Control of Wet End Chemistry by Organic Polymers Part XI : Cationic Guar Gum as Wet End Additive*

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ABSTRACT:-- Cationic guar gum prepared in the laboratory was applied to beaten cotton linter pulp in order to evaluate its efficiency in developing dry strength of paper and also retention of filler. The cationic guar gum has been found to be an effective beater additive for improving dry strength, especially burst. Even, in presence of 50% filler, bursting strength improvement as high as 41% can be attained with 0.5% addition of cationic guar gum (DS 0.07-0.1) on the basis of pulp.

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INTRODUCTION

Guar gum is a carbohydrate polymer containing galactose and mannose as the structural building blocks. Its usefulness as a thickening agent for water and as a reagent for adsorption and hydrogen bonding with mineral and cellulosic surface has led to extensive investigation of this natural polymer to such varied applications as in the production of petroleum and natural gas, as wet end additives in paper industry, as dye solution thicknener in textile printing and as flocculant to produce liquid solid separation in mining industry etc.

We had a project on development of a cheap and economic hydraulic fracturing chemical for increased production of petroleum crude and gas. One of the chemicals used by us for this purpose contains guar gum and its derivatives. It is with this aim in view that we studied modification of guar gum in details. While our studies in the development of fracturing fluid is still in progress, we made considerable headway for using guar gum in paper industry for improvement of strength and retention of fillers and the results of our investigation are reproduced in this article.

Use of guar gum and its derivatives for improving paper properties is quite old. The Japanese has been aware of the benefits of these gums for many centuries[1]. The use of gums and starches as dry strength additives has been exhaustively reviewed[2-4].

There have been very few reliable sources of information that make it possible to estimate the quantity of guar gum used in paper making in this country. It is known that usually the modified high viscosity guar gum is the most widely accepted although new developments such as low viscosity modifications and highly cationized derivatives have also been introduced.

It has been observed that unmodified guar gum swells strongly and disperses in water to form very viscous solution at low concentration. This solution when added to pulp get adsorbed on the pulp surface and strong adhesion takes place between the fibres when they are dried. However, for optimum

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strength development about 5% guar gum is necessary[2]. The effects of modified guar gum, such as cationic guar gum in improving strength of paper, in retaining fines and fillers are rather scanty.

The purpose of employing guar gum is to increase paper strength in general but sometimes the improvement of bonding strength and splitting resistance of boards, sheet formation and filler and fines retention are also intended.

In our previous publications on this series[5-8] we had reported the use of acrylamide polymer and cationic starch as wet end additives. In this paper we are reporting the wet end behaviour of cationic guar gum with particular reference to improvement of dry strength and retention of filler. Also, if any synergistic effect can be derived from a combination of cationic starch and cationic guar gum has been investigated.

EXPERIMENTAL

Materials

The pulps used in the experiments were commercially available bleached cotton linter pulp supplied in dry form by M/s Sri Silk Ltd., Sirpur, Kagaznagar, A.P. After disintegration, the pulp was beaten to about 400 ml CSF in a valley beater.

The clay used in this investigation for retention experiments was a common filler grade type. The clay slurries were dispersed with the aid of 0.3% sodium hexametaphosphate. The filler content in the sheet is expressed as the mass fraction of the mass of the sheet.

The cationic guar gum (CGG) used in this investigation was prepared in the laboratory from commercial guar gum supplied by a local firm. The method of preparation, in short, is as follows.

5 gm of diethylaminoethyl chloride hydrochloride was dissolved in one litre aqueous solution containing 10 gm of a 30% sodium hydroxide solution. To the contents in the flask (2 L capacity) is now added 50 gm of the dried guar gum with stirring till a very homogeneous jelly like mass was formed.

The flask with the content is then heated over a constant temperature bath (40-45°C) for 3 hours. After the reaction is over, it is neutralized by a slow addition of 6 N HCl. The CGG thus produced was then precipitated with methanol and washed several times with methanol till free from impurities. The purified CGG was dried, and powdered. The yield of the product was 88-90%. The Degree of Substitution (DS) of the CGG was determined by nitrogen estimation. The D.S. was found to be 0.07 to 0.1.

