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[54] **METHOD FOR IMPROVING WATER DRAINAGE FROM A PAPER WEB ON A WIRE-SCREEN OF A PAPER MACHINE BY USING A MODIFIED POLYACRYLAMIDE PREPARED FROM A WATER-SOLUBLE POLYACRYLAMIDE BY THE HOFFMAN REACTION**
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[56] **References Cited**

UNITED STATES PATENTS

2,729,560	1/1956	House et al.	162/168
2,890,978	6/1959	Woodberry	162/168

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ABSTRACT: The sheeting or paper web forming operation in a paper making process, can be facilitated by addition to a pulp stock, of a modified polyacrylamide prepared from a water-soluble polyacrylamide by the Hoffmann reaction.

METHOD FOR IMPROVING WATER DRAINAGE FROM A PAPER WEB ON A WIRE-SCREEN OF A PAPER MACHINE BY USING A MODIFIED POLYACRYLAMIDE PREPARED FROM A WATER-SOLUBLE POLYACRYLAMIDE BY THE HOFFMAN REACTION

The present invention relates to a method for improving water drainage from paper web on a wire-screen of a paper machine.

For the formation of paper web in a paper making process, water in a pulp slurry is drained through a wire-screen leaving the pulp fibers on top, and the rate of the drainage has a direct concern with the efficiency of paper production. It has long been known that the addition of aluminum sulfate to pulp slurry facilitates the water drainage from the web on a wire screen. Various water-soluble polymers have been proposed as additives which impart more effective drainage to paper web than the aluminum sulfate. It is believed that these additives bond pulp fibers so that water may pass through the bonded fibers. By this bonding action, however, these additives sometimes take up unwanted fillers and fine fibers within the web thereby depressing the drainage. Further, these additives may contaminate a wire-screen, felt or dryers by adherence thereto, or may damage the texture of paper. Therefore, careful selection and control are required when these additives are used. Recently, there have been proposed to use polyethyleneimine as such an additive that improves the water drainage without damaging the texture of paper and without contaminating a wire-screen, felt or dryers. However, polyethyleneimine is not wholly satisfactory in that it is too expensive to be practically used by paper making, that difficulties are encountered in preparing it because the starting material, ethyleneimine is very poisonous and tends to polymerize very vigorously so that the control of the polymerization reaction is difficult, that it shows little draining effect when added to an acidic pulp slurry, that during the sheeting step, it tends to react with resins retained in the pulp slurry thereby to generate foams, which form pin holes on sheeted paper, and which, in the case of multilayer sheets of paper, weaken the bonding between the laminated sheet layers, and that it decreases the degree of whiteness of paper.

From the systematic research on such additives that facilitate the water drainage from a web on a wire-screen when added to a pulp slurry, the inventors have found that the most satisfactory result without any disadvantages inherent to polyethyleneimine can be obtained by a water-soluble cationic polymer converted from a water-soluble polyacrylamide, in particular, by such a polymer prepared by the Hoffmann degradation.

A water-soluble cationic polymer prepared from polyacrylamide by the Hoffmann reaction is known as an agent which improves dry strength of paper: see Norman T. Woodberry et al. U.S. Pat. No. 2,890,978 granted June 16, 1959. According to that patent, the cationic polymer to be used for the purpose of improving dry strength of paper, is prepared by subjecting a water-soluble polyacrylamide having an average molecular weight in excess of about 10,000 to the Hoffmann reaction until between about 0.1 percent and 15 percent of the amide groups therein have been degraded to amino groups. The cationic polymer thus prepared is added to an aqueous suspension of cellulose fibers in an amount between about 0.1 percent and 0.5 percent based on the dry weight of the fibers, in order to impart an improved dry strength to paper.

Whereas, the water-soluble cationic polymer according to the present invention is added to a pulp slurry for the purpose of improving the water drainage from a web on a wire-screen. The use of such a cationic polymer as an agent to facilitate the water drainage is very novel and has never been proposed nor known before. The polymer used in the method of this invention is prepared by subjecting a water-soluble polyacrylamide having an average molecular weight of 100,000–600,000 to the Hoffmann reaction until more than 15 percent of the amide groups therein have been degraded to amino groups. Satisfactory draining effect is obtained when the polymer thus

prepared (hereinafter called as the modified polyacrylamide) is added to a pulp slurry in an amount between 0.01 percent and 0.1 percent based on the dry weight of the pulp fibers in the slurry. However, the modified polyacrylamide may preferably be added in an amount between 0.03 percent and 0.06 percent. With the amount below 0.01 percent, no sufficient draining effect can be produced. Addition of the modified polyacrylamide in excess of 0.1 percent should be avoided, otherwise the modified polyacrylamide is likely to cause a damage to the texture of paper or to adhere to the wire-screen, felt and dryers.

