Competitive Environment Friendly Pulping And Bleaching Strategy

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ABSTRACT

Presently, Indian Paper Industry is witnessing a rapid progress in adopting cleaner technologies. But for many reasons, much of this effort has been focused on large size mills only. Process of pulp production generates systematic and extensive pollution while wasting large quantities of raw materials. Yet, waste can be minimised and pollution can be reduced significantly by the application of CLEANER PRODUCTION TECHNOLOGIES. Which include; conservation of fibrous raw materials, chemicals, water and energy; eliminating the use of toxic chemicals and reducing the quantity and toxicity of all emissions and wastes before they leave the pulp production stage and also enhancing the production capacities. Environmental concerns have necessitated measures to reach lower lignin content in pulp before bleaching. A lower kappa number in pulp means that the chlorinated organic matter will also be reduced in bleach plant effluent. ITC - PSPD. , Unit : Bhadrachalam , is also the leader in the application of cleaner technology in pulping and pulp bleaching. Also setting a BENCH MARK for the INDIAN PAPER INDUSTRY. It has implemented ECF technology five years ahead of legislation, and now progressed to an even more advanced Lite ECF (with ozone bleaching) technology with added capacity.

Introduction

Paper industry in India is one of the oldest core sector industries serving the nation by producing different quality of paper and paperboards, and meeting the demands from all corners of the society. The socio-economic importance of paper in the nation development is very high as it is directly related to industrial and economic growth of the country (1). At present, India is one of the fastest growing economies in the world; paper industry has its role to play. The environmental issues in the context of paper industry are getting more and more importance. This in turn, may result in closure of small and environmentally unsafe production lines. For survival and competitiveness, environmental sustainability is important. The shortest and safest route to competitiveness and profitability is having better cost-efficiency compared to that of the competition. At the same time it requires investments in removing productivity bottle - necks. In pulp production, the global trend is to strive for the economies of scale ie : by building a large production unit as possible, and using mostly plantation wood as raw material (2).

Competiveness And Environment Governance

Under the global market, the export of paper from India is minimal because of inferior quality of paper, high cost of production and non-eco-friendly approach. The cheaper paper is imported to the country at a cost lower than the cost of paper made in Indian Paper Industries, thus hampering their market. The major reason for global absence of Indian Paper Industry are the obsolete paper machinery, lack of adoption of modern technologies, large manpower and poor automation. The Indian industries use more raw materials, more energy, more waste generation, low resource recovery per unit of product compare to global industry (3). Yet, in Indian paper industry, waste can be minimized and changing pulping and bleaching processes by application of cleaner production technologies can reduce pollution significantly (4).

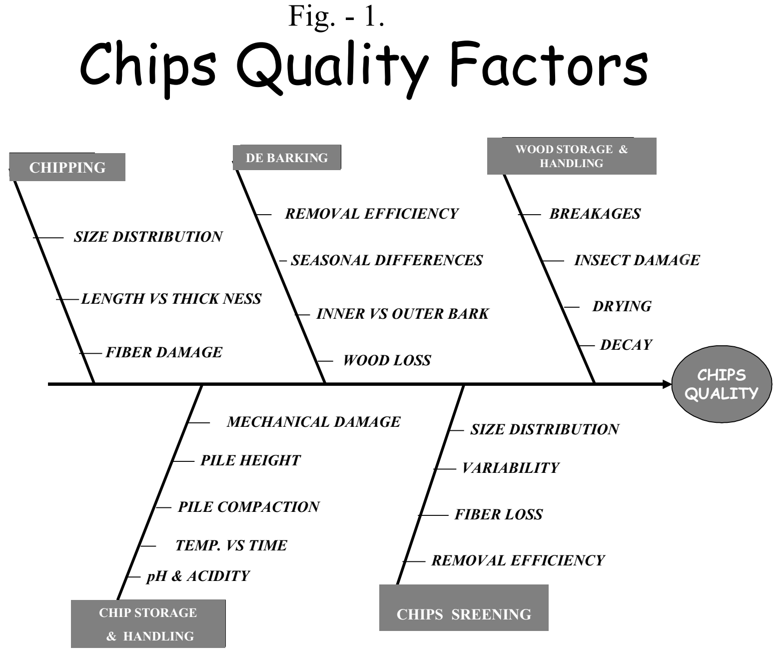
Literature Survey

Environmental regulations have driven the development of methods to maximize delignification in the pulping process prior to bleaching. Effluent flow, toxicity, and dissolved organics are thus reduced by shifting more delignification to pulping.

