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EFFICIENT RESOURCES MANAGEMENT FOR REDUCED PRODUCTION COST IN PULP MILLS (PART 1)

SUMMARY

In a continued effort towards improving environmental efficiency, a thorough audit of a mill is needed to optimize process conditions on a routine basis. This audit usually reveals key areas of focus particularly when the standard process conditions, which may deviateover a period of time, creates a negative impact on resources management. A comprehensive mill audit and data analysis should include various processes for their usage of raw materials, water and energy per ton of pulp and paper. Based on the report, the mill management will have options to work on short and long term targets to be achieved for cost reduction through an efficient use of raw material, energy and water leading to an enhanced sustainability. The mills can achieve better energy and water management by chalking out plans such as improving wood handling including debarking, chips quality, digester runnability, washing, bleaching plant operations and at the same time cleanliness of heat exchangers and other equipment. Since there are significant issues with the chip quality, mills can take advantage of digester additives for increased delignification while protecting carbohydrates and reducing the cooking time to enhance production and subsequently saving energy. In mills where chip furnish and quality changes on a day to day basis and contains significantly high bark content, the use of scale control chemistries besides optimum process conditions will be needed to increase productivity and energy efficiency by keeping heat exchangers, pumps, pipes and other equipment clean. While optimizing the process, these few measures are aimed to bring an extra impetus to mill's efforts to reduce carbon footprint and at the same time minimize production cost significantly.

KEY WORDS

Environmental Efficiency, Sustainability, Chip Quality, Digester Operations, Digester Additive, and Scale Control

INTRODUCTION

Though the pulp and paper manufacturing is very much based on renewable resources but it is still viewed as an industry which increases pollution. We need to raise an awareness to change public's perception. The mills will require a continuous focus on process optimization and use of new technologies, which are cost effective and environmentally efficient to minimize carbon footprint. As pulp and paper makers, we can proactively set higher targets to manage our vital resources – wood, water and energy to enhance environmental sustainability and minimizing production cost at the same time. But in achieving all this, the organizational practices and the policies will play a major role to achieve these targets.

As part of the resources management, a comprehensive mill audit of various sections from raw material preparation to finished product will identify areas for required improvements. This process will involve regular review of standard operating procedures for each section of the mill to modify and maximize the utilization of raw material, water and energy. Though a focused approach to solve such issues will add long-term measureable value but for one or the other reasons, enough efforts have not been made in this direction. In all the mills, the top management has a good understanding of such issues and an intention to set things right. But unfortunately they do not have enough time and/or resources to focus on the same. On the other hand, the production team is fully (and sometimes firefighting) engaged in day to day mill operations to achieve production and quality targets. Hence under such situation, there is not much time left to focus on improvement in environmental sustainability through such projects unless forced upon in most of the mills.

For an improved resources management, the road map should include planning and evaluation of key sections in the mill and accordingly taking corrective actions in a stepwise manner. The author believes that the starting point for the same should be raw material procurement and subsequently chipping operations, which are generally left behind for any improvements in a pulp mill. If we can optimize these two areas, which are generally complicated in Indian mills, it will not only improve pulp quality and environmental sustainability but also reduce production cost significantly.

The purpose of this article is an effort to continuously share author's experience in stipulating a process improvement strategy, which will positively contribute to not only reducing the carbon footprint and improving pulp quality but also and most importantly in lowering the production cost. A small positive step, which does not necessarily require any capital expenditure, in this direction will contribute significantly to meet Sustainability Targets set by the mill.

CHIPS PREPARATION FOR COOKING

Any efforts for resources management in a pulp mill should start from the optimization of chips' quality (size) as it plays an important role in cooking and the quality of pulp coming out of a digester and subsequent operations. In any pulp mill, the cooking operations significantly depend upon the chips quality (accept fraction, over-thick chips, fines and bark), moisture content and bulk density. For given wood species, pulp-maker's focus should be on chip quality as it will determine digester operations and the quality of pulp to a very large extent.

