Biogas Generation From Bagasse Black Liquor by Anitron System

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ABSTRACT

Mini-paper mills pulping bagasse do not have chemical recovery operations and the black liquor discarded as an effluent is the single major source of pollutant released by the mill. A typical 30 TPD paper mill will release BOD load equivalent to 100 TPD mill equipped with chemical recovery facilities. This also represents a significant recurring loss of alkali used for pulping and loss of thermal energy potential of the dissolved organics. Currently, there are several issues pending to be resolved to establish the techno-economic viability of adopting emerging developments in pulping/chemical recovery for mini mills.

The regulatory stipulations have made it mandatory to curtail the load of pollutants and regulate the quality of effluents finally discharged by the mills The high concentration of organic compounds in the paper mill effluents are effectively handled by stream segregation and adopting energy efficient anaerobic-aerobic treatment sequences to achieve the desired effluent quality A typical case is considered to illustrate the potentials for energy recovery from black liquor by enaerobic treatment using ANITRON system based on extensive research and development efforts towards a viable scheme for handling mini-paper mill effluents.

INTRODUCTION

Bagasse is now well established universally as a valuable fibrous raw material for making paper and is utilised on a large scale as well as for operating small and miniscale mills. This paper is concerned mainly with the latter category of bagasse based Paper mills. Soda pulping is adopted by this sector for producting various grades of paper and boards.

Recovery of caustic soda from black liquor for reuse in pulping is generally regarded as an uneconomical proposition and has not been seriously considered by mini-paper mills using bagasse or straws. There are several apprehensions impeding a proper appraisal of the techno-economic viability of a chemical recovery system. Some issues pending to be resolved relevant to bagasse pulp production are listed below.

(1) Optimum size of the mill for an economical conventional chemical recovery system is advocated to be above 50 TPD and hence not favourable for mini-mill operations.

(2) Black liquor from bagasse pulp mill operations tends to be rather dilute due to higher digester bath ratio for uniform cook, direct steam injection for digester heating and higher dilution factor during washing of the slow draining black liquor pulp.

(3) Rapid increase in viscosity of bagasse black liquor would tend to limit the maximum concentration of strong black liquor in conventional evaporators to about 35%.

(4) Silica in bagasse black liquor would adversely affect the evaporation rate as well as combustion efficiency and causticizing efficiency.

(5) The quantity of lime mud produced will be small for an efficient reburning system.

(6) The low energy potential of black liquor solids would require auxiliary fuel for operating a conventional recovery boiler.

Thus, direct adoption of a scaled down version of a conventional three-stage recovery system with multiple effect evaporation, recovery boiler and recausticization for the regeneration of caustic by mini-paper mills would tend to be rather elaborate and not econo-

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mical. An alternative strategy seeks to be adopt emerging developments for handling bagasse/straw black liquors. The development of an appropriate technology and base-line to establish the techno-economic viability of new routes such as 'DARS' would entail significant efforts and resources.

Consequently, black liquor is presently discarded as an effluent combined with wastewaters from other operations in the paper mill. Weak black liquor representing only 15–25% of the total flow contributes substantially (70–80%) to the pollution load released by the mill. Weak black liquor contains an appreciable concentration of carbohydrates resulting from the degradation of pentosan in bagasse during pulping. The degraded polysaccharides will contribute mainly to the biological oxygen demand (BOD) while the dissolved lignins regarded as bio-refractory are responsible for the persistent chemical oxygen demand (COD) and residual colour. The effluents from bleach plant operations from a typical chlorination—extraction—hypochlorite sequence also contain a higher proportion of degraded carbohydrates besides oxidatively degraded dissolved lignin fragments. A conventional treatment scheme currently adopted involves primary treatment for the removal of fiber and other suspended matter and secondary biological treatment by activated sludge process or aerated lagoons to reduce the BOD levels. It has been estimated that the pollution load of a 30 TPD bagasse paper mill making printing/writing grade of paper will be equivalent to the BOD released by a large mill of 100 TPD capacity equipped with chemical recovery facility.

The characteristics of bagasse black liquor from small/mini-scale paper mills shows a wide range owing to varying mill practies. BOD 5000–12000 mg/l, COD 15000-36000 mg/l. The high concentration of biodegradable constituents in bagasse black liquor suggests consideration of emerging anaerobic biotechnology processes for the recovery of the biochemical energy potential as biogas. Anaerobiosis should enable utilisation of degraded polysaccharides and other organic matter as substrates for methanogenesis and conversion to methane.

ANITRON BIOGAS GENERATION SYSTEM

The anaerobic decomposition of organics is an exceedingly complex phenomenon involving a variety of anaerobic and facultative bacteria for the bio-conversions. Generally, anaerobic stabilisation is regarded as a three-stage process comprised of Hydrolysis, Acidogenesis and Methanogenesis reactions. During hydrolysis polysaccharides and other complex organics are converted by extra-cellular enzymes to simple molecules amenable to acidogenic bacterial action and transformed to volatile fatty acids such as acetic, propionic and butyric acids. The latter are finally converted by methanogenic bacteria to yield methane and carbon dioxide. The biochemical energy potential is substantially recovered (85–90%) as biogas and the balance utilised in cell production as well as dissipated as work energy.

The active biomass solids produced during the anaerobic reactions must be retained in the system to achieve high treatment efficiency. A significant advance of environmental biotechnology is the recognition of the concepts of solids retention time (SRT) and hydraulic retention time (HRT) which together determine process efficiency. SRT is the fundamental design parameter controlling process stability and sludge production while HRT controls equipment sizes. The segregation of the roles of SRT and HRT during bioreactor operation have led to a number of competitive proprietory reactor configurations with high SRT and low HRT to give compact equipment. The DORR OLIVER ANITRON system utilises a hydraulically fluidised bed of media for promoting a higher concentration of biomass solids in the system.