Chipping Of Raw Material:

The uniformity of pulp and productivity of a pulp mill are influenced by many factors, but chip quality is most important. The factors, which affect the chips quality, are shown in Fig-1.Chippers are one of the major consumers of power in a wood based paper mill. It is suggested that energy

Fig. - 1.



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efficient, high capacity, chippers be selected. Issue to be seen in achieving optimum efficiency at chipper house is the optimal feed rate. Some of the apparent problems with chipping equipment are the production of long slivers instead of chips. This can lead to blockages inside the chipper.

Drum Chipper

Among the first commercially available, and still in production today, drum chippers employ a mechanisms consisting of a large steel drum powered by a motor, usually by means of a belt. The drum is mounted parallel to the hopper and spins towards the output chute. Chippers of this type have many drawbacks include high noise and other safety issues.

Disk Chipper

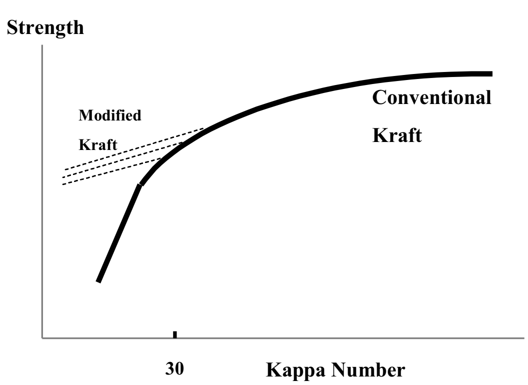
A newer chipper design employs a steel disk with knives mounted upon it as the chipping mechanism. As the disk spins, the knives cut the material into chips. These are thrown out the chute by flanges on the drum (5).

Kraft Pulping

Environmental regulations have driven the development of methods to maximize delignification in the pulping process prior to bleaching. Effluent flow, toxicity, and dissolved organics are thus reduced by shifting more delignification to pulping.The conventional kraft pulping process is well known for producing a bleachable grade pulp with superior strength characteristics at kappa numbers of 30 to 34. However, substantial strength losses occur if unbleached kappa numbers are reduced below 30.The limitations in the form of strength vs kappa number is shown in Fig-2.Conditions inherent to the conventional kraft process prevent lowering the kappa number to desired levels.

Fig. – 2.

LIMITATIONS OF CONVENTIONAL KRAFT PULPING



The Basic Disadvantages Include The Following:

* Loss in selectivity, especially at the preliminary stages of cooking, due to high concentrations of OH sup - and SH sup - ions
* Low concentration of active OH sup - and SH sup - ions at later stages of cooking, resulting in lower delignification rates
* High dissolved lignin concentration in the later part of cooking prevents further dissolution of lignin
* High temperature of the cooking process results in loss in selectivity.

Change In Kraft Pulping Process

One of the improved pulping process is Modified Continuous Cooking (MCC). In MCC, the total alkali charge has been distributed through the different stages of cooking to maintain a more even alkali profile. The improved selectivity achieved by the MCC process allows to lower the kappa number to 22 or below. Although selectivity is improved, the MCC process has a disadvantage. The high temperature of the cooking process has been identified as a major factor in contributing to significant yield losses. This is due to the fact that the preference of attack by the nucleophiles between the cellulose and lignin fractions is lowered when the temperature increases.To address this problem, further modifications have been incorporated to the MCC process to lower the cooking temperature and prolong the cooking time, still achieving the desired "H factor." The result is development of Extended MCC (EMCC) or the Isothermal Cooking Process (ITC) as designated by the Kamyr and Kvaerner systems, respectively. In MCC, pulping is carried out at 170 ºC for 120 to 186 min. as compared with 160 ºC and 270 min. in EMCC. A recent modification to EMCC includes low solids pulping developed by Kamp to minimize the buildup of dissolved lignin concentration in cooking liquor during the cook.Concurrently, the batch pulping process has gone through similar evolution. The development of the Rapid Displacement Heating (RDH) cooking process by Beloit, the SuperBatch process by Sunds Defibrator (Metso), and the EnerBatch process by Voest Alpine/Impco represent significant advancements over the conventional kraft batch pulping process. The loss in strength due to fiber damage is minimized by practicing cold blow, which means pumping out the stock from the digester after displacement of the hot spent liquor by cold washing filtrate. The cold blow is also a step toward being more environmentally friendly since it lowers gas emissions during a blow (6).