PRESENT SITUATION IN INDIAN PULP MILLS

Based on author's experience with many mills, it is always a challenging situation when it comes to procuring the raw material and/or managing its stock in mills in India. On the other hand, chipping operations is comparatively a low priority area in pulp mills. Given this, the pulp mill manager has a limited control on chip's furnish mix, moisture content, quality (accept, over-thick chips and fines) and most importantly on bulk density. The over thick chips will determine chemical mass-transfer (1) for lignin-alkali reactions and subsequent dissolution. The bulk density, which can change in every shift, is a measure of the dry weight entering the digester hence the alkali needed to achieve desired K#. With all the uncertainties prevailing, the pulp maker continuously faces a serious challenge to manage digester operations and pulp quality. Leaving aside the capacity (size) of the pulp mills, the production cost is amongst the highest in Indian pulp mills. The author believes that simple measures such as using robust communication techniques with the farmers will not only help to create a data base for the type of wood available with them and when but also managing a minimum stock in the mill. It will be a major step forward in minimizing the variations in chips' furnish and quality on a daily basis for pulp makers.

The Figure 1 shows a huge difference in the quality (#1, #2 and #3) of chips, ready to be cooked, obtained from various mills in India and elsewhere. As shown in Figure 1 (#1), the chips quality is considerably uneven and contains lots of bark, over-thick chips and fines.

Figure 1: Quality of chips in various mills in India (#1 & # 2, Mixed Hardwood) and in a Modern Mill (#3, Eucalyptus)

EFFECT OF BARK CONTENT IN CHIPS

The bark will not only consume more alkali, which is primarily meant for dissolving the lignin, but also darken the pulp requiring more chemicals particularly in bleaching down the stream. Moreover the bark content is extremely negative to the stringent quality parameters such as metal ions and ash content for the dissolving grade pulp. The bark content is very rich (20-40 times more than wood) in calcium, silica and Oxalic Acid hence it will also tend to induce scale deposition particularly in digester and bleach plant. The bark content in the chips needs to be minimized by debarking wood logs at optimum moisture content and screening the chips before sending them for cooking. The acceptable bark content should not be more than 0.5% of the total chips.

EFFECT OF OVER THICK, PINS AND FINES IN CHIPS

The chip thickness is a major parameter for uniform cooking of chips in digesters. For higher pulp yield, the standard chip thickness should be between 2-8 mm (called accept fraction) and overall % of such chips should be more than >90% for screened chips. Based on authors experience with different mills around the world, the over-thick chips and fines should not be more than 8-10% of the total chips. On the other hand, the fines content should be <2% of the chips. If over-thick chips exceed an optimum level, it will overload knotters, at times lead to reduced production, and other handling issues related to the recycling of knots.

IMPROVE PULP MILL OPERATIONS

For improved pulping operations, it is necessary that the mills measure the quality of chips (as per SCAN and/or TAPPI Test methods) at least once per shift. Based on the over-thick chips and fines in the chips, the mills can optimize chipping operations stepwise to improve quality from #1 to #2 and eventually to #3 (as shown in Figure 1) for an optimum chip quality. These efforts will ultimately help mills to utilize resources in a better way for an improved sustainability. Moreover the mills will be able to have better plant runnability for higher output and enhanced pulp quality at a lower cost.

If the bark content (>0.5%), and the ratio of chips <2 mm thick or the ones passing through 3 mm screen (called pins) and >8 mm thick (called over-thick chips) increases in the chips, it will have a significantly negative impact on the pulp yield (lower by 1-2%). With a 30% drop in chips quality (outside of 2-8 mm thickness band), the pulp yield is likely to be lower as much as by 0.7% (2). This loss may result in more than $1.3 million per year (Assuming a produced pulp price of $550/ADT, 330 days/year) in revenue based on a 1,000 TPD pulp mill.

The mills, which do not have sufficient debarking and screening capacities, should use anti-scaling chemistries to mitigate the risk of scale build up tendency on instruments and process equipment due to higher bark content in the chips. At the same time, the use of digester additives will help the mills to improve pulp yield and maintain pulp viscosity (>600 cm^3/g) if the chips accept (between 2 -8 mm thick) is lower than 90% of the total chips entering the digester.

