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(54) **Method and system for manufacturing mechanical pulp and mechanical pulp obtainable by the method**

(57) The invention relates to mechanical pulp, and a method and a system of manufacturing mechanical pulp. The method for manufacturing mechanical pulp may be implemented in a system comprising a refiner line comprising a first refiner and a second refiner, the first refiner and the second refiner being single disc refiners comprising a rotating disc and a stationary disc, and having a plate gap. The method comprises feeding wood chips to the refiner line, the feeding rate of the wood chips to

the refiner line being at least 300 adt/d, and refining the wood chips in at least two refining stages using said single first refiner and said second disc refiners in order to manufacture mechanical pulp. The method further comprises measuring and/or estimating at least two parameters from the refiner line and/or from the mechanical pulp that is refined in the refiner line, and controlling at least one parameter of the manufacturing process using said at least two parameters.

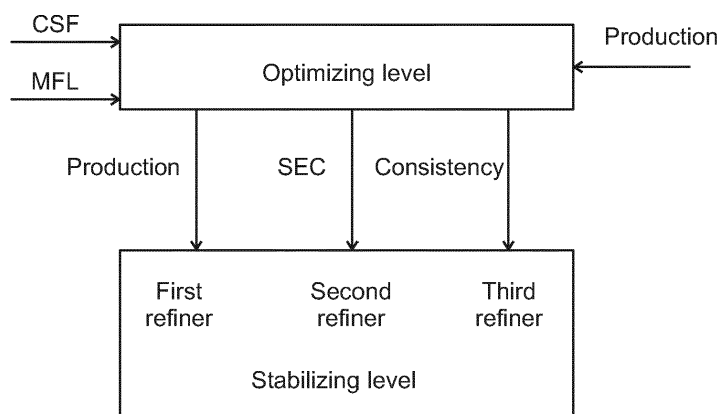


Fig. 3

DescriptionField of the Invention

[0001] The present invention relates to mechanical pulp, and a method and a system of manufacturing mechanical pulp.

Background of the Invention

[0002] In prior art, mechanical pulping from cellulose based fiber material may be performed in thermomechanical pulp (TMP) -plants. In TMP-plants, mechanical pulp is produced by refining wood chips between rotating refiner plates under pressure and high temperature. Due to mentioned circumstances, refining stages of mechanical pulp production consume lots of energy. Reducing the energy consumption of refining process, especially without sacrificing quality of the manufactured pulp, may be vital for mechanical pulp mills due to the ascending price of electricity. There is, therefore, a need for a new method for manufacturing mechanical pulp.

Summary of the Invention

[0003] The present invention relates to mechanical pulp, and a method and a system of manufacturing mechanical pulp. In the novel solution of the present invention, the mechanical pulp is produced from wood material, preferably from wood chips. The invention further discloses a use of the produced mechanical pulp as a raw material in paper, paperboards or boards.

[0004] According to a first aspect there is provided a method for manufacturing a mechanical pulp in a system comprising a refiner line comprising a first refiner and a second refiner, the first refiner and the second refiner being single disc refiners comprising a rotating disc and a stationary disc, and having a plate gap,

wherein the method comprises:

- feeding wood chips to the refiner line, the feeding rate of the wood chips to the refiner line being at least 300 adt/d, and
 - refining the wood chips in at least two refining stages using said first refiner and said second refiner in order to manufacture mechanical pulp,
- wherein the method further comprises
- determining at least two parameters from the refiner line and/or from the mechanical pulp that is refined in the refiner line, and
 - controlling at least one parameter of the manufacturing process using said at least two parameters.

[0005] According to a second aspect there is provided a system for manufacturing mechanical pulp, the system comprising

- a refiner line comprising a first refiner and a second refiner for refining wood chips into pulp in at least two refining stages, the first refiner and the second refiner being single disc refiners comprising a rotating disc and a stationary disc, and having a plate gap,
- and the system further comprises
- an apparatus for feeding wood chips to the refiner line, the feeding rate of the wood chips to the refiner line being at least 300 adt/d, and
 - at least one device for determining at least two parameters from the refiner line and/or from the mechanical pulp that is refined in the refiner line, and
 - an apparatus for controlling at least one parameter of the manufacturing process using said at least two parameters.

[0006] According to a third aspect there is provided mechanical pulp that is obtainable by the process defined in any of the method claims 1 to 15.

Description of the Drawings

[0007] In the following, the invention will be described in more detail with reference to the appended drawings, in which

Figs 1 to 5 show schematically some example embodiments of the present invention,

Fig. 6 shows a side projection of a single disc refiner, wherein the operating principle of the refiner is illustrated, and

Fig. 7 illustrates a principle of a multivariable process.

Detailed Description of the Invention

[0008] In the following disclosure, all pressures are overpressures (i.e. pressure above normal atmospheric pressure), if not indicated otherwise.

[0009] In the following disclosure, all percentages are by dry weight, if not indicated otherwise.

[0010] The following reference numbers are used in this application:

10 cellulose based raw material, preferably wood chips,
 12 an apparatus for pre-impregnation, impregnation stage,
 15 refined pulp,
 20 refiner line,
 21 first refiner, primary refining stage,
 22 second refiner, secondary refining stage,
 23 third refiner, tertiary refining stage,
 31 steam separator device,
 40 control system,
 41 control block,
 42 receiving means,
 43 memory,
 44 data transmission means,
 45 display,
 46 keyboard, and
 47 storing block.