RDH (Rapid Displacement Heating) Kraft Pulping

In the operating cycle of the RDH system, the batch digester is charged with chips and packed with liquor or steam. The technique increases packing density to 10%, thereby increasing pulp production per digester. The digester is filled with warm liquor of high sulfidity (low active alkali) at 100ºC. The elevated pressure in the digester serves to uniformly impregnate the chips. The warm liquor is displaced with hot, white and black cooking liquors. The digester is heated, and the cook continues to the desired H-factor. At the end of the cook, displacement continues with washer filtrate until the pulp temperature is below boiling point. The displaced liquor is collected in an accumulator. The digester is discharged either with compressed air or by using pumping machine. Special heat exchangers are employed to preheat the white liquor for the next cook to about 155ºC. (7).

Super Batch Kraft Pulping

"Super Batch" is a cooking process based on the principles of extended delignification. This technology has been developed to reduce the chlorinated compounds in the discharge of bleach plant effluent. The "Super Batch" cooking system was originally developed to make batch cooking more energy efficient. The system has been modified to achieve extended delignification. The drawbacks of delignification have been overcome by coupling this technology with "Super Batch" cooking. This cooking cycle is shown in Fig-3. In the "Super Batch" system the chips are pre-impregnated and preheated with warm black liquor. Impregnation improves air removal from the chips. The digester will be hydraulically filled with liquor thus resulting in more uniform cooking. Impregnation is followed by displacement with hot black and white liquor which gives very uniform pulp quality, high strength, low shives content, good heat economy, higher yield and makes extended cooking with good pulp properties possible. Fig-4. shows the variation of Kappa number Vs H-factor in Super Batch pulping of eucalyptus pulp. Displacement with wash liquor at the end of cooking stops cooking reactions, cools the pulp and improves pulp washing by lowering the final black liquor solids (8).

Oxygen Delignification

Further removal of lignin present in pulp during the cooking process may be achieved with a higher alkali charge. The consequent effect is yield loss. However, Increased delignification can instead be achieved by adding an oxygen stage, which under the appropriate conditions of pressure, temperature, and alkali charge, results in higher delignification without any significant loss of pulp yield. Effect of oxygen delignification on eucalyptus pulp is shown in Fig-5. The kinetics of two-stage oxygen delignification is shown in Fig-6. Due to high selectivity of oxygen to remove lignin, this process is normally added to delignify pulp before bleaching. At this stage, the kappa number of pulp can be reduced, making possible to produce higher brightness pulp and reduce chemical consumption in the bleach plant. On the other hand, lower kappa number at the bleaching stage helps in close-up of filtrates possible, helps the implementation of new re circulations, and simultaneously reduces liquid effluent volume discharged from the bleach plant. Dezincification systems in two stages are currently designed in such a way that the first phase of the reaction occurs in first reactor, which has a shorter residence time. The second stage has a longer residence time to allow the second phase of dezincification reaction (60 min.) to be carried out. Further more, both the stages have different conditions of pressure, temperature, and alkali charge, which together contribute to maximizing the dezincification reaction selectively (9).

Pulp Bleaching

In India, most of the Paper Mills still use elemental chlorine as a bleaching chemical. In this era of strict environmental regulations, usage of elemental chlorine is frowned upon. For wood based paper mills, use of elemental chlorine does not permit compliance with the tolerance limits for total organic chlorides in the mill effluent. Hence, new plants have to consider Elemental Chlorine Free (ECF).

Fig. – 3.

