Economy in pulping : anthraquinone

P. MATH U *

ABSTRACT

The most Prevalent Processes of Chemical Pulping are Kraft, Soda and Alkaline-Sulphite and all these processes suffer from "Peeling Reaction" which results in loss of yield and increased consumption of alkali. Anthraquinone has been found to be the most effective additive in arresting this reaction and increasing Pulp Yield, cooking rate and reducing alkali consumption, load on effluent etc. Anthraquinone can also be utilised effectively in overcoming pulping bottlenecks like Digester chip feeder limitation, Digestion capacity limitation, Recovery being organics or alkali limited. Anthraquinone is available in powder form and can be dispersed in water, cooking chemical or black liquor. It can be added in a metered way, alongwith chips to the Digester.

INDIAN PULP MAKING PRACTICES :

The most prevalent process of pulping conventional raw materials in India or the world is the Kraft Process while for non-conventional raw materials it is Soda or Alkaline-Sulphite. These processes have their own advantages and disadvantages from the point of view of Yield, Capital Costs, Pulp Properties, Environmental Impact etc.

NEED FOR ADDITIVES :

However, all these processes suffer from one particular phenomena known as "Peeling Reaction" where the Carbohydrates are dissolved causing both loss in yield and increased alkali consumption. These reactions cause dissolution of end groups of Cellulose and Hemicellulose Polymer chains, one unit at a time, and consume a significant portion of the cooking chemicals. (1)

Most of the modifications in Pulping Process have been aimed at arresting this peeling reaction by way of adding chemicals to improve yield while maintaining other advantages like Pulp Quality, Strength Properties, low cost of pulping etc.

Some additives like Sodium Borohydride, Hydrazine have been found to be effective but too expensive for commercial application. Relatively cheaper chemicals like Hydrogen Sulphide, Polysulphides addition has resulted in aggravating the problems of Odour and Air Pollution and also additional capital costs due to the need for further processing. (1)

After conducting studies with more than 300 species it was found that Non-Polar and apparently insoluble Anthraquinone (AQ) was extraordinarily effective in improving Pulping (1)

ANTHRAQUINONE (AQ) :

It is an organic compound available in powder form which can be dispersed in water, cooking chemical or black liquor. It remains stable during cooking reaction and gets burnt in Recovery Boilers without affecting the recovery operation adversely.

A very small addition (1 lb/Ton) of AQ accelerates the Kraft Process dramatically and gives a 2% to 3%

*Elof Hansson (India) Private Ltd., Calcutta.

yield increase, when added to a soda process Kraft type yields, cooking rates and pulp strength properties are possible.

It is very safe for use in Pulping and FDA of USA has given its approval for AQ use in Food Container Grade Pulps.

ECONOMICS OF AQ - PULPING :

It has been established on lab, Pilot Plant and plant scale that about 0.05% AQ addition on BD raw material positively and drastically affects the pulping results irrespective of raw material or chemical process adopted.

In order to understand and realise the multifaceted benefits of AQ Pulping let us analyse the chemical pulping process in terms of inputs & outputs and AQ impact on them.

Inputs :

The inputs in any Chemical Pulping Process are raw material to be pulped, cooking chemicals, thermal energy and time.

Raw Material :

With the addition of 0.05% AQ on raw materials the yield improves by 2 to 3% in case of Kraft Process and 3 to 8% in case of semi - Chemicals Soda or Alkaline Sulphite process resulting in reduction of raw material consumption per ton of Pulp.

Cooking Chemicals :

Because of arrest of peeling reaction with the addition of 0.05% AQ on RM the alkali consumption reduces by about 10% for the same Kappa no. This can be of significant gain in Recovery Plants which are limited in generating white liquor due to capacity limitation in Causticizing or Lime Kiln.

Rate of Cooking/Cooking Time :

It has been established that with the addition of AQ the H-factor can be reduced substantially keeping the same Kappa no. About 30% reduction in cooking time has been experienced with AQ Pulping. This can be of immense advantage when pulping capacity is to be increased immediately due to sudden spurt in pulp demand or paper machine production since additional capacity requires a time period of one to one and half years for procuring the capital equipment.

