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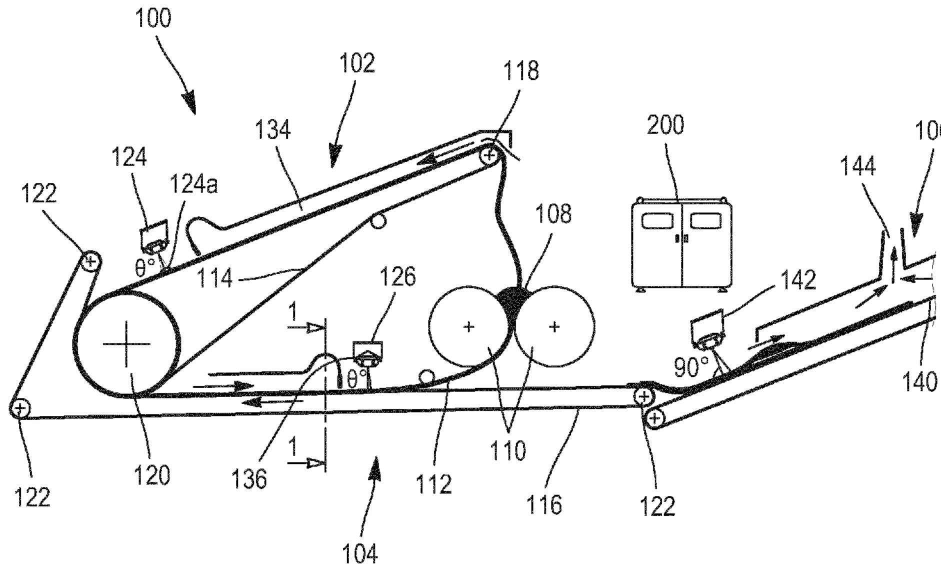

FIG. 1

(57) Abstract: A process for controlling the addition of water in a rubber mixture produced during a mixing cycle in which the rubber mixture (108) is transported in the form of a continuous sheet (112) and along at least a portion of which at least one spray system sprays water that is controllably evacuated by at least one aspiration system, characterized in that the process comprises the following steps: obtaining data unique to each rubber mixture that includes at least a predetermined water flow rate delivered by the spraying system, a predetermined air flow rate delivered by the aspiration system and target values of temperature and water content for the rubber mixture; detecting an amount of water added at an elapsed during the mixing cycle; using the detected amount of water to predict values of temperature and water content for the rubber mixture at the end of the mixing cycle in progress; comparing the target values and the predicted values; and between successive mixing cycles, adjusting the actual water flow rate when a comparison indicates non-

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PROCESS FOR CONTROLLING THE ADDITION OF WATER IN A RUBBER MIXTURE FOR PRODUCING TIRES

TECHNICAL FIELD

The described invention relates generally to the production of rubber mixtures and vehicle tires made from them. More particularly, the disclosed invention relates to the control of water that is added to the rubber mixture as a function of controlling its temperature and water content during production.

BACKGROUND

The production of rubber for a vehicle tire includes a plurality of successive mixing steps. For example, patent GB423,637 discloses a means for maintaining a predetermined temperature of rubber during mixing on a cylindrical roller. This means operates by expansion and contraction of an element that responds to the change in the rubber temperature and sends water to the cylindrical roller. An initial mixture of elastomeric materials with a carbon black filler and/or silica is often carried out inside a mixer, where the temperature of the mixture rises, for example up to values of between 150°C to 200°C. An automated external mixer (also called "roll mixer" or "roller tool") in which this mixture is then transferred works the mixture, causing it to flow between two rolls so as to convert it into a continuous sheet. Vulcanization products (including, without limitation, sulfur) may be added to the mixture later in the mixing cycle to obtain the final mixture for commercial use.

During the mixing process, repeated rolling results in plasticization of the mixture and causes the temperature to rise accordingly. The mixture is cooled to prevent premature partial vulcanization and/or degradation of insoluble additives. To perform cooling, some methods include cooling fans or integrated cooling systems (e.g., fluid circulating within the cylinders). Other methods employ spray and aspiration equipment that add water to the mixture being worked.

The properties of the mixture, however, are very sensitive to the proportions of its constituent ingredients. Added water can compromise the quality of the finished tire. Vaporization offers an effective solution to cool the mixture and can be used with temperature control during mixing so that the beneficial properties of the tires are preserved.

SUMMARY

The invention provides processes for controlling the addition of water in a rubber mixture during a mixing cycle in which the rubber mixture is transported in the form of a continuous sheet and along at least a portion of which at least one spray system sprays water whose vapors are evacuated controllably by at least one aspiration system.

A process according to the invention includes obtaining predetermined data relative to the rubber mixture, including at least a predetermined water flow rate delivered by the spraying system, a predetermined air flow delivered by the aspiration system and target values of temperature and water content of the rubber mixture. The method also includes detecting an actual water flow attained throughout the mixing cycle. Based upon the detected values, the values of temperature and water content of the rubber mixture at the end of the mixing cycle are predicted. The target values and the predicted values are compared and, between successive cycles, the actual water flow is adjusted when a comparison indicates non-equivalence. The process results in a rubber composition having improved fluidity relative to a rubber composition resulting from a control process without spraying.

Some processes also include spraying of the continuous sheet during transport thereof proximate an upper spray station and a lower spray station. For these embodiments, each spray station includes one or more spray rails positioned at each upper and lower spray station. Each spray rail is in communication with a water supply source and an air supply source in order to provide water and air to one or more nozzles. Air containing evaporated water is removed by aspiration, and the continuous sheet is transported in a predetermined direction during spraying and aspiration.

For some embodiments of the invention, each aspiration system may include one or more aspiration hoods positioned downstream of each rail. Each aspiration hood is in communication with an air supply source for the aspiration of air at a predetermined air flow rate. Some of these hoods may include at least one heating element that prevents condensation of sprayed water.

For some embodiments of the invention, the predetermined water flow rate is selected in a range of water flow rates in the range of about 40 liters/hour to about 400 liters/hour. The predetermined air flow rate is selected in a range of air flow rates in the range of about 5000 m^3/h to about 30,000 m^3/h. A target value of the temperature of the rubber mixture is about 70° C. A target value of water added to the rubber mixture does not exceed about 0.20% by weight of the rubber mixture.

For certain embodiments of the invention, the method further includes the step of iteratively performing at least one of the step of detecting water flow, the step of using detected flow rates allowing the prediction of temperature and water addition values, the step of comparing target values and predicted values and the step of adjusting the actual water flow when a comparison indicates a non-equivalence until the comparison indicates equivalence.

For certain embodiments of the invention, the method further includes the step of obtaining a detection system for performing the detection and for generating one or more signals indicative of the actual water flow rate; the actual air flow rate; and the presence of an ambient pressure suitable for atomizing air droplets. For these embodiments, the method further includes the step of obtaining a monitoring system configured to receive the signals generated by the detection system and to send one or more proportionate control signals to effect the adjustment. For some embodiments, the monitoring system includes at least one programmable controller in signal communication with at least one of the spraying installation and the evacuation installation so that the data can be selected from a plurality of established data values for a selected rubber mixture.

