Role of Additives in Papermaking

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SUMMARY

Two typical guar gums designated as A and B were tested for the dry strength improvement of paper. Factors like acidity of backwater, stuff consistency, fibre composition, dosage of gums and slowness of pulp stock were studied with respect to the effectiveness of the gum. Acidity of backwater above 200 ppm as H_2SO_4 decreased the strength properties of paper and the degree of sizing. Gums were effective with the pulps having upto 50% fines. Gums added at lower slowness, say 1.0% gum at 20°SR would give better strength properties as would have been obtained without gum at 30°SR. Breaking length would increase by 8–10% and burst factor by 15–17%. These improvements were achieved at the same time saving 57% of the beating period, which is in other words, a saving in power. Pulp became freer by about 15%, giving a scope to get more production. Gums could be successfully used by controlling factors like proper preparation of gum solution, control of acidity and control of optimum stuff consistency for getting better dry strength of paper.

INTRODUCTION

In India Bamboo is the chief raw material for pulp and paper manufacture, although to some extent hardwoods are also used. Number of varieties of paper are manufactured, using the same basic furnish, though the end product might have different properties. This variation of properties of paper can be accomplished in a number of ways. Right

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from pulping of bamboo to the preparation of stock, many changes might be introduced.

This study mainly deals to have better strength properties with the modification of the stock only.

One of the most important aspects of papermaking is to prepare the fibrous material in such a form that intimate contact between fibres and fibrils can occur on a molecular scale. This is one of the reasons for the beating and refining of the pulps. This may be termed as the mechanical hydration ([1]).

The intimate contact between the fibres and fibrils can be achieved by chemical hydration also. The chemical hydration is the adsorption of a colloidally active film or chemical substance which will result in the improved physical characteristics such as are obtained in refining. Chemical hydration in combination with mechanical treatment is highly effective in improving the internal bonding and thus the strength properties of paper.

Guar gum is derived from the seeds of the guar plant, *lyamopsis tetragonolobus* of family *leguminosa*. The endosperm which consists of about 35–42% of the seed is separated from the hull and the germ is ground to a fine particle size and is marketed as guar gum. The chief chemical constituent is galactomannan.

Through extensive literature survey ([5],[6],[7]), it is found that the characteristics of the gums decide its suitability for dry strength improvement of the paper. In India number of gums based mainly on guar seeds are manufactured with some modifications, by different manufacturers, under different trade names.

A study of these gums for their physical and chemical properties revealed that they very quite a lot from one another. For example ash content varies from 0.5 to 2.0% while in some gums it is upto 10%. Protein content varies between 3 to 10%, Galactomannan content varies between 65 to 85%. Brookefield viscosity of 1.0% cooked gums varies between 150 to 3600 cps. at room temperature. This indicates that their chain length or degree of polymerisation varies a lot. A paper maker wants a gum which can give "free" stock on high speed machine and at the same time increase the strength properties of the paper. In this paper a study of two typical guar gums is given.

Successful use of gums on paper machine depends upon a number of factors. A gum found to be effective on a laboratory scale may not yield the same result on paper machine. There are a number of factors to reckon with on paper machine. Some of the important parameters were studied and are discussed in this paper. These are :

(1) Chemical and physical properties of gums.

(2) Point of addition-addition before and after refining.

(3) Effect of fibre composition.

(4) Relation between adsorption and retention of gums on fibres and effect on strength properties.

(5) Effect of acidity and pH.

(6) Stock consistency in the moid (Head box) and formation.

(7) Slowness of the stock and different dosage of the gums.

EXPERIMENTAL

I. The physical and chemical properties of the gums were determined as per ISI Standard procedure ([8]) laid down for guar gum analysis. The results are tabulated in Table—I for gum A and B.

TABLE—I

SOME PHYSICAL AND CHEMICAL PROPERTIES OF THE GUMS A&B

Sl. No.	Properties	Gum A	Gum B
1	Moisture, %	11.20	12.60
2	Ash, %	0.96	1.04
3	Protein, % (Kjeldhal's method)	3.96	4.74
4	Acid insolubles, % (ISI method)	4.56	3.78
5	Galactomannan, % (by difference)	79.52	77.84
6	Particle size		
	+200 mesh	46.80	..
	−200 mesh	53.20	..
7	Viscosity of 1% solution, cps. (Brookefield viscosity with spindle No. 3 at rpm 12)	1420 (uncooked) 2600 (cooked)	550 (uncooked) ..