[0011] The term "MFL" refers to Medium Fiber Length.

[0012] The term "CSF" refers to Canadian Standard Freeness. However, the freeness may also be determined by using another measurement method than the CSF based measurement method.

[0013] The term "SEC" refers to Specific Energy Consumption.

Figure 1 shows schematically an example system for manufacturing mechanical pulp according to the present invention. In the example shown in Figure 1, raw material is conveyed to a refiner line 20 of TMP plant in which the raw material is refined using a first refiner 21, a second refiner 22, and a third refiner 23. The system preferably comprises a steam separator device 31 after each of said refiners. After the refiner line 20, the raw material is refined into refined pulp 15.

Figure 2 shows schematically another example system for manufacturing mechanical pulp according to the present invention. In the example shown in Figure 2, the raw material 10 is first pre-impregnated 12 and then conveyed to the refiner line 20 in order to manufacture refined pulp 15.

Figures 3 to 5 show schematically some examples according to the present invention. Figure 3 shows an example of a control system, Figure 4 shows an example of a freeness estimation, and Figure 5 shows an example of a control system.

Fig. 6 shows a side projection of a single disc refiner, wherein the operating principle of the refiner is illustrated. Preferably the first refiner 21, the second refiner 22, and the third refiner 23 of the refiner line 20 are single disc refiners.

[0014] The mechanical pulp manufactured according to the present invention comprises or consists of the cellulose based fiber material. Advantageously, the content of the cellulose based fiber material in the refined pulp, for example in the latency removal stage, is at least 95%, more preferably at least 98%, and most preferably at least 99% or at least 99.9 %.

[0015] Advantageously, at least 60 wt. % or at least 70 wt. %, more preferably at least 80 wt. % or at least 90 wt. % and most preferably at least 95 wt. % or at least 99 wt. % of the cellulose based fiber material is wood based material.

[0016] The wood based material preferably comprises softwood trees, most preferably spruce, pine, fir, larch, douglas-fir and/or hemlock. The wood material may also comprise hardwood trees, such as birch, aspen, poplar, alder, eucalyptus, or acacia. Most advantageously the used wood material comprises or consists (at least mainly) of soft wood. Advantageously at least 60 wt.% or at least 70 wt.%, more preferably at least 80 wt.% or at least 90 wt. %, and most preferably

at least 95 wt. % or at least 99 wt.% of the cellulose based fiber material comes from softwood.

[0017] According to an advantageous embodiment, said soft wood material consists (at least mainly) of spruce, pine and/or larch. Preferably, at least 60 wt.% or at least 70 wt.%, more preferably at least 80 wt.% or at least 90 wt. %, and most preferably at least 95 wt. % or at least 99 wt.% of the softwood is spruce, pine and/or larch.

[0018] According to an advantageous embodiment, the raw material 10 comprises wood chips. Preferably, at least 60 wt.% or at least 70 wt.%, more preferably at least 80 wt.% or at least 90 wt. %, and most preferably at least 95 wt. % or at least 99 wt.% of the raw material 10 is in form of wood chips.

[0019] Advantageously at least 60 wt.% or at least 70 wt.%, more preferably at least 80 wt.% or at least 90 wt. %, and most preferably at least 95 wt. % or at least 99 wt.% of the cellulose based fiber material used are virgin.

[0020] The mechanical pulp manufactured according to the present invention is preferably thermomechanical pulp (TMP). In the TMP process, the main raw material is wood chips. Thermomechanical pulp is produced by treating wood chips using heat and mechanical refining.

[0021] Mechanical pulp contains the lignin of the wood, and thereby the yield of pulp may be double compared with the yield of pulp in chemical pulping processes. Advantageously, yield calculated from the amount of the cellulose based raw material 10, is at least 80%, or at least 85%, more preferably at least 90%, or at least 93%, and most preferably at least 95%, or at least 96%. For example, with fresh debarked spruce wood the yield may be over 98%.

[0022] In thermomechanical pulping (TMP), wood refining preferably takes place under pressure. Some of the mechanical work is typically turned into heat through friction forces. Hot steam, which is typically formed in the process, softens the lignin between wood fibers and, hence, causes the links between the fibers to open up. The hot steam typically affects the fiber separation so that the process produces longer fibers.

[0023] Advantageously, the wood chips are first washed before they are conveyed to the TMP refiner line. The washed chips are preferably pre-steamed in the preheater. If the preheater is used, chips are fed into the pressurized or unpressurized preheater.

[0024] The objective of the preheating is typically to warm the raw material 10 (wood chips) and equalize the moisture content of the raw material 10 before refining. The pressure in the preheater is preferably less than 560 kPa, less than 500 kPa, less than 400 kPa, less than 300 kPa, less than 200 kPa, or less than 150 kPa. Advantageously, the pressure in the preheater is between 40 and 120 kPa, more preferably between 50 and 110 kPa.

[0025] The retention time in the preheater is preferably between 10 seconds and 10 minutes, more preferably between 30 seconds and 5 minutes, and most preferably between 1 and 3 minutes.