For some embodiments of the invention, the method includes the step of adding one or more vulcanization products during the circulation of the continuous sheet. For these embodiments, the method includes the step of attaining the target values of temperature and water added to the rubber mixture before adding the vulcanization products.

For some embodiments of the invention, the method includes the step of conveying the continuous sheet to an evacuation station. For such embodiments, the evacuation station has one or more spray rails positioned thereat with one or more aspiration hoods positioned downstream thereof. Using the spray rails, the continuous sheet is sprayed during its transport proximate the evacuation station. With the help of the aspiration hoods, the air containing the evaporated water is evacuated at the evacuation station.

For some embodiments of the invention, the fluidity of a rubber composition realized by the process is improved by about 25% over the fluidity of a composition realized by a control method without spraying.

The invention also relates to the use of the method according to the invention for increasing the fluidity of an elastomeric material. A method of measuring fluidity is described hereinbelow.

Other aspects of the present invention will become apparent from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The nature and the various advantages of the present invention will become more apparent upon reading the following detailed description in conjunction with the accompanying drawings, wherein like numbers designate like parts throughout, and in which:

FIG. 1 shows a schematic of an exemplary system that produces rubber according to an exemplary process as described herein.

FIGS. 2 to 4 show partial views of the system of FIG. 1.

FIG. 5 shows a schematic sectional view of Section 1-1 of FIG 1.

FIG. 6 shows an exemplary aspiration device used in the system of FIG. 1.

FIGS. 7 and 8 show steps of a mixing cycle effected by the system of FIG. 1.

DETAILED DESCRIPTION

Now referring further to the figures, in which like numbers identify like elements, FIG. 1 shows an exemplary system 100 for producing one or more rubber products to be incorporated into one or more vehicle tires. As used herein, the term “tires” includes but is not limited to tires used with lightweight vehicles, passenger vehicles, utility vehicles (including heavy trucks), leisure vehicles (including but not limited to bicycles, motorcycles, ATVs, etc.), agricultural vehicles, industrial vehicles, mining vehicles and engineering machines. It is also contemplated that the products produced by the presently disclosed invention include full and partial tire treads such as those used in known retreading processes.

System 100 includes at least one upper spray station 102 (shown and described in more detail with reference to FIG. 2) and one lower spray station 104 (shown and described in more detail with reference to FIG. 3) that are integrated with at least one spray system and at least one aspiration system, to control the temperature and the addition of water in a rubber compound produced by them. The spray system sprays water that is discharged after evaporation in a controllable manner by the aspiration system.

System 100 may also include an optional evacuation station 106 (shown and described in more detail with reference to FIG. 4) that also incorporates spraying and aspiration devices, to perform an optional additional treatment of the rubber mixture as needed.

It is understood that the system 100 may operate independently or that there may be one or more of these systems in a production plant.

In a rubber producing method, an elastomeric material (e.g., natural rubber, synthetic rubber and combinations and equivalents thereof) is mixed with one or more ingredients in an internal mixer (not shown) to thereby obtain a rubber mixture 108. Preferably, a method according to the invention is used to increase the fluidity of an elastomeric material comprising natural rubber, preferably more than 25% by weight relative to the total weight of the elastomeric material. More preferably, natural rubber is 50%, 60%, 70%, 80%, 90% or even 100% by weight relative to the total weight of the elastomeric material.

The ingredients may contain carbon black and/or silica in varying amounts depending on the desired properties and performance for the vehicle tire. The rubber mixture 108 is transferred to an external mixer having a pair of cylinders 110 with an adjustable gap 110a therebetween. Each cylinder 110 rotates about its axis of rotation, and the cylinders are disposed such that their axes of rotation are parallel to one another as they rotate in opposite directions. The cylinders 110 may have identical diameters and identical lengths to ensure consistent and repeatable performance in successive mixing cycles. One or both cylinders 110 may have a fluid cooling means or other cooling means as known in the art. The system 100 moves the rubber mixture 108 between the cylinders 110 to form a continuous sheet 112 having a selected thickness and width.

System 100 circulates the continuous sheet 112 along a predefined path having one or more continuous conveying means (e.g., one or more conveyor belts or similar transport means). In the embodiment of FIG. 1, the predefined path is formed at least partly by a continuous belt 114 disposed at the upper spray station 102 and another continuous belt 116 positioned at the lower spray station 104. The belts 114, 116 are driven at least by an upper roller 118 and a lower roller 120 of larger relative diameter. One or more auxiliary rollers 122 may complement the conveyance of belts 114, 118 as is known in the art.

Although the belts 114, 116 are shown as separate means of conveyance, a single continuous belt can replace them. It is understood that the predefined path is not limited to belts and that other means of transport can replace without departing from the scope of the invention described. The predefined path can remain "without end" (i.e., uninterrupted) when at least one mixing cycle is in progress and may circulate without end during one or more successive mixing cycles. Depending on the properties of the selected rubber mixture, the speed of the belts 114, 116 may be adjusted during a mixing cycle or between successive mixing cycles according to need.

Referring to FIGS. 2 and 3, system 100 includes a spray system that sprays water along at least a portion of the continuous sheet 112 as the sheet travels the predefined path. The spray system includes one or more upper spray rails 124 positioned at the upper spray station 102 and one or more lower spray rails 126 positioned at the lower spray station 104. As used herein, the terms "spray rails” and "rails" are used interchangeably.

Each rail 124, 126 is in communication with a water and air supply source (not shown) for the supply of water and air to one or more respective nozzles 124a, 126a that may be identical or may include a variety of nozzle sizes of types. In some embodiments, each spray rail is equipped with a spray bar 128 including eight (8) nozzles that are linearly disposed and evenly spaced along a common axis extending through all or part of the continuous sheet 112 (for example, along at least a portion of the width of the sheet) (see FIG. 5). In some embodiments, each nozzle of the rail supplies water at the same pressure and at the same rate. In such embodiments, in the case of malfunction of a nozzle, fluid circulation (e.g., water and air) is stopped and prevents the introduction of excess water in the rubber mixture. After stopping the flow of fluid, the properties of the rubber mixture can be verified manually or automatically before resuming production. For example, an actual temperature and/or actual water content in the rubber mixture can be detected when the fluid circulation stops, which time is determined in the mixing cycle. At this time, if the detected values of temperature and/or water content did not reach the respective target values for the elapsed time, it is unlikely that the rubber mixture reaches the predicted values of temperature and/or water content at the end of the mixing cycle. Thus, between successive mixing cycles, fluid flow can be adjusted.

It is understood that the rails 124, 126 are not limited to the represented bars and nozzle configurations and can be customized to suit the operation of the system 100. Each rail 124, 126 should be configured to deliver a predetermined flow rate of water spray as determined for the selected mixing cycle. It is understood that the water flow can be changed between successive mixing cycles, and that in some mixing cycles, a rail may deliver a different water flow than that delivered by another rail in the same system. In some embodiments, the water flow may be about 70 liters/hour to about 400 liters/hour.