II. In all the experiments the furnish used was bamboo unbleached pulp with a Kappa Number of about 35. This pulp was collected from the pulp mill.

The gums were cooked at 1.0% concentration at 80°C. for 30 minutes. The temperature of the water was raised to 80°C. using indirect steam and to this water gum was added to get 1.0% concentration and this solution was held at that temperature for half an hour.

In all the experiments, where strength properties of handsheets were determined, the handsheets were prepared on Noble and Wood Sheetmaking machine with white water circulation system,

after beating the pulp in the Hollander Beater. Rosin, gum and alum were used in sequence in all the cases. The handsheets were tested after conditioning as per the Tappi Standard for the strength properties. The surface bonding strength was found out by Ivano's method ([9]).

Gum retention and adsorption were determined by finding out the gum content in the backwater by phenol-sulphuric acid method.

OBSERVATIONS AND DISCUSSION

PHYSICAL AND CHEMICAL PROPERTIES OF GUMS

The results tabulated in Table—I show that the gums A and B vary in almost all properties like protein content galactomannan content and viscosity. Gum A was more viscous than gum B at 1.0% concentration after cooking.

ADDITION OF GUM DURING AND AFTER REFINING

1.0% gum on pulp was added before beating in Hollander Beater, mixed well and then the pulp was beaten to various levels of slowness. In another case, pulps were drawn at various levels of slowness and then 1.0% gum on pulp was added and sheets were prepared. The results tabulated in Table—II show that:

(i) Retention of gum was reduced by 5 to 10% when it was added during refining instead of after refining.

(ii) There was no apparent advantage at least in strength properties, if the gum is added during refining.

(iii) Gum would give better performance, if added after refining as indicated by the increase in strength, apart from giving more retention.

EFFECT OF FIBRE COMPOSITION

Beating and refining are two different operations producing pulps of different composition of fibres and fines. In laboratory the pulp was beaten in Hollander beater, whereas in plant, Jordan and Disc refiners are used. With this in view, experiments were carried out to find out the effect of fibre composition on gum effectiveness. Samples of unbleached stock were collected from (i) mixing chest, (ii) Kalle flow box and (iii) Head box. In machine working, there is always some recirculation of white water at different stages, which is rich in fibres and fines. This result in the change in the composition of pulp from one point to another. Sheets were prepared in all the cases using 1.0% gum and without gum. The result are tabulated in Table—III.

TABLE—II

EFFECT OF THE ADDITION OF GUM 'A' DURING AND AFTER REFINING ON THE DRY STRENGTH OF PAPER

Sl. No.	Particulars	Mode of addition of gum							
		During Refining				After Refining			
1	Beating time, Secs	0	240	310	370	80	300	400	475
2	Slowness of pulp, °SR	15.0	21.0	25.0	33.5	15.0	20.0	25.0	33.0
3	Slowness (after all addition), °SR	16.0	20.0	25.0	35.0	21.5	25.0	31.0	45.0
4	Drainage time, Secs/700 ml	4.7	11.4	14.9	31.6	12.9	20.2	30.5	45.0
5	Gum added, % (on pulp)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	Gum retained, % (on pulp)	0.52	0.60	0.62	0.66	0.71	0.73	0.58	0.72
7	pH of the stuff (after all addition)	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
8	Basis wt., g/m²	98.9	96.3	103.0	96.3	100.8	96.8	95.1	97.4
9	Bulk, cc/g	1.56	1.50	1.46	1.44	1.55	1.52	1.47	1.43
10	Breaking length, kms.	3.92	5.26	5.55	5.83	4.77	5.23	5.59	6.20
11	Strength, %	2.0	2.4	3.3	2.8	3.1	3.5	4.2	4.1
12	Tear factor	84.6	76.0	76.6	70.8	86.4	80.6	77.8	77.8
13	Burst factor	24.4	32.2	40.4	40.4	32.1	39.0	42.5	43.3
14	Folding endurance, D.F. (MIT)	34	65	109	159	50	69	150	206