Thermal Energy :

Due to increased Pulp Production per digester the energy consumption per ton of pulp gets reduced. Though this appears to be a small contribution on per digester basis it becomes significant in the long run.

Outputs :

The outputs of a Chemical Pulping Process are Pulp, Spent Liquor etc.

The quantitative gain in pulp per ton of raw material has already been discussed. This gain becomes important when digester feeding is limited and additional feeding requires capital equipment.

So far as strength properties are concerned the AQ Pulping results in pulp comparable quality as compared to non-AQ-Pulping. The Breaking length and Burst factor are found to be marginally improved while Tear factor is marginally reduced

Moreover in case of kraft process, lower sulphidity levels can be maintained with AQ addition without affecting the pulp strength properties This becomes significant when Mills have to operate at lower sulphidity levels due to Recovery boiler shut down as pulp strength properties can be maintained with AQ addition.

Spent Liquor :

Due to increase in the yield the organics content of the spent liquor is reduced. This can be of critical advantage when the Recovery boiler is organics limited as addition of AQ increases pulp production on one hand and further allows additional pulp production due to reduced organics. It also reduces Air Pollution

In case of small mills without Recovery Boilers, AQ addition results in reduced organics load on the effluent.

Cost-Benefit Analysis :

The benefits of AQ-Pulping are both tangible and intangible in nature. For determining the tangible benefits of AQ-Pulping the following equation was developed by Dr. Pravin Goyal and Dr. N.D. Mishra. (2)

Sample Calculation for developing Cost Matrix for Economical Viability of Anthraquinone Dosage.

Basic Fquation

$$\text{Net Saving in Rs/Ton} = \frac{\text{Tons OD Chips}}{100}\left[\left|\text{Increase in Yield \%}\right|\left|\text{Raw Material Cost Rs/Ton}\right| + \left|\text{Reduction in Alkali Dosage \% ODRM}\right|\left|\text{Cost of Operation}\right|\right]\left|\text{AQ Dosage \% on Chips}\right|\left|\text{AQ Cost Rs/Ton}\right|$$

$$\text{Where Cost of Operation} = \left|\text{Cost of Recovery Rs./Ton}\right| + \left|\frac{100 - \%\ \text{Recovery}}{100}\right|\left|\text{Cost of Chemical Rs / Ton } Na_2O\right|$$

Presumed parameters

Raw Material (Bamboo) landed cost = Rs. 1400/Ton

Cost of Makeup Chemical = Rs. 5610/Ton Na_2O
(Where makeup is 70% Salt Cake, Rs. 3300/MT, 30% Caustic, Rs 11000/MT)

Approx Cost of Recovery = Rs. 3000/Ton Na_2O after correcting for steam generation.

Recovery % = 80 %

With the above costs the gross profit for 1 Ton OD Chips is as given below :

$$\text{Gross Profit in Rs} = \frac{1}{100} \text{ Y X } 1400 + \text{A } 3000 + \frac{100-80}{100} \text{ X } 5610$$

$$= 14\ Y + 41.22\ A$$

Where Y = % increase in Yield

A = % Reduction in Alkali Dosage.

By putting different values i.e. 0 5, 1 0, 1.5% etc for Y & A we get the cost Matric as below giving the Gross Profit arising out of different % gains in Yield and reduction in Alkali charge.

% Reduction in Alkali Charge

% Gain in Yield	0.5	.10	1.5	2.0	2.5
0 5	27.61	48.22	68.83	89.94	110.05
1 0	34.61	55.22	75.83	96 44	117.05
1.5	41.61	62.22	82.83	103.44	124.05
2.0	48.61	69.22	89.93	110.44	131.05
2 5	37.06	76 22	96.83	117.44	138 05

Assuming a landed cost of Rs. 130,000/Ton for Anthraquinone the cost per ton of OD Chips is Rs. 65.00 for 0.05% AQ addition on ODRM.