In some embodiments of system 100, nozzles 124a, 126a are positioned at a predetermined height H_1 between the nozzle outlet and the continuous sheet 112 and create an angle θ between the water spray and the continuous sheet. For example, as shown in FIGS. 2 and 3, nozzles 124a at the level of the upper spray station 102 are positioned at a height H_1 of at or about 250 mm, while nozzles 126a at the level of lower spray station 104 are positioned at a height H_1 of or about 260 mm. In this example, the height H_1 is selected so that the spray angle θ remains substantially normal to the continuous sheet 112 during current and successive mixing cycles. It is understood that such parameters of height are adjustable and can be selected to achieve different spray angles θ without departing from the scope of the described invention. The height can also be considered in relation to the spacing between nozzles to prevent overlapping of the spray zones of adjacent nozzles.

Still referring to FIGS. 2 and 3, system 100 includes an aspiration system to remove the water particles generated by the rails 124, 126. The aspiration system includes at least an aspiration hood 134, 136 positioned downstream of each respective rail 124, 126 and in communication with an aspiration source (not shown). In some embodiments, a bifurcated duct 135 applies aspiration to hoods 134, 136, the aspiration rate being adjustable automatically or manually (e.g., by a manual controller 137 as shown) (see FIG. 6). This rate represents a volume of air aspirated during an elapsed time.

As shown particularly in FIGS. 2 and 3, the aspiration creates a circulation of air in the direction opposed to the direction of circulation of continuous sheet 112. Thus, the upper belt transports the continuous sheet 112 in the direction of the upper roller 118 and the lower belt transports the sheet in the direction of the lower roller 120, while the hoods 134, 136 aspirate in respective opposite directions.

Each aspiration hood 134, 136 has a respective entry 134a, 136a through which a portion of the evaporated water is combined with that water already evaporated in a respective elongated conduit 134b, 136b in order to be finally evacuated. In some embodiments of system 100, each entry 134a, 136a may be positioned at a predetermined distance D_1, as measured between the entry and a respective rail 124, 126 in proximity thereof (and, in particular, a position of nozzles 124a, 126a thereof). Considering in detail FIGS. 3 and 6, each entry 134a, 136a may also have a lip 134c, 136c positioned at a predetermined height H_2 between the lip and the continuous sheet 112 that ensures unimpeded evacuation of the water particles that pass by entry 134a or 136a and elongated pipe 134b or 136b. Each pipe 134b, 136b may have a predetermined height H_3 and a predetermined length L_1 which provides an unobstructed conduit for both the aspiration of air and the discharge of water particles. In some embodiments, at the level of upper spray station 102, the entry 134a can be positioned a distance D_1 of approximately 510 mm and a height H_2 of about 120mm. Conduit 134b may have a height H_3 of about 240 mm and a length L_1 of about 5500mm. At lower spray station 104, inlet 136a may be positioned at a distance D_1 of about 540mm and a height H_2 of at or about 130mm. Conduit 136b may have a height H_3 of about 270 mm and a length L_1 of about 2800mm. It is understood that the values of height, length and distance are given by way of example and can be adjusted to the unique properties of rubber mixture 108.

Referring further to FIG. 6, at least one aspiration hood 134, 136 may also include a respective lip 134c, 136c having an integrated heating element (not shown). Each lip 134c, 136c may be fabricated from a flexible material (e.g., silicon) having an electric heating wire or a similar heating element incorporated therein. The selective heating of lips 134c, 136c during the transport of the sheet 112 is a means to prevent condensation. While the lips 134c, 136c do not contact sheet 112, they are sufficiently heated to prevent the entry of water droplets into rubber mixture 108. In some embodiments, the lip 134c, 136c are heated to about 70°C.

The addition of water by the rails 124, 126 loads the ambient air with moisture. The air containing the evaporated water is aspirated in order to prevent the introduction of excess water into the rubber mixture 108. Each rail and aspiration hood combination serves as a checkpoint that optimizes cooling of the rubber mixture throughout the process production line.

Further referring to FIG. 4, some of the embodiments of system 100 may include an optional evacuation station 106 for discharging continuous sheet 112. In such embodiments, evacuation station 106 includes an evacuation belt 140 that receives the sheet from belt 116. At least one spray rail 142 having nozzles 142a is positioned to spray the continuous sheet 112 during the transport thereof on the evacuation belt. Spray rail 142 has a configuration similar to that described above with respect to rails 124, 126. At least one aspiration hood 144 is located downstream of the rail 142 and has a configuration similar to that described above with respect the hoods 134, 136.

In some embodiments of the evacuation station, nozzles 142a may be positioned at a predetermined height H_4 at a predetermined spray angle θ' that ensures the spraying of water between the nozzle outlet and continuous sheet 112. For example, as shown in FIG. 4, the nozzles 142a are positioned at a height H_1 of about 200mm to about 290mm. In this example the spray angle θ' remains substantially normal to continuous sheet 112 during the discharge.

In some embodiments of evacuation station 106, an entry 144a of the aspiration hood 144 may be positioned at a height H_5 of about 335mm. In some embodiments of the evacuation station, a conduit 144b of aspiration hood 144 can have a height H_6 of about 500 mm and a length L_2 of about 16225mm. It is understood that these values are given as examples and can be adjusted based on the unique properties of rubber mixture 108.

System 100 may also include a detection system having at least one flow sensor. The detection system is used to perform the detection and to generate one or more signals indicative of the actual water flow. The detection system includes sensors to detect an actual flow rate delivered by each rail 124, 126 (and also in some embodiments that involve the evacuation station 106).

The detection system of system 100 may also include an air flow sensor 150 at the level of each aspiration hood that verifies the flow rate of aspirated air (see FIG. 5). Such verification may involve determining that a detected air flow meets the predetermined air flow rate values for the indicated rubber mixture. Each air flow sensor 150 may generate one or more signals that are indicative of the actual sensed air rate. Each aspiration hood 134, 136 (and also the aspiration hood 144 in the embodiments that include evacuation station 106) can be configured to deliver a predetermined air flow rate. In some embodiments, this flow rate may be about $5000m^3$/hr to about $30000m^3$/h.

The detection system also includes at least one sensor that detects the presence of an ambient pressure suitable for atomizing air droplets. The detection system generates one or more signals indicative of suitable pressure (at a value specified in the documentation of the nozzle manufacturer).

The detection can be continuous or intermittent so that an actual water flow rate in real time can be determined at any time during the mixing cycle in progress (i.e., the mixing cycle performed at the time of detection).

System 100 may also include a monitoring system that is configured to receive the detected signals (e.g., the signals indicating water flow and/or aspirated air flow rates and/or the presence of a predetermined pressure) and for sending one or more proportionate control signals. Monitoring may be continuous or intermittent so that the control signal effects a real-time adjustment of the water flow and/or aspirated air flow in response to detected actual flow rates at any time during the cycle during mixing. The monitoring system can be programmed to stop spraying when detecting a fault in system 100. It is simple to check the operation of each mixer and every nozzle without undergoing a prolonged delay between mixing cycles.