[0026] The temperature of the preheater is preferably between 70° and 160°C, more preferably between 90 and 140°C, and most preferably between 100 and 130°C. The temperature used may have an effect on strength properties, shive content of the pulp, and optical properties of the pulp. Advantageously, the chips are preheated with blow-back steam from the first-stage refiner and/or with steam from the heat recovery system. However, the chips may also be preheated with steam from a refiner of another stage than the first stage. From the preheater, the chips are preferably conveyed to the refiner feeding system with a conveyor, most preferably with a plug screw.

[0027] Advantageously, the raw material 10 is pretreated in an impregnation stage 12. The impregnation stage 12 is preferably placed between the chip washing and the refiner line 20. Advantageously, the raw material 10 is enzyme pretreated in the enzyme impregnation stage. Alternatively or in addition, the raw material 10 may be pretreated in a water impregnation stage.

[0028] The retention time in the impregnation stage 12 (after the enzyme is added) is preferably between 0.5 and 4 hours, more preferably between 1 and 3 hours, and most preferably between 1.5 and 2.5 hours. The enzyme(s) is/are preferably added in a screw impregnator. The retention time may be implemented, for example, by using a retention vessel, such as a retention tower. When pretreating of the wood chips is carried out in a water impregnation stage, the wood chips may be impregnated with water without adding enzyme and thus no retention time exists.

[0029] Some technical effects may be achieved, if an impregnation stage 12 is used, i.e. it may be possible

- to open the wood chip structure before refining,
- get even moisture content in refiner feed, and
- to press a considerable share of extractives out.

[0030] Thanks to the impregnation stage 12, the production rate in the following refiner line 20 may be higher than without said impregnation stage. Due to the impregnation stage 12, the chips may be more densely packed to the feeding screws than without the impregnation stage.

[0031] Advantageously, consistency in the enzyme treatment stage is between 20 and 45%, or between 25 and 40%, or between 30 and 35%. Advantageously, the temperature in the enzyme treatment stage is in the range of 45-70°C.

[0032] The retention time in the enzyme treatment step is preferably between 0.5 and 4 hours, or between 1 and 3 hours, or between 1.5 and 2.5 hours.

[0033] In an embodiment, the enzyme used for the impregnation stage comprises

- cellulases, and/or
- glucanases, and/or
- laccases, and/or
- lipases, and/or
- 5 - pectinases, and/or
- xylanases.

[0034] Advantageously, the above mentioned enzymes comprise at least 70%, or at least 80%, more preferably at least 90%, and most preferably at least 95% of the enzymes used in the impregnation stage 12.

[0035] The enzymes used are preferably unreacted after the impregnation stage 12, at least mainly. Therefore, preferably at least a portion of the enzyme solution is collected and reused. This may be implemented, for example, by collecting the enzyme solution pressed out from chips, for example, in the plug screw following the impregnation stage 12.

[0036] If the system comprises the impregnation stage 12, the refiner line 20 is preferably placed after the impregnation stage.

[0037] The system typically comprises the refiner line 20. The actual refining is preferably carried out in two or three stages. The refiner line 20 has preferably between 1 and 4 refiners, more preferably exactly 2 or 3 refiners, and most preferably exactly 3 refiners.

[0038] At least one refiner 21, 22, 23 is preferably a single-disc (SD) refiner, a double-disc (DD) refiner, a conical refiner and/or a twin refiner. More preferably, at least one refiner 21, 22, 23 is the single-disc and/or the double-disc refiner.

[0039] The single-disc (SD) refiner comprises one rotating blade, i.e. a rotor equipped with refiner plates, the double-disc (DD) refiner has two blades which rotate in opposite directions, i.e. it has two counter-rotating blade discs mounted on cantilevered shafts, the conical refiner is conically shaped and the twin refiner is a double disc refiner having a circle of refining plate segments mounted on each side of a rotor working.

[0040] Advantageously, at least one of the refiners in the refiner line is a single-disc refiner, more preferably at least two of the refiners in the refiner line are single-disc refiners, and most preferably all refiners in the refiner line are single-disc refiners. Therefore, the first refiner 21, and/or the second refiner 22, and/or the third refiner 23 of the refiner line 20 is the single-disc refiner. Most preferably, the three single-disc refiners are in a series in the refiner line.

[0041] Advantageously, the single-disc refiner has two blade-discs: one rotating disc and one stationary disc (shown in Figure 4). In the single-disc refiner, preferably a ribbon-type screw feeds the chips into the eye of the rotor disc, which feeds the chips into a gap between the rotating disc and the stationary disc. This gap may also be called as a plate gap. The plate gap in the single-disc refiner is preferably between 0.1 and 1.0 mm, more preferably between 0.2 and 0.9 mm, and most preferably between 0.3 and 0.8 mm.

[0042] The refiner load of the single-disc refiner is preferably controlled by adjusting the refiner disc clearance, i.e. by adjusting the plate gap. The generated steam and the centrifugal forces may transport the fibers from the eye of the refiner to the refiner output, from which they are blown out. Advantageously, there are two or three single-disc refiners in a series in the refiner line 20.