TABLE—III

EFFECT OF FIBRE COMPOSITION ON GUM EFFECTIVENESS

Sl. No.	Particulars	Pulp collected from: Mixing chest		Kalle flowbox		Headbox	
1	Gum added, % (on pulp)	..	1.0	..	1.0	..	1.0
2	Gum retained, % (on pulp)	..	0.72	..	0.72	..	0.68
3	Slowness, °SR	26	30	27	32	43	54
4	Drainage time, Secs/700 ml	16.2	26.6	17.3	26.5	42.4	85.6
5	Basis weight, g/m²	100.9	100.1	96.6	103.0	99.8	102.2
6	Bulk, cc/g.	1.48	1.43	1.51	1.40	1.44	1.42
7	Breaking length, kms.	5.56	6.30	5.64	6.14	5.20	5.80
8	% increase in B.L. over blank	..	13.3	..	8.9	..	11.5
9	Stretch, %	2.7	2.6	2.3	2.3	2.2	2.2
10	Tear factor	73.9	66.9	74.5	68.0	61.1	60.6
11	% increase in T.F. over blank	..	–9.5	..	–8.7	..	–0.8
12	Burst factor	36.1	42.5	34.1	42.5	31.6	37.8
13	% increase in B.F. over blank	..	17.7	..	24.6	..	19.6
14	Folding endurance, D.F. (MIT)	72	125	74	109	39	36
15	% increase in D.F. over blank	..	73.6	..	47.4	..	–7.7

Bauer McNett Fibre Classification

Sl. No.	Sample	% Retained on: + 50	− 50 + 100	− 100 + 150	− 150
1	Mixing chest	55.00	4.54	3.22	37.24
2	Kalle flowbox	52.49	3.98	3.66	39.87
3	Headbox	43.65	3.67	2.78	49.90

It was seen that the gum addition has improved breaking length and burst factor for all the samples. This suggested that eventhough the head box sample was rich in fines (about 50%), still an improvement in the breaking length and burst factor could be obtained in the laboratory after the addition of the gum. It also showed that gum would not lose its effectiveness due to high content of fines even upto 50%. The results also showed that breaking length, burst factor, tear factor and double folds were on the lower side for the head box sample, compared to the mixing chest and the Kalle flow box samples. This was obviously clear because of the excessive amount of fines in the head box sample, compared to the other two samples of mixing chest and Kalle flow box.

ADSORPTION AND RETENTION OF GUMS

The capacity of pulp fibres to adsorb gums chemically varies depending upon the characteristics of gums and the amount of the gum added. Adsorption of gum on pulp fibres is a chemical phenomenon known as chemisorption, whereas retention of gum in paper is a chemical plus physical phenomenon. To find out the relation between absorption and retention of gum and to know the possible dosage, few experiments were carried out using different dosages of gums. The results recorded in Table—IV show that maximum adsorption (90%) of gum on pulp fibres occurred at 0.5% addition. The amount of gum adsorbed, goes on increasing based on pulp fibres as the addition of gum increased. However, if considered on the basis of gum added, percentage of gum adsorbed decreased as the addition of gum increased. Same trend was observed in the case of the retention of gum on paper. The retention of gum was higher than the adsorption of gum by 10-17%. This difference was due to the fact that after the for-

mation of the sheets the free gum content would be retained partially by the pulp mat formed and when pressed and dried, it would attach itself to the fibres. These results help in fixing the optimum dosage of gum to get good results.