The monitoring system may include at least one programmable controller in signal communication with at least one of the spray system and the aspiration system. The programmable controller may have programmed therein established data for a plurality of rubber mixtures each having a unique mixing cycle profile. The data may include established water flow rates and air flow rates such that the actual detected water flow rate and actual detected air flow rate can be respectively compared thereagainst. Additional data may include at least a predetermined flow rate to be delivered by each spray rail during a mixing cycle, a target temperature of the rubber mixture at an elapsed time and a target water content of the rubber mixture. Using these data, the monitoring system may be configured to receive the detected signals and execute a corresponding adjustment. All or part of the surveillance system can be housed in a central control center such as control center 200 shown in FIG. 1.

All or part of the surveillance system can be controlled remotely via a network.

In some embodiments, the target temperature of the rubber mixture, at the end of mixing in the external mixer and during the mixing cycle in progress, is about 70° C, the temperature at which the reproducibility of the process is assured. In some embodiments, the target water content in the rubber mixture after an elapsed time during the current mixing cycle does not exceed about 0.20% by weight of the rubber composition, at which level the existing equipment can cool the rubber during working thereof.

System 100 can be employed to perform one or more rubber production processes, as in the example described in relation to FIGS. 7 and 8. In some embodiments, one or more vulcanization products (e.g., sulfur) may be added during circulation of continuous sheet 112. In one embodiment, the target temperature and the target water content are attained before adding the vulcanization products. The cycle time can thus be shortened while maintaining the beneficial properties of the selected rubber mixture, allowing an optimal productivity.

Referring to FIG. 7, during a mixing cycle in progress, rubber mixture 108 is obtained from a mixture of elastomeric material and other ingredients (e.g., carbon black, silica, etc.) and transported by belt 114 in a direction for treatment at upper spray station 102 (indicated by the arrows A in FIG. 7). Belt 114 transports the rubber compound 108 between cylinders 110 to form continuous sheet 112. Belt 116 transports the sheet in a direction for treatment at lower spray station 104 (indicated by arrows B in FIG. 7). Based on the unique properties of rubber mixture 108, each rail 124, 126 sprays water at a predetermined flow rate and each respective aspiration hood 134, 136 aspirates the air containing evaporated water at a predetermined flow rate.

Referring further to FIG. 8, the mixing cycle terminates. The direction of transport of continuous sheet 112 is then reversed. Belt 114 transports sheet 112 in the direction of treatment at the level of lower spray station 104 (indicated by arrow A' in FIG. 8). Belt 116 transports the sheet toward evacuation belt 140 (indicated by arrow B' in FIG. 8). In the embodiments employing evacuation station 106, rail 142 sprays water at a predetermined flow rate and exhaust hood 144 delivers air at a predetermined air flow rate. The predetermined flow rates may vary and they may be different at each spray station, with the flow rates being selected to give the rubber mixture a target temperature and target water content at the end of the mixing cycle in progress.

It is understood that other cycles may include more or fewer adjustment parameters that ensure the control of the addition of water in the final rubber mixture. During a mixing cycle, the temperature and/or the addition of water can be detected and compared to respective target temperature and water content values. For example, if at an elapsed time, the temperature of the mixture is greater than a predicted target temperature, the water flow rate (e.g., as delivered by rail 124 or rail 126) can be adjusted to a rate higher than that which would be delivered at a lower temperature. The water flow adjustment may be performed alone or in combination with an adjustment of the aspiration air flow rate (e.g., as delivered by aspiration hood 134 or aspiration hood 136).

When successful adjustments are made over time, such adjustments may be repeated in successive mixing cycles to ensure that the addition of water to any rubber mixture is limited to the target value thereof. The detection system can detect, at each checkpoint, the actual water flow rate and the actual flow rate of aspirated air at an elapsed time in the current mixing cycle. The detection system can also detect at each checkpoint, the presence of the correct pressure for droplet atomization (a value specified in the documentation of the nozzle manufacturer). In this manner, the detection system can verify that the fluid flow rate and air flow rate realized at the moment of detection are satisfactory to meet the target temperature and the target water content.

The monitoring system can receive the detection signals from the detection system and, depending on the actual water flow rate detected and/or the actual aspiration air flow rate detected, predict an actual temperature value of the rubber mixture and an actual water content value at the end of the current mixing cycle. The prediction may include the prediction that the target temperature and the target addition of water will be reached or not. The monitoring system is configured to compare the target quantities of temperature and water content with respective predicted quantities. In advance of a successive mixing cycle, the monitoring system may generate control signals to adjust one or both of the actual fluid flow rate and the actual air flow rate when a comparison indicates non-equivalence.

The invention contemplates the use of existing equipment to control the water content of rubber mixtures produced thereby. Water content influences the workability of the rubber in the current mixing cycle and successive mixing cycles. Thus, while a threshold water content is expected, maintenance of the water content at or below the established threshold prevents premature vulcanization and preserves the integrity of the rubber’s performance in its commercial embodiments. Moreover, such control enables predictable and repeatable mixing cycles having reduced cycle times. Enhanced productivity levels can therefore be planned and maintained while also maintaining beneficial rubber characteristics.

Comparing with known methods of implementation of the internal and external mixer type (introduction of the crosslinking system), the present invention also makes it possible to obtain a mixture whose fluidity property is increased, all the other properties being otherwise equal.

By way of example, the following comparative results were obtained for a final rubber composition as described in the table below:

Components	in PCE
NR	50
BR	50
N234	45
Plastifier	13
SULFUR	1,5
CBS	1
Z_NO	2,5
Stearic acid	1

TABLE 1

The rubber compositions of the non-spray control and the spray mixture were obtained with the process adjustments as described in the table below.

	Control A	**Test A**
	With spraying	**Without spraying**
	Internal mixer (MI)	
Drop température (°C)	170	170
Specific energy (MJ)	198	201
Mixing time (min)	2	2
Array speed (t/min)	50	50
	External mixer (ME)	
Mixing time (min)	13	13
Gap distance (mm)	5	5

Cylinder diameter (mm)	860	860
Cylinder 1 speed (t/min)	33	33
Cylinder 2 speed (t/min)	33	33
Volume of added water (L/hr)	0	100

TABLE 2

The following comparative values (in base 100) were obtained:

Module at 10%	100	100
ML(1+4) 100°C	100	100
Fluidity	100	125
Fixation at 130°C	100	130
Karl Fischer	100	100

TABLE 3

By “module at 10%” is meant the modulus of elongation of a specimen of the rubber composition after vulcanization at 150° C.

These measurements are carried out in accordance with the French standard NFT 46-002 of September 1988 that provides the measurement in first elongation (i.e., without accommodation cycle, the modules are then denoted M) of true secant modules (i.e., calculated by reducing to the actual section of the test piece), expressed in MPa, at 10% elongation. These tensile measurements are carried out under normal conditions of temperature and hygrometry (23° C +/- 2° C, 50 +/- 5% relative humidity, French standard NF T 40-01 of December 1979).

