Alkaline and Neutral Sizing: Latest Trends and Selection of Specialty Chemicals to Make Fine Quality Paper Cost Effectively

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ABSTRACT

Alkaline paper making with calcium carbonate filler has become the global industry standard practice over the past few decades. Now paper makers in India are increasingly adopting this practice to capture the benefits of lower manufacturing costs and improved brightness it brings. Typically newer machines experience little difficulty in converting to alkaline from acid papermaking, however, the older machines may require specific chemical and mechanical solutions be successful. Indian mills have creatively adopted neutral sizing or binary sizing as a method to capture at least some of the benefits of alkaline papermaking. Decision criteria on type of size to use are discussed below along with recent trial experiences. Best practices for alkaline papermaking chemistry are included.

INTRODUCTION

Paper makers have practiced alkaline paper making commercially for various paper grades for over 50 years. In the 1960's fine Printing and Writing (P&W) grades, egl. Book Paper and Archival Bond, were converted to alkaline pH to achieve improved "permanence", ie better longevity vs acid papers, when libraries saw old books and documents made with acid papers deteriorating on the shelf. Cellulose retained more strength when paper extract pH was raised to alkaline; paper brightness was also higher. Then alkyl ketene dimer (AKD) was the principle alkaline size and mainly high brightness clays were used as fillers. Retention systems were simple, eg. only wet end starch and machine performance could be less than optimum in terms of speed, deposits, drying etc. Much has been learned since that time.

The European P&W segment first converted to alkaline papermaking to capture the economic benefits of filler for fiber substitution using local chalk ($CaCO_3$); North and South American mills followed in the early 1990's using GCC and then PCC; and Asian mills in the mid to late 1990's. Now the Indian mills are moving forward in this global process.

The benefits of alkaline papermaking are numerous and include: stronger paper, higher brightness, lower manufacturing costs, cleaner machine, fewer deposits, improved run-ability, lower BOD and COD environmental loading, increased water system closure etc.

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Sizing Theory

Sizing in paper and board is defined as the resistance to penetration of water and aqueous solutions. Note that water vapor resistance is not part of the definition.

There are many reasons for sizing paper including: 1. operability on the paper machine-this is the most common reason and includes better size press holdout, calendar water box holdout, and coating holdout. 2. sizing against accidental wetting-eg. for office papers and dry product packaging for boxes and bags. 3. paper end use requirements egl. liquid packaging, offset printing, wet food packaging, glue-ability, water based ink holdout etc.

While there are numerous candidate chemistries for internal paper size, only a few can meet all the practical requirements which include: 1. inherently hydrophobic; 2. uniform distribution in the stock system; 3.retention on the fiber; 4. uniform distribution on the fiber; 5. anchored to the fiber surfaces; 6. proper orientation on the fiber and filler surfaces; 7. inert to aqueous penetrants; and 8. minimum adverse impact on the paper making process

Sizing Options

Over the past 3-4 decades, two main alkaline sizing chemistries have emerged which are widely used today by papermakers world wide: alkyl ketene dimmer (AKD) and alkyl succinic anhydride (ASA). Both have inherent strengths and weaknesses. Both need a systems approach within the entire papermaking process to give the optimum results, ie consider other chemical additives, pulps, fillers, machine setup, and grade requirements.

A third option commonly practiced in India has been neutral sizing with talc filler using rosin emulsion sizes, either anionic or cationic.

An in between option is to combine two of the above products to meet special requirements. This is called binary sizing.

Comparative strengths and weakness of AKD vs ASA

Both AKD and ASA are cellulose reactive type sizing agents. AKD is composed of a reactive lactone ring coupled with linear stearic and palmitic fatty acids (C16/C18). While ASA is based on olefin feed stocks of C16/C16 and contains an anhydride reactive group. The AKD reaction is more alkalinity sensitive, while ASA is more versatile reacting over a pH range of 5 to 8.5.

AKD offers comparative advantages in being easy to handle and the most effective sizing agent vs a broad range of penetrants; however its cellulose reaction rate is moderate to slow and its furnish is limited in precision converting grades, ie it can contribute to paper slip.

On the other hand, ASA offers a fast

cellulose reaction rate and does not contribute to paper slip; however it does require in-mill emulsification as its emulsion has a very short shelf life, and it has poor hold out vs acid penetrants.