METHODS

Hand Sheet Making

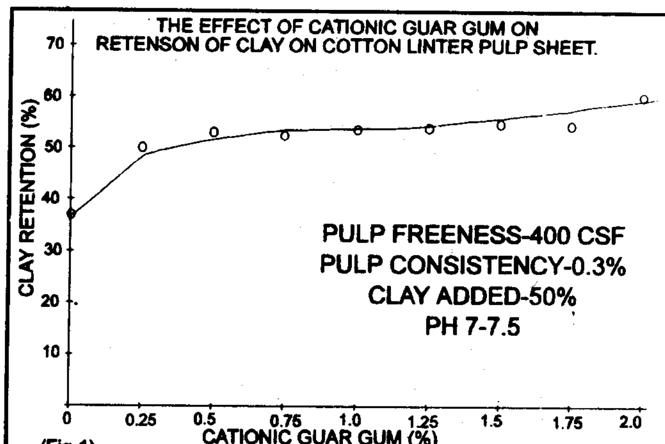
After the pulp had been mixed with the filler, the mixture was diluted with tap water to a stock consistency of 3 gl^{-1}. The pH of the stock was 7-7.5 unless otherwise stated and was not further adjusted. The sheet was formed with a nominal grammage of 60 gm^{-2} on a standard hand sheet former. The sheets were then pressed in a laboratory press and dried in vacuum.

Average strength values were obtained from a total of 10 tests on sheets. The tests were carried out in conventional testing machines using 100 mm long strip for tensile tests, the rate of elongation being 0.16 mmS^{-1}. Bursting strength of the sheets were measured with a Minden paper tester (Japan).

The nitrogen content of the CGG was determined by micro Kjeldahl method.

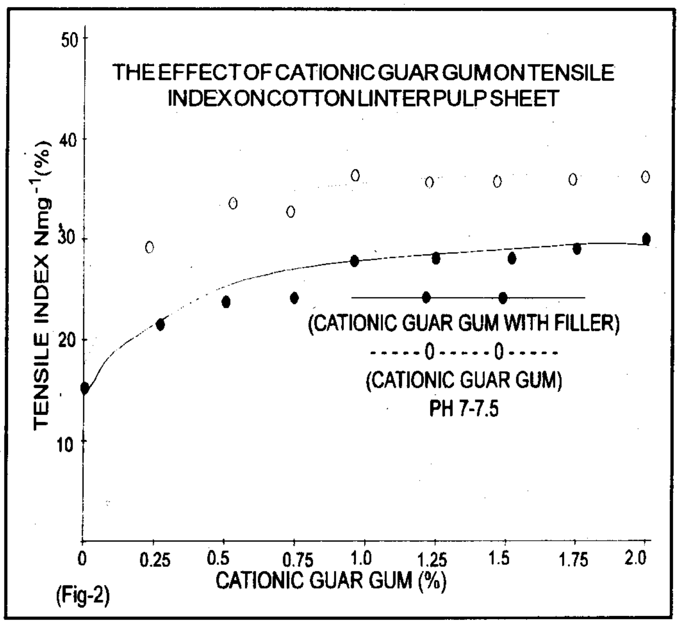
RESULTS AND DISCUSSION

The dry pulp was soaked overnight in measured quantity of distilled water and then beaten

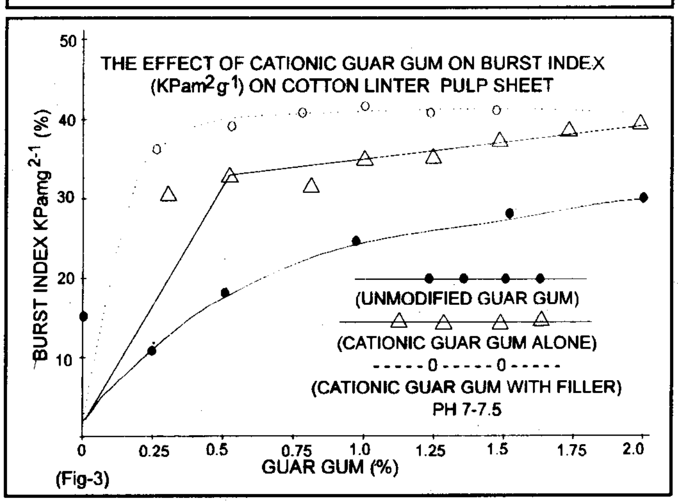


(Fig-1)

in a valley beater. The beating operation was continued till the freeness of the pulp reached 400 CSF (Canadian Standard Freeness). A measured portion of the beaten pulp was withdrawn from the beater from time to time and was treated with different amount of guar gum (CGG) and standard 60 gm^{-2} sheets were made. The bursting strength and tensile strength were determined as usual. The bursting strength and tensile strength of paper obtained with different percentages of CGG were plotted in Fig. 2 & 3. Similarly, a measured portion of the pulp was mixed with clay (filler) in the pulp to filler ratio 2:1 along with a measured quantity of CGG and mixed throughly. Then 60 gm^{-2} sheets were made and their tensile strength, bursting strength and retention of filler were determined. The values are plotted on Fig. 1,2 & 3.



