CONTROLLING THE CUTTING TO HYDRATION RATIO IN THE REFINING OF PULP

8 Claims, 2 Drawing Figs.

ABSTRACT: The quality of paper being manufactured is maintained constant by keeping the cutting to hydration ratio of pulp stock during refining constant. The drying rate of the paper is an indication of the cutting to hydration ratio of the refined pulp stock. The drying rate is compared with a desired drying rate and the difference therebetween is used to adjust the refining so that the actual cutting to hydration ratio is maintained the same as the desired cutting to hydration ratio.
CONTROLLING THE CUTTING TO HYDRATION RATIO IN THE REFINING OF PULP

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to the manufacture of paper; and in particular to apparatus and methods for controlling the quality of paper.

2. Description Relative to the Prior Art

Depending on the refining of pulp pulp, “cutting” and “hydration” are produced in varying amounts. The cutting relates to the severing of pulp fibers (formation); and the hydration relates to the mashing of pulp fibers (strength). Hydration is not “water content.”

It is the present practice to remove periodically a sample strip from paper being manufactured, thereby to perform various checks to determine the characteristics of such paper. It is, as a result of such checks, usual to find that paper strength has gradually increased at the expense of gradually decreasing paper formation, thus evidenced that the pulp refiner has gradually dulled. A technician will then adjust the pulp refiner to increase its ability to “cut,” thereby to maintain the paper formation at, or close to, a predetermined set point.

Aside from consuming valuable technician time, the prior art method of controlling paper formation (via a-vis paper strength) is lacking in tight control, i.e., considerable low-quality paper may be manufactured before and during the time when the technician is performing his checks.

The best known prior art may be found in U. S. Pat. Nos. 3,260,642, 2,951,007, 2,942,352, 2,922,475, 1,971,296 and 3,073,153.

SUMMARY OF THE INVENTION

The invention permits the preselection and maintenance of a given quality for paper being manufactured. To this end, the invention employs a computer that effectively calculates the cutting to hydration ratio (C/H) of refined pulp, i.e., stock, used in paper manufacturing, thereby to control paper formation (with respect to paper strength). It has been found that the rate at which stock dries into paper during paper manufacture is a reflection of its hydration: the greater the hydration, the lower the rate at which such stock dries, and vice versa. Thus, for a given stock (and drying temperature) the drying rate thereof will vary directly with the cutting thereof, and inversely with the hydration thereof. By equating the actual drying rate (d) for a given stock with a preselected drying rate (d'), for that stock (which preselected drying rate—at a given drying temperature—may be made with paper of a certain desired formation, the error therebetween may be used to control—either manually or automatically—the adjustment of the pulp refiner, thereby to maintain the desired paper formation. As presently preferred, the drying rate for stock is determined from the moisture content of such stock before and after such stock respectively enters and exits from a paper drying stage. (Such drying stage, however, should not be one wherefrom “bone dry” paper exits, this being because no moisture is removed from such paper for part of its passage through such drier; and so, the entering and exiting moisture measurements would lead to a false indication of the drying rate.) As intimated above, the drying rate for stock is dependent not only on the cutting to hydration ratio, but is also directly dependent on the drying temperature, i.e., d = f (C/H), where S is some temperature dependent variable such as the pressure of steam within the drying stage. Thus, the cutting to hydration ratio is more properly reflected in terms of stock drying rate per units of temperature (d/S); and in the presently preferred form of the invention, the instantaneous d/S is equated with a reference d/s, for quality control purposes.

An object of the invention is to provide improved apparatus and methods for manufacturing paper.

Another object of the invention is to provide apparatus and methods for controlling the quality of paper during manufacture thereof.

Another object of the invention is to detect, and correct for, inefficient operation of a pulp refiner.

Another object of the invention is to provide control of a pulp refiner in accordance with the cutting to hydration ratio of pulp stock processed thereby.

Another object of the invention is to provide a way to determine the cutting to hydration ratio for pulp stock from its drying rate.

The invention will be described with reference to the figures, wherein

FIG. 1 is a diagram useful in describing the invention, and FIG. 2 is a block diagram illustrating a presently preferred form of the invention.

Referring to FIG. 1, a family of three curves illustrates the relationships among stock drying rate (d); drying temperature (S), and paper formation (C/H). For a given drying temperature (S), and a given desired paper formation ((C/H)2), the drying rate for stock should be d'. Thus, in the event that the drying rate decreased to a level d—and there being no drying temperature change—a decrease in paper formation, to one having a cutting to hydration ratio ((C/H)3), is evidenced. The present invention, as indicated below in connection with FIG. 2, employs such drying rate differences to control paper formation.

Referring then to FIG. 2, raw pulp is passed through a refiner 10 such, for example as a jordan. The refiner 10, typically, has parts 12 and 14, which are relatively rotatable about a common axis by means of a motor 16.

The stock output of the refiner is, in conventional manner, passed through a paper-forming fourdriner 18, after which such stock is dried (22,24) into a “bone dry” paper web, calendared (26), and rolled (28). The driers 22, 24 are steam (30) operated; and the stock drying rate, as presently preferred, is determined as follows.