TABLE—IV

ADSORPTION OF GUM ON UNBLEACHED BAMBOO PULP FIBRES

Constant Conditions

Pulp used	..	Unbleached bamboo pulp
Kappa No. of the pulp	..	45.4
Slowness of the pulp	..	25°SR
Rosin added, %	..	1.0
Alum added, %	..	3.0
Pulp consistency during addition, %	..	3.0
Consistency of the diluted slurry, %	..	0.8
pH of the slurry	..	4.2 – 4.4

Gum added, % (on pulp)	0.5	1.0	1.5	2.0
Gum adsorbed, % (on pulp)	0.45	0.66	0.78	1.53
Gum adsorbed, % (on gum)	90.0	66.0	52.0	51.0
Gum retained, % (on pulp)	0.39	0.73	1.04	1.89
Gum retained, % (on gum)	78.0	73.0	69.0	63.0

EFFECT OF ACIDITY AND pH

In this study the acidity and pH of the stuff was varied by adding different amounts of alum. For dilution and circulation, water acidified with sulphuric acid was used. The results are given in Table—V.

Some interesting observations were made in this study. (a) When a stuff or any acidity, for any consistency was mixed with water of same acidity, the acidity of the resulting mixture was less than the initial acidity of the stuff or water. This was probably because the pulp fibres take up some acid. It was also noted that the drop was more in lower acidity than at higher acidity level. This was because at higher acidity the pulp has already taken the acid that was required and hence only marginal decrease in acidity occurred after dilution. (b) The slowness of the pulp decreased as the acidity increased and the pulp became freer at higher acidity when no gum was added. When gum was added, eventhough the slowness of the pulp decreased, the drainage characteristics as measured by the drainage time in the Schopper Riegler freeness tester, remained the the same. (c) At higher level of acidity the strength properties of the sheets decreased, with or without gum. A marked decrease was observed in double folds as the acidity of the stuff was increased. (d) Sizing was drastically affected at high acidity. 50 secs. of sizing at 8.3 ppm acidity was reduced to 7 secs. when the acidity was increased to 296 ppm. Same trend was observed with gum also. These results indicated that, high acidity was determental to the physical strength properties and to the degree of sizing. Lower acidity was preferred when gums were used.

EFFECT OF STUFF CONSISTENCY

Stuff consistency in the head box of paper machine is one of the important factor which may influence the formation of paper and hence, may also influence the effectiveness of any additive added. Though there was some limitation to alter the consistency in the Noble and Wood Sheetmaking machine mould, nevertheless few experiments were carried out using different consistencies of the stuff in the mould along with gum. 2% gum was used so that any change or effect in the retention could be easily noticed. The results in Table—VI show that (a) Increase in the stuff consistency in the mould prior to the formation of the sheet did not affect the retention of gum in the sheets. This may mean that, the gum once adsorbed by the pulp fibres was not leached out by dilution of the stuff. (b) At higher consistency, the strength properties were low eventhough the gum retention was same as that of at lower consistency. The formation of sheet at higher consistency was not good. This means that, eventhough the retention was the same, proper distribution of the fibres in the sheet was also an important factor in improving the strength properties. Effectiveness of the gum might be enhanced or retarded by the type of formation. This might also mean that stuff consistency should be on lower side when gum was used, than when gum was not used.

EFFECT OF SLOWNESS AND GUM DOSAGE

Apart from factors like acidity, fibre composition and stuff consistency the quantity of gum and the degree of refining required to get good results were the most important factors because these were the factors that finally determine the suitability of a gum economically. A gum which might be effective at certain dosage and degree of refining might not be economically suitable because of cost factor. In order to find out the optimum dosage and degree of refining, a number of experiments were carried out. Two gums A and B whose characteristics are tabulated in Table— I were used for the study. The pulp was beaten to various levels of solwness and different dosages of gums A and B were added. The results are tabulated in Table—VII and VIII. The results show the following general features when the gums were used :