[0043] Advantageously, the first refiner 21 and/or the second refiner 22 and/or the third refiner 23, which are preferably single-disc refiners, has a diameter of a blade between 55 and 75 inch (between 140 and 191 mm), more preferably between 60 and 70 inch (between 152 and 178 mm), and most preferably between 63 and 67 inch (between 160 and 170 mm). In some embodiments one or more of the single-disc refiners have a diameter of 65 inches. The single-disc refiner(s) used is/are preferably so called SD65 refiner(s).

[0044] Advantageously, the plate gap of the first refiner 21 and/or the second refiner 22 and/or the third refiner 23 is measured. These measurements may be used to control and/or to secure reliability of the refiner line and, hence, the quality of the manufactured pulp.

[0045] Advantageously the first refiner 21 and/or the second refiner 22 and/or the third refiner 23 of the refiner line 20, most preferably the first refiner 21 and the second refiner 21 of the refiner line are equipped with plate gap measurements.

[0046] Advantageously the first refiner 21 and/or the second refiner 22 and/or the third refiner 23 of the refiner line 20, more preferably the first refiner and the second refiner of the refiner line are equipped with plate gap temperature measurements. The plate gap temperature measurements may be used for estimation of quality of the pulp, or for controlling the manufacturing process.

[0047] In an example embodiment, the plate gap temperature measurements are used to determine the amount of dilution water needed for a plate gap. The temperature of the plate gap may be used to understand the current load of said blade section. In addition, it may be used to analyze refining results. Advantageously, the plate gap dilution water is controlled using at least the plate gap temperature measurement(s). Advantageously, the plate gap temperature is between 80 and 230°C, or between 90 and 200°C, or between 100 and 180 °C.

[0048] Advantageously, the plate gap dilution water is used for at least one refiner 21, 22, 23. The plate gap dilution water is preferably used in the first refiner 21 and/or the second refiner 22 in the refiner line 20. Advantageously, the amount of the dilution water is controlled in order to keep the consistency of the pulp at approximately the same level

over one refiner, i.e. the input consistency of the pulp does not differ more than 20%, more preferably not more than 10% from the output consistency of the pulp.

[0049] Preferably, the dilution water is fed to the plate gap of the first refiner and/or the second refiner by using at least one dosage point, more preferably between 2 and 20 dosage points, or between 3 and 15 dosage points, and most preferably between 5 and 12 dosage points, or between 7 and 10 dosage points.

[0050] The refiners of the refiner line 20 are preferably pressurized. The blades are preferably encompassed by a shell, which is preferably connected to the outside world only through a vent. Advantages of pressurized refining may be the reduced volumetric steam flow and improved stability of the refiner load. As a result, the pulp quality objectives are more easily achieved. The retention time in one refiner is preferably between 1 and 10 s, more preferably between 2 and 7 s.

[0051] The input pressure, the output pressure, and/or the refining pressure, most preferably at least the refining pressure, of the first refiner 21 of the refiner line is preferably at least 1 bar, at least 1.5 bar, more preferably at least 2 bar, at least 2.5 bar, and most preferably at least 3 bar. The input pressure, the output pressure, and/or the refining pressure of the first refiner 21 is preferably less than 9 bar, or less than 8 bar, more preferably less than 7 bar or less than 6 bar, and most preferably less than 5 bar or less than 4 bar.

[0052] The input pressure, the output pressure, and/or the refining pressure, most preferably at least the refining pressure, of the second refiner 22 of the refiner line is preferably at least 1 bar or at least 2 bar, more preferably at least 3 bar or at least 4 bar, and most preferably at least 5 bar. The input pressure, the output pressure, and/or the refining pressure, most preferably at least the refining pressure, of the second refiner 22 is preferably less than 9 bar, more preferably less than 8 bar, or less than 7 bar and most preferably 6 bar at the most.

[0053] The input pressure, the output pressure, and/or the refining pressure, most preferably at least the refining pressure, of the third refiner 23 of the refiner line is preferably at least 1 bar or at least 2 bar, more preferably at least 3 bar or at least 3.5 bar, and most preferably at least 4 bar. The input pressure, the output pressure, and/or the refining pressure, most preferably at least the refining pressure, of the third refiner 23 is preferably less than 8 bar, more preferably less than 7 bar, or less than 6 bar and most preferably less than 5.5 bar or 5 bar at the most.

[0054] Advantageously, the power of the first refiner 21 of the refiner line is between 3 and 30 MW, more preferably between 4 and 20 MW, or between 5 and 15 MW, and most preferably between 6 and 14 MW, or between 7 and 13 MW.

[0055] Advantageously, the power of the second refiner of the refiner line is between 4 and 30 MW, more preferably between 5 and 25 MW, or between 6 and 20 MW, and most preferably between 7 and 17 MW, or between 8 and 15 MW.

[0056] Advantageously, the power of the third refiner of the refiner line is between 3 and 25 MW, more preferably between 5 and 20 MW, or between 6 and 15 MW, and most preferably between 7 and 13 MW, or between 8 and 12 MW.

[0057] In some embodiments the power of the first refiner of the refiner line is between 0.5 and 1.3 times the power of the second refiner of the refiner line, and the power of the third refiner (if exists) of the refiner line is between 0 and 1.0 times the power of the second refiner of the refiner line.

