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(54) **Apparatus and method for controlling the operation of a cigarette maker.**

(57) The moisture content of the cigarette rod of a cigarette maker is controlled by sensing the rod moisture content and utilizing the sensed moisture content to adjust the moisture content of the input tobacco to the maker.

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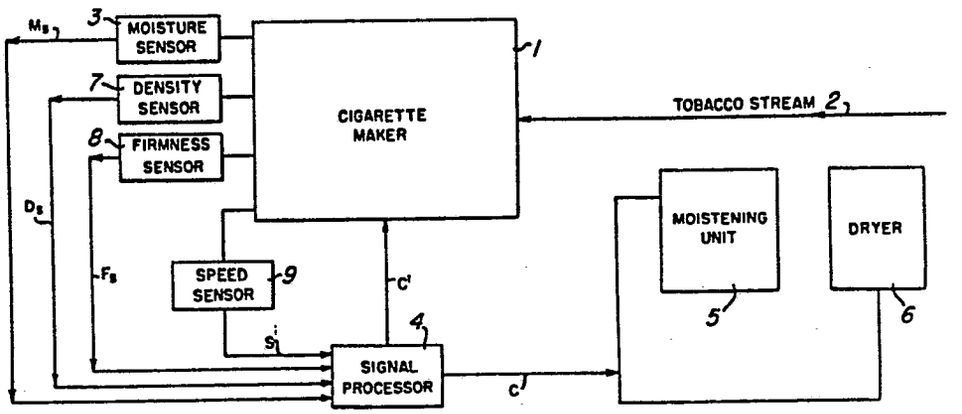
MOISTURE SENSOR
DENSITY SENSOR
FIRMNESS SENSOR
SPEED SENSOR
CIGARETTE MAKER
TOBACCO STREAM
MOISTENING UNIT
DRYER
SIGNAL PROCESSOR
3
7
8
9
1
2
5
6
4

FIG. 1

APPARATUS AND METHOD FOR CONTROLLING THE OPERATION OF A CIGARETTE MAKER

This invention pertains to cigarette manufacture and, in particular, to control of cigarette manufacture at the cigarette maker.

In cigarette manufacture, it is customary to provide conditioning of the tobacco in the primary processing of same. As part of this conditioning, the tobacco is subjected to procedures wherein tobacco moisture content is measured, and measured moisture content used to control drying or moistening apparatus to achieve a predetermined moisture content. Procedures of this type are disclosed in U.S. patents 3,840,025; 3,482,162; and 3,502,085.

After primary processing, the tobacco is usually stored for a period of time, which may be up to three days, in storage areas before being further processed into actual cigarettes at a cigarette maker. In conventional practice, these storage areas are subjected to a controlled climate in order to maintain the tobacco moisture content at the predetermined level established during the primary processing. This storage procedure is costly and the tobacco may still undergo moisture changes during subsequent transport of the tobacco to the cigarette maker. These moisture changes adversely affect maker operation, particularly in cases where the maker is provided with controls for establishing preselected values for various cigarette rod parameters such as, for example, rod density and/or rod firmness. This is mentioned in British Specification 1,376,747 which discloses a microwave system for controlling tobacco rod density. In this system, since the microwave energy is affected by

moisture as well as tobacco content, the system is constructed to permit obtaining values of each of these parameters from microwave signals which depend on both.

It is an object of the present invention to provide more effective moisture control in the manufacture of cigarettes.

It is a further object of the present invention to provide a method and apparatus for improved cigarette maker operation.

SUMMARY OF THE INVENTION

In accordance with the principles of the present invention, the above and other objectives are realized in a practice for cigarette manufacture wherein a cigarette maker is provided with means for determining the moisture content of the rod of the maker and wherein means responsive to the determined moisture content is provided for controlling moisture content of the input tobacco to the maker.

In the illustrative form of the invention disclosed hereinafter, determined rod moisture content is utilized to control the moisture content of the input tobacco as it is being conveyed to the maker. Control is effected by determining the difference between the output rod moisture content and a desired target moisture content and using this difference to control the addition or subtraction of moisture to the input tobacco until output rod moisture content is at target mositure.

The invention further contemplates utilization of a number of techniques for determining rod moisture content. These techniques require a number of sensors for generating sensor signals related to output rod parameters such as

moisture, firmness, density and speed.