TABLE—V

EFFECT OF ACIDITY AND pH ON SLOWNESS, DRAINAGE TIME AND STRENGTH PROPERTIES OF THE HANDSHEETS WITH AND WITHOUT GUM

Alum added %	1.0		1.5		2.0		3.0		4.0	
Gum added, %	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
Acidity of the water used to dilute to 0.8% cy, ppm H_2SO_4	17.6	20.6	36.3	32.3	51.9	46.1	196.0	184.2	358.7	331.2
Acidity of the stuff at 0.8% cy, ppm H_2SO_4	8.3	7.8	13.7	8.8	39.2	34.3	149.0	153.9	303.8	296.0
pH of the stuff	6.6	6.5	4.8	4.9	4.15	4.2	3.35	3.2	2.8	2.8
Acidity of the water used to make the sheets, ppm H_2SO_4	8.8	12.7	16.7	16.7	33.3	31.4	166.0	157.0	313.6	323.4
Final pH of the recirculated water	7.2	7.15	7.0	6.9	4.85	4.8	3.65	3.45	3.3	3.0
Final acidity of the recirculated water, ppm H_2SO_4	3.9	3.9	5.9	4.9	16.3	17.6	145.0	117.6	258.8	266.6
Slowness, °SR	30	37	31	36	27	35	26	35	25	31
Draining time, Secs/700 ml	21.0	25.0	20.2	24.1	16.5	24.3	14.5	26.4	13.5	24.9
Basis weight, g/m²	97.0	97.6	93.2	98.0	97.2	100.5	96.0	95.3	93.0	97.0
Bulk, cc/g.	1.48	1.46	1.53	1.47	1.50	1.44	1.53	1.49	1.54	1.49
Breaking length, kms.	5.66	6.11	5.01	5.64	5.23	5.63	5.06	5.60	4.90	5.24
% increase in B.L. over blank	..	7.95	..	12.60	..	7.66	..	10.70	..	6.94
Stretch, %	2.3	2.6	2.8	2.5	2.5	2.5	2.1	2.1	2.3	2.5
Tear factor	79.4	75.8	78.4	79.2	83.8	76.6	85.4	74.5	85.4	75.8
% increase in T.F. over blank	..	−4.54	..	+0.95	..	−8.60	..	−12.8	..	−11.2
Burst factor	35.1	41.4	33.1	39.3	31.7	38.7	30.3	39.0	30.3	38.6
% increase in B.F. over blank	..	18.0	..	18.8	..	22.1	..	28.7	..	27.4
Folding endurance, D.F. (MIT)	78	111	50	105	45	78	37	78	32	64
% increase in D.F. over blank	..	42.4	..	110	..	51.1	..	111	..	100
Bonding strength, Kg/mm²	0.086	0.088	0.083	0.103	0.085	0.095	0.078	0.090	0.081	0.094
Sizing, Secs.	50	46	46	40	44	47	31	9	7	1

TABLE—VI

EFFECT OF VARIATION OF STUFF CONSISTENCY IN THE MOLD ON THE STRENGTH PROPERTIES AND GUM RETENTION OF UNBLEACHED, UNREFINED BAMBOO PULP

Sl. No.	Particulars	Blank	2.0% gum	2.0% gum	2.0% gum
1	Consistency of the stuff in the mold, %	0.036	0.036	0.053	0.125
2	Slowness, °SR before additions	14	14	14	14
3	Slowness, °SR after all additions	15	17	17	17
4	Drainage time, Secs./700 ml	3.0	4.8	4.8	4.8
5	pH of the stuff	4.2	4.3	4.3	4.3
6	Acidity of the stuff at 0.8% consistency, ppm H_2SO_4	46.1	46.1	46.1	46.1
7	Acidity of the white water after making the sheets, ppm H_2SO_4	21.6	30.4	27.4	25.5
8	Gum retained in the sheets, % (on pulp basis)	..	1.18	1.20	1.31
9	Gum retained in the sheets, % (on gum basis)	..	59.0	60.0	65.5
10	Basis weight, g/m²	97.8	98.2	95.0	93.3
11	Bulk, cc/g.	1.70	1.60	1.61	1.70
12	Breaking length, kms.	3.32	4.26	4.00	3.32
13	Tear factor	100.1	95.8	101.0	120.5
14	Burst factor	18.6	27.1	27.4	20.0
15	Folding endurance. D.F. (MIT)	14	38	31	21