OPTIMIZE DIGESTER OPERATIONS

In any type of a cooking process – batch or continuous or for any wood quality, impregnation of chips is very important in determining the quality of pulp. However in majority of the cases, this has been compromised as there has always been a push for an increased production. In a super batch process, the Hot Fill Efficiency, second impregnation stage, has a direct impact on the pre-O_2 K#. As the Hot Fill Efficiency

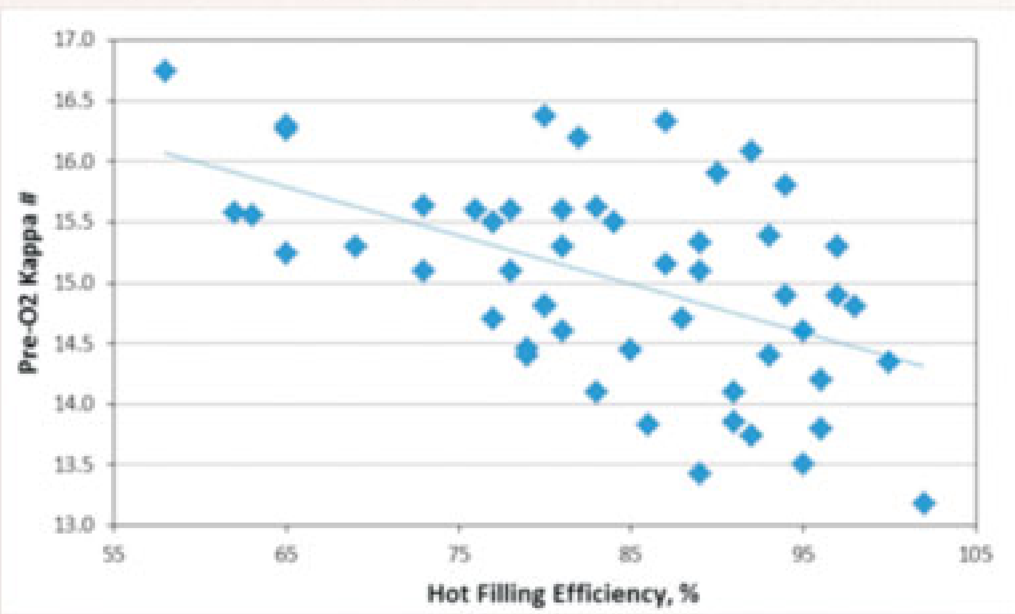

Figure 2: Effect of hot (liquor) filling efficiency on pre-O_2 Kappa #

decreases, pre-O_2 K# increases. Due to channeling issues, hot liquor filling is cut short, which not only reduces time available for the impregnation of chips but also causes shortage of alkali during cooking to and at temperature. As shown in Figure 2, the K# of the pulp entering to an Oxygen Delignification decreased as the hot (liquor) filling efficiency improved. In G2 continuous cooking, any unused alkali will be lost if the impregnation time is reduced in an Impbin hence causing higher K# after cooking in the main vessel. On the other hand, it will lead to reduced viscosity and significant yield loss if K# is maintained by increasing alkali and digester/cooking temperature.

IMPROVE PULP PRODUCTION AND QUALITY WITH DIGESTER ADDITIVES

With the chip quality not being as per specifications and mill facing operational issues, it is necessary that a digester additive – surfactant is introduced during impregnation of chips. While dispersed anthraquinone or a judicious emulsion of anthraquinone and surfactant is added to digester during cooking to and at temperature to protect carbohydrates and at the same time increase delignification. The use of such digester additives will not only fasten delignification to achieve desired K# particularly when increased production is the target but also improve selectivity to get higher pulp yield and viscosity. An application of digester additive can be customized to achieve different benefits including reduced alkali demand and/or increase in pulp production.

While retaining more cellulose and hemicellulose, the extended lignin removal will help on several counts – increased pulp yield means higher production, improved viscosity resulting in better strength properties, more energy, and reduced chlorine dioxide demand in bleach plant. At the same time, it will significantly reduce environmental load from bleach plant effluents. As shown in Table 1, an optimum application of a surfactant during impregnation and cooking stages (650 TPD, mixed hardwood) has provided several benefits such as lower alkali usage to achieve same K#. Depending on what the mill's target is, a digester additive application can realize a net saving of $2.5 - $8.0 per ton of pulp.