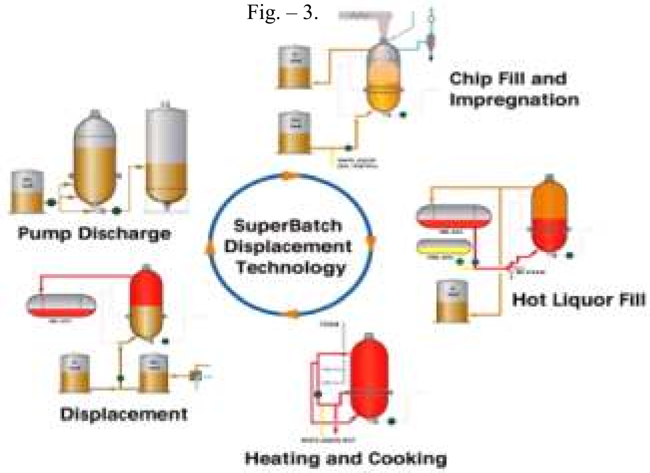


Fig. – 4.

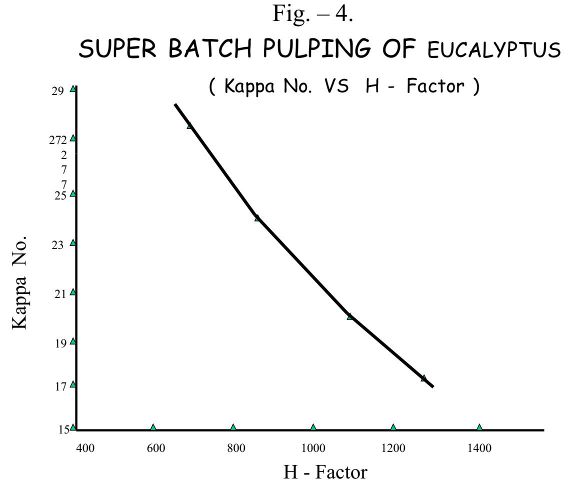


Fig. – 5.

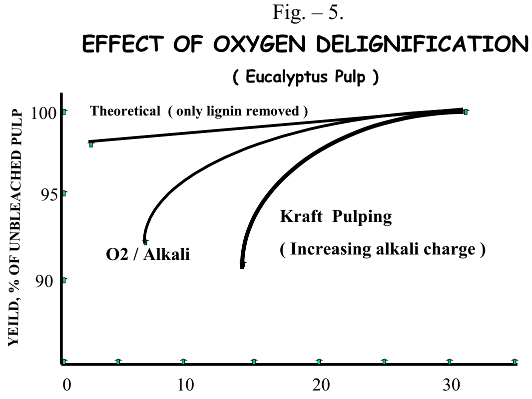
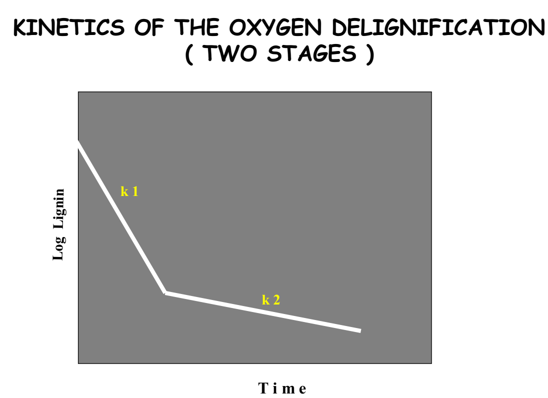


Fig. – 6.



ECF (Elemental Chlorine Free) Bleaching

Bleaching with chlorine produces large amounts of organochlorine compounds, including dioxins. Increased public awareness of environmental issues, as evidenced by the formation of organizations like Green peace and other NGO`s, influenced the pulping industry and Governments to address the release of these chemicals into the environment. Replacing some or all of the chlorine with chlorine dioxide has reduced the amount of dioxin. The use of elemental chlorine has declined significantly and ECF (elemental chlorine-free) pulping using chlorine dioxide is now the dominant technology worldwide (10).

