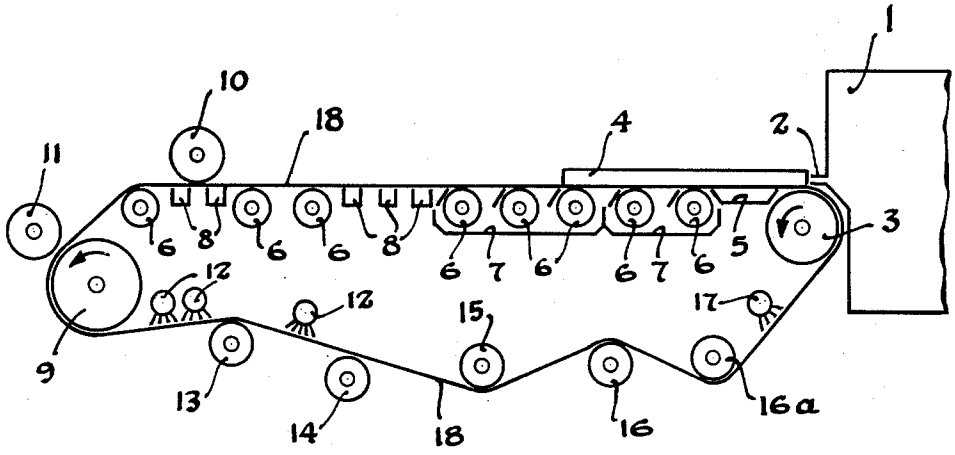
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TREATMENT OF FOURDRINIER WIRE

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TREATMENT OF FOURDRINIER WIRE

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This invention relates to a method for improving by chemical means the operational efficiency of a Fourdrinier paper making machine. More specifically, the invention is concerned with extending the life of Fourdrinier wires commonly employed in Fourdrinier paper making machines.

One of the most versatile machines used in the manufacture of paper is the well-known Fourdrinier paper making machine. Utilizing machines of this type, a wide variety of paper products are produced in mills located throughout the entire United States. Such conventional paper and paper products as bags, building boards, paper boards, various book stocks, and such specialized paper products as carbon paper stocks, cigarette papers, glassine and greaseproof papers, napkins, newsprint, pulp, tissue, wrapping, and writing stock may be produced on Fourdrinier machines.

As Fourdrinier machine technology has been improved over the years, there has been an increased tendency to use Fourdrinier machines which operate at extremely high speeds. While high speed Fourdrinier paper making machinery enables the mills using such machines to produce large tonnages of various types of paper and paper products, there is a disadvantage encountered in that the abrasive wear of the Fourdrinier wire used in the machine is excessive. The life of a typical Fourdrinier wire, particularly in a high speed machine, is short. In some instances, Fourdrinier wires only last several days whereas in other cases, particularly on slower speed machines, it is possible for a Fourdrinier wire to last for as long as several weeks to a month or more. In complex Fourdrinier machines, Fourdrinier wire replacement becomes an expensive and time consuming operation when it is considered that production must stop and elaborate procedure must be followed in order to replace the Fourdrinier wire. Depending upon the particular type of paper being produced on the machine, the cost of a new Fourdrinier wire can range from as little as $3500 to as much as $5000, or more. When the wire costs are considered in conjunction with labor costs required to install Fourdrinier wires, it is readily apparent that any method, either chemical or physical, for reducing wire loss by extending the life of a Fourdrinier wire without sacrificing speed or production would be a valuable benefit to the paper making industry.

Numerous mechanical solutions to Fourdrinier wire wear have been proposed. They have met with only limited success. Most mechanical systems for improving Fourdrinier wire life involve the installation of expensive rolls and tension regulating devices, and to this end their installation is only practical in the design of new machinery and is not particularly adaptable to be installed in existing Fourdrinier machines. A practical approach to the problem of reducing the wear and extending the life of Fourdrinier wire resides in the use of chemicals whereby the wire may be treated at low economical dosages, either intermittently or on a continuous basis, to substantially increase the operating life of a Fourdrinier wire.

For a chemical treatment to effectively improve the life of Fourdrinier wires, it is necessary that it perform several vital functions which will tend to alleviate the basic problems which cause Fourdrinier wire wear. Microscopic examination of worn Fourdrinier wires has made it evident that there are numerous factors which effect wire life. One of the most common factors causing Fourdrinier wire failure is the abrasive wear caused by a friction between the bottom of the wire and the suction boxes, forming boards, and deflectors. Most of this wear occurs at the suction boxes. A serious form of abrasive wear comprises a burring of the bottom of the wires, particularly the warp knuckles. In some cases, wear spots develop in wires. This is most commonly attributed to the forming of foreign substances which are entrapped in the wire.