Table 1: Comparison of Process/Quality Parameters from a Digester Additive Trial

Parameter	Units	Pre-trial	DA Results	Benefits
Blown Kappa	#	17.3	**17.5**	
O_2 Delignification Kappa	#	9.2	**9.3**	
White Liquor	Kg/ADT	510.0	**448.9**	Significantly Lower
Final Pulp Viscosity	CPS	8.9	**9.3**	Higher
ClO_2	kg/ADT	16.3	**16.1**	
Caustic usage (ODL + EOP)	kg/ADT	23.0	**20.7**	Significantly Lower!
Sulfuric Acid	kg/ADT	24.3	**23.3**	Lower
Oxygen in EOP	kg/ADT	3.6	**2.8**	Significantly Lower
H_2O_2	kg/ADT	10.5	**11.1**	Higher
Final Pulp Brightness	%	87.2	**87.2**	

INPUT OF CALCIUM AND OXALIC ACID WITH CHIPS AND ITS IMPACT ON SCALE FORMATION

On a given day, a typical pulp mill (basis: 1,000 TPD) can introduce 1,500 to 2,000 kg of calcium (as CaO) with chips (2.2 T/ADT, CaO: 300 ppm), white liquor (WL) (4.0 m^3/T, total suspended solids (TSS): 80 ppm) and hot water (4 m^3/ADT in brown stock washing, Ca-hardness: 100 ppm). Though a majority of this calcium will go or circulate with the WBL but a significant amount of calcium will also enter bleach plant where it can create severe Ca-carbonate/oxalate deposits. On the other hand, the presence of calcium in WBL may cause serious issues in heat exchangers and on the screens of continuous digester if the process conditions are not handled properly.

The hardwood bark and chips (debarked) can introduce 9-15and 0.1-0.3 kg/T respectively of oxalic acid, a major source for Ca-Oxalate scale in bleach plants, to the digester. At 1% bark content in chips, the amount of oxalic acid entering in to the system could range between 400 -1,000 kg on a given day in a 1,000 TPD mill. Besides this, oxidizing stage will generate another significant amount of oxalic acid. Since Ca-oxalate scale generally forms between the pH range of 2-9, the presence of abundant oxalic acid is hardly an issue for any oxalate related scale deposit to form in this area particularly when the pH (10.5-11.5) significantly high (3). On the other hand, the scale formation in bleach plant particularly in D0 or in D1 will very much depend on the carryover of oxalic acid, and pH and temperature conditions in these bleaching stages. For mills having Ozone bleaching, the Ca-Oxalate deposits formation could be more severe as one third of the oxalic acid generated in this stage is absorbed on to the fibers and cannot be knocked off during washing (4). Thus when the pulp passes various pH changes in bleaching, this absorbed oxalic acid is released in bleaching hence causing Ca-oxalate deposit.

EFFECT OF SCALE FORMATION ON PRODUCTIVITY AND EQUIPMENT LIFE

The scale related issues have cost (down time and removal cost) millions of dollars to pulp and paper mills across the globe. In majority of the cases, the mills have faced inorganic scale problem in pipes, screens, heat exchangers and other equipment on a regular basis. A 1.5 mm thick inorganic scale formation can cause an up to 10% reduction in heat transfer (3). There are some specific scales like barium sulfate but the most common inorganic deposits have been calcium related such as calcium carbonate (digester, bleaching and vacuum pumps), calcium oxalate and sulfate (bleach plants), dual salt (called Pirssonite) of calcium and sodium carbonates in green liquor lines, and dual salt (called Burkeite) of sodium carbonate andsodium sulfate in evaporators. These scale deposits created severe operational issues often leading to productivity loss if not treated properly. Moreover the scale deposits have carried severe corrosion related issues, which have reduced equipment life significantly.

SOLUTION TO MITIGATE SCALE RELATED ISSUES IN A PULP MILL

The author understands the difficulty of removing bark from the logs prior to chipping in India. However an improved screening can remove quite a bit of the bark (if not <0.5% in ideal conditions) from the chips.

Though not much can be done for the calcium entering with chips to pulp mill, but efforts should be made to reduce WL TSS to <40 ppm (With X-filter for GL and CD filter for WL, the TSS goes down to even below <10 ppm.) and water hardness to <80 ppm. Moreover it is necessary that more focus is given to choose a right pulp mill defoamer, which not only controls foam but also improves drainage to leach out maximum alkali, oxalic acid and other unwanted organic matter from the pulp before it enters in to bleach plant. At the same time, the washing, which is a lower priority in most of the cases, in the bleach plant should be equally (as is in unbleached plant) paid attention to. A drainage aid particularly for EOP wash stage will boost the removal of oxalic acid hence Ca-oxalate scale in subsequent stage/s. A better control of pH and temperature in various stages in the bleach plant will also reduce the risk of scale formation in bleaching plants.