Also contemplated is utilization of the moisture control system with a firmness control system to provide a rod of a preselected or target firmness at a preselected or target moisture.

Brief Description of the Drawings

The above and other features and aspects of the present invention will become more apparent upon reading the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 shows a system for controlling cigarette rod moisture content at a cigarette maker in accordance with the principles of the present invention.

Detailed Description

FIG. 1 shows a system in accordance with the principles of the present invention for providing moisture control at a cigarette maker 1. The latter maker can be of conventional type such as that manufactured by Molins Ltd. of the United Kingdom under model number MK8 or MK 9.

In typical operation, the maker 1 provides from the input tobacco stream 2 a continuous cigarette rod which is cut into lengths to provide individual cigarettes. In accordance with practice under the present invention, cigarette maker operation is controlled such that the cigarette rod has a moisture content which is substantially equal to a desired or target moisture value M_t. In this manner, individual cigarettes resulting from the rod have a substantially equal precisely determined moisture content, thereby providing enhanced uniformity in cigarette production and improved quality control.

A moisture sensor 3 at the cigarette maker 1 monitors the cigarette rod and generates an output electrical signal M_s indicative of rod moisture content. The moisture sensor signal M_s is fed to a signal processor 4 which develops an output control signal C for controlling the moisture content of the rod. In accordance with the invention, such control is effected by changing or varying the moisture content of the input tobacco 2 until the output rod moisture content is at the target moisture value. This may be accomplished by utilizing the signal C to appropriately control conventional moistening means and/or dryer means situated adjacent the conveyance path of the input tobacco.

In the illustrative case of FIG. 1, a moistening unit 5, which might comprise, for example, a steam source followed by a controllable valve, and a dryer 6 are responsive to the signal C and add and subtract moisture, respectively, to and from the input tobacco 2. With this form of control, the control signal C brings the moistening unit 5 into operation during periods when the output rod moisture content is below target moisture and brings the dryer 6 into operation during periods when the output rod moisture content is above target moisture.

In modified practices in accordance with the invention, operation is carried out utilizing the moistening unit 5 or the dryer 6 only. In the former modified practice, the tobacco 2 is processed during primary processing and storage such that its moisture content is always below the target value M_t upon entry to the moistening unit, thereby always requiring the addition of moisture thereto to obtain a moisture content of M_t for the output rod. In the latter

modified practice, on the other hand, the tobacco 2 is processed during primary processing such that its moisture content is always above the target value M_t upon entry to the dryer 6 thereby always requiring the subtraction of moisture to obtain a moisture content of M_t for the output rod.

The processing operations of the signal processor 4 involve the generating of a rod moisture content signal M_c from the moisture sensor signal M_s and the formation of the control signal C from comparison of the generated signal M_c with the target moisture M_t. Generation of the signal M_c by the processor 4 depends to a large degree on the particular moisture sensor being used and such generation is carried out by processing the signal M_s to provide a signal which is representative of the actual or true rod moisture content. Where the characteristics of the moisture sensor are such that the sensor signal M_s is itself representative of true rod moisture content, then this processing is carried out by equating M_c to M_s. On the other hand, where the sensor characteristics result in an M_s signal varying from true rod moisture content, adjusting factors are provided to account for the influence of the sensor characteristics. In actual practice, these adjusting factors can be empirically determined for each particular moisture sensor.

As will be discussed hereinbelow, in further practice in accordance with the present invention, further sensors 7 and 8 for measuring the mass or density and the firmness of the cigarette rod are employed for enabling moisture sensor signal adjustment. In still further practice under the present invention, a speed or velocity sensor 9

may be provided for cigarette rod speed determination and included for sensor signal adjustment.

A first sensor which might be employed for the sensor 3 is a resistance type moisture sensor. Such a sensor might be formed on the above-mentioned conventional maker by inserting probes through apertures spaced along the length of the so-called tongue of the maker whereat the rod is being formed, the probes being of sufficient length to enter into the tobacco rod. A current or voltage could then be supplied to the probe and the resultant voltage or current through the probe circuit measured to determine the tobacco rod resistance, and, therefore, the rod moisture content. In particular, such probes could serve as inputs to the internal circuitry of a model No. TM-80 sensor manufactured by Testron to provide the moisture measurement.