Other types of wear in Fourdrinier wire may be ascribed to frictional effects and present themselves as worn wire in the forms of scores and distortions. Frequently excessive wire wear may be attributed to poor drainage characteristics, either because of improper vacuum on the suction boxes or other similar reasons. Also, a poor quality water will cause scaling and edge filling. Similarly, due to mechanical characteristics of the wire, edge cracks, edge splits, and edge distortion frequently occur in Fourdrinier wires operating on various types of Fourdrinier machines.

A factor which sometimes tends to accelerate abrasive wear of Fourdrinier wires is corrosion. In and of itself, corrosion is not particularly damaging to Fourdrinier wire, but it tends to substantially reduce abrasion resistance and draining characteristics of the wire so that frictional effects imposed on the wire are increased.

A careful study of the above types of wear of a Fourdrinier wire leads one skilled in the art to the obvious conclusion that if abrasive wear or frictional properties of Fourdrinier wire, caused by its contacting the various parts and sections used in a Fourdrinier machine, could be reduced and if the drainage characteristics of the wire could be improved, thereby preventing blockage by either fiber or foreign substances, then a practical solution to the extension of Fourdrinier wire life could be achieved. Therefore, if a chemical treatment is to succeed in improving the operation characteristics of a Fourdrinier paper making machine by the extension of the useful life of the Fourdrinier wire used in such machines, such a treatment must function in a twofold manner, e.g., it must be capable of both preventing abrasive wear by providing a lubricating action on the wire, and secondly, it must act as a dispersant or cleansing agent to prevent or to remove deposits between the open areas defined by the mesh of the particular wire used. It therefore becomes an object of the invention to provide a chemical treatment, which when applied in low, economical dosages, will improve the operational efficiency of a Fourdrinier paper making machine.

Another object of the invention is to provide a chemical which will substantially reduce the abrasive wear of Fourdrinier wires.

A further object is to provide a chemical which will tend to improve drainage and thereby prevent the blockage of the open areas between the mesh of the wire by foreign matter and cellulosic fibers.

Still a further object is to provide a chemical treatment which will accomplish the above objects and will not interfere with normal paper making operations. Other objects will appear hereinafter.

In accordance with the invention it has been found that the operational life of a Fourdrinier paper making machine may be greatly improved by treating the bottom of the wire with a combination of chemicals comprising (A) a water soluble, extreme pressure lubricant, (B) a water miscible nonquaternary cationic dispersant, and (C) a water dispersible organic silicon-containing compound which may be either an organo silicon oxide condensation product or an organo functional silane. By using this combination of ingredients it is possible to treat a Four-

drinier wire with as little as .005 pound of treating agent per ton, based on the weight of the paper formed on the wire with the above combination of ingredients, to substantially increase wire life. The chemicals have a two-fold effect in that they afford lubricity and improve the drainage of the stock formed, thereby providing a surface which has less tendency to abraid than an untreated wire, when passing over the various sections of a typical Fourdrinier machine. My investigations have led me to believe that localized areas of stress are excessive to the point that high pressures are involved. This means that conventional lubricants are of little value in the solution of the problems enumerated above.

For a more comprehensive understanding of how the compositions of the invention are applied to improve the operational characteristics of a Fourdrinier machine, reference may be had to the drawing.

The drawing is a simple schematic diagram of a typical Fourdrinier end of a paper making machine. The numerals used in the drawing represent the various components of the Fourdrinier system. It is to be understood that the drawing is simplified, but serves to illustrate generally a typical Fourdrinier system. The headbox and slice area are generally represented by the numerals 1 and 2 respectively. The breast roll is illustrated by the numeral 3 whereas the deckle rolls and forming board are shown by the numerals 4 and 5. The table roll 6, tray 7, and suction flat boxes 8 are another common group of components found in Fourdrinier machines.

The couch roll 9, dandy roll 10, and lump breaker roll 11, might be considered as ending the top section of a typical Fourdrinier asemblage. Wire showers 12, wash rolls 13, automatic guide rolls 14, stretch rolls 15, and wire return rolls 16 and 16A all compose what is generically referred to herein as the return section of the Fourdrinier wire, and operate to control the bottom movement of the wire. The wire itself is indicated by the numeral 18. An important concept of the invention resides in the use of a shower applicator 17 which is located between a wire return roll 16A and the breast roll 3. This shower spray is a preferred application point for applying the wire life extending chemicals of the invention. It is obvious that the spray 17 should be positioned so that it uniformly sprays the chemicals onto the entire width of the wire 18.