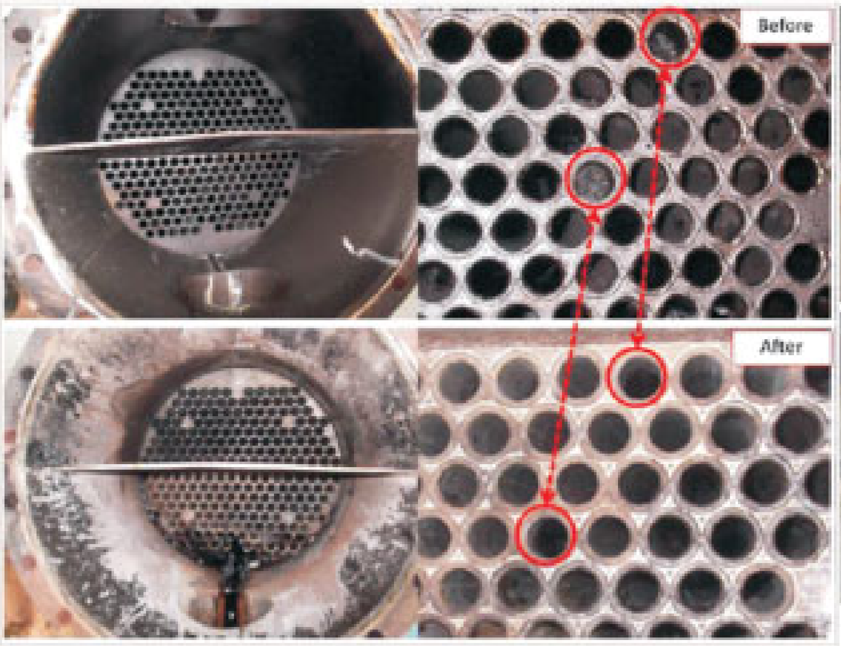

Figure 3: Heat exchanger after chemical boilout

Figure 4: EOP washer before and after treatment

Despite all the efforts as mentioned above, there will always be some scale deposits in the pulp mills. This scale related issue can be minimized with the use of cost-effective scale control chemistries/technologies on a continuous basis for an improved productivity and pulp quality. In addition to a regular treatment, the author also recommends of carrying out periodic system boilouts to remove scale deposits for better heat transfer in heat exchangers and plant ruannability as a whole. For more details, please refer to Figure 3, which clearly shows the removal of scale after the boilout. The Figure 4 (pictures taken at different places of the washer) clearly indicates the efficacy of a regular chemical treatment to remove inorganic cum organic deposit from an EOP washer. The Figure 4 (Before) indicates the condition of an EOP washer after a week of the boilout while Figure 4 (After) is after eight weeks of a continuous treatment started immediately after the boilout.

CONCLUSION

The chip quality plays a major role in determining plant runnability and quality in pulp mills. Hence the raw material and chipping operations certainly need more focus to reduce bark (<0.5%), over-thick chips(<8%) and fines (<2%) entering the digester. The same can be achieved by monitoring chips' quality on a daily basis as it will not only improve chipping operations but most importantly digester runnability and its output also. The good quality chips (accept >90%) will help to increase pulp yield hence reduced raw material, a vital component for resources management, usage. At the same time, the mills having limited choices to improve chip quality will need digester additive to maximize pulp yield and/or reduce white liquorusage besides achieving better pulp bleachability and viscosity. For scale related issues, the problem can be mitigated with an improvement in chip quality (bark<0.5%), lowering suspended solids in white liquor to <40 ppm and minimizing calcium hardness of raw (or hot) water to <80 ppm or better as starting steps. Moreover the pulp mills should also focus on improved drainage of pulp in unbleached and bleaching sections to remove more calcium from the system. Together with these operational focus, the pulp mills are also advised to run scale control applications on a regular basis to minimize scale deposit and subsequent process issue. With an improvement in chip quality and reduce calcium content with WL and water, a mill (Basis: 1000 TPD) can reduce its production cost by $1.5 to 2.0 million per year.

ACKNOWLEDGEMENT

The author would like to thank Mr. Shyam Biyani, Director Pulp, for providing his valuable technical and editorial inputs during the preparation of this paper. Thanks are also due to Mr. Wai Kit Cheong, Marketing Manager, for his editorial comments and support in the publication of the same article.

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