In a practical process for preparing the modified polyacrylamide, an aqueous solution of polyacrylamide is mixed with an aqueous alkaline solution containing a sufficient amount of an alkali metal hypohalite to convert at least 15 percent of amide groups in the polyacrylamide to amino groups, whereby the Hoffmann degradation proceeds until the hypohalite is consume by the reaction. The reaction product, i.e. the modified polyacrylamide forms a white precipitate in a solution having a pH value below 3.5 and forms a gel or precipitate in a solution having a pH value greater than 5.5. In an alkaline solution, it undergoes further changes. According to this invention, the solution of the modified polyacrylamide is adjusted to a pH value between 3.5 and 5.5 by an acid and is maintained at the pH value in order to keep the product unchanged.

The solution of the modified polyacrylamide thus prepared is continuously added to a pulp slurry so that the mixture will contain 0.01–0.1 percent, or preferably 0.03–0.6 percent, based on the dry weight of the pulp fibers therein, of the modified polyacrylamide. In order to avoid a partial concentration of the modified polyacrylamide, the mixture is thoroughly stirred.

The pulp slurry added with the modified polyacrylamide solution is then fed to a wire-screen belt or cylindrical screen of a sheeting machine, where water in the slurry is drained through the screen leaving the pulp fibers as a paper web on the screen.

The rate of drainage can be pronouncedly increased by addition of the modified polyacrylamide to a pulp slurry. The draining action by the modified polyacrylamide will last for about 10 minutes after the addition and thereafter will cease with time. Therefore, the sheeting operation must be completed while the draining action continues.

The invention will be further described by the following specific examples. These examples represent preferred embodiments of the invention and are not to be construed as limitation thereon.

EXAMPLE 1

a. Preparation of an Aqueous Solution of the Modified Polacrylamide

To 200 grams of an aqueous solution of polyacrylamide having an average molecular weight of 300,000 (the solution containing 8 percent by weight of polyacrylamide) there were added slowly over 15 minute period while stirring and cooling 140 grams of an aqueous alkaline solution of sodium hypochlorite (the solution containing 28.5 grams of sodium hypochlorite and 2.2 grams of sodium hydroxide). The mixture was allowed to react for an additional period of 60 minutes at 25° C. and then adjusted to a pH value of 4.6 with a diluted aqueous hydrochloric acid. The resulting reaction mixture was 404 grams, of which 3.8 percent was the modified polyacrylamide. It was found that about 20 percent of amide groups in the polyacrylamide was converted to amine groups.

b. Preparation of an Aqueous Solution of the Modified Polyacrylamide as a Control

To 200 grams of an aqueous solution of polyacrylamide having an average molecular weight of 300,000 (the solution containing 8 percent of polyacrylamide) there were added slowly over 10 minute period while stirring and cooling

grams of an aqueous alkaline solution of sodium hypochloride (the solution containing 7.2 grams of sodium hypochlorite and 0.57 grams of sodium hydroxide).

The mixture was allowed to react for an additional period of 60 minutes at 25° C. and then adjusted to a pH value of 4.5 with a diluted aqueous hydrochloric acid. The resulting reaction mixture was 400 grams, of which 3.8 percent was the modified polyacrylamide. It was found that 5 percent of amide groups were converted to amine groups.

Tests on Water Drainage from the Web on a Wire-screen

To 7 liters of a 0.143 percent aqueous suspension of beated ground pulp (Canadian freeness of 310 c.c.) there was added the aqueous solution of the modified polyacrylamide prepared by the above process (a) in an amount equivalent to 0.06 percent based on the dry weight of the ground pulp in the suspension, of the modified polyacrylamide. The mixture thus obtained was stirred for one minute and then subjected to sheeting operation by TAPPI Standard Sheeting Machine, where water in the mixture was drained through a cylindrical wire-screen of the machine to form a paper web on the screen. The rate of drainage was measured as the time required for the drainage.