The values above 65.00 in above matrix show profitable level of operation. Thus the various combination of % Yield gain and % Reduction in Alkali to the right of the Dark Line show economic gains by use of AQ in pulping while loss to the left of this line.

This matric can be developed for 85%, 90% recovery levels as applicable to a particular case with correct values for various costs.

RESULTS OF PLANT SCALE OPERATIONS OF AQ PULPING :

Shreyans Paper Mills, India :

Raw Material : Wheat & Rice Straw, Bagasse,Grass etc.

Process : Soda Pulping

By addition of 0.05% AQ on BD raw material the following improvements were observed.

- Permagnate no. reduced from 15.9 to 14.4 for the same alkali addition.
- The yield increased from 51.2% to 52.8%.

Huafeng Paper Mill, China (4) :

Raw Material : Wheat Straw

Process : Soda

Addition of 0.05% AQ resulted in the following :

- NaOH consumption reduced from 16.4 to 13%.
- Cooking time reduced by 90 Minutes.
- K No. reduced from 11.0 to 9.9.
- The screened pulp yield increased from 45.9 to 51.0% and bleached pulp yield from 39 to 45.5%.
- Cl_2 in bleaching increased from 4.9 to 5.13%.
- Marginal improvement in pulp strength properties.

Jute Pulping using Alkaline Sulphite Process :

Addition of 0.5% AQ resulted in reducing the digester cycle time by 3 hrs. enabling increased pulp production.

West Coast Paper Mill, India :

This Mill is adding AQ whenever the Sulphidity level in the Kraft pracess goes below 15 due to Recovery plant shut down to maintain pulp strength properties.

La Tuque, Canada (3) :

The Mill had conducted plant scale comparison of K aft and Alkaline - Sulphite - AQ Pulping and found the following results with 0.1% AQ addition.

	AS-AQ	Kraft
Yield (%)	70	54
Kappa No.	106	80
Breaking length, KM	10.6	9.9
Burst factor, MN/Kg.	7.0	7.0
Tear Index	12.5	15.1
Stretch %	3.1	3.1
Ring Crush, N/M	1803	1540

Emami Paper Mills, India

Rice Straw Pulping using Soda Process :

The plant scale trials have shown reduction in caustic consumption from 7% to 6% on raw material and trials for longer periods are underway.

RECOMMENDATIONS FOR INTRODUCTION IN EXISTING MILLS :

As indicated earlier AQ is available in the form of powder which can either be used as it is or dispersed in water, cooking chemical etc.

For uniform distribution of AQ it is advisable to use a metering device e g. a small bin with rotary feeder over the raw material conveyor belt to digester. Otherwise it can be dispersed in a pre measured cooking chemical charge.

To realise and evaluate the impact of AQ pulping various factors like raw material consumption, pulp production,Kappa No.,cooking chemicals consumption etc. have to be properly monitored and recorded. In the absence of instrumentation in most of the Pulp Mills AQ addition

benefits can't be established with a short period trial and should be evaluated over a period of 4-6 months.

CONCLUSION :

The AQ addition has been established as an economical way of improving pulping process and reducing pulping costs. Those Mills having Soda Process can be further benefited by improvement in pulp strength properties which become comparable to Kraft process.

The AQ addition can also be used for increasing Pulp production from existing equipment, reducing load on effluents etc.

Due to its suitability to all chemical and semi chemical pulping processes and raw materials, AQ has emerged as the most effective and economical additive for bringing Economy in Pulping.

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REFERENCES :

1. Soda additive softwood pulping : A major new process By Hutch Holton, Vol. 78, No. 10 OCT. 1977, PULP AND PAPER, CANADA.
2. Use of anthraquinone in Bamboo Pulping, Dr. N. D. Misra and Dr. Pravin Goyal, PPI, NOV 1981.
3. 70% yield alkaline sulfite - anthraquinone pulp for liner board, M. Stradal, J. Perrault, O.V. Ingruber Tapp - Vol. 66, No. 10 Oct. 1983.
4. The utilisation of AQ in Straw Material Digestion-Qian Zhi - Li & Tang Zhi - Chao, Huafeng Paper Mill, China.