[0058] Advantageously, the energy consumption of the refiner line 20 is less than 2.4 MWh/adt, more preferably less than 2.1 MWh/adt, and most preferably less than 1.9 MWh/adt, when the freeness of the refined pulp is between 100 and 250 ml, more preferably between 120 and 200 ml, and most preferably between 140 and 180.

[0059] In an advantageous example, the refiner line 20 comprises three refiners, and the power of the first refiner is between 20 and 39 % of the powers of the all refiners, the power of the second refiner is between 25 and 40 % of the powers of the all refiners, and the power of the third refiner is between 25 and 35 % of the powers of the all refiners in the refiner line.

[0060] In another example, the refiner line comprises two refiners, and the power of the first refiner is between 48 and 55 % of the powers of the all refiners, and the power of the second refiner is between 45 and 52 % of the powers of the all refiners in the refiner line.

[0061] Advantageously, a feeding plate is used for the first refiner and/or the second refiner and/or the third refiner. The design of bars and grooves preferably follows a unidirectional pattern (comp. bidirectional pattern) and/or the angle of said bars and grooves is preferably in the pumping direction. Advantageously, the refiner line 20 comprises a feeding refiner plate for the first refiner. In addition or alternatively, the refiner line preferably comprises a feeding refiner plate for the second refiner. In addition or alternatively, the refiner line preferably comprises a feeding refiner plate for the third refiner.

[0062] Preferably, retention time between the first and the second refiner is minimized by implementing as short blow pipe between the refiners as possible and by utilizing a mechanical steam separator with a short residence time.

[0063] In an example embodiment, the mechanical steam separator is located between two refiners and is preferably used, in addition to the steam separator, as a refiner feeder. In another example embodiment, the mechanical steam separator is located after the last refiner.

[0064] In an example embodiment, the mechanical steam separator comprises or consists of inlet, steam outlet, pulp outlet and feed device, such as a feed screw. The feed screw may feed the pulp into the refiner and the steam may be transported together with back flowing steam to the steam outlet.

[0065] Advantageously, there is a mechanical steam separator at least between the first refiner 21 and the second refiner 22. In this case, the mechanical steam separator may be used to separate steam and fibers and to stabilize the second refiner stage. Alternatively or in addition, the mechanical steam separator is placed between the second refiner and the third refiner of the refiner line. In this case, the mechanical steam separator may be used to separate steam and fibers and to stabilize the third refiner stage. Alternatively or in addition, the mechanical steam separator is placed after the third refiner of the refiner line. In this case, the mechanical steam separator may be used at least to separate steam and fibers.

[0066] Advantageously, the refiner line 20 comprises 1, 2 or 3 mechanical steam separators. There is preferably no more than exactly one mechanical steam separator after each of the refiners in the refiner line. In other words, there is preferably no more than one steam separator for one refiner.

[0067] Advantageously, the fiber length of the cellulose based material is measured after the third refiner 23, for example between the last refiner of the refiner line and the following process step, such as a latency removal step, and/or after the latency removal step, preferably by an online-device, such as KajaaniMap analyzer or a similar device.

[0068] Advantageously, freeness of the cellulose based material is measured after the third refiner, for example between the last refiner of the refiner line and the following process step, such as a latency removal step, and/or after the latency removal step, preferably by an online-device, such as KajaaniMap analyzer or a similar device.

[0069] Advantageously, shives content and/or fiber length distribution of the cellulose based material may also be measured e.g. after the third refiner, for example between the last refiner of the refiner line and the following process step, such as a latency removal step, and/or after the latency removal step, preferably by an online-device, such as KajaaniMap analyzer or a similar device.

[0070] The production of a TMP mainline may be defined by input of the refiner line. Advantageously, the production of the one refiner line 20 is at least 300 adt/d, for example between 300 and 700 adt/d more preferably at least 350 adt/d, or at least 400 adt/d, for example between 350 and 600 adt/d, and most preferably at least 430 adt/d or at least 450 adt/d, for example between 450 and 550 adt/d. Therefore, feeding of the refiner line 20 is preferably at least 300 adt/d, more preferably at least 350 adt/d, or at least 400 adt/d, and most preferably at least 430 adt/d or at least 450 adt/d calculated from the amount of the cellulose based raw material 10 conveyed to the first refiner 21 of the refiner line 20.

[0071] After the refining stages in the refiner line 20, the pulp 15 is preferably conveyed to a latency removal step. The purpose of the latency removal step is typically to remove the curliness of the pulp fibers. In the latency removal step, the pulp is preferably first mixed in a latency pulper between 1 and 15 minutes, more preferably between 2 and 10 minutes, and most preferably between 3 and 7 minutes. The consistency in the latency removal is preferably between 1 and 7%, more preferably between 2 and 4%. The temperature in the latency removal is preferably between 60 and 95°C, more preferably between 70 and 90 °C, and most preferably between 75 and 85°C.

[0072] Advantageously, the method according to the present invention comprises a step, in which a multivariable control system such as a multivariable model predictive control (MPC) is used, preferably comprising a multivariable analysis, is used.