Global Trends in Printing & Writing Papers

The major trend in P&W grades is the move toward increased ash content to achieve filler for fiber cost savings. This is driving the prevalence of size press surface treatments to meet increasing demands of the printer as well as to minimize internal size addition and machine deposits while meeting sizing requirements in hard to size highly filled grades.

Combining these trends with the comparative strengths of AKD and ASA, papermakers are making a clear choice: ASA is the dominant size in commodity or precision converting P&W grades, eg copy paper, envelop, and forms bond where paper slip cannot be tolerated; while AKD is still dominant in specialty grades eg highly filled offsets, financial papers, catalog, bible papers, photo base etc where hard sizing is required.

Indian Mill Experience

Filler for Fiber as Economic Driver

Much alkaline conversion activity in India is centered on P&W grades, including copy paper which is a fast growing grade. The major benefits realized range from increased paper brightness vs acid papermaking for the integrated mills, to the reuse of secondary fibers which contain CaCO3 for the de-inking mills, or recycled CaCO3 coated broke. Most mills continue to use only talc as filler, however, a few mills are now using GCC or PCC for at least a portion of their filler requirements. GCC and PCC use will continue to grow as supply increases and cost becomes more competitive with talc. India's imports of foreign P&W papers containing CaCO3 will also drive consumer demand for these higher brightness papers.

Neutral or Binary Sizing for P&W and MG papers

Neutral sizing has been commonly adopted in India as a step to capture at least a portion of the benefits of alkaline sizing. This practice employs rosin emulsion size with alum or PAC at machine pH of 6-6.5 and talc as filler.

Some mills find that AKD, ASA or rosin size alone cannot completely meet their needs, so they choose to employ "binary sizing", ie use a combination of products to obtain the benefits of one which can offset the detrimental effects of the other.

For example, a P&W producer may want the fast on machine cure of ASA for size press hold out, coupled with the hard sizing provided by AKD.

Some MG machines combine AKD with rosin emulsion in a "neutral sizing" pH environment; here cationic rosin emulsion size provides MG performance together with AKD for hard sizing in the finished paper.

At least one conventional P&W machine combines ASA and cationic rosin emulsion to optimize size press run-ability and meet Cobb targets.

There are mills in India which now practice each of these options.

AKD- the initial sizing choice

Numerous alkaline sizing trials have been run in recent years in P&W grades, mostly with AKD due to its simple handling requirements. Another reason for the early adoption of AKD in India is the relatively low Cobb, ie hard sizing specifications in the industry. Many P&W mills run copy papers to a 22gm/M2 Cobb test vs 30gm specification in mills outside India. The reason given is that these papers are multi use for both copy paper and school notebook paper which needs hard sizing to meet pen and ink feather requirements. This increases sizing costs and deserves further investigation.

Alkaline Conversions of Modern vs Older Machines

In India the more modern machines have converted to alkaline papermaking with few problems as the machines experienced no problems converting from acid to alkaline. All use retention and biocide programs to optimize their systems. Several use internal starch for strength and retention. Some are equipped with film transfer type size presses and add surface size to augment internal sizing. It is important to realize that modern machines with state of the art forming sections, press sections and ample drying capacity almost never experience the problems of limited drainage, press picking and lost speed that can de-rail alkaline conversions on older machines.

Alkaline trials on the older machines have been much more challenging as many experienced moderate to severe press picking and reduced speeds due to poor drying after the size press which terminated alkaline conversion activity in many cases. Certainly there are examples of successful alkaline conversions on older machines; at least one has been running AKD in P&W grades including copy paper for over 10 years. This mill runs good retention and biocide programs as well. This machine also has good drainage and drying which combine with proper chemistry to keep AKD furnishes low.

Recent Copy Paper Experience

Major Indian copy paper producers with integrated pulp mills have run various alkaline trials with AKD and ASA using talc filler and GCC. Some experienced machine run-ability issues during early trials including press picking and lost speed.

Recent trials at one of these has focused on copy papers with ASA as earlier AKD trials demonstrated paper slip issues on converting equipment and lost speed, ie poor size press hold out on one machine. The company intends to convert all its P&W machines to ASA to standardize its grade formulations. Challenges arose during the trials as all the machines did not respond the same way to alkaline papermaking as they were varying ages with varying limitations in drainage, press design and drying.