TABLE—VII

EFFECT OF GUM "A" ON THE DRY STRENGTH IMPROVEMENT OF UNBLEACHED BAMBOO PULP

Beating time, Min.	3.5					6.0					9.5				
Slowness, °SR	20	20	20	20	20	25	25	25	25	25	30	30	30	30	30
Gum added, % (on pulp)	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
Slowness after the addition of Rosin, gum & alum, °SR	16.5	18.0	20.0	21.0	24.0	19.0	21.0	24.0	23.0	26.0	22.0	25.0	25.0	27.0	27.0
Drainage time, secs/700 ml	5.2	6.8	9.2	12.5	11.5	8.3	10.2	13.3	12.8	13.0	12.0	11.5	12.0	16.7	23.4
Bulk, cc/g.	1.74	1.61	1.58	1.54	1.50	1.62	1.56	1.53	1.54	1.48	1.55	1.49	1.49	1.48	1.50
Breaking length, kms	3.52	4.02	4.40	4.78	4.98	3.35	4.55	5.23	5.58	5.44	4.50	5.43	5.55	5.82	5.86
Stretch, %	2.4	2.6	2.7	3.1	3.2	2.3	2.3	3.3	3.2	3.6	2.6	3.1	3.2	3.4	3.5
Tear factor	104.5	95.0	98.0	93.0	89.5	104.0	91.7	85.5	86.5	85.8	92.7	79.6	80.8	80.4	79.7
Burst factor	20.3	28.3	32.5	36.0	35.8	26.0	35.8	35.9	38.7	39.5	32.4	36.6	38.3	38.4	38.9
Folding endurance, D.F.	14	48	46	92	86	43	76	74	106	131	50	105	105	144	153
Bonding strength, kg/mm²	0.03	0.041	0.058	0.052	0.056	0.043	0.051	0.058	0.054	0.056	0.065	0.074	0.074	0.075	0.072

TABLE—VIII

EFFECT OF GUM "B" ON DRY STRENGTH IMPROVEMENT OF UNBLEACHED BAMBOO PULP

Beating time, Min.	3.0					5.5					7.0				
Slowness, °SR	20	20	20	20	20	25	25	25	25	25	30	30	30	30	30
Gum added, % (on pulp)	0	0.5	1.0	1.5	2.0	0	0.5	1.0	1.5	2.0	0	0.5	1.0	1.5	2.0
Slowness after the addition of Rosin, gum & alum, °SR.	19.0	18.5	20.0	19.0	22.0	19.0	20.0	23.0	21.5	23.0	21.5	22.0	24.0	26.0	27.0
Drainage time, secs/700 ml	6.4	7.2	8.0	10.0	9.5	11.5	11.5	14.8	14.7	13.0	11.5	15.5	16.5	18.6	18.5
Bulk, cc/g.	1.76	1.75	1.70	1.70	1.64	1.74	1.67	1.65	1.61	1.64	1.70	1.65	1.62	1.60	1.60
Breaking length, kms	3.47	3.84	4.03	4.13	4.33	3.54	4.36	4.57	4.68	4.75	3.82	4.48	4.68	4.65	5.10
Stretch, %	2.3	2.5	2.7	2.7	2.9	2.8	3.0	2.9	3.3	3.0	3.2	3.5	3.7	3.4	3.7
Tear factor	92.8	93.6	91.8	89.4	87.0	83.5	88.0	83.3	85.4	83.8	91.3	88.7	85.3	83.3	80.5
Burst factor	21.1	25.8	29.2	30.8	30.4	24.8	30.6	30.4	34.0	31.6	25.8	31.2	34.0	34.4	36.7
Folding endurance, D.F.	19	29	31	39	49	23	29	41	62	81	31	54	61	70	81
Bonding strength, kg/mm²	0.036	0.050	0.047	0.050	0.060	0.046	0.053	0.059	0.063	0.061	0.055	0.067	0.064	0.073	0.076

A. Addition of any dosage of gum to a pulp of any slowness,

(a) increased the final slowness of pulp,

(b) increased the drainage time of stuff,

(c) slightly decreased the bulk,

(d) decreased the tear factor,

(e) increased the breaking length, burst factor, bonding strength and double folds,

(f) generally the retention of gum was increased at higher level of slowness.

B. Gum was more effective percentage-wise compared to blank at lower slowness level than at higher slowness level. In other words, at higher level of slowness the desired strength was obtained with the gums. However, the percentage increase in the strength properties, compared to the blank at a particular level of higher slowness, is lower than at lower slowness level.