To be effective, it is desirable that the chemical be applied to the bottom of the wire. The word "bottom" is used to refer to any point in the return section of the Fourdrinier wire between the couch roll 9 and its point of subsequent contact with the breast roll 3. This wire "bottom" section is admirably suited for application of the treating agent. It is preferable that the application point be as near the breast roll as possible.

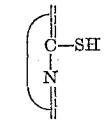
An alternative method of applying the chemicals of the invention would be to coat the chemicals by suitable means (not shown) on the wire return roll 16, whereby the bottom of the wire would be coated uniformly. Regardless of the mode of application, it is important that the entire wire 18 be covered with the chemical and that the chemical be applied in the form of a dilute aqueous solution.

From the above description it is apparent that the chemicals in the invention are most preperably applied as a dilute aqueous solution to the bottom of the wire just prior to its engagement with the stock entering from the headbox 1 through the slice 2. The application of a dilute aqueous solution may be achieved by dissolving the chemicals into a suitable water source (not shown) and thereby applying them through the header or spray 17. The chemicals may be prepared initially either as dry chemicals to be subsequently diluted at the mill site or point of use, or they may be made up into an aqueous concentrate for efficiency in shipment to the mill site where it may be diluted by the machine operators.

The water soluble, extreme pressure lubricants are

sulfhydryl-containing compounds. They may be classified broadly as nitrogen-containing heterocyclic compounds characterized by a ring nitrogen bonded to a ring carbon. To the ring carbon is attached a non-ring sulfhydryl group. The characteristic structural formula covering this sulfhydryl heterocyclic combination of elements may be illustrated by the Formula I below:

FORMULA I

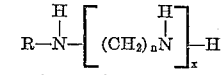


Compounds having this illustrative molecular configuration and which are valuable in the practice of the invention are such well-known compounds as 2-mercaptothiazole, 2-mercaptobenzimidazole, 2-mercaptobenzoxazole, and 2-mercaptobenzothiazole. Of these compounds, 2-mercaptobenzothiazole is preferred since it is relatively inexpensive and is commercially available.

The above compounds are, for practical purposes, relatively water insoluble, but they are rendered readily soluble by converting them to their alkali metal salts. Any of the well-known alkali metal salts of these compounds, e.g., sodium, potassium, cesium, and rubidium may be used, although due to availability and economics, the sodium salts are preferred. Equivalent to the sodium salts of these compounds are the ammonium salts, but they are not particularly preferred due to volatility problems encountered when the machines are operated at elevated temperatures.

The water miscible, non-quarternary cationic dispersants used in the practices of the invention should contain at least one, but not more than two aliphatic groups of at least 6 carbon atoms in chain length. Preferably the aliphatic groups should contain 12–22 carbon atoms. It is also contemplated that the carboxylic and inorganic salts of these compounds may also be used, e.g., acetates, sulfates, chlorides, and the like.

One class of non-quarternary cationic dispersants that are useful in the practice of the invention, are the aliphatic amines having the general structural formula:



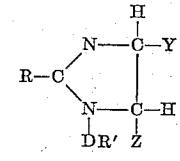
In the above formula, R is an aliphatic group of from 12–22 carbon atoms in chain length, n is an integer of from 2–6 and x is an integer of from 0–5.

Commercially available compounds falling within the above structural formula include the well-known aliphatic monoamines and the fatty substituted alkylene diamines and polyalkylene polyamines. Typical fatty monoamines useful in the practices of the invention are such products as n-dodecyl amine, n-tetradecyl amine, dicoco amine, n-hexadecyl amine, n-octadecyl amine and the like.

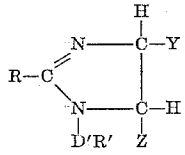
Useful fatty substituted alkylene diamines are the "Duomeens" manufactured by Armour Chemical Division which products provide such commercially available chemicals as N-lauryl trimethylene diamine, N-coco trimethylene diamine, N-soya trimethylene diamine, and N-tallow trimethylene diamine.

From the above list of aliphatic monoamines and fatty alkylene diamines, it is apparent that the invention contemplates using amines which contain mixed fatty aliphatic groups of the type commonly found as components of animal fats and vegetable oils.

