Binary Sizing with AKD for Manufacturing MG Products

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ABSTRACT

The driving forces to change from acid sizing process to neutral/alkaline sizing process are process advantage, product improvement and environmental considerations. SPB initiated neutral/alkaline sizing process in the year 1999 in one of it's MF machine. Since then, neutral/alkaline sizing process is implemented in all three MF machines. Due to single dryer in Yankee machine, the consumption of neutral/alkaline sizing chemical is found to be extra ordinarily high. As a result of which the same could not be implemented commercially. In MG machine, the consumption of neutral sizing chemical (cationic rosin) alone is found to be very high and alkaline sizing chemical (AKD) alone resulted in loss of gloss of paper/board by 5 to 6 units due to it's waxy nature. These problems in MG machine are overcome at SPB with the suitable combination of both cationic rosin and AKD and the same is being continued successfully till today. This paper deals with the problems encountered in MG machine with separate neutral and alkaline sizing chemical and the solutions evolved to overcome the same.

INTRODUCTION

The sizing of paper and board is done to control wettability and absorbency. Wet-end sizing controls the surface energy of the exterior fiber and the interior pores. Surface energy in solids is the equivalent of surface tension in liquids. The higher the surface energy value, the more hydrophilic (water-loving) is the surface, the lower the surface energy value, the lower is the hydrophilicity. The classic wet end sizes contain a hydrophobic hydrocarbon group and an anchoring group to attach it to the fiber and ensure the hydrophobic group stands clear of the surface.

Although rosin is the most widely used as sizing chemical, there are applications where it is not completely satisfactory. This may be the case when paper or paper board requires high resistance against alkaline solutions. In addition, internal sizing with rosin and alum weakens the fiber due to acidic conditions resulting poor permanency of paper. Further, this being a plant by-product, availability of rosin is uncertain.

To overcome these problems, synthetic sizes (having a reactive group) are available, which can form a covalent bond directly between the size and the cellulose, which is hydrophobic and much more stable to water. Since, alum is not necessary for synthetic sizes, the wet end of the paper machine can be run under neutral or alkaline conditions.

In addition to several advantages of alkaline sizing like, (I) reduction in corrosion of equipment, (ii) avoidance of pH adjustment of effluent, (iii) improved paper strength, (iv) better paper permanency etc., certain disadvantages with alkaline sizing are, poor retention of size, fiber and filler fines at high pH levels. With rosin sizing, alum plays a major role in retention of all these, but, alum is ineffective and usually not used at high pH levels. As a result, use of specialized starches / retention aids along with synthetic sizes is needed for better retention.

Another technology in sizing system is neutral rosin system. In this system, cationic rosin size is used. Because of it's cationic charge, it is self retaining and normally attractive to anionic pulp fibers and as such improves it's retention in the paper making system. This system needs 4.0 to 5.0 kgs of alum per ton of paper and system pH of 5.0 to 6.5.

INTERNAL SIZING PROCESSES AT SPB

Presently, SPB is having three numbers of MF machines, one number each of MG and Yankee machine. Total production from all five machines is about 380 tons per day. SPB makes mostly writing and printing paper and a small quantity of packing grade paper. Except, for Duplicating paper and Yankee poster of 28-37 gsm, all other varieties are internal sized papers. In the year 1999, alkaline sizing process was tried first at SPB. After several successful plant trials on alkaline sizing and neutral sizing process, SPB has gradually switched over to neutral/alkaline sizing process from acid sizing process for all three of it's MF machines.

In Yankee machine, due to very high neutral sizing chemical consumption, acid sizing process could not be changed till date. High consumption of neutral sizing chemical in Yankee machine may be due to it's single dryer cylinder.

In MG machine, trials were taken with AKD, ASA and neutral sizing chemicals separately. But, due to the problem experienced on product quality, machine runnability and high chemical consumption (trial details are described in later) , alkaline/neutral sizing process could not be implemented in MG machine for some times. While putting forward the problems we faced in MG machine during neutral/alkaline sizing process to the sizing chemical suppliers, one of them suggested to go for combination of neutral sizing chemical (cationic rosin) and alkaline sizing chemical (AKD) , based on the plant performance of this binary sizing process in one of the mills in UK with their sizing chemicals. Based on their suggestion we conducted bench scale and plant scale trials and obtained very encouraging results. Presently, in MG machine, we follow binary sizing process with cationic rosin and AKD at neutral pH of stock on continuous basis.