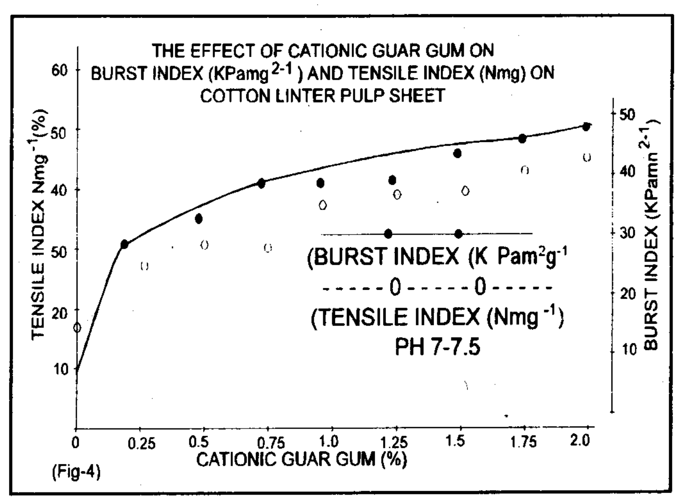
(Fig-2)



(Fig-3)

Swanson[2] showed that addition of 0.5% guar gum based on the weight of the pulp to a coniferous bleached sulfite pulp beaten for 15 min gave hand sheets of the same bursting strength as that of pulp which had been beaten for 50 minutes representing a reduction of 70% of the beaten time and an increase in bursting strength of 32%. However, we did not get such high value with cotton linter pulp using unmodified Guar gum at 7-7.5 pH. But with addition of 0.5% CGG prepared in the laboratory we could get 33% increase in bursting strength at pH 7-7.5 than that of the blank. With 50% filler addition in the pulp and with same concentration of CGG and pH we obtained a still higher increase i.e. 41% increase over that of the control. The bursting strength improvement with CGG and filler (2:1) and unconverted guar gum in beaten bleached cotton linter pulp (400 ml CSF) were shown in Fig.3. It was observed that with addition of filler (50%), tensile strength did not increase as expected with CGG. The considerable increase in bursting strength as evident from Fig.3, indicates that bursting strength depends much on increased number of bonding sites and compactness of the fibre mat, on the other hand, tensile strength depends more on individual fibre length and length breadth ratio which is not achieved by this. Addition of filler material perhaps act as an anchor in better retention of CGG over fibre through adsorption and bonding.

Therefore, it helps in sheet consolidation. The density improvement alongwith drying stress built up during sheet consolidation shows much higher burst increase with clay filled papers than for paper of zero filler content. Also, it is observed as shown in



(Fig-4)

Fig.1 that filler retention can be considerably increased by incorporation of small amount of CGG on pulp. On addition of 0.5% CGG on the pulp at pH 7-7.5, retention of filler increases to 58% i.e. an increase of 50% over that of the control. This is, because of its positive charge which is substantive to anionic fibre and filler held them tenaciously to withstand turbulence of a paper machine and the other is that CGG helps in flocculation of fines and filler and therefore retention is enhanced.

Swanson[2] have indicated that a synergistic effect can be had when the gum and starch (in the ratio 40 : 60 by wt) are cooked together before addition to pulp. Cushing[9] investigated the synergistic effect in both the laboratory and in commercial trials. He explains the effect by assuming that the increase in strength is due to increase in retention of the amylose component of the whole starch. However, using CGG and cationic starch we could not detect any such synergistic effect in the laboratory.

CONCLUSION

Cationic guar gum prepared in the laboratory has been found to be an effective dry strength additive.

It is found that cationic guar gum prepared in the laboratory is an effective retention aid of filler and improvement of 50% filler retention can be achieved.

Using cationic guar gum along with as much as 50% filler paper can be made without loss of bursting strength.

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