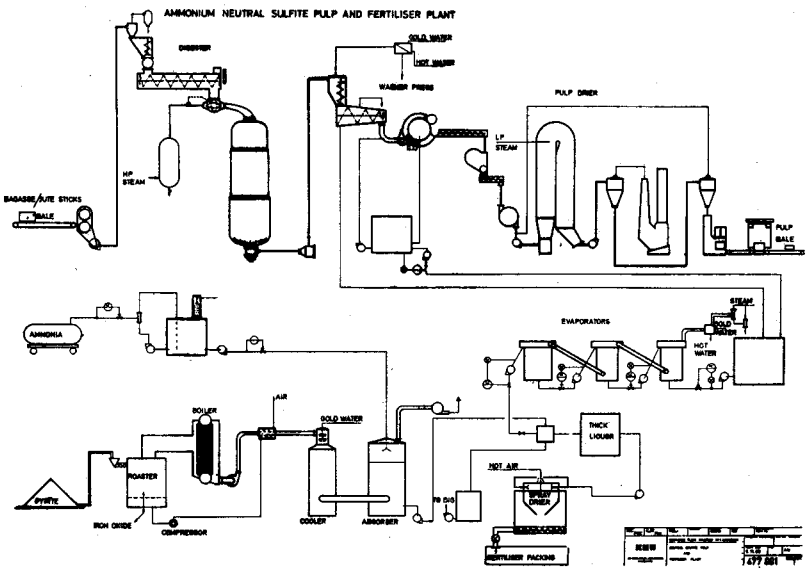


Fig. 1. Simplified flow diagram of Ammonium sulphite pulping.

BAGASSE.

Due to seasonal cultivation, bagasse is available directly from the sugar mill during a period of 120 days/year. One big sugar mill or a group of sugar mills with a total daily crushing capacity of approximately 2200 t/d is sufficient for a 50 t/d pulping unit based on ANS process. Mill capacity need not be very big for an economic unit. Details of estimated capital cost and operating cost are shown in **Appendix 1, 2, and 3.**

Lately there is a growing interest to prehydrolyse bagasse before sulphate cook. While prehydrolysis of bagasse will give furfural, a combined furfural and pulp can be conceived. Both the pre-hydrolysis stage and sulphate cook can be performed in one unit by utilizing a continuous tower of Kamyr type with some modification. **Figure 2** shows a block flow diagram of an inte-

Appendix 1. Capital cost estimate for A 50 AD T/D Ammonium Neutral sulphite pulp mill with waste liquor dehydration plant — raw material bagasse

Equipment Cost	Estimated Cost
Department	Indian Rs
Raw Material Handling & Preparation	1,200,000
Continuous Digester	2,800,000
Refining, Washing & Screening	2,100,000
Pulp Drying & Baling	2,300,000
Liquor Evaporation	1,500,000
Spray Drier & Packing	1,500,000
Steam & Power Plant	1,000,000
Cooking Liquor Preparation	1,500,000
Services and Utilities	2,000,000
Total Machinery & Equipment	15,900,000
Construction & Engineering	2,500,000
Building & Site	2,000,000
Total Plant Investment	20,400,000
Working Capital	3,000,000
Total Capital Cost	23,400,000

grated sugar mill, which utilizes all its byproduct viz. bagasse, pith, and molasses.

One ton of b.d. bagasse (containing 25% pith and 75% fibre) gives 100 kgs of furfural. Sales prices of furfural approx 1500 Rs/ton i.e. 150 Rs/ton bagasse. The hydrolysed residue gives 300 kgs of unbleached sulphate pulp of high quality. In other words, contribution of 210 Rs/t bagasse (unbleached pulp 700 Rs/ton). Total value of product from one ton bagasse is therefore 360 Rs, whereas the fuel value is hardly above 30 Rs/t.

Every kilogram of hexose fermented under proper condition gives 0.5 kg yeast. Sale value of yeast in bulk is therefore approximately 175 Rs per ton sugar, based on a price of 1 Rs/kg yeast. While there is a severe scarcity of high protein food in India, particularly containing most of the major amino acids, efforts to utilize molasses for this purpose should be urgently stressed.

JUTE STICKS

The best utilization of jute sticks would be in production of newsprint and other cheap grade of paper, if the natural colour of the material can be preserved. The The natural colour of jute sticks is white. It is liable to fungial and white ant attacks, which makes dark spots within a short period. It is well known that under water storage or pretreatment hinders discolouration for most types of wood. Khulna newsprint mill in E. Pakistan utilizes under water stored 'Sunderi' for ground wood and sodium sulphite impregnated 'Sunderi' for chemiground wood. Similar treatment with jute sticks at the collection points followed by baling and compacting would open up new possibilities for utilization of jute sticks. Jute stick pulp shows remarkably high wet strength, one of the most essential factors for high speed operation of a paper machine. Modern paper machine with KMW UNI press would enable jute stick