[0073] Multivariable control is used to control processes where there are several controlled process variables (CV's) which are controlled by adjusting several manipulated variables (MV's) (multiple input, multiple output process). The multivariable control is especially useful when process variables are coupled i.e. CV or CV's is/are dependent on several manipulated variables. Multivariable control is able to take this kind of process interactions into account so that better control result may be obtained. Figure 7 illustrates an example of a multivariable process and its interactions.

[0074] The multivariable control system may comprise inner loop (stabilizing level) and outer loop (optimizing level). The inner loop may reduce process variations and variations in pulp properties. In addition, the pulp properties may be controlled in a long term perspective by the outer loop. However, the multivariable control system may also be implemented at one level, i.e. without inner and outer loops, so that all variables are adjusted in one controller. There may also be other applicable ways to implement the multivariable control system for a mechanical pulp process.

[0075] A thermomechanical pulp process is usually a multivariable process, in which many input parameters may affect to, not only one process parameter, but to two or more process parameters. Therefore, by adjusting one control parameter on the basis of one input parameter may not achieve good enough result in the thermomechanical pulp process. For example, loading of the process may affect to the power of the thermomechanical pulp process and to the consistency as well as to the temperature of the thermomechanical pulp process or a part of the thermomechanical pulp process.

[0076] Another example of a multivariable process relates to a forward end of a pulp process in which actuators may affect to the operation of refiners of later stages, for example to the refining consistency, plate gap, and/or freeness.

[0077] Furthermore, at least some parameters regarding the quality of the thermomechanical pulp process may also be dependent on each other. The power of the refiners 21, 22, 23 may affect to the freeness and the fiber length. Also the amount of the raw material at the input of the process may have implications on the production rate, freeness and fiber length.

[0078] Hence, due to the nature of the thermomechanical pulp process it is advantageous to use a multivariable control

system in controlling the thermomechanical pulp process.

[0079] Figure 5 shows an example of a control system 40, such as a multivariable system, according to a preferred embodiment of the present invention in a reduced block chart. The control system 40 preferably comprises a control block 41, such as a processor or the like, whose operation can be controlled by means of program commands. The control system also comprises receiving means 42 for receiving data, such as measurement results, and preferably a memory 43 for storing data. The control system 40 may also comprise a display 45 for displaying data, so that the user of the control system can monitor the situation, and a keyboard 46 for entering data, control commands *etc.* in the control system. The data defined in the control block can also be stored, for example, in the memory 43 of the control system, or in the memory of another device (not shown). Furthermore, the control system 40 may comprise, *inter alia*, data transmission means 44 for transmitting data defined in the control block further. For generating and implementing the model preferably used in the invention, it is possible to apply, for example, a computer program which comprises program commands for controlling the operation of the control system 40 so that the measurement results can be used for forming the necessary initial data. The computer program, the program commands, and/or the model optionally used can be stored, for example, in the memory 43 of the control system. This is represented by block 47 in Fig. 5.

[0080] Advantageously, the solution according to the present invention comprises the following measurement(s):

- the power of the first refiner, and/or
- the power of the second refiner, and/or
- the power of the third refiner, and/or
- the total power of the refiner line, and/or
- the plate gap of the first refiner, and/or
- the plate gap of the second refiner, and/or
- the plate gap of the third refiner, and/or
- the amount of the plate gap dilution water(s) in the first refiner, and/or
- the amount of the plate gap dilution water(s) in the second refiner, and/or
- the amount of the plate gap dilution water(s) in the third refiner, and/or
- the plate gap temperature(s) and/or temperature profile in the first refiner,
- the plate gap temperature(s) and/or temperature profile in the second refiner,
- the plate gap temperature(s) and/or temperature profile in the third refiner,
- refining consistency in the first refiner, and/or
- refining consistency in the second refiner, and/or
- refining consistency in the third refiner, and/or
- the feeding rate of the refiner line, and/or
- freeness after the refiner line, and/or
- fiber length after the refiner line, preferably MFL, and/or
- fiber length distribution of the refiner line, i.e. fiber fractions, and/or
- shive content after the refiner liner, and/or
- plate vibration of the first refiner, and/or
- plate vibration of the second refiner, and/or
- plate vibration of the third refiner, and/or
- SEC of the first refiner, and/or
- SEC of the second refiner, and/or
- SEC of the third refiner, and/or
- SEC of the refiner line.

[0081] Advantageously, the multivariable control system uses 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28 or all of the above mentioned measurements, including any ranges and partial ranges, to control the manufacturing process.

[0082] In an advantageous embodiment, a plate vibration of at least one refiner of the refiner line and/or a plate gap of at least one refiner of the refiner line is measured and used to control the manufacturing process.

[0083] In an advantageous example, the solution according to the present invention comprises the following measurement(s):

- the power of the first refiner, and/or
- the power of the second refiner, and/or
- the power of the third refiner, and/or
- the total power of the refiner line, and/or
- refining consistency in the first refiner, and/or

- refining consistency in the second refiner, and/or
- refining consistency in the third refiner, and/or
- the feeding rate of the refiner line, and/or
- freeness after the refiner line, and/or
- 5 - fiber length after the refiner line, preferably MFL, and/or
- shive content after the refiner liner.

