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(71) Applicant: **NALCO CHEMICAL COMPANY**
Naperville Illinois 60563-1198 (US)

(72) Inventors:
- **Surface, Thomas G.**
  Chesterfield, VA 23838 (US)
- **Noe, Jeffrey S.**
  Millersport, OH 43046 (US)
- **Weatherman, David J.**
  Claremore, OK 74017 (US)

(74) Representative: **Harrison, David Christopher et al**
MEWBURN ELLIS
York House
23 Kingsway
London WC2B 6HP (GB)

(54) Method of retention aid addition for improved paper board production

(57) The present invention relates to a method for manufacturing paper board which contains no inorganic filler. Pulp fines from the white water system and retention agents are mixed and then fed to the stock upstream of the paper machine prior to blending with the long fiber stock. Once flocculation takes place, the stock is drained to form a sheet and the sheet is dried.

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Description

European Patent Specification publication number 0 041 056 teaches a method of paper manufacture in which inorganic filler, colloidal silica and cationic starch are added to an aqueous suspension of cellulose fibers upstream of the inlet to the papermaking machine for the purpose of enhancing paper strength and improving filler retention on the wire. Swedish Patent Application 850016206 teaches a method of paper manufacture in which an aqueous suspension of an inorganic filler is first mixed with pulp fines, whereafter a retention agent is added (coflocculation) and the flocs thus formed are introduced into the pulp suspension at a location upstream of the paper machine thereby improving filler retention and enhancing paper properties. U.S. Patent No. 4,889,594, issued to Gavelin, teaches the use of an apparatus attached to a paper machine for use in co-flocculating filler and fine pulp.

Although the method taught by EP 0 041 056 provides a very good result it has the drawback of requiring the use of large quantities of expensive starch and is very difficult to apply in practice due to the complexity of the added ingredients and their reactions with locally occurring substances. Thus, the results may vary from plant to plant. The method according to the Swedish Patent Application 8500162-6, although presenting a simpler solution, still causes problems in achieving a result which can be reproduced in practice. It has been found that the resultant flocs or filler and fine pulp are broken down to some extent prior to being charged to the pulp suspension, resulting in impaired retention and necessitating careful control of flocculation and degradation in a particular manner and with the aid of special apparatus in order to achieve the result desired.

U.S. Patent No. 4,889,594, issued to Gavelin, teaches the use of an apparatus attached to a paper machine to provide a suitable environment for mixing a retention agent and inorganic filler for use in the manufacture of fine papers. These patents address the problem of strength loss when the level of inorganic filler is increased.

Many compositions and applications which are useful in the manufacture of fine paper are inappropriate for use in the manufacture of paper board. Several factors contribute to this incompatibility. Traditionally, no retention aid is used in the manufacture of paper board since retention aid tends to hurt formation when it is added to whole furnish. This is because paper board uses the longest fiber to achieve increased strength and long fiber is most susceptible to flocculation leading to formation loss. Poor formation causes loss in strength and poor dewatering of the sheet.

Secondly, the manufacture of paper board does not incorporate the use of any fillers since it is unbleached fiber and does not require the brightness conveyed by the addition of fillers. The use of fillers would, in fact, hurt the overall strength of the paper board, which is its most important sheet property. Since paper board is primarily designed for strength, the use of a filler would not be appropriate. Accordingly, it is an object of this invention to provide an improved method of flocculating fines in the manufacture of paper board.

The present invention relates to a method for manufacturing paper board, which contains no inorganic filler. Pulp fines from the white water system of the paper machine are mixed with one or more retention agents and then fed to the stock upstream of the paper machine. This introduces the fine/retention aid mixture prior to blending with the long fiber stock. Once flocculation takes place, the stock is drained to form a sheet and the sheet is dried.

When carrying out the process of the invention, fine pulp is flocculated with the aid of one or more retention agents, prior to the pulp being introduced into the long fiber stock fed to the paper machine. This results in flocculation of the fine particles without flocculation of the long fiber with resulting loss of formation.

Suitable retention agents for use in accordance with the present invention are any of the typical retention agents used in papermaking, including high molecular weight polymers which provide an irreversible bridge formation between particles. Anionic, cationic and nonionic polymers can be used herein. In order to charge the polymer to the system effectively and to obtain effective flocculation, it is necessary for each polymer molecule to come into contact with the largest number of particles possible. When flocculating in accordance with the invention, flocculation is effected in the presence of a small proportion of the total headbox furnish and when the flocs come into contact with the long fiber stock, at a later stage, the retention agent has already reacted and is, to a great extent, bound to active groups on the fine pulp.