The fluidised state of the media provides a vast surface area for microbial growth as a fixed film leading to the development of a high biomass concentration (SRT). Some of the salient features of this system are listed below :

- Provision of high SRT with minimal HRT in the ANITRON system significantly reduces the ractor volume compared to other suspended and fixed film bioreactor configurations.
- High biomass concentration gives high efficiency of the bio-conversion processes.
- Produce low amounts of excess bio-mass.
- Reactor is vertical and requires much less floor space.

- System exhibits excellent process stability and can withstand high organic/hydraulic loading variations. It also has the unique ability to recover after shocks and adopt to changes in influent characteristics.

- Energy requirements are substantially lower compared to conventional aerobic treatment processes and can achieve significant energy savings in a total treatment scheme combining anaerobic and aerobic treatment stage.

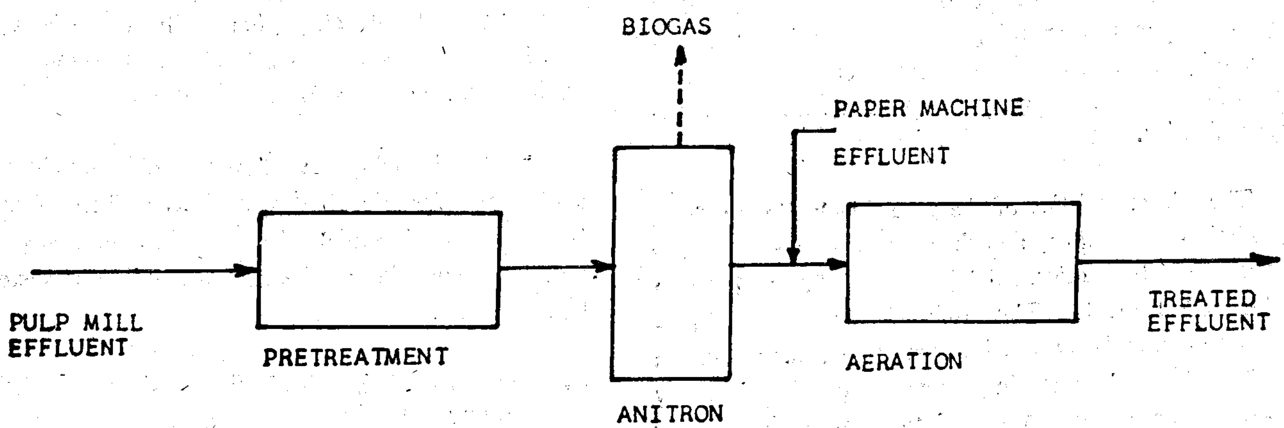
- ANITRON reactors can be designed for operation as single phase units combining acidification and methanation as well as for two-phase operation with two reactors in series.

- Other benefits of the system include savings in nutrient demande.

TYPICAL EXAMPLE

Several full scale plants are in operation in Europe and North America for both anaerobic (ANITRON) and aerobic treatment (OXITRON) of industrial wastewaters based on fluidised bed processes. A rational design basis for a fluidised bed system can be formulated by combining the hydraulic model for fluidisation of the media with a model for biofilm growth kinetics. In addition, treatability studies for specific wastewaters would also give a base-line for process design of commercial size plants. The proposed scheme for biogas generation by ANITRON system handling bagasse or straw black liquors is the outcome of extensive research and development efforts towards a viable scheme for handling mini-paper mill effluents. A large number of effluent samples from bagasse/straw based paper mills were used for developing the base-line data and for scale-up criteria.

The pulp mill effluent can be treated anaerobically to recover biogas and subsequently combined with paper machine effluent for further aerobic treatment. A block diagram of a treatment scheme suitable for mini-paper mill effluents is shown in Figure 1. The combined anaerobic-aerobic treatment scheme has several techno-economical benefits compared to conventional schemes. A summary listing these benefits is given in Table 1.



(ANITRON ™ : ANEROBIC FLUIDISED BED BIOREACTOR)

FIGURE 1 : ANAEROBIC—AEROBIC TREATMENT SCHEME FOR EFFLUENTS FROM MINI—PAPER MILLS.

TABLE 1
RELATIVE TECHNO-ECONOMIC BENEFITS OF ANAEROBIC TREATMENT OF MINI PAPER MILL EFFLUENTS

Mill capcity	: 25 TPD pulp production	
RELATIVE PERFORMANCE		
Parameters	Conventional Aeration	Anitron-* Aeration
Power consumption	100	40—50
Nutrients	100	50—60
Excess sludge	100	25—30
Area	100	40—45
Energy recovery	Nil	Biogas
Anaerobic treatment	: Single stage	
Aerobic treatment	: Single stage	
Over-all BOD removal, percent	: 95—97	
Biogas yield, M^3		
Methane/KG BOD	: 0.32—0.35	
Methane content, percent	: 70—75	
Calorific value, KCAL/M^3	: 6250 (70%CH_4)	
Equivalent coal, T/D	: 7—9	
Steam potential, T/D	: 35—40	

*Performance with conventional aeration as reference.

The estimates are based on a hypothetical paper mill producing 25 TPD of straw/bagasse soda pulp, suitable for making printing and writing grade of paper. The significant tangible benefits of anaerobic treatment would offer substantial savings in operational costs of the total effluent treatment system. Thus, a liability can be effectively translated into an asset through by-product energy recovery as biogas.

SUMMARY

The paper presents an over-view of the options available for handling the weak black liquor from mini-scale bagasse paper mills. The tangible benefits of anaerobic treatment in a fluidised bed ANITRON system with energy recovery as biogas are high-lighted and compared to conventional aerobic processes.