Ozone Bleaching

Due to the fact that the ozone is a highly competitive bleaching chemical, many pulp mills in the world have chosen in their bleaching process. Properties of ozone is shown in Table-1. Reliable on-site generation of ozone and simple combination with other bleaching systems are the reasons why ozone has become an established technology. With focus on the pollution abatement and mill closure as well as trends for market driven pressure to produce Lite ECF and TCF bleached products, ozone has demonstrated its feasibility as a viable bleaching chemical alternative. Ozone as a complimentary delignifying agent after oxygen delignification and in some cases in combination with chlorine dioxide, ozone is known and conventionally applied as an efficient reagent for chemical pulp in the middle of bleaching sequence. Depending on the bleaching strategy to be implemented, different bleaching technologies are proposed to mix ozone with the pulp. High consistency ozone bleaching system represents one of the most efficient solutions. Such high consistency ozone installations have been made for both soft wood and hardwood pulps where the ozone charge varies between 2-9 Kg. ozone conc. / ADT for the different installations (11).

Competitiveness Of ITC In Cleaner Production Technology

ITC LIMITED PSPD.,UNIT: BHADRACHALAM was set up in the year 1979 on the banks of river Godavari in Andhra Pradesh. Then its production capacity was 40, 200 TPA. Today it has grown more than ten folds with a production capacity of 5,20,000 TPA paperboards, of which is 2,35,00TPA lite ECF bleached pulp .It is a leader in the World (ranking fifth position) Paper Industry and also trend setter for Indian Paper Industry. Growth and development in harmony with the environment has always been the approach of ITC Limited PSPD. This has been repeatedly demonstrated in the pulp mill modernization and expansion by adopting "Cleaner Technology". In the pursuit of international competitiveness and commitment to environmental responsibility , it had selected Elemental Chlorine Free technology while modernizing the front line. ITC's PSP Division was the first paper/board mill in India to adopt this technology. The facility was commissioned in September 2002 and well ahead of government regulations. Once again in the year 2007-08, pulp mill has been further up graded and expanded by replacing the old batch cooking technology with ***Super batch*** cooking system and a new pulp bleaching system has been added, where ,***Ozone bleaching*** has been introduced, which is more environment friendly. The modified fiber line flow sheet (with Ze-D-P) is shown in Fig-7. Since, the equipment and know how for the cleaner technology is not available in the country, dependence on costly imported equipment and knowledge was inevitable. Adoption of Best Available Technology and Best Management Practices with more environment friendly process, viz. Super Batch Pulping, Oxygen Delignification, and Elemental

Table – 1.

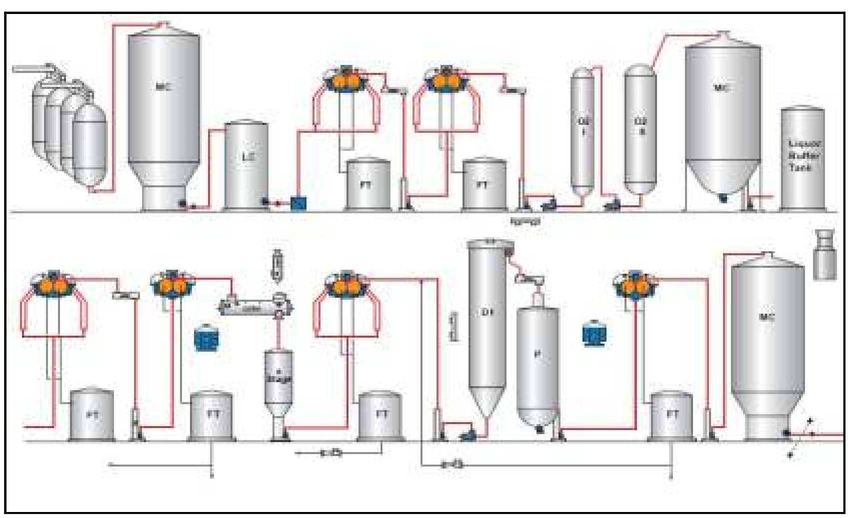
PROPERTIES OF OZONE

- Ozone is a powerful oxidising agent and hence a most potential bleaching agent.
- It is over 3000 times more powerful than chlorine in its dis infection property and over 50 times more powerful in its oxidative property.
- Ozone is an instable gas is produced nearby by the point of use from oxygen.Ozone is used under 6-13 wt %.