In some processes, at the outlet of the internal mixer, the drop temperature of the initial rubber blend composition does not exceed 180° C, and at the outlet of the external mixer, the exit temperature of the initial rubber blend composition does not exceed 120°.

Fluidity

This measurement is adapted from the fluidity measurement commonly used in the plastics industry for the characterization of extrudability including thermoplastic materials. The measurement is described in ASTM D1238 (or NF T 51-016), and modified as follows. The operating parameters of the mixing installation are chosen so that the fluidity of the rubber composition at the outlet of the installation is improved by about 25% with respect to the fluidity of a composition leaving the installation pursuant to a control method without spraying.

In a capillary rheometer, the sample of the elastomer mixture is heated to a controlled temperature (about 90 ° C). The eluted mass (extrudate) is then measured through a cylindrical die (diameter 2 mm) of tungsten carbide by means of a loaded piston. The fluidity value corresponds to the displacement of the piston under the effect of the load, in hundredths of mm for a time of 10 seconds (it corresponds to a flow). The index 100 is given for the fluidity of the control composition, with an index greater than 100 indicating a greater fluidity, and a lower index indicating less fluidity.

Viscosity

The “Mooney” viscosity, also known as viscosity or plasticity, characterizes, in a known manner, solid substances. Use is made of an oscillatory consistometer as described in ASTM standard D1646 (1999). The Mooney plasticity measurement is carried out according to the following principle: the sample, analyzed in the raw state (i.e., before curing), is molded (formed) in a cylindrical chamber heated to a given temperature (for example, 35° C or 100° C). After preheating for one minute, the rotor rotates within the test specimen at 2 rpm, and the torque needed to maintain this movement is measured for 4 minutes of rotation. The Mooney viscosity (ML 1 + 4) is expressed in "Mooney unit" (MU, with 1MU = 0.83 Nm) and corresponds to the value obtained at the end of the 4 minutes.

Scorch Time

The scorch time (noted T5) is also measured, at 130° C, according to the French standard NF T 43-005 (1991); the variation of the consistency index as a function of time also makes it possible to determine this scorch time of the rubber compositions, evaluated according to the aforementioned standard, by the parameter T5 (case of a large rotor), expressed in minutes, and defined as the time required to obtain an increase in the consistometric index (expressed in MU) of 5 units above the minimum value measured for this index.

Dosage of the water:

The Karl-Fisher method is used.

At least some of the various techniques described herein may be implemented in connection with hardware or software or, where appropriate, with a combination of both. For example, electrical data processing functionality may be used to implement any aspect of power computation and adjustment, including implementation in connection with a computing device (including a mobile networking apparatus) that includes hardware, software, or, where appropriate, a combination of both.

As used herein, the term “method” or “process” refers to one or more steps that may be performed in other ordering than shown without departing from the scope of the presently disclosed invention. As used herein, the term "method" or "process" may include one or more steps performed at least by one electronic or computer-based apparatus having a processor for executing instructions that carry out the steps.

The terms "at least one" and "one or more" are used interchangeably. Ranges that are described as being "between a and b" are inclusive of the values for "a" and "b."

While particular embodiments of the disclosed apparatus have been illustrated and described, it will be understood that various changes, additions and modifications can be made without departing from the spirit and scope of the present disclosure. Accordingly, no limitation should be imposed on the scope of the presently disclosed invention, except as set forth in the accompanying claims.

WHAT IS CLAIMED IS:

1. A process for controlling the addition of water in a rubber mixture produced during a mixing cycle in which the rubber mixture (108) is transported in the form of a continuous sheet (112) and along at least a portion of which at least one spray system sprays water that is controllably evacuated by at least one aspiration system, characterized in that the process comprises the following steps:

obtaining data unique to each rubber mixture that includes at least a predetermined water flow rate delivered by the spraying system, a predetermined air flow rate delivered by the aspiration system and target values of temperature and water content for the rubber mixture;

detecting an amount of water added at an elapsed during the mixing cycle;

using the detected amount of water to predict values of temperature and water content for the rubber mixture at the end of the mixing cycle in progress;

comparing the target values and the predicted values; and

between successive mixing cycles, adjusting the actual water flow rate when a comparison indicates non-equivalence.

2. The process of claim 1, further comprising the following steps:

spraying the continuous sheet (112) during transport thereof proximate each of an upper spray station (102) and a lower spray station (104);

evacuating air that contains the sprayed water; and

transporting the continuous sheet (112) in a predetermined direction during the spraying and evacuating.

3. The process of claim 2, wherein:

each spraying system includes one or more rails (124), (126) positioned at each of the upper spray station (102) and lower spray station (104), each rail (124), (126) being in communication with a source of water and air to supply water and air to one or more nozzles (124a), (126a) at a predetermined water flow rate and a predetermined air pressure; and

each aspiration system includes:

one or more aspiration hoods (134), (136) positioned downstream of each rail (124), (126), each aspiration hood being in communication with an air supply source for aspiration at a predetermined air flow rate;

at least one heating element prevents condensation of sprayed water; and

at least one transport means performs the transporting.

4. The process of claim 3, wherein the nozzles are linearly arranged along a common axis perpendicular to the axis of circulation of the continuous sheet (112).

5. The process of any of claims 2 to 4, wherein:

the predetermined water flow rate is selected from a range of water flow rates in a range from about 40 liters / hour to about 400 liters / hour;

the predetermined air flow rate is selected from a range of air flow rates within a range of about 5000 m^3/h to about 30000 m^3/h;

a target value of the temperature of the rubber mixture is about 70°C; and

a target value of the water content in the rubber mixture does not exceed about 0.20% by weight of the rubber mixture.

6. The process of claim 5, further comprising iteratively performing at least one operation among detecting, predicting, comparing and adjusting until the comparison indicates equivalence.

7. The process of any one of claims 2 to 6, further comprising the step of providing at least one of:

a detection system for performing detection and to generate one or more signals indicative of the actual water flow rate, the actual air flow rate; and a presence of a pressure suitable for atomizing air droplets; and

a monitoring system configured to receive signals that are generated by the detection system and to send one or more commensurate control signals to perform the adjusting.

8. The process of claim 7, wherein the monitoring system includes at least one programmable controller in signal communication with at least one of the spraying system and the aspiration system such that the data may be selected from a plurality of established data values for a selected rubber mixture.

9. The process of any preceding claim, further comprising at least one of the following steps:

adding one or more vulcanization products during transport of the continuous sheet; and

before the adding, reaching the target values of temperature and water content for the rubber mixture.