[0084] Alternatively or in addition to the above mentioned consistency measurements, the refining consistencies may be calculated, for example, by using known or estimated amount of fed wood material and water, and generated steam in the refiner(s).

[0085] In an example embodiment,

- specific energy consumption (SEC), and/or
- production rate of the refiner line, and/or
- 15 - consistency of the first refiner, and/or
- consistency of the second refiner, and/or
- consistency of the third refiner, and/or
- plate gap temperature(s) of the first refiner and/or
- plate gap temperature(s) of the second refiner, and/or
- 20 - plate gap temperature(s) of the third refiner, and/or
- is controlled by using
- fed speed of the refiner line, for example preheater discharge plug screw speed, and/or
- refiner load of the first refiner, and/or
- refiner load of the second refiner, and/or
- 25 - refiner load of the third refiner, and/or
- plate gap dilution water flow(s) of the first refiner, and/or
- plate gap dilution water flow(s) of the second refiner, and/or
- plate gap dilution water flow(s) of the third refiner, and/or
- power usage distribution between the refiners used of the refiner line.

[0086] Advantageously, variables that are controlled and/or estimated comprise

- freeness after the refiner line, for example before, during or after the latency removal stage, and/or
- production rate of the refiner line, and/or
- 35 - fiber length after the refiner line, for example before, during, or after the latency removal stage.

[0087] Advantageously, the following parameter(s) is/are estimated according to the above mentioned measurement(s) used in the multivariable control:

- 40 - freeness after the refiner line, and/or
- fiber length after the refiner line, and/or
- fiber distribution, i.e. fiber fractions after the refiner line, and/or
- shive content after the refiner line, and/or
- SEC of the refiner line, and/or
- 45 - refining consistency in the first refiner, and/or
- refining consistency in the second refiner and/or
- refining consistency in the third refiner, and/or
- production rate of the refiner line.

[0088] Advantageously, the multivariable control system uses 1, 2, 3, 4, 5, 6, 7, 8 or 9 of the above mentioned estimates, including any ranges and partial ranges, to control the manufacturing process.

[0089] In an advantageous example, the following parameter(s) is/are estimated according to the above mentioned measurement(s) and/or used in the multivariable control:

- 55 - freeness after the refiner line, and/or
- fiber length after the refiner line, and/or
- shive content after the refiner line, and/or
- production rate of the refiner line.

[0090] The parameters, such as a feeding rate of the refiner line 20, is preferably controlled in order to control the quality of the manufactured pulp and to minimize specific energy consumption (SEC) of the refiner line 20. Advantageously, the SEC of each refiner 21, 22, 23 of the refiner line 20 is on-line measured and controlled. The feeding rate of the refiner line 20 may also be used to affect the quality and to the specific energy consumption level of the process.

[0091] To reach a maximized production with good pulp quality and acceptable energy consumption, it may be necessary to understand the conditions inside the actual refining zone of a refiner. Advantageously, control of the refining zone temperature stabilizes the refining zone conditions, which results in a stabilization of the refiner motor load.

[0092] In an example embodiment, a multivariable control system is used to reduce pulp quality variations and/or reduce energy input by controlling temperature profile of the plate gap. In an advantageous example, the multivariable control system uses plate gap temperature measurements.

[0093] Typically, every refiner has a different characteristic regarding the temperature profile. Thus, preferably plate gap temperature(s) is/are measured from the first refiner and the second refiner of the refiner line, more preferably from every refiner used in the refiner line.

[0094] The temperature profile(s) is/are preferably measured from each section in a refiner, for example by using an array of 1 to 10 sensors located in the refining zones of the refiner. Instead of using the entire temperature profile, the concept may only use the maximum temperature.

[0095] Advantageously, the maximum plate gap temperature in the first refiner and/or the second refiner and/or the third refiner is controlled within 30°C or within 25°C, more preferably within 20°C or within 15°C, and most preferably within 10°C, or within 5°C. This temperature typically corresponds to a variation in motor load. Therefore, the stabilization of the temperature profiles may result in less variation in the refiner motor loads. In addition, the variations in freeness, mean fiber length and shives may be reduced.

[0096] The refiner load is preferably used for controlling the refining zone temperature profile. This may give a stabilization of the entire temperature profile. Thereby, stabilization of motor load and pulp properties may also be obtained.

[0097] Advantageously, the temperature profile of a refiner is controlled by using at least plate gap dilution water of the refiner.

[0098] In an example, uneven split of dilution water is used for at least to different refining zones of one refiner, i.e. at least two dilution water dosage points feeds different amount of the dilution water. Increased dilution water flow rate may give smaller plate gap and/or reduced residence time.

[0099] Advantageously, the manufacturing process is controlled in such a way that quality variation of the pulp is minimized. Pulp properties, such as freeness, and/or fiber length (MFL) and/or shive content is/are measured preferably after the latency removal stage, for example after a latency removal chest and/or in a latency removal pulper and/or after the latency removal pulper. Advantageously, at least the mean fiber length is used in the multivariable analysis.