A first beta gauge 32, for producing a signal (MA) representing the stock moisture content per unit of web area, is situated at the entrance of the drier 22; and a second beta gauge 34, for producing a signal (M/A) representing the stock moisture per unit of web area is situated at the exit of the drier. The moisture levels (MA) and (M/A) are compared (subtraction device 38) to produce a loss in moisture signal (Δ(M/A), which when multiplied (40) by the web speed (tachometer 42) and web width (selector 44) produces a signal (d') representing the actual rate at which the stock dries into paper.

Since steam pressure is analogous with the drying temperature of the driers (22,24), it is used to drive, via a diaphragm actuator 46, the wiper 48 of a pickoff potentiometer 50, thereby to produce a signal (S), representative of the actual temperature of the driers 22, 24. A divider 52 is provided to produce the quotient signal (d/S) which is directly related to the cutting to hydration ratio (C/H) for the paper being manufactured. See the equations of FIG. 1. A comparator 54 equates the signal (d/S), with a preselected formation signal (d'/S);—selector 56—the error therebetween being applied to control the operation of a motor 58. The motor 58 relatively positions axially the parts 12,4 of the refiner 10, thereby to close (or open) the bite of the refiner. An error signal produced by the comparator 54 evidences a duling of the refiner parts 12,14, and which duling would be reflected in a degraded product formation were it not for the fact that, in accordance with the invention, the bite of the refiner 10 is taken up to cancel such error signal, thereby to maintain product formation.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention. Below is a list of some of the modifications which are within the purview of the invention:

a. Whereas beta gauges are employed for determining drying rates, the use of other drying rate measurement devices is possible.
b. Whereas the cutting to hydration ratio is calculated, the hydration to cutting rate could just as easily have been calculated, the operation of the motor 58 being reversed accordingly.

c. Whereas paper formation is indicated as being controlled in relation to paper strength, the reverse is a possibility.
d. Where as analogue computation is indicated, digital computation may be employed instead. Various analogue elements for implementing the computation may be found in ELECTRONIC ANALOGUE COMPUTERS, Korn and Korn, McGraw-Hill Book Company, Inc., N.Y.

e. Whereas closed loop control of the refiner is indicated, the signal output from the comparator 54 may instead have been applied to a meter—rather than to the motor 58—thereby to control manually the refiner setting without the indicated prior art need for paper tests.

5 f. A lead device may be employed between the comparator 54 and motor 58 to compensate for the delay (fourdriner 18, drier 22) between the time the refiner first starts to produce stock with a low cutting to hydration ratio and the time such cutting to hydration ratio is computed; or application of the signal output from the comparator 54 may be applied to adjust the bite of the refiner in discrete increments, etc.

What is claimed is:

1. In a paper making system of the type having adjustable means for regulating the cutting to hydration ratio of pulp stock, the improvement comprising:
   a. means for producing a control signal proportional to the difference between a preselected cutting to hydration ratio and the actual cutting to hydration ratio of the said pulp stock, and
   b. means responsive to said signal for use in setting the said adjustable means to maintain the actual cutting to hydration ratio the same as the said preselected cutting to hydration ratio.

2. The system of claim 1 wherein:
   a. said adjustable means is a pulp refiner, and
   b. said signal is applied to adjust said pulp refiner in proportion thereto.

3. The system of claim 1 wherein said signal producing means includes:
   a. means for producing a signal that varies directly with the drying rate for said stock,
   b. means providing a drying rate reference signal, and
   c. means producing a signal dependent on the difference between said signal that varies directly with said drying rate and said reference signal, said difference dependent signal being said control signal.

4. The apparatus of claim 3 wherein said system includes a plurality of stock drying means, and said means for producing a signal that varies directly with said drying rate produces a signal that varies directly with the drying rate for said stock at at least one of said stock drying means which precedes that drying means where said stock becomes dry.

5. The system of claim 3 wherein said signal that varies directly with said drying rate is a signal that varies as a direct function of the rate of drying for said stock and as an inverse function of the stock drying temperature.

6. The system of claim 4 wherein said signal that varies directly with said drying rate is a signal that varies as a direct function of the rate of drying for said stock and as an inverse function of the stock drying temperature.

7. In combination with a paper making machine having a jordan, a paper forming means, and stock drying means, a. means for producing a signal that varies directly with the rate at which said stock is dried by said drying means, b. means providing a drying rate reference signal, c. means for comparing said reference signal and said signal that varies directly with said drying rate to produce a control error signal, and d. means for use in adjusting said jordan in proportion to the magnitude of the said control error signal.

8. The method of controlling paper quality comprising the steps of
   a. refining pulp into stock,
   b. feeding said refined stock through a paper forming means,
   c. drying said stock to form paper,
   d. determining the drying rate for said stock relative to a desired drying rate that is compatible with a certain quality paper, and
   e. regulating the refining of said pulp so that the actual drying rate for said stock is the same as said desired drying rate.