In brief, following internal sizing processes are being adopted at SPB for different machines :

1. MF1 machine: For orange

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varieties, acid sizing process
For all other varieties, alkaline sizing process

2. MG machine : For yellow and orange varieties, acid sizing process
For all other varieties, binary sizing process

3. Yankee machine : For all varieties, acid sizing process

4. MF2 machine : For Non-surface sized paper, alkaline sizing process
For surface sized paper, neutral sizing process

5. MF3 machine : For all varieties paper, alkaline sizing process

ABOUT MG MACHINE AT SPB

MG machine at SPB is having open head box with 3.6 meter wire width. Wire part is having de-watering elements like hydrofoil, slow drainage vacuum foils and suction boxes and couch roll. This machine is having 2 presses (one is suction press and another is plain press) , 9 numbers pre-dryer cylinders, one MG dryer cylinder having 4.5 meter diameter, horizontal pond type size press arrangement, 8 numbers post-dryer cylinders and calendar stack with 3 nip facility. This machine produces MG poster, MG maplitho, Bristol paper/board, etc. with average production capacity of 65 tons per day.

In the approach flow system of this machine, refined pulps (hardwood and/or bagasse) are taken to blending chest, from which pulp is supplied to machine flow box through machine chest, control refiner, constant level head box, fan pump, GL&V centri-cleaning system and pressure screen after addition of various chemicals at different stages, as shown in figure-1.

Table 1 : Properties of paper with neutral sizing process and acid sizing process

Particulars	UOM	MG Poster,68 gsm(W)		MG Poster,75 gsm (W)		MG Maplitho,130gsm(W)	
		Acid sizing	Neutral sizing	Acid sizing	Neutral sizing	Acid sizing	Neutral sizing
One pass solid retn.	%	85.0	82.2-84.6	83.6	82.2-85.2	80.6-83.0	80.8-84.1
One pass ash retention	%	39.4	48.6-50.1	34.9	50.7-52.7	41.6-46.1	52.5-55.3
Substance	gsm	67.5-66.9	68.0-70.2	74.0	74.5-75.3	129.0-131.8	129.3-129.8
Bulk	cc/g	1.44-1.46	1.47-1.50	1.47	1.42-1.50	1.40-1.43	1.40
Burst factor	-	16-17	16-18	16-17	17-18	16-17	16-18
Tear factor MD	-	43-46	51-54	47-48	44-47	41-47	41-47
Tear factor CD	-	46-49	59-63	50-52	51-53	47-50	48-53
Breaking length MD	m	4000-4100	4000-4300	4100-4200	4000-4300	4500-4600	4200-4700
Breaking length CD	m	2400-2500	2700-3200	2500-2700	2800-3200	2600-2800	2700-3000
Double folds MD	no	14-15	16-20	14-15	15-16	18-22	20-22
Double folds CD	no	7-8	8-11	7-9	8-10	10-11	10-12
Brightness	%	78-79	78-79	78	78-79	78-79	78-79
Opacity	%	94	95	96	96-97	99	99
Gloss	%	20-21	20-24	19-21	20-22	17-19	17-19
Cobb sizing TS/BS	gsm	22/25	21/25	22/27	22/27	24/28	22/27
Wax pick F/B	no	6/7	6/7	6/7	6/7	6/7	6/6
Ash content	%	9.6-10.8	10.2-11.1	10.5	10.3-11.2	9.1-10.2	10.8-11.1

Experiences of various sizing processes in MG machine

ACID SIZING PROCESS

Till end of 2004, acid sizing process was followed continuously. In this process, fortified rosin was being added at suction line of fan pump and alum at fan pump outlet line. On an average , consumption of fortified rosin and alum was about 16kg and 60kg respectively per ton of paper. In this process, pH of back water normally maintained in the range of 4.0-5.0. Alum in this process, serves as a precipitating and anchoring agent for the size and also serves as a retention aid for fiber and filler fines, dyes and improves drainage rate.

Though, machine runnability, sizing quality and shade of paper are very normal in this sizing process, required strength properties of paper could not be maintained even at slight increase in ash content of paper and permanency of paper in terms of post color number is not at the satisfactory level.

NEUTRAL SIZING PROCESS

The sizing chemical being used in this process is dispersed rosin having cationic in nature. Normally, this type of rosin is white liquid having specific gravity of 1.04-1.08, pH of 3.0-4.0, total solids content of 35+/-1.0% and viscosity at 20^0C is less than 50cps. Dispersed rosin size consists of rosin acid droplets, which have considerable surface areas. Therefore, it's retention is a consequence of colloidal and surface chemistry. Dispersed rosin does not react readily with alum to form aluminium resinate. The alum acts as a bridge between the negatively charged fiber and negatively charged rosin micelle. The dispersed rosin size particles are relatively free to migrate during the drying process in the paper web. As the paper temperature increases on it's movement over the drying cylinder, the heat creates a sintering process where the rosin particles melt and distribute uniformly over the surface area of the fibers to form the aluminium resinate.