Another group of useful water miscible non-quaternary cationic dispersants are those imidazolines having the structural formulas:



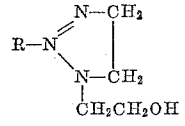
and



In the above formula, D represents a divalent non-amino organic radical containing less than 25 carbon atoms. D may be composed of the elements C, H, O and N. D' represents a divalent organic radical containing less than 25 carbons and composed of the elements C, H, O, and N and contains at least one amino group. R is an aliphatic group which may contain at least 7 carbon atoms in chain length, although it preferably contains from 11 to 21 carbon atoms. R' may be an aliphatic group similar in all respects to R with the exception that R' may also be hydrogen. Y and Z may be either hydrogen or lower alkyl groups of not more than 6 carbon atoms.

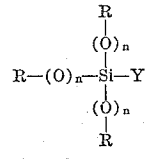
Imidazolines of the above type are well-known and are described in Wilson U.S. Patents 2,267,965 and 2,355,837. Typical imidazolines of the type shown in the above structural formulas are such compounds as 1-(2-amino-ethyl)-2-heptadecyl imidazoline and 1-(2-hydroxyethyl)-2-heptadecyl imidazoline. For a comprehensive description of the imidazolines of the type described above which may be used, reference may be had to Clausen, U.S. 2,865,817.

Of all the imidazolines thus far described, a favored group of these chemicals are those having the structural formula:



In the above formula, R is a saturated aliphatic group containing from 11–21 carbon atoms.

The silicon containing compounds may be of two general types, the first being an organo silicon oxide condensation product which encompasses such well-known products as the condensed esters of ortho and metasilicic acid and the well-known silicon polymers such as the poly dimethyl siloxanes. Products of this general type are described in detail in Trautman et al., U.S. 2,416,503–4. When silicon containing compounds of this type are used, it is important that they be at least colloidally dispersible in water. When the compounds are not dispersible per se it is possible to form them into a sufficient state of subdivision, e.g., 1 micron or less, thereby making it possible to colloidally disperse such silicon containing compounds into the water and to this extent they are usable. A preferred group of silicon containing compounds are the organo functional silanes generically represented by the following formula:



In the above formula, R is a lower aliphatic hydrocarbon group of not more than 4 carbon atoms in chain length. Y is an aliphatic amine-containing group and $n=0$ or 1. Typical examples of compounds coming within the above structural formula are gamma-amino-propyl triethoxy silane, delta-amino butyl methyl-diethoxy silane and 2-(3-trimethoxy silyl propylamino) ethyl amine. The above described water dispersible, organic silicon-containing compounds not only tend to improve the lubricating characteristics of the formula, but they also in some instances act as a deforming agent to prevent excessive foam formation at the point of formula application.

In treating the Fourdrinier wire to provide increased life during its normal operation, the chemicals are fed at a relatively low dosage, e.g., .005 pound per ton based on the dry weight of the paper formed on the Fourdrinier wire, with the preferred dosage being from 0.025 to 0.1 pound per ton.

The chemicals are combined so that the water soluble, extreme pressure lubricant is present in an amount ranging between 5–97.99% by weight. The water miscible non-quarternary cationic dispersant may be employed in amounts ranging from 2–92% by weight, and the organic silicon-containing compound is advantageously employed in amounts ranging from 0.01–5% by weight.

The proportions of the ingredients, of course, may be varied, depending upon the particular condition of the Fourdrinier machine and wire to be treated. For example, if it is determined that abrasive wear is due extensively to plugging of the mesh openings of the wire, then it would be desirable that a larger quantity of surface active agent and/or the silicon containing compound be employed, whereas if abrasive wear is the predominant problem, then the amount of water soluble extreme pressure lubricant should be increased.

The compositions of the invention may be either formulated as a dry mix and then diluted at the point of use, or preferably, they are prepared as an aqueous concentrate which is then diluted to use concentration.

A typical composition useful in the practices of the invention is the aqueous concentrate illustrated by Formula II below.

FORMULA II

Ingredient:	Percent by weight
Sodium-2-mercaptobenzothiazole	25
Isopropanol	20
1-(2-hydroxyethyl)-2-heptadecyl imidazoline	20
2-(3-trimethoxy silyl propylamino)-ethylamine	0.1
Soft water	34.9

To illustrate the invention, the following are presented by way of example.

Example I

This test was conducted on a Fourdrinier machine which produced 600 tons per day of unbleached kraft liner board. The machine, prior to the test, had an average wire life of about 7 days. Inspection of the wires after removal from the machine showed that abrasion was the primary source of wire wear. Formula II was applied at a dosage of 0.25 pound per ton for the first 6 hours of the test and was then reduced to 0.1 pound per ton for the remainder of the test period. The chemical was applied by means of a shower spray at a point just prior to the breast roll. The wire life during the test period was 10 days at which time a mechanical puncture necessitated wire removal. An inspetcion of the wire showed that there were still several days of wear remaining. In a second test at the same location, the same dosages were maintained and the wire ran for 16 days without necessitating shutdown.