- Molecular weight : 47.98 g /mol.
- Liquid phase : Liquid density : 1.013
- Boiling point : - 111.3 °C
- Critical temperature: - 12.2°C
- Critical pressure : 55.73 bar (Density : 540 Kg /m³)

Fig. - 7.

FIBER LINE AT ITC-PSPD. Unit : BCM



Chlorine Free(ECF)/Ozone bleaching coupled with energy efficient process and plant & machinery, resulted in minimizing the impact on environment and produces quality product, which fetches better returns.

The Following Best Available Imported Equipment are Installed For Enhancing The Cleaner Production

- Installation of energy efficient high capacity Chippers.
- Installation of Super Batch Pulping system.
- Up gradation of ECF bleaching system to Lite- ECF bleaching system.
- Ozone generation plant
- To balance the production capacity, indigenously available best auxiliary processes equipments such as Free Falling Film Evaporators, Chemical Recovery Boiler, Lime Kiln, Utility Boiler, TG etc.,

Chippers

There were three 20 TPH each drum chippers. These chippers have been in operation for more than 25 years and have become old and obsolete. The chips were not of uniform size and resulting in poor pulp quality . In view of increased chips requirement these chippers are replaced with three Disk Chippers of each handling capacity of 1200 TPD plantation wood and to get uniform chip size with better angle of cutting to facilitated high raw material yield, better cooking and facilitates for homogeneous pulping. These **Camura** chippers incorporates the benefits of eleven different patented features. Added to this, existing high energy consuming pneumatic chip handling system has been replaced with low energy consuming belt conveyor system.

Pulping (State of the -- art "*Super Batch*" Pulping Technology)

The mill had six vertical stationery batch digesters, each of 80 m^3 capacity and two 100 m^3 capacity batch digesters. These digesters had the supporting capacity of producing 300 TPD bleached pulp. To augment the increased pulp requirement, Super Batch Pulping Technology has been adopted. The existing digester plant consists of four digesters of each having a volume of 350 m^3, two liquor accumulators, and two atmospheric tanks. The liquor feeding into the digesters is based on an idea of digester specific feed pumps. Advanced piping/pumping design has been incorporated in order to utilize the piping more effectively and decrease the number of equipment/control valves, there by making the system more cost effective, more maintenance friendly and in adoption, more flexible from the operational point of view.

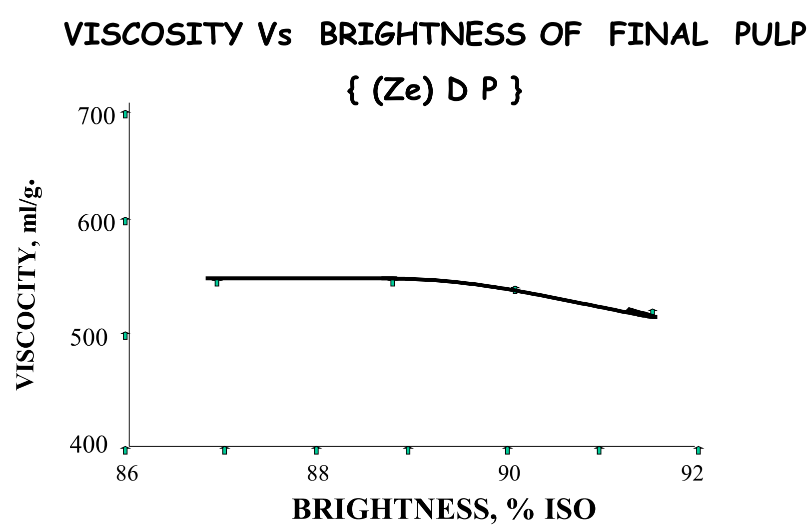
Two Stage Oxygen Delignification

Oxygen delignification is a process between cooking and bleaching sequences, where part of the residual lignin left in pulp after cooking is removed using oxygen and alkali. Oxygen delignification is a direct extension to delignification in cooking. The targeted reactions are the oxidation of lignin and breaking it down in parts which dissolve in alkali, as well as destroying the coloured groups in lignin and removal of impurities, such as resin. Delignification with oxygen is a more gentle way of reducing the kappa number, than extended cooking. In a two stage oxygen delignification, initially delignification is fast and slows down in the second stage, by this way, the pulp properties are also protected. It also lowers bleach plant effluents. Therefore oxygen delignification system is an environmental friendly and an economic investment.