In this process, cationic rosin chemical is added through dosing pump to thick stock at fan pump inlet. The dilute retention aid chemical at 1.0gpl concentration is added to the selectifier pressure screen outlet. pH of stock is maintained near neutral, i.e., 6.0-6.5.

From several trials taken it is seen that, to maintain cobb sizing of paper of 30gsm(max.), the consumption of cationic rosin, alum and retention aid is in the range of 19-20kg, 22-25kg and 55-60g respectively, per ton of paper. This indicates high consumption of sizing chemicals.

After several plant trials, this sizing process was followed continuously from Nov'2005 to July'2006 for manufacturing all varieties paper except yellow and orange colored varieties.

A comparative statement on paper properties with acid sizing process and neutral sizing process is presented in table-1.

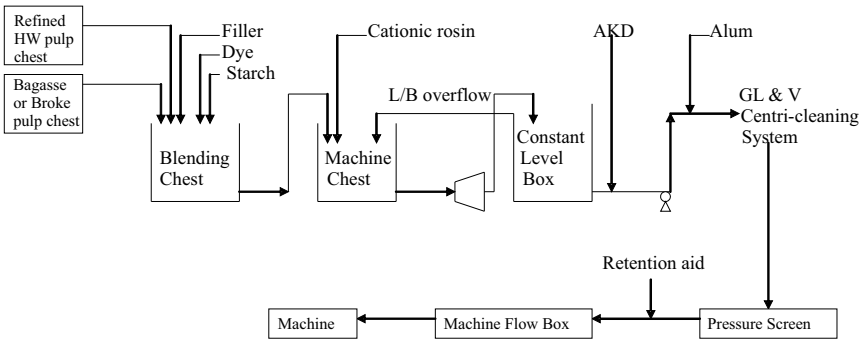

Figure : Flow diagram of Stock Preparation System (Binary Sizing Process)

Compared to acid sizing process , following observations are made during neutral sizing process :

- One pass solid/ash retention values are comparable in both process
- Paper strength properties are marginally high in neutral sizing process compared to paper obtained with acid sizing process
- Gloss value of MG variety paper is achieved 2-3 units more in neutral sizing process
- The permanency of paper in terms of post color number with cationic rosin is in the range of 2.3-2.5, which is marginally low compared to acid sized paper(2.8-2.9)
- Pollution load in terms of Chemical Oxygen Demand(COD) of machine back water is found to be comparable(232-240 ppm) in both sizing process

ALKALINE SIZING PROCESS

In MG machine, alkaline sizing process was tried separately with both AKD and ASA sizing chemical. Trial performan - -ces are individually described below.

AKD SIZING PROCESS

Alkyl Ketene Dimer(AKD) is derived from the waxy fatty acid. This sizing process was tried in MG machine during April'2004. AKD was added at the suction line of fan pump, Cationic scavenger(coagulant) was added at machine chest and retention aid was added at outlet of selectifier pressure screen.

For obtaining maximum 30gsm cobb sizing of paper, 20-25kg of AKD was consumed and cationic scavenger of 700g and retention aid of 100g per ton of paper.

Though, we could achieve required sizing and better strength of paper, gloss of MG product, which is very much important property, was found to be reduced by 5-6 units. The reduction of gloss, is mainly due to the waxy nature of AKD material. This sizing program could not be continued in MG machine due to loss in gloss of paper and high chemical consumption.

Table 2 : Properties of paper with ASA sizing process and acid sizing process

Particulars	UOM	MG Poster,68 gsm(NS)		MG Poster,80 gsm (NS)		MG Maplitho,170gsm(NS)	
		Acid sizing	**ASA sizing**	**Acid sizing**	**ASA sizing**	**Acid sizing**	**ASA sizing**
One pass solid retn.	%	82.7-85.1	81.5-89.3	82.8-88.4	86.6-87.3	88.7-90.8	94.1-96.2
One pass ash retention	%	49.1-50.6	49.0-51.0	50.0-52.0	48.4-50.2	68.9-72.0	75.0-78.6
Substance	gsm	67.0-67.9	68.3-68.7	81.1	80.8-81.1	167.2	169.5-170.5
Bulk	cc/g	1.40-1.43	1.40-1.52	1.40	1.48-1.59	1.40	1.39-1.45
Burst factor	-	17-18	19-20	23	20-22	19	21-22
Tear factor MD	-	45-50	45-51	46	55-63	56	48-53
Tear factor CD	-	55-57	51-54	55	60-70	61	53-58
Breaking length MD	m	4500-5200	4300-5600	5300	5400-5800	5600	5700-5900
Breaking length CD	m	2700-2800	2800-3200	3400	3100-3400	3100	3100-3200
Double folds MD	no	14-15	15-16	14-15	14-16	19	20-21
Double folds CD	no	7-8	8-9	7-9	7-8	10	10-12
Brightness	%	74-75	73-74	74	73-74	72	73-74
Opacity	%	88-89	88-89	90	89-90	98	99
Gloss	%	18-21	15-18	18-20	16-19	19-20	14-16
Cobb sizing TS/BS	gsm	24/28	23/27	24/28	24/29	22/29	24/27
Wax pick F/B	no	6/6	6/7	6/6	7/7	6/7	6/7
Ash content	%	11.0-11.2	11.6-12.6	11.2	10.0-11.2	10.5	11.8-12.2