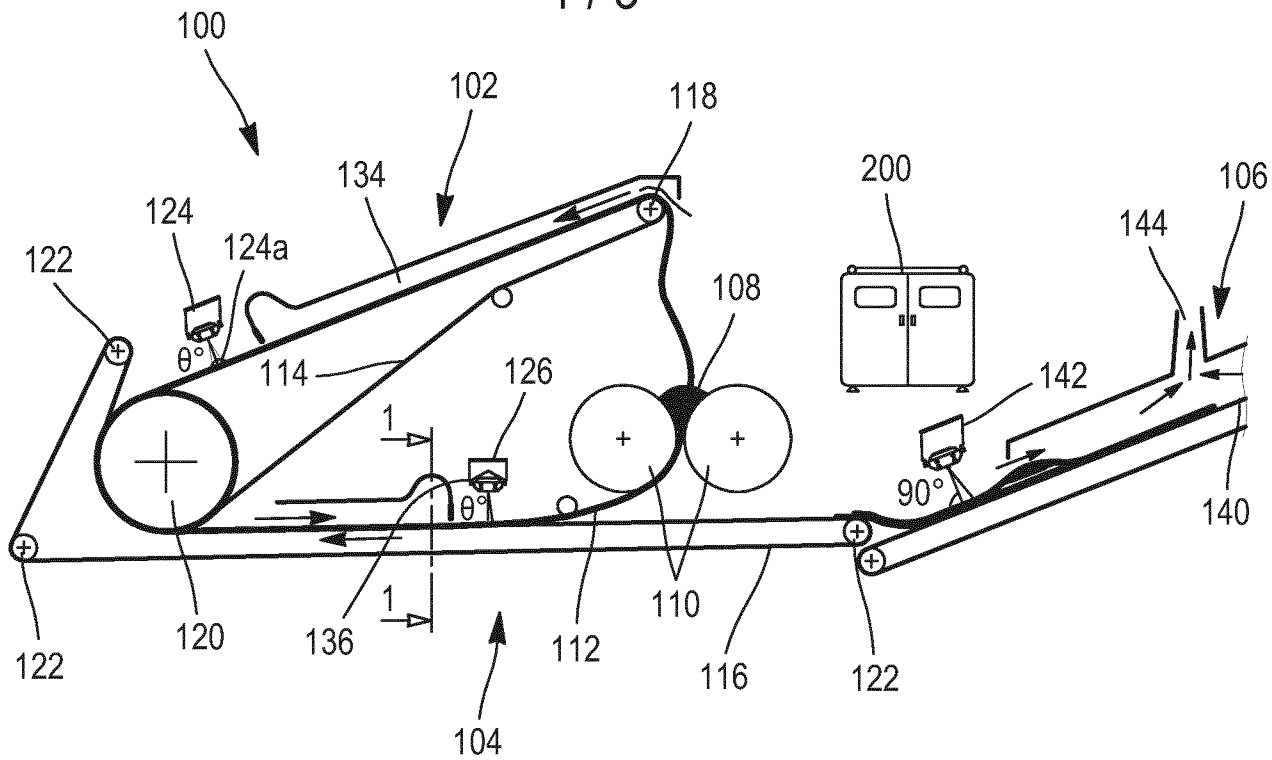
10. The process of any preceding claim, further comprising the following steps:

transporting the continuous sheet to an evacuation station (106), the evacuation station (106) comprising one or more spray rails (142) positioned at the level thereof and one or more aspiration hoods (144) positioned downstream thereof;

using the spray rails (142), spraying the continuous sheet during transport thereof near the evacuation station; and

using the aspiration hoods (144), evacuating the air containing evaporated water at the level of the evacuation station.

11. The process of any preceding claim, in which the fluidity of a rubber composition realized by the process is improved by about 25% with respect to the fluidity of a rubber composition realized by a control method without spraying.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102
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124
124a
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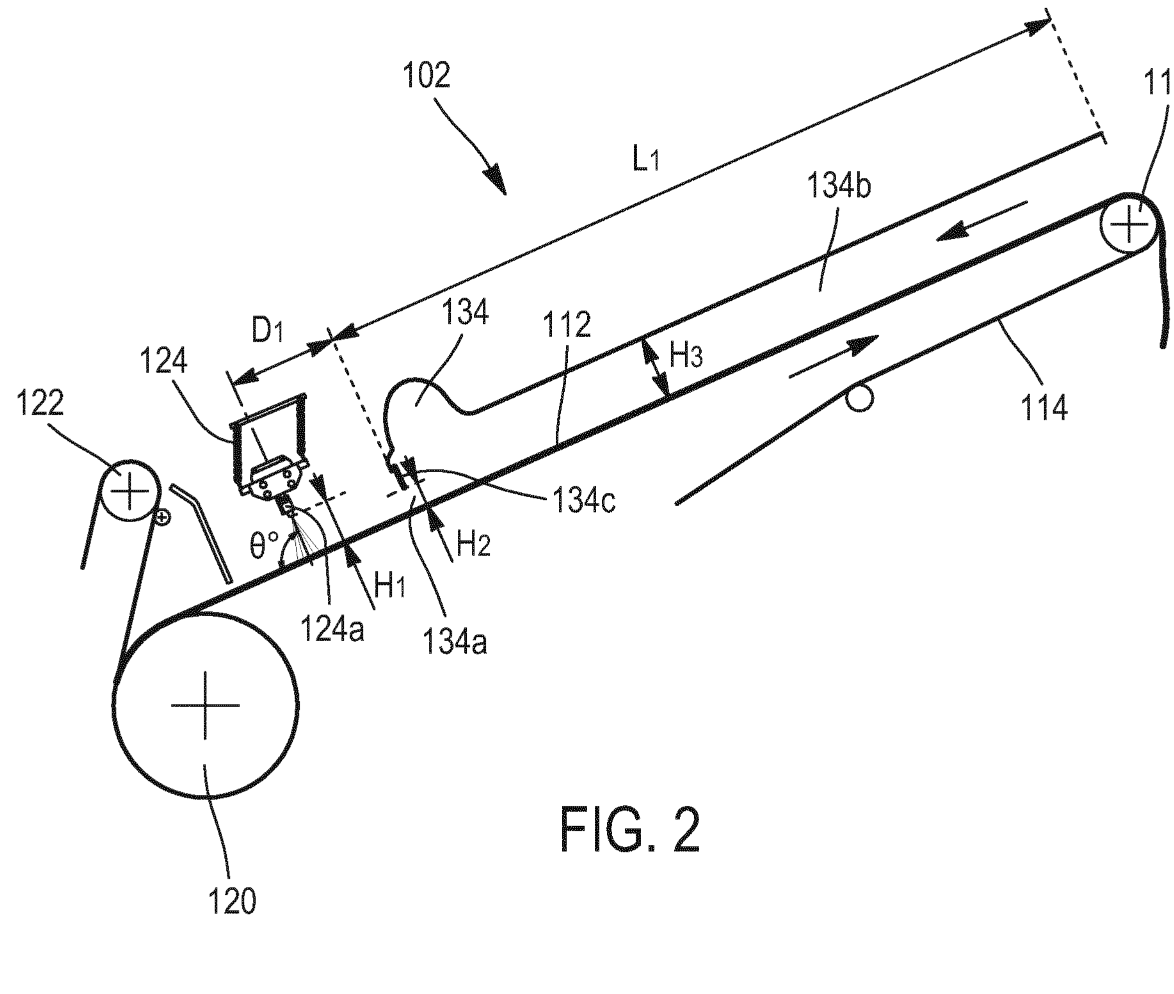
142
90°
140