For the purpose of comparison, tests similar to the above were carried out by substituting the aqueous solution of the modified polyacrylamide according to the process (a) by an aqueous solution of polyacrylamide (made by Seiko Kagaku Kogyo Co. Ltd., Japan and commercially available under the trade mark STARGUM A-10), by polyethyleneimine (made by B.A.S.F., Germany and commercially available under the trade mark POLYMIN K) and by the aqueous solution of the modified polyacrylamide as contrast according to the process (b) hereinbefore mentioned. Further, the similar test was followed without addition of any polymer.

The time required for the drainage in the respective cases is listed below.

Added Polymer	Time for drainage
Aqueous solution of the modified polyacrylamide according to this invention	82 seconds
Aqueous solution of Polyacrylamide	157 seconds
Polyethyleneimine	85 seconds
Aqueous solution of the modified polyacrylamide as contrast	140 seconds

It will be understood from the above list that the time required for the drainage can be shortened considerably by the use of the aqueous solution of the modified polyacrylamide according to this invention.

EXAMPLE 2

The aqueous solution of the modified polyacrylamide prepared by the process (a) in example 1 was used in the production of white paperboard (440 grams/m²) consisting of eight layer sheets of paper. Running speed of the paper machine was set so that a laminated paperboard conveyed to a winder would contain 8 percent of water. It will be understood that with the paper machine so set, the running speed corresponds to the rate of the drainage.

The following table 1 shows the type of the wire-screen, the type of the pulp, Canadian freeness of the pulp, the additives and the pH value of the pulp slurry, employed or conditioned for sheeting the respective sheet layers.

Just prior to the sheeting process, the aqueous solution of the modified polyacrylamide according to this invention was continuously added to the pulp slurry for each layer. The slurry was fed to the wire screen about 10 seconds after the addition. Then, the sheeting operation was carried out at the above mentioned running speed.

TABLE 1

Layer	Type of wire-screen	Type of pulp	Canadian freeness (c.c.)	Additives (percent based on dry weight of pulp)	pH value of slurry
First	Belt	{LBKP 4 / NBKP 6}	200	{Rosin 0.5 / Alum 1.0}	4.4
Second	Cylinder	GP of deinked waste paper	310	None	6.1
Third	do	Mixed waste paper	310	do	6.3
Fourth	do	do	310	do	6.3
Fifth	do	do	310	do	6.3
Sixth	do	do	310	do	6.3
Seventh	do	do	310	do	6.3
Eighth	do	do	310	{Rosin 1.0 / Alum 2.0}	4.7

N.b.: LBKP=lapifoliape bleached kraft pulp; NBKP=needleleaf bleached kraft pulp; GP=ground pulp.

For the purpose of comparison, the process as above was followed without addition of the modified polyacrylamide solution or by substituting the modified polyacrylamide solution by polyethyleneimine.

The sheeting speed in the respective cases is listed in table 2 in which amounts of the added polymers are represented by percentage based on the dry weight of the pulp in the slurry.

TABLE 2

Added polymer	Amount of added polymer (percent)	Sheeting speed (meter/minute)
The modified polyacrylamide according to the invention	0.03	86
Do	0.06	92
Polyethyleneimine	0.06	88
None	None	80

It will be understood from table 2 that the production rate can be remarkably increased by the present invention. Further, it should be noted that in the case of polyethyleneimine, generation of foams in the slurry was observed and the paperboard thereby prepared showed weak bonding between the laminated layers. No such a drawback was observed according to the present invention.

We claim:

1. A method for improving water drainage from paper web on a wire-screen of paper machine, which comprises adding to a cellulosic pulp slurry, an aqueous solution having a pH value between 3.5 and 5.5, of a modified polyacrylamide prepared by subjecting a water-soluble polyacrylamide having an average molecular weight between 100,000 and 600,000 to the Hoffman degradation until more than 15 percent of amide groups therein have been degraded to amine groups, in an amount equivalent to from 0.01 to less than 0.1 percent based on the dry weight of the pulp, of the modified polyacrylamide, sufficiently stirring the mixture thus obtained, and then feeding the mixture to a running wire-screen of a paper machine, whereby water in the mixture is drained through the screen thereby forming a paper web on the screen.

2. A method according to claim 1, wherein the aqueous solution of the modified polyacrylamide is added to the cellulosic pulp slurry, in an amount equivalent to 0.03–0.06 percent based on the dry weight of the pulp, of the modified polyacrylamide.

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