Retention of the flocs in the paper board is caused by two mutually contributory reaction processes. According to the first of these processes, the flocs are filtered out and fasten in the meshes of the fiber network on those sites at which they are located when the fiber network is consolidated during the process of dewatering the stock on the wire of the paper machine. According to the second of these processes, which applies when using a cationic retention agent, the cationic flocs are attracted to anionic fiber surfaces in the fiber network, which amplifies the filtering process and contributes towards uniform distribution of the flocs in the direction of the Z-axis of the paper.

The method according to the invention is not dependent on the use of any particular kind of retention agent. The choice of retention agent depends on those demands placed on the process and on paper quality. A few retention agents which can be used in accordance with the invention are given below.

Flocculants such as copolymers of acrylamide with cationic or anionic monomers, which can be obtained at various molecular weights and degrees of substitution. Coagulants, including DADMACs, epi-DMAs, condensation products of ethylene dichloride and amines, polyethylene imine, modified polyethylene amines and polyamido amines. These coagulants may be used alone or in conjunction with flocculants in dual polymer programs. Nonionic flocculants such as polyacrylamide and polyethylene oxide. Both may be used with an enhancer such as phenol formaldehyde resins. Cationic starch can be added to the stock in order to increase the dry strength of the paper or to reduce the Z-potential of the system and cause coagulation of fine fraction.

Other polymers of the type polyamide, polyamideamine condensate, cationic polystyrene latex, and inorganic compounds of the type alum, polyaluminum chloride and sodium aluminate can also be used as retention agents in accordance with the present invention.

It is also possible when practicing the invention to use combinations of different retention agents, e.g. two-component systems or three-component systems. For example, a cationic retention agent can be combined with an anionic agent, in which case the cationic agent is preferably prior to the addition of the anionic agent.

A microparticle may also be added to any of the single or dual polymer programs described above. Particles currently in use include colloidal silica, bentonite, other smectite clays and anionic latex polymers.

Suitable three-component systems for use in accordance with the invention are the combination cationic starch/anionic polyacrylamide/cationic polyacrylamide and the combination bentonite or colloidal silica/anionic polymer/cationic polymer.

Suitable addition points for adding the retention aid according to the invention are any paper machine locations containing only fines, e.g., the tray, white water silo and suction side of the fan pump. Preferably , the addition occurs at a point where at least a low level of turbulence occurs, e.g., the suction side of the fan pump.

Numerous advantages are realized as a result of utilizing the method of the invention. The foremost advantage is the increase in retention that occurs without a loss of dewatering, while increasing runnability and tensile/crush strength of the end product These benefits cannot be achieved by adding the retention aid to the whole furnish (long fiber plus fines) because long fiber flocculation will lead to loss in formation, with resulting loss in dewatering, runnability and strength.

A second advantage is the reduced amount of retention aid that is required for use throughout the paper machine system. This reduction is realized because long fiber is not heated, as is done to paper fibers used in the production of finer paper grades.

The following examples are presented to describe preferred embodiments and utilities of the invention and are not meant to limit the invention unless otherwise stated in the claims appended hereto.

Example 1

The effect of adding Nalco® 7523, a low charge density (0.14 meq/g) cationic flocculant, was measured at a paper board manufacturing facility manufacturing corrugated medium from semi-chemical pulp. The 7523 was fed to the wire pit (fines only) and compared to pre-screen (conventional method - whole furnish).

Although addition of the Nalco® 7523 in a conventional manner to the whole furnish is beneficial, wire pit addition reduced *total wet-end breaks* by 59.2% (from an average of 9.7 breaks/day down to 3.9 breaks/day). Total wet-end breaks reflects both the fabric (wire) and press section breaks. On average, fabric breaks were reduced by ~72% when Nalco® 7523 was being run through the wire pit on the paper machine. Likewise, the break level in the press section (1st and 2nd presses) was reduced by ~42% when the polymer was being fed to the paper machine at the wire pit.

The lost time resulting from all wet-end breaks was reduced by ~58% when comparing the periods that the polymer was fed at the wire pit vs. those times when it was fed pre-screen. The average total lost minutes, when combining all wire pit vs. Pre-screen feed evaluation periods, was 70.3 minutes/day with normal polymer feed and 29.9 minutes/day with wire pit polymer feed. This represents a net gain in production time of 40.4 minutes/day or 0.675 hours/day. Using a production rate of 15.66 TPH, there is an increase in daily production of 10.54 Tons per Day @ 100% operating efficiency).