C. Slightly beaten pulp gives better strength properties over its own blank and that of unbeaten pulp, confirming the view of Swanson (1), that roughening of fibre surface is essential for the gum to be more effective.

D. Comparison of strength properties of blanks i.e. without gum, of pulp of higher slowness, with that of pulps having varying amounts of gums at lower slowness, a very distinct picture emerged, showing the importance of the use of additives. The following examples with gum B (Table— VIII) makes the point clear. Same observations also be made with gum A (Table—VII). Comparison of strength properties of sheets prepared with different dosages of gum at 20° SR is made with that of blanks i.e. without gum at 20°, 25° and 30°SR.

(1) Beating period was reduced by 40 and 57% compared to the blanks of 25 and 30° SR respectively.

(2) Drainage time was reduced by 37%, 30%, 13% and 17% compared to blanks of 25°SR and almost to the same extent compared to the blank of 30°SR with 0.5%, 1.0%, 1.5% and 2.0% gum respectively. However, drainage time as compared to the blank of 20°SR was increased by 13%, 25%, 58% and 50% respectively with 0.5%, 1.0%, 1.5 and 2.0% gum.

(3) Bulk was reduced from 2 to 3% in all the cases.

(4) Breaking length increased by 10.7%, 16.1%, 19.0% and 24.0% over the blank of 20°SR by 8.5%, 13.9%, 16.7% and 22.3% over the blank of 25° SR and by 0.5%, 5.5%, 8.1% 13.3% over the blank of 30°SR with 0.5%, 1.0%, 5% and 2.0% gum respectively.

(5) There was little change in tear factor in all the cases.

(6) Burst factor increased by 22.3%, 38.4%, 46.0% and 44.0% over the blank of 20°SR and increased by 4.0%, 17.7%, 24.2% and 22.6% over the blank of 25°SR and increased by 0%, 13.2%, 15.5% and 17.9% over the blank of 30°SR with 0.5%, 1.0%, 1.5% and 2.0% gum.

(7) Double folds increased by 81.3%, 93.6%, 143% and 203% over the blank of 20° SR, by 26.0%, 34.8%, 69.5% and 113% over the blank of 25°SR with 0.5%, 1.0%, 1.5% and 2.0% gum. No increase in double folds was observed compared to the blank of 30°SR with 0.5% and 1.0% gum. However, 25.8% and 58.0% increase was observed with 1.5% and 2.0% respectively.

(8) Surface bonding strength increased by 39.0% 30.6%, 55.5% and 66.7% over the blank of 20°SR, an increase of 8.7%, 0.2%, 21.8% and 30.4% was observed over the blank of 25° SR and no increase was observed over the blank of 30°SR with 0.5%, 1.0%, 1.5% and 2.0% gum respectively.

CONCLUSIONS

(1) Gums could be used more advantageously when added after refining.

(2) Fibre composition did had a bearing on the strength properties of paper. More the fines less would be the strength properties. However, fines to the extent of 50% did not affect the effectiveness of gums. Even at this level of fines, improvement in strength properties was observed.

(3) Maximum adsorption of gums on pulp fibres took place at 0.5% addition (90% adsorption). This went on decreasing at higher percentage of gum addition. However,on the basis of pulp, it increased. Same trend was observed in the case of retention of gums in paper. Retention of gum was always higher by 10–15% than adsorption of the gum at the same dosage.

(4) High acidity above 200 ppm as H_2SO_4 was detrimental to the strength properties of paper and the degree of sizing. It reduced the effectiveness of gums. Gums could be used effectively at lower acidity preferably between 100–150 ppm as H_2SO_4.

(5) Higher stuff consistency would adversely affect the formation of paper, eventhough the retention was not altered. The required stuff consistency may vary, as this should be foundout by actual work on the plant.

(6) Gums were effective as dry strength improves. Any dosage right from 0.5% to 2.0% was effective at any slowness level. However, depending upon the quality of paper required, cost of gum and other plant conditions, the optimum dosage of gum and the slowness of the stuff, should be determined. Generally 1 to 1.5% gum at 20°SR would give better dry strength improvement, as well as higher production compared to the pulps without gum.

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