Appendix 2 Manufacturing cost estimate

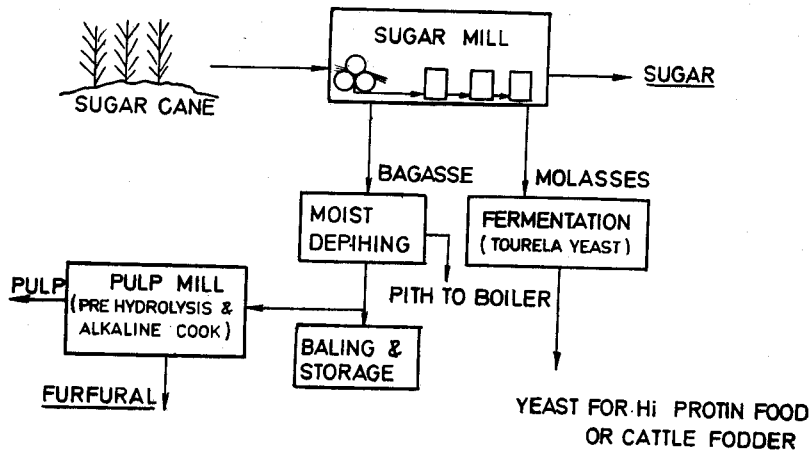
Output and Operating Requirements :
Per ton AD Pulp

Item	Unit	Unit price Rs/ton	Amount
Fibrous Raw Material (Partially depithed, in bales)	1400 kgs	72	100
Chemicals :			
Ammonia	75 kgs	1700	128
Pyrite	200 kgs	170	34
Fuel (Coal)		40	90
Power	400 kwh/t.p.	0.05/kwh	20
Labour	10 man hr/t.p.	(5 Rs/man hr)	50
Supervision			10
		Rs	432

Total Annual Manufacturing Cost, based on 300 operating days per year, (50 x 300 x 432) = Rs. 6,480,000.

Appendix 3 Gross Earning Estimate

Item		
Annual Production Pulp		15,000 A.D. tons
Fertilizer (10% N)		9,000 B.D. tons
Mill Net Sales Price Pulp		700 Rs/t.
Net Sales Price — Fertilizer (10% N)		150 Rs/t.
Annual Net Sales Pulp	Rs 10,500,000	
Fertilizer	Rs 1,350,000	
Total Net Sales	Rs 11,850,000	
Annual Manufacturing Cost	Rs 6,480,000	
Annual Gross Profit	Rs 5,370,000	
Total Capital Investment	Rs 23,400,000	
Interest during Construction	Rs 2,600,000	
Total	Rs 26,000,000	
Gross return before Interest, Depreciation and Taxes		20.7%



BY-PRODUCT UTILIZATION OF A CANE SUGAR MILL

Fig. 2. Block flow diagram of By-product utilization of a cane sugar mill.

stock to have some runnability as any other slow stock furnish. The resultant paper would have low opacity, a factor which Indian newsprint readers will have to get used to.

CLOSING REMARK

As an equipment manufacturer for pulp and paper industry we have made considerable efforts in designing suitable equipment for jute sticks and bagasse. We are proud to be the major equipment supplier to IPP, who so creditably pioneered jute stick bisulphite pulp. There is considerable potential in jute sticks when the major hurdle of collection, transport and storage problems is solved.

I wish to express my thanks to the management of KMW for allowing me to present this paper.

Presented by P. B. Chaudhuri at the International Seminar of IPPTA, held at New Delhi, December 3—5, 1969.

boards, corrugating medium etc. Literature survey revealed that very little work has been published on high yield kraft pulping of bamboo chips. Few years ago a research programme on high yield kraft pulping of bamboo chips was initiated at the West Coast Paper Mills Ltd., and as a part of this programme Jauhari etal (5) prepared high yield kraft pulps from

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length. If the results for the tear factor are compared at any breaking length, the tear factor was found to be highest at 54 percent yield.

Bleaching of the pulps of 52, 54, 57 and 59 percent pulp yield was carried out using the sequence chlorination — chlorination + lime neutralization—alkali extraction—hypochlorite. Bleached yields were not found to vary much, though the consumption of the bleaching chemicals was different at different yields. For bleachable pulps the optimum degree of cooking, as determined from the kappa number seems to be 34, corresponding to the unbleached pulp yield of 54 percent. Under the conditions used the strength properties of the bleached pulps were found to be dependent on unbleached pulp yield.

Bambusa arundinacea and found that pulps in 60-62 per cent yield with satisfactory strength properties could be obtained. The pulps were easily bleached by the C/E/C. $Ca(oH)_2$/H sequence to 76-78 per cent brightness. However, the bleach requirement and bleaching losses were high. The present study is also a part of the said research programme and was carried out chiefly. for the bleachable varieties of pulps, through the studies on lignin-holocellulose relationship at varying unbleached pulp yields bleach consumption, bleached yields and the over all economics.