ASA SIZING PROCESS

Alkenyl Succinic Anhydride (ASA) is a petroleum based oil. It need emulsification at site. During emulsification, a cationic carrier is added to ASA. Due to it's high reactivity, the diluted emulsion shelf life is very short, i.e., for few hours, while undiluted ASA shelf life is unlimited. This chemical reacts with cellulose to form a water resistant substrate. The cellulose-sizing bond is highly resistant to hydrolysis. The efficacy of the chemical depends upon how efficiently it is distributed and retained in the wet web.

About 3 days trial with this sizing process was taken in MG machine during September'2004.

In order to obtain required cobb sizing of paper, consumption of sizing chemicals in this process was as follow:

Alkenyl Succinic Anhydride : 0.83kg
Cationic rosin : 16kg
Retention aid chemical : 90g
Liquid starch : 1.91kg
Alum : 7kg

A comparative statement on paper properties with acid sizing process and ASA sizing process is presented in table-2.

Following are the observations on the performance of ASA sizing process as against acid sizing process:

- Retention values are comparable in both sizing process
- Physical strength properties of paper with ASA sizing are high even at high ash level of paper compared to the paper with acid sizing process
- On line cobb sizing is obtained as in case of acid sizing process
- Optical properties of paper in both sizing process are comparable
- MG paper gloss with ASA sizing process is on lower side(15-18%) compared to that of acid sized product(18-21%)
- Low post color number of paper with ASA sizing, indicates, better permanency of paper compared to acid sized paper
- High cost of ASA sizing chemicals including cationic starch, cationic rosin, alum and retention aid

Due to high chemical cost, reduction in gloss of paper and some starch lumps problem, ASA sizing process also could not be continued in MG machine.

BINARY SIZING PROCESS

Binary sizing process may be neutral/alkaline one. In this article we discuss about binary neutral sizing process. The term binary used here because, this sizing process involves combination of two sizing chemicals, namely, cationic rosin (dispersed rosin) and Alkyl Ketene Dimer(AKD).

From our earlier trials in MG machine we experienced that, with neutral sizing process, the consumption of sizing chemical is high, i.e., in the range of 19-20kg per ton of paper and with AKD sizing process, in addition to high chemical consumption there is significant loss of gloss in paper. As a

result of which we could not implement these sizing processes on regular basis. However, these problems could be overcome by using combination of cationic rosin and AKD in an optimised proportion and using little quantity of alum to maintain stock pH of about 7.0.

In this process, cationic rosin is added first to the system, i.e., at machine chest, AKD is added at fan pump inlet and alum is added at fan pump outlet. Retention aid is added at selectifier screen outlet.

The positive aspect of this sizing process is that, with minimum quantity of cationic rosin and alum, paper web gets partly sized even before entering the size press section and further it gets sized to the required level by the use of minimum quantity of AKD. In this binary sizing process, rosin and aluminium species are ionically bonded to each other and these precipitates render the fiber hydrophobic and in case of AKD sizes, a covalent bond is formed between the hydrophobic molecule and cellulose of the pulp fibers. Aluminium incorporated into protective colloid of the AKD particle increases it's self retention thereby strong attachment of AKD to the fiber will reduce press picking.

After obtaining successful results from bench scale study, first plant trial was conducted in MG machine in August'2006 and the results were very much encouraging. Subsequently, after taking few more successful plant trials, this sizing process is commercially implemented in MG machine since November'2006.
From plant trial data of binary sizing process, it is seen that, for obtaining required cobb sizing paper of 30gsm(maximum), it needs, 7-8kg of cationic rosin, 8-9kg of AKD, about 9kg of alum and 50g of retention aid chemical. This consumption pattern of sizing chemicals has resulted a significant quantity of cost saving over acid sizing process(details are given later).