During the second test described above, the feeding of the chemical was discontinued for several minutes for comparative measurement of the couch motor power requirements. Amperage at the cessation of the treatment, jumped from 850 amps. to 1100 amps. Continuation of the treatment within a matter of minutes reduced the amperage to 850.

Example II

At another paper mill Formula II was tested on a Fourdrinier machine producing unbleached kraft and paper board. The output of the machine averaged between 200 and 400 tons per day. The Fourdrinier wire was 220 inches in width and was run, during the test

period, at speeds ranging between 1100 and 2100 feet per minute. The pH of the white water system was between 5.5 and 6.5. A record of prior wire life indicated an average wire to last 7.5 days to 9 days.

The composition was used to treat four successive wires at an initial dosage of 0.1 pound per ton, which after several hours, was reduced to 0.07 pound per ton. The chemical was applied from a shower header located across the wire bottom at a point between the return roll and the breast roll. At the end of the four tests the average wire life experience was 16.3 days.

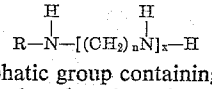
In both Examples I and II, inspection of the wires showed them to be extremely clean and bright. There was a dramatic improvement in both test series, of the stock drainage characteristics as well as in the efficiency of the entire machine operation.

An important result as shown above achieved by practicing the invention, is the great improvement noticed in the drainage of the stocks formed on the treated wires. This effect permits a better quality of paper to be produced, faster drying and sheet formation. Also, the invention permits greater variations in refining and machine speeds to be utilized.

I claim:

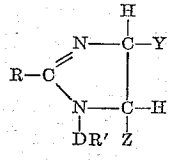
1. A method for improving, by chemical means, the operational efficiency of a Fourdrinier paper making machine which utilizes a continuous Fourdrinier wire upon which paper and paper products are formed, which comprises treating the bottom of said Fourdrinier wire with a dilute aqueous solution which contains at least .005 pound per ton, based on the dry weight of the paper and paper products formed on said Fourdrinier wire, of a composition having the formula: (A) from 5–97.99% by weight of a water soluble, extreme pressure lubricant comprising a nitrogen-containing heterocyclic compound characterized by a ring nitrogen bonded to a ring carbon to which is attached a sulfhydryl group, (B) from 2–92% by weight of a dispersant from the group consisting of water miscible, non-quaternary cationic dispersants and salts thereof which contain at least 1, but not more than 2, aliphatic groups of at least 6 carbon atoms in chain length, and (C) 0.01–5% by weight of a water dispersible, organic, silicon-containing compound from the group consisting of organosilicon oxide condensation products and organo functional silanes.

2. The method of improving, by chemical means, the operational efficiency of a Fourdrinier paper making machine in accordance with claim 1 where the non-quaternary cationic dispersant has the structural formula:

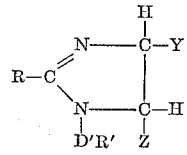


where R is an aliphatic group containing from 12–22 carbon atoms in chain length, n is an integer of from 2 to 6, and x is an integer of from 0 to 5.

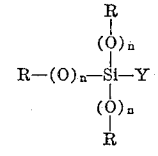
3. The method for improving, by chemical means, the operational efficiency of Fourdrinier paper making machines in accordance with claim 1 wherein the water miscible, nonquaternary cationic dispersant is an imidazoline having a structurel formula from the group consisting of:



and

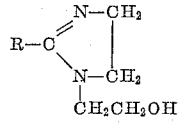


where D represents a divalent, non-amino organic radical containing less than 25 carbon atoms, composed of elements from the group consisting of C, H, O, and N; D′ represents a divalent organic radical containing less than 25 carbon atoms from the group consisting of C, H, O, and N, and containing at least one amino group; R is an aliphatic group containing from 11 to 21 carbon atoms in chain length, and R′ is from the group consisting of H and aliphatic groups of from 11 to 21 carbon atoms in chain length, Y and Z are from the group consisting of hydrogen and lower alkyl groups or not more than 6 carbon atoms; and the organo functional silane has the formula:



where R is a lower aliphatic hydrocarbon group of not more than 4 carbon atoms in chain length and Y is an aliphatic amine-containing group and n has the value of 0–1.

4. The method for improving by chemical means, the operational efficiency of Fourdrinier paper making machines in accordance with claim 3 wherein the imidazoline has the structural formula:



where R is a saturated aliphatic group containing from 11 to 21 carbon atoms, and the organo functional silane is 2-(3-trimethoxy silyl propylamino) ethylamine.

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