FIG. 1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θ°
H1
H2
124a
134a
120

FIG. 2

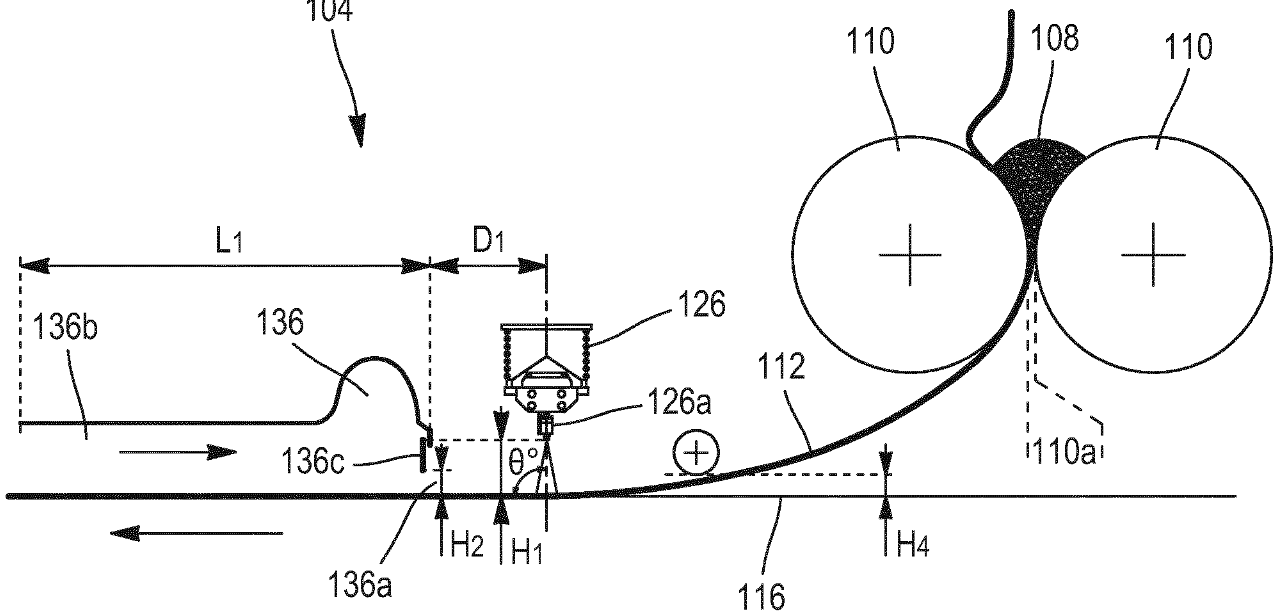

FIG. 3

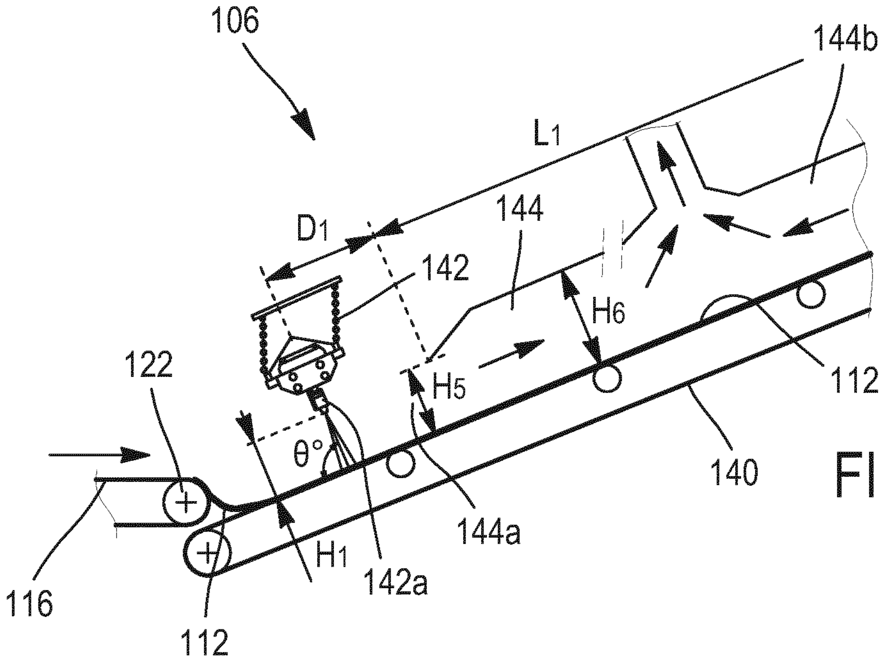

FIG. 4

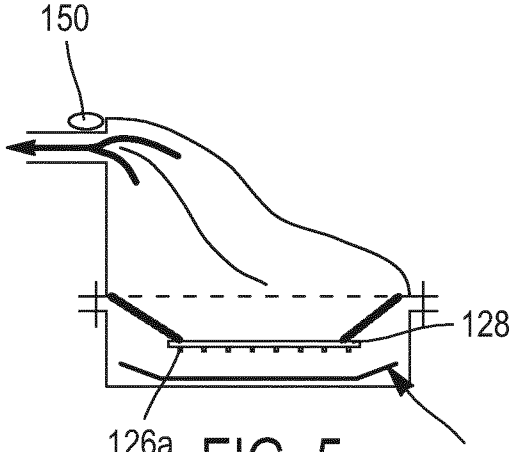

FIG. 5

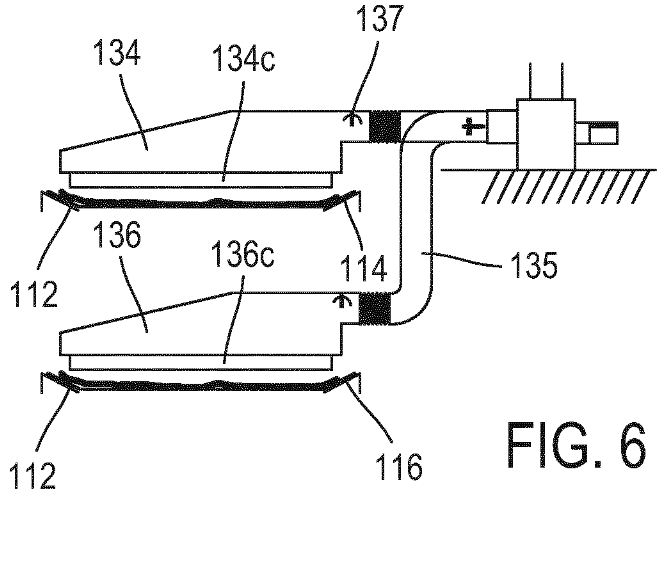

FIG. 6

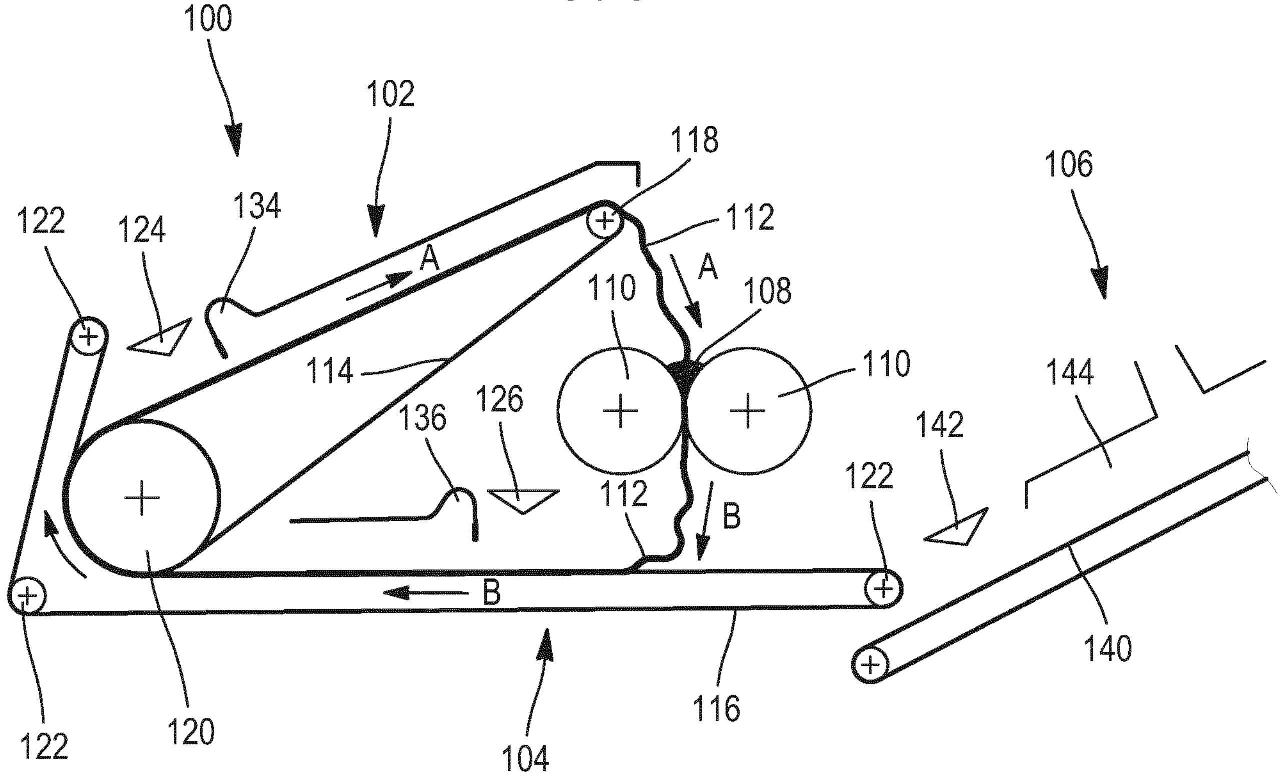
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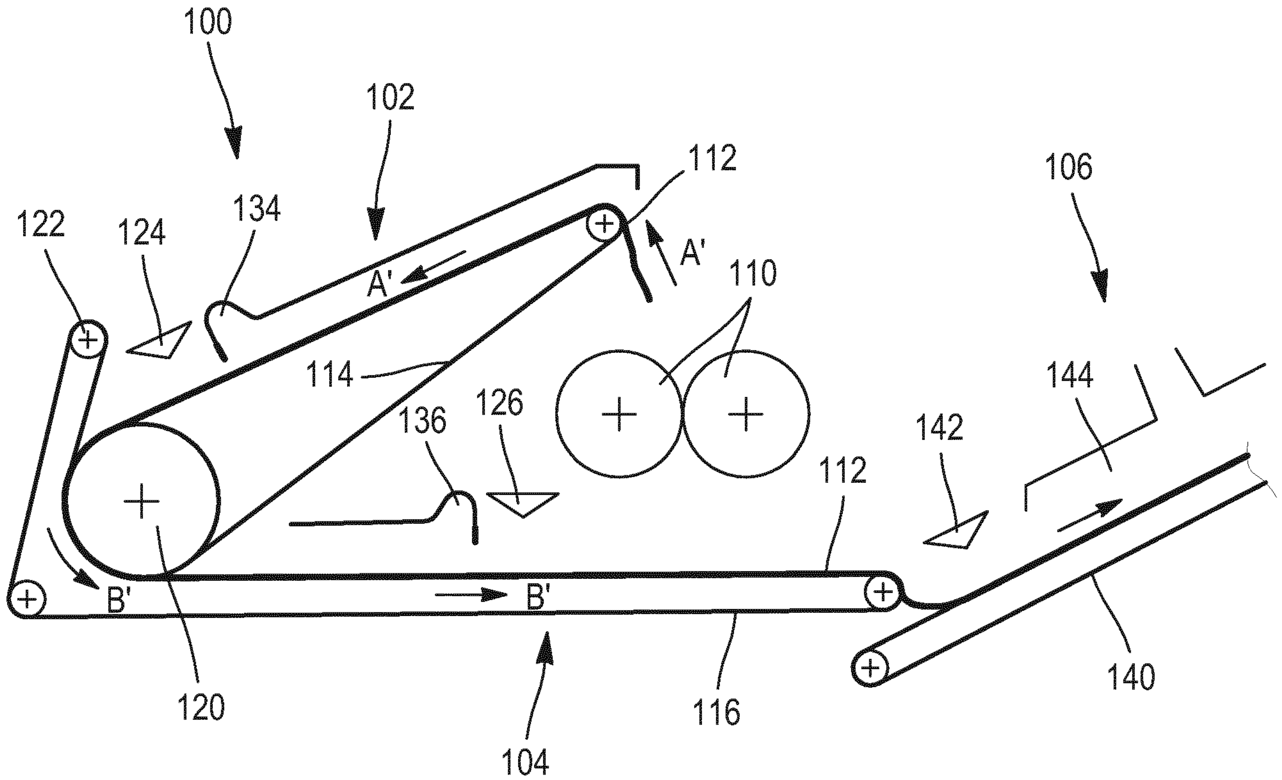
FIG. 7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126
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112
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B'
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116
104
140

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/081711

A. CLASSIFICATION OF SUBJECT MATTER
INV. B29B7/82 B29B7/56 B29B7/74 B29B7/72
ADD. B29B7/62

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B29B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X,P	WO 2017/102332 A1 (MICHELIN & CIE [FR] ET AL) 22 June 2017 (2017-06-22) page 1, lines 3-5 page 6, line 5 - page 8, line 21 page 11, line 26 - page 12, line 8 abstract; figure 2	1-11
X,P	WO 2017/102333 A1 (MICHELIN & CIE [FR] ET AL) 22 June 2017 (2017-06-22) the whole document	1-11

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 February 2018	21/02/2018

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Authorized officer

Brunold, Axel

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/081711

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