Utilizing such a resistance moisture sensor provides a moisture sensor signal M_s requiring adjustment for arriving at the actual rod moisture content M_c. In particular it has been found that the sensor moisture signal M_s requires adjustment related to rod firmness and rod speed. Thus, for this sensor, moisture content can be expressed as follows:

$$M_c = A_0 + A_1M_s + A_2F_s + A_3S \qquad (1)$$

Where A_0-A_3 are constants which can be empirically determined for each particular tobacco blend and resistance sensor. With the resistance type sensor, the signal processor 4 utilizes the sensor signal M_s, the firmness sensor signal F_s and the speed sensor signal S to derive the moisture content signal M_c based on the expression (1).

Other techniques for monitioring rod moisture content utilize microwave components. One microwave technique

depends upon the measurement of the power absorbed largely by the moisture in the cigarette rod as it moves through a suitable microwave cavity. With this type of moisture sensor, the moisture sensor signal M_s is a function of reflected and transmitted microwave power values in the absence and presence of the cigarette rod, these values being suitably adjusted for temperature variations in the cavity and/or the rod. Hence, M_s is as follows:

$$M_s = \frac{(R_a + T_a) - (R_p + T_p)}{(R_a + T_a)} \cdot 100 \qquad (2)$$

where R_a and T_a are temperature adjusted values of the reflectance and transmittance of microwave power in the absence of the the cigarette rod and R_p and T_p are temperature adjusted values of the reflectance and transmittance in the presence of the cigarette rod. In this case, the obtained sensor signal M_s requires adjustment related to the mass of the cigarette rod. Hence, the moisture content is given as:

$$M_c = B_0 + B_1 M_s/D_s \qquad (3)$$

In this situation the constants B_0 and B_1 can also be empirically determined for the particular tobaccco blend and microwave sensor being used.

As above-noted, the signal processor 4 determines the control signal C based upon the sensor signal M_s adjusted by certain of the other sensor signal F_s, D_s and S as provided in equations 1, 2 and 3. The processor 4 might typically take the form of a general or special purpose digital computer programmed in accordance with such equations and having stored therein the target values and appropriate constants. A typical microcomputer might be an Intel System 80/204

provided with an Intel System SBC 116 board. Interfacing such microcomputer with the analog signals M_s, F_s, D_s, S and C might typically be a model MP 8418-PGA-AO Burr-Brown A/D-D/A converter.

The firmness sensor 3 utilized with the present invention can be of a strain gauge type and may, for example, be of a type as shown and described in United States Patent No. 4,033,360. Additionally, the density sensor 7 might be a beta gauge type manufactured by Molins Ltd. and supplied with its model number MK8 or MK9 cigarette maker. The speed sensor 9, on the other hand, might be a tachometer of conventional design yielding a value of voltage to represent revolutions per minute.

The practice of the present invention can be utilized with other controls at the maker to enhance or promote maker efficiency. Thus, for example, the signal processor may be utilized to also generate a firmness control signal C' designed to control the maker such that the output rod has a predetermined or target firmness F_t at the target moisture M_t. Since the moisture control of the system maintains the output rod moisture content substantially at target moisture M_t, the firmness variations requiring correction will depend almost solely on tobacco content variations.

A system for controlling firmness in this manner is disclosed in commonly assigned U.S. patent application Serial No. 111607 . In the system of the latter patent application, the control signal C' is expressed as follows:

$$C' = (F_s - F_{sm}) - F_t \qquad (4)$$

where F_{sm} is firmness content in the tobacco attributable to moisture referenced to target moisture and is given as

$$F_{sm} = K_1 (M_c - M_t)$$

The latter expression, in turn, is derivable from rod firmness attributable to moisture which can be expressed as:

$$F_m = K_0 + K_1 M_c \quad (5)$$

where K_0 is a constant determined by the tobacco blend and the rod weight per unit volume and K_1 is a negative constant determined by the tobacco blend only.

In a system of this type firmness control can be achieved by utilizing the control signal C' to adjust the height of the ecreteur blade used to cut the tobacco stream at a given depth during rod formation. Alternatively, the control signal C' might be used to control the maker distributor to obtain the desired control. Such practices are disclosed, for example, in U.S. patent No. 3,595,067.