Table-3 represents the comparison of paper properties between binary sizing and acid sizing process.

Following are the observations on binary sizing process in MG machine over acid sizing process:

- There is definite increase in both one pass solid and ash retention in binary sizing process

- Cobb sizing of paper is achieved as per the norm of 30gsm(maximum) after oven curing at 105^0C for 5 minutes. Without curing(as such roll sample) cobb sizing is found to be 60 to 70gsm. The same sample after 24 hours of natural curing, the same is found to be in the range of 26-29gsm (without oven curing)

- Gloss value of MG variety paper with binary sizing process is found to be very much similar to that of acid sized paper. This could be achieved due to the use of very low quantity of AKD chemical and the extent of adverse effect on gloss with AKD may be getting compensated by cationic rosin, as it improves the gloss of paper

- Physical strength properties of MG paper with binary sizing process could be maintained as that acid sized paper, even with the increase in ash content of paper by 1.0-2.0 units

- No change is observed in optical and surface strength of binary sized paper

- Post color number of binary sized paper is in the range of 1.8-2.2, which is very much low compared to acid sized paper of 2.6-3.0. This indicates, the permanency of paper using binary sizing process is better than the paper with acid sizing

- No abnormalities are experienced in handling of cationic rosin and AKD chemical

Table 3 : Properties of paper with binary sizing process and acid sizing process

Particulars	UOM	MG Poster,70 gsm(NS)		MG Maplitho,120gsm(NS)		MG Maplitho,130gsm(W)	
		Acid sizing	**Binary sizing**	**Acid sizing**	**Binary sizing**	**Acid sizing**	**Binary sizing**
One pass solid retn.	%	76.8-82.8	77.2-85.7	80.9-58.0	81.6-87.0	80.6-83.0	82.0-84.6
One pass ash retention	%	46.8-49.8	48.5-50.4	37.4-44.2	43.7-50.6	41.6-46.1	42.8-50.0
Substance	gsm	69.1-70.2	68.3-70.6	116.8-119.8	120.3-121.2	129.0-131.8	129.0-130.8
Bulk	cc/g	1.42-1.43	1.46-1.53	1.48-1.49	1.40-1.48	1.40-1.43	1.45-1.47
Burst factor	-	19-20	17-19	16-17	19-20	16-17	18-20
Tear factor MD	-	52-54	50-52	45-50	53-54	41-47	47-56
Tear factor CD	-	56-57	56-58	48-58	56-60	47-50	53-59
Breaking length MD	m	4800-5200	4900-5400	4500-4700	4500-5200	4500-4600	5000-5300
Breaking length CD	m	2700-2900	3100-3300	2500-2600	2900-3000	2600-2800	2800-3100
Double folds MD	no	20-22	24-26	17-19	24-26	18-22	24-26
Double folds CD	no	10-12	16-17	10-12	14-16	10-11	15-16
Brightness	%	75-76	75	74	73-74	78-79	79
Opacity	%	88	91	94	99	99	99
Gloss	%	16-18	16-17	16-18	15-18	17-19	16-19
Cobb sizing TS/BS	gsm	24/27	23/28	25-28	25/27	24/28	23/26
Wax pick F/B	no	6/7	6/7	6/7	6/7	6/7	6/7
Ash content	%	10.5-10.6	11.1-12.0	10.5-10.7	11.0-11.3	9.1-10.2	11.8-12.2

- Machine runnability is observed better than acid sized process may be due to better drainage and retention of fines

- No adverse effect in the quality of machine wire water is observed from the point of pollution load in terms of Chemical Oxygen Demand (COD) by the use of binary sizing chemicals. COD of machine wire water in both sizing process is found to be in the range of 220-240 ppm

- No slippage is observed in paper conversion and finishing section with binary sizing system

- Time gap between two wire cleaning process is found to get increase from once in 3 days during acid sizing system, to once in 15 days during this binary sizing system

- Binary sizing process in MG machine is found to be cost effective over acid sizing process

CONCLUSIONS

In our experience, for MG machine, while going for neutral/alkaline sizing process, for obtaining improved sheet strength , improved paper stability on aging and reduction in corrosion, binary sizing process at near neutral pH is found to be beneficial compared to separate neutral sizing with cationic rosin or alkaline sizing with AKD/ASA from the point of low sizing chemical cost and retaining the gloss of MG paper .

Binary sizing process for MG products is found to have advantage over acid sizing process from the point of :

- low cost of sizing
- better retention
- maintaining clean wire for longer period and
- keeping high ash content in paper.

This sizing process also gives a flexibility to easily switch over to acid sizing process and vice versa.

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