In general, this group found simple alkaline sizing systems gave better performance on their machines, ie a chemical system comprised of a coagulant added to the thick stock followed by alum to the fan pump inlet and ASA to the pressure screen accepts. This system provides approximately equivalent First Pass Retention(FPR) and First Pass Ash Retention(FPAR) levels as they had with acid/neutral sizing and good run-ability. Higher FPR levels with retention systems had earlier resulted in press picking.

A recent trial on a sister machine

demonstrated that severe press picking resulted from high FPR and lost drainage as evidenced by a two point increase in sheet moisture leaving the couch making a weaker sheet in the press section. It was theorized that increased water release on the table with the alkaline system resulted in "sheet sealing" ie wire side fines accumulation which inhibited further drainage on the wire, so steps were taken to slow drainage by removing table foils and moving addition points for ASA and talc back from the dilute to thick stock. After these changes the sheet moisture in the press section returned to normal and the machine ran acceptably.

Advantage of starch in ASA emulsions

Another observation during our ASA trials has been about the benefit of using cationic starch vs cationic polymer to prepare the ASA emulsion. Starch is most widely used in other countries for this purpose as it stabilizes the ASA emulsion and provides retention benefits. In India an additional benefit of reduced deposit tendencies on machines with integrated pulp mills has been observed when using liquid starch vs polymer to emulsify ASA.

These mill trial experiences demonstrate that even older machines with various mechanical limitations can successfully convert to alkaline papermaking given time and experiment to optimize mechanical settings and chemical systems. The most needed support is commitment from upper management to make the conversion a success.

Indian Raw Material Requirements

Size demand for any type of sizing chemistry primarily depends on the raw materials in the papermaking system: water, filler and pulp types.

The choice of fillers is a primary factor determining size demand as sizing efficiency is dependant on particle size, eg PCC with its fine particle size requires more size than GCC or talc. In addition, pulp size-ablity varies widely with type, eg Indian mills use many types of fiber furnishes ranging from wood to agro based to recycled waste which vary widely in charge demand, conductivity and size-ability. Water quality also plays an important role in wet end chemistry and varies greatly from location to location in terms of hardness, alkalinity, and conductivity.

As a result, suppliers need to offer tailor made products which are designed for specific applications to optimize machine performance and economic requirements.

Customer References

Ivax alkaline sizing P&W papers customers include: Shreyans Paper Mills Ltd who was the initial straw based mill to convert to alkaline using AKD and talc to capture the benefits of higher brightness, higher productivity and lower costs. Other alkaline mills using AKD and talc include: Sheshashayee Paper Board, and West Coast Paper Mill.

Two mills on binary sizing include Century Paper using AKD with ASA; and APPM using AKD with cationic rosin on MG machines. Other machines at these mills use AKD with talc; APPM produces specialty grades using GCC and AKD. Both units of JK Paper are primarily using ASA with talc and now trialing PCC.

Best Practices with Alkaline Sizing

With the combined experiences from around the globe, we can offer some guidelines to the best alkaline sizing practices which apply equally well to AKD as ASA. These include:

- Alkaline size, AKD or ASA, is usually added to the thin stock between the fan pump and pressure screen accepts.
- A good multi component retention system is important especially on newer faster machines. This should include starch, for strength and retention purposes, a flocculent and a micro particulate, or small amount of alum as a coagulant. The starch and alum should be co-mixed with the size. Retention levels should be maximized (FPR>80% and FPAR>50%).
- A good biocide program is also important to maintain system cleanliness and minimize deposits and sheet defects.
- Avoid close addition of size to filler, surfactants, and oxidizers.
- Utilize surface size to minimize internal size furnishes.

For ASA we add the following:

- Make a good quality emulsion using proper equipment.
  - o Maintain proper particle size and distribution for good retention.
  - o Use proper starch for emulsion stability and retention. Minimize machine deposits.

CONCLUSION

Alkaline papermaking has evolved over the past 50 years to become the standard practice of the global industry. Out side of India, CaCO3 in various forms is the alkaline filler of choice, however, in India CaCO3 filler is just beginning to replace talc. The Indian paper industry is becoming aware of the benefits of alkaline papermaking and is now adopting this technology.

While the newer machines are successfully converting to alkaline papermaking following global practices, the older machines often require unique, tailor made solutions to successfully overcome various design limitations. These specific solutions require a systems approach to include chemical systems, pulps, fillers, and mechanical changes to meet specific grade specifications and machine run-ability targets. This can only be achieved via a team approach between the mill and its suppliers, together with mill management's commitment to make the alkaline conversion a success.