In all cases, it is understood that the above-described arrangements are merely illustrative of the many possible specific embodiments which represent applications of the present invention. Numerous and varied other arrangements can readily be devised in accordance with the principles of the present invention without departing from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. Apparatus for controlling the operation of a cigarette maker, said maker being fed input tobacco from which it provides a cigarette rod, said apparatus including:

first sensor means for providing a moisture sensor signal related to the moisture content of said rod;

and means responsive to said moisture sensor signal for controlling the moisture content of said input tobacco.

2. Apparatus in accordance with claim 1 further comprising:

a second sensor means for providing a firmness sensor signal related to the firmness of said rod.

3. Apparatus in accordance with claim 2 further comprising:

means responsive to said firmness sensor signal for controlling the firmness of said rod.

4. Apparatus in accordance with claim 3 wherein:

said moisture control means maintains the moisture content of said input tobacco at a level to cause said moisture content of said rod to be at a predetermined moisture content;

and said firmness control means maintains the firmness of a said rod at a predetermined firmness at said predetermined moisture content.

5. Apparatus in accordance with claim 2 further comprising:

a third sensor means for providing a speed sensor

signal related to the speed of said rod.

6. Apparatus in accordance with claim 5 wherein:

said first sensor means is a resistance type moisture sensor.

7. Apparatus in accordance with claim 2 further comprising:

a further sensor means for providing a density sensor signal related to the density of said rod.

8. Apparatus in accordance with claim 7 wherein:

said first sensor means is a microwave type moisture sensor.

9. Apparatus in accordance with claims 1,2,5,6,7 or 8 wherein:

said control means includes:

a signal processor responsive to said sensor signals for generating a moisture content signal corresponding to the actual moisture in said rod;

and moisture control means responsive to said moisture content signal for adjusting the moisture content of said input tobacco.

10. Apparatus in accordance with claim 9 wherein said input tobacco is at a moisture content below a predetermined moisture content desired in said rod and wherein:

said signal processor generates a control signal dependent upon a comparison of said moisture content signal and said predetermined moisture content;

and said moisture control means is responsive to said control signal and includes means for adding moisture

to said input tobacco.

11. Apparatus in accordance with claim 9 wherein said input tobacco is at a moisture content above a predetermined moisture content desired in said rod and wherein:

said signal processor generates a control signal dependent upon a comparison of said moisture content signal and said predetermined moisture content;

and said moisture control means is responsive to said control signal and includes means for subtracting moisture from said input tobacco.

12. A method for controlling the operation of a cigarette maker, said maker being fed input tobacco from which it provides a cigarette rod, said method comprising:

sensing the moisture content of said rod to provide a moisture sensor signal;

and controlling the moisture content of said input tobacco based on said moisture sensor signal.

13. A method in accordance with claim 12 further comprising:

sensing the firmness of said rod to provide a firmness sensor signal.

14. A method in accordance with claim 13 further comprising:

controlling the firmness of said rod based on said firmness sensor signal.

15. A method in accordance with claim 13 wherein:

the step of controlling the moisture content of said input tobacco is carried out by maintaining said moisture content of said input tobacco at a level which causes the moisture content of said rod to be at a predetermined moisture

content;

and the step of controlling the firmness of said rod is carried out by maintaining said firmness at a predetermined firmness at said predetermined moisture content.

16. A method in accordance with claim 12 further comprising:

sensing the density of said rod to provide a density sensor signal;

and said step of controlling said moisture content of said input tobacco is based on said moisture and density sensor signals.

17. A method in accordance with claim 13 wherein:

said step of controlling the moisture content of said rod is based on said moisture, firmness and speed sensor signals.

18. A method in accordance with claim 12,13,15,16 or 17 wherein:

said step of controlling the moisture content of said input tobacco comprises:

processing said sensor signals to generate a moisture content signal corresponding to the actual moisture in said rod;

and adjusting the moisture content of said input tobacco based on said moisture content signal.

19. A method in accordance with claim 18 wherein said input tobacco has a moisture content below a predetermined moisture content desired in said rod and wherein:

said step of processing said sensor signals includes comparing said moisture content signal and said predetermined moisture content;

and said step of adjusting said moisture content of said input tobacco is carried out by adding moisture to said input tobacco based on said comparison of said moisture content signal and said predetermined moisture content.