Ozone Bleaching

ITC PSPD Unit Bhadrachalam, is the first mill in India to introduce the Ozone Bleaching Technology for bleaching of hard wood pulp. The ECF (Elemental Chlorine Free) technology exists in the mill since seven years. The existing Pulp mill at Unit: Bhadrachalam of ITC Limited has a design capacity of producing 800 TPD blown pulp from Super Batch cooking plant. Fiber line 1, commissioned in the year 2002 has a design capacity to process 300 TPD of bleached pulp and Fiber line - 2 , commissioned in the year 2008 has a design capacity to process 400 TPD of bleached pulp. Fiberline-1 was originally built with ECF sequence of Do EOP - D1 and is retrofitted with Ozone bleaching in year 2008. Thus present bleaching sequence is Ze D EOP - D. Fiberline-2 has a bleaching sequence of Ze - D - P. The final bleached pulp properties, Brightness Vs Viscosity is shown in Fig-8.Ozone bleaching is primarily a delignification stage, however , brightness improvement also takes place. The pulp from the post oxygen stage at a Kappa around 10-11 and brightness of 42-45% ISO is fed to a press after diluting with the back water . The backwater pH is maintained in the range of 2-3 to enhance lignin selectivity and purge out metal ions before Ozone stage. The pulp is pressed in a twin drum press to obtain a pulp consistency of 35-40%. High consistency is essential for efficient utilization of the Ozone gas. At the top of the ozone reactor, the combined shredder and fluffer feeds the pulp to the reactor. The fluffed pulp falls through the gas separator part of the reactor into the reactor conveyor tube. In the tube there is a central axially mounted shaft with a large number of paddles mounted at a specific angle. The action of the

Fig. – 8.



conveyor is to lift, disperse and convey the pulp forward to the outlet of the ozone reactor. This action leads to high degree of uniform bleaching.Ozone coming from the ozone generator is at 12% concentration in oxygen gas and is introduced counter currently of the pulp flow in the ozone reactor. In order to facilitate the gas circulation counter currently, the gas is extracted in the opposite side by fan, which helps in maintaining a light under pressure in the reactor. The off-gases from the reaction contain oxygen around 75-80% and a very small quantity of ozone about 0.5%, which needs to be eliminated prior the gas is released to the atmosphere The bleaching condition at Z stage is shown in Table 2. The un reacted ozone is destructed by heating the off gas heated to a high temperature about 300°C. in a catalytic destructor. Due to the fact that those gas also carry fibers, the fibers have to be washed away prior to gas heating to avoid the risk of fire. This is done in a fiber scrubber where gases are washed by an alkaline solution. An ozone detector is also placed to check the ozone in the ambient air and it also trips the reactor functioning.

Table – 2.

CONDITIONS (Z Stage)

- Pulp consistency % : 35 – 40
- Pulp feed : 10 – 11 Kappa (42 – 45 % Brightness)
- Temperature : 55 °C
- pH : 2.5 – 2.8
- Residence time : Less than one minute
- Reaction Pressure : W L (-50 mm)
- Ozone dosage(cons.) : 12% strength
- AOX in Effluent : 0.054 Kg / T

Ozone Generator

Ozone is also called activated oxygen containing three atoms of oxygen. Ozone generation is through silent electric discharge between two electrodes in the oxygen rich feed gas stream of 93% purity. A WEDCO ozone generator of capacity 200 Kg / Hr. ozone at 12% conc has been installed to feed the ozone to the reactor.

Conclusion

Cleaner technology should be applied to obtain both high resource utilisation and economic efficiency. If possible, any waste should be recycled, recovered as raw material or it should be used as a source of energy before safe disposal is considered. A well functioning, reliable control and monitoring system in combination with cleaner goals will make any paper mill into a profitable operation.

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