During the Nalco 7523 evaluation periods, the data suggests that the steam usage on the paper machine was reduced by ~5% when polymer was being fed at the wirepit. As a result, first-pass retention levels (during 26# medium production) increased from an average range of 70% - 72% to an average range of 79% - 81% with polymer added at the wire pit.

There appears to be a significant improvement in the polymer performance by changing the feed point to the drive-side of the wire pit (fines only) relative to pre-screen (whole furnish). In many instances, feeding the polymer to the white water essentially "pre-flocculates" the fines before being brought back into the headbox. By targeting the polymer at initially only recirculating tray water solids, this aims a very high initial dosage of chemical at the fines which are difficult to retain and that have the most detrimental impact on the paper machine drainage (due to their high relative surface area and water holding capabilities). More importantly, it provides improvements in retention and drainage, without potentially compromising sheet formation.

Maintaining good formation means that forming area vacuums will remain at higher effective levels (less light and heavy areas where vacuum integrity can be lost), sending a more uniform sheet of higher consistency and wet web strength into the press section.- This can mean less opportunity for press picking, fewer wet-end breaks, and better opportunity for the wet presses to remove water and build internal sheet strength.

Example 2

The drainage and drying effects of Nalco® 7523 on paper board manufacturing machipery were measured. Effects of the polymer on reel moisture, steam pressure, flatbox vacuums, and reel speed were calculated. Differences before, during, and after this evaluation on 33# heavyweights regarding average CFCO tests, average machine speeds, and average tons/hour were then measured. Nalco 7523 was added to the drive side of the wire pit at a target addition rate of 21b/ton. Three days later, Nalco 7523 flocculant was removed from the paper machine system at least at the same, if not slower, rate than it was taken out during previous evaluations. Some of the observations made during this time period where the feed rate was reduced from 2 lb/ton down to 0 lb/ton are as follows.

The effect of reduced polymer dosages on the reel moisture levels was measured. Before each subsequent polymer dosage reduction, the reel moisture was allowed to stabilize below 8.8% via increases in the 4th and 5th section steam pressure, changes in the rush-drag to reduce the amount of water being carried down the table, reduced dilution water, or through reductions in machine speed, before the feed rate was further reduced. Reel moistures were at 8.2% at a 2 lb/ton dosage and soared to a maximum moisture level of 13.3% when the polymer was removed entirely from the addition to the wire pit.

Prior to decreasing the polymer dosage (i.e., 2 lb/ton), the steam pressure was at ~ 43 psi. Upon making the final reduction in dosage from 0.5 lb/ton) down to 0 lb/ton, the steam pressure reached a maximum level of ~ 94 psi. The 3rd section steam increased slightly from ~ 112 psi up to ~ 116 psi, throughout the removal of the polymer from the paper machine.

A decrease in wire drainage was observed after removing the retention and drainage aid on the wire. This decrease in wire drainage was shown by the significant increase in the #3 Flatbox vacuum level. At the 2 lb/ton dosage, the #3 Flatbox vacuum was ~7.35"Hg. This increased by ~ 27% up to a vacuum reading of 9.3"Hg when the polymer had been completely shut off. This increase remained at this high level even after the machine tender attempted to compensate through reductions in rush-drag (-60 fpm to -75 fpm) and machine speed. The wet line position carried ~ 3 feet further down the machine (toward the press section) when comparing the 2 lb/ton dosage to no polymer addition. In addition, the CD moisture 2-sigma moisture profile was much poorer after the removal of the polymer (1.30% @ 2 lb/ton versus 1.85%+ @ 0 lb/ton).

As to machine speed, at the 2 lb/ton dosage, the machine was running at a reel speed of 1,370 fpm. Once the polymer had been completely removed, the reel speed had been reduced down to 1,355 fpm for a net reduction in speed of 15 fpm (while running at significantly higher steam pressures).