20. A method in accordance with claim 18 wherein said input tobacco has a moisture content above a predetermined moisture content desired in said rod and wherein:

said step of processing said sensor signals includes comparing said moisture content signal and said predetermined moisture content;

and said step of adjusting said moisture content of said input tobacco is carried out by subtracting moisture from said input tobacco based on said comparison of said moisture content signal and said predetermined moisture content.

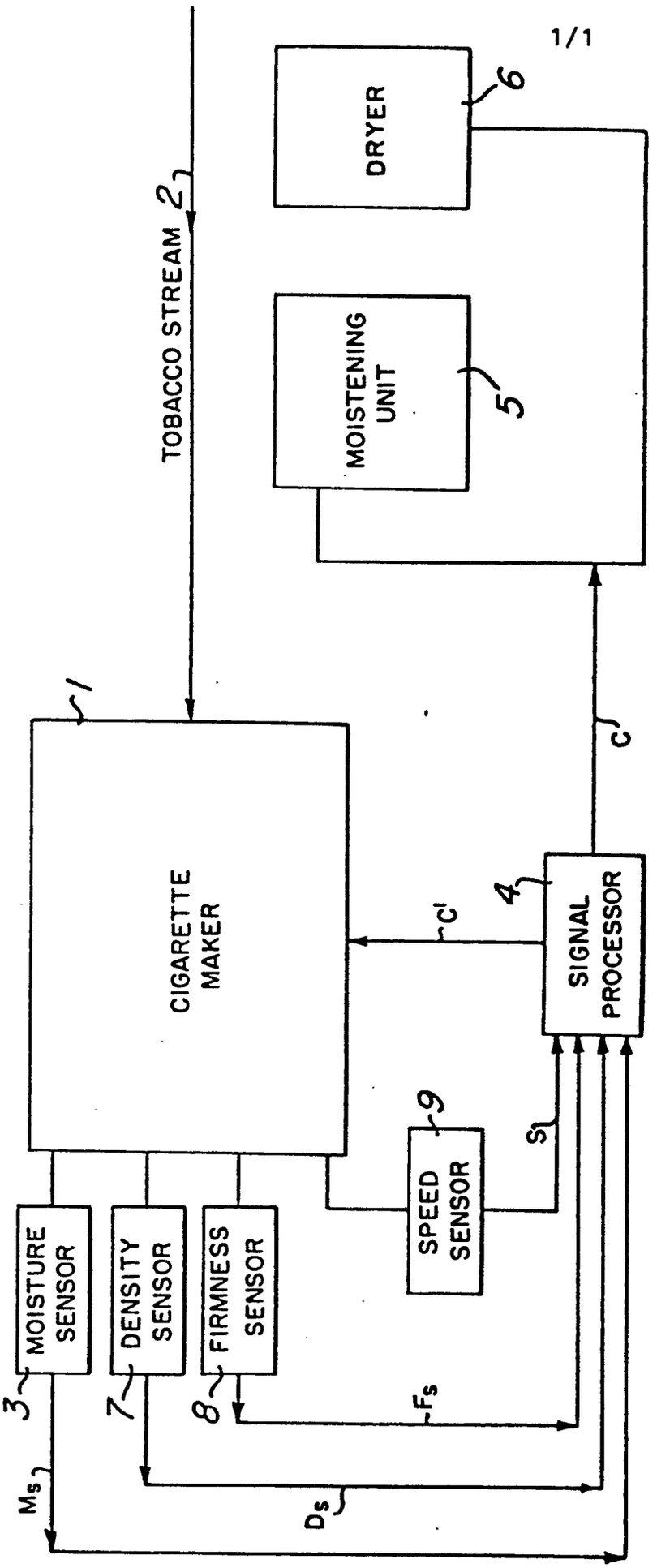
DRYER
6
TOBACCO STREAM
2
MOISTENING UNIT
5
1
CIGARETTE MAKER
C
C'
4
SIGNAL PROCESSOR
9
SPEED SENSOR
S1
MOISTURE SENSOR
DENSITY SENSOR
FIRMNESS SENSOR
3
7
8
Fs
Ms
Ds

FIG. 1