Pre-trial, trial, and post-trial period CFCO test averages during the 33# heavyweight run were as follows:

- Pre-Trial 74.4 psi
- **Nalco 7523 Trial 77.2 psi**
- Post-Trial 72.8 psi

Average machine speeds during the pre-trial, trial, and post-trial periods during the evaluation of Nalco® 7523 polymer while running 33# medium were as follows:

- Pre-Trial 1449 fpm
- **Nalco 7523 Trial 1461 fpm**
- Post-Trial 1442 fpm

The production rates (tons/hour) when comparing the pre-trial, trial, and post-trial periods are as follows:

- Pre-Trial 15.72 tons/hour
- **Nalco 7523 Trial 17.22 tons/hour**
- Post-Trial 16.09 tons/hour

In summary, when comparing the effects of a 2 lb/ton polymer feed rate with no polymer addition, the following observations were documented. To achieve the same reel moisture levels without polymer, approximately 41 psi of additional 4th and 5th section dryer steam pressure was required (~43 psi @ 2 lb/ton versus 84 psi @ 0 lb/ton). Additionally, a reduction in machine speed of 15 feet per minute (fpm) was also necessary due to the poorer wire drainage and higher moistures/poorer moisture profiles. It was also necessary to reduce the rush-drag from -60 fpm to -75 fpm while reducing the dilution valve position from 78% down to 69%.

Example 3

TABLE 1

Item	Pre-Trial	During Trial
CSF,mls	350	400
FPR, %	85	93
Freeness Drop,ml	100	150
MD Tensile Strength, lbf/0.5in	71-73	78-81
MK Formation		Better
Flock Count	70	100+
Flock Size	19	14.8
Flock Area, %	70	50

At this mill, linerboard for gypsum wallboard is produced on a Fourdrinier using 100% recycle furnish. The initial retention/drainage program consisted of a flocculant fed pre-screen, a coagulant and alum fed on the suction side of the fan pump and a microparticle fed post-screen. This is the pre-trial column shown in Table 1 above. The trial consisted of changing the flocculant feed point from pre-screen (whole furnish including long fiber) to the white water silo (fines only). This configuration is denoted as "During Trial" in Table 1 above. This change in feed point resulted in increased drainage as measured by Canadian standard freeness (CSF), increased first pass retention (FPR), increased machine direction sheet strength and improved formation.

Example 4

The retention/drainage program of the invention was incorporated into a dual headbox Fourdrinier machine producing virgin unbleached kraft linerboard. It was found that by feeding the dual polymer retention program that had been in use at the machine to the wire pit (fines only) production was increased from 850 to over 900 tons per day. Significantly, a 2% reduction in white top liner furnish was realized as a result of improved retention of the brown unbleached kraft fines gained by the change in feed points.

Changes can be made in the composition, operation and arrangement of the method of the present invention described herein without departing from the concept and scope of the invention as defined in the following claims:

Claims

1. A method of manufacturing paper board using a paper machine in which stock is fed to a headbox of the paper machine to form the paper board, the method comprising the steps of:

   mixing white water pulp fines from the stock with a retention aid to form flocs;
   feeding the flocs to the long fiber stock upstream of the headbox;
   draining the stock to form a sheet; and
   drying the sheet.

2. A method according to claim 1, wherein retention aid is introduced to machine white water.

3. A method according to claim 1 or claim 2, wherein at least one flow of fine pulp is delivered to at least one headbox in a paper machine provided with multiple headboxes.

4. A method according to claim 1, claim 2 or claim 3, wherein the retention aid is a copolymer of acrylamide with cationic or anionic monomer.

5. A method according to claim 1, claim 2 or claim 3, wherein the retention aid is DADMAC, epi-DMA, a condensation

product of ethylene dichloride and amine, polyethylene imine, a modified polyethylene amine or polyamido amine.

6. A method according to claim 5, wherein the retention aid is used in conjunction with one or more flocculants.

7. A method according to claim 1, claim 2 or claim 3, wherein the retention aid is a polyacrylamide or polyethylene oxide.

8. A method according to claim 7, further comprising the addition of a phenol formaldehyde resin.

9. A method according to claim 1, claim 2 or claim 3, wherein the retention aid is selected from the group consisting of polyamide, polyamideamine condensate, cationic polystyrene latex, alum, polyaluminum chloride and sodium aluminate.

10. A method according to claim 1, claim 2 or claim 3, wherein the retention aid is a starch/anionic polyacrylamide/cationic polyacrylamide, colloidal silica/anionic polymer/cationic polymer or bentonite/anionic polymer/cationic polymer.

11. A method according to any one of the preceding claims, further comprising the addition of cationic starch to the stock.

12. A method according to any one of the preceding claims, further comprising the addition of a microparticle to the stock.

13. A method according to claim 12, wherein the microparticle is selected from the group consisting of colloidal silica, bentonite, other smectite clays and anionic latex polymers.

14. A method according to any one of the preceding claims, wherein the retention aid is added to the tray, to the white water silo and/or to the suction side of the fan pump.