[0100] Advantageously, the freeness (CSF) and/or fiber length and/or shive content measurements are implemented after the refiner line, for example during the latency removal stage, and used in the multivariable control system. In an example embodiment, slow time control between 5 and 10 minutes is used to stabilize CSF and/or fiber length (MFL). In some example embodiments the measurements are implemented with a sampling rate between 1 and 60 minutes, more preferably between 10 and 40 minutes, and most preferably between 15 and 35 minutes. However, the measurements may also be conducted at longer or shorter periods than mentioned above.

[0101] Better insight about the properties of the produced pulp can be obtained if additional variables are studied, beside CSF and mean fiber length, such as properties of fiber fractions.

[0102] In an advantageous embodiment, freeness (CSF) of the cellulose based material is estimated using the following equation:

$$\widehat{CSF} = (\alpha_1 \cdot X_1 + \beta_1 \cdot SEC_1) + (\alpha_2 \cdot X_2 + \beta_2 \cdot SEC_2) + (\alpha_3 \cdot X_3 + \beta_3 \cdot SEC_3) + X_0.$$

where

α_i, β_i = model parameters,
 X_i = plate vibration [%] of refiner i ,
 SEC_i = specific energy consumption [MWh/adt] of refiner i , and
 X_0 = offset parameter [ml].

[0103] In an example, an adaptive filter is used to change the offset parameter in the estimate. Offset parameter is preferably adjusted every day, more preferably every hour, and most preferably it is adjusted every time there is a new laboratory and/or an online-measurement available so that the freeness estimate becomes more accurate.

[0104] Advantageously, an extended Kalman filter is used, wherein all the model parameters X_0 , α_i and β_i are estimated

substantially simultaneously. A Kalman filter is capable of adjusting all model parameters (X_0 , α_i , β_i , etc.) of each refiner, for example. The adjustment may be performed e.g. each time a new freeness measurement is available. A Kalman filter provides more accurate and robust estimate of the freeness.

[0105] In an embodiment, the freeness estimate and/or new SEC set point is calculated at least in every 1 hour, every 30 minutes or every 20 minutes or every 10 minutes, more preferably in every 5 minutes, 3 minutes or 1 minute, and most preferably in every 40 seconds, every 30 seconds, every 20 seconds, or every 10 seconds. Thus, the estimation may give very fast control of *inter alia* freeness, consistency and/or production rate.

[0106] Conventionally, big sized refiners are preferably used to achieve wanted production rate. In the present invention, the production rate of the refiner line may be increased even with quite small refiners, such as SD65 refiners. Thanks to the present invention, the refiner line 20 may refine between 1.5 and 3 times greater amount of cellulose based material than conventional refiner lines comprising similar refiners.

[0107] The calculation preferably used may provide, among other things, high frequency freeness value after mainline refining enabling fast freeness control.

[0108] Advantageously the manufactured pulp has the following properties:

- CSF: 100.-250 ml measured according to standard ISO 5267-2;
- MFL: 1.35-1.80mm measured according to standard ISO 16065-2:2007;
- Tensile index: 32-50 Nm/g measured according to standard ISO 1924-3;
- Tear index: 6.1-8.6 mNm²/g measured according to standard ISO 1974.

[0109] Advantageously, the manufactured pulp is used in LWC (Light Weight coated) paper machine in order to manufacture LWC paper. In addition or alternatively, the manufactured pulp is preferably used in SC (Super Calandered) paper machine in order to manufacture SC paper. In addition or alternatively, the manufactured pulp is preferably used in newsprint paper machine in order to manufacture newsprint paper.

[0110] The following examples show some experimental tests:

Example 1

[0111] In this example, thermomechanical pulp was manufactured for LWC paper machine.

[0112] The manufacturing process comprised a three stage refiner line. A mechanical steam separator, this time perifeeder manufactured by Metso, was used to separate steam and fibers between the first refiner and the second refiner of the refiner line, and to stabilize the second refining stage. Plate gap dilution waters were conveyed to the first and the second stage refiners. In addition, feeding plates were used for the refiners. Power distribution was 36% for the first refiner, 32% for the second refiner, and 32% for the third refiner.

[0113] In addition, thermomechanical reference pulp was manufactured using conventional power distribution.

[0114] The new line gave better energy reduction than the conventional power distribution. Results are shown in Table 1.

Table 1. Results from the trial

	Invention, new line	reference, old line
Freeness, ml	160	160
Production, adt/d	400	200
SEC, kWh/adt	1650	2000
Fiber length, mm	1.58	1.63

Example 2

[0115] In this example, thermomechanical pulp was manufactured.

[0116] The refiner line comprised three SD-65 refiners. Power distribution was 35% for the first refiner, 40% for the second refiner, and 35% for the third refiner. With these parameters the production was 440-500 t/d, and SEC was 1.6 MWh/t.

[0117] The reference refiner line comprised two SD-65 refiners. Power distribution was 60% for the first refiner, and 40% for the second refiner. With these parameters, the production was 160-200 t/d, and SEC was 2.0 MWh/t.

[0118] Thus, thanks to the three SD-refiners used and the optimized power distribution, the production rate of the refiner line increased while the SEC of the refiner line decreased.

Example 3

[0119] In this example, thermomechanical pulp was manufactured. The refiner line comprised three SD-65 refiners. Dilution water flow to the first and the second stage refiner plate gap was divided into three zones on the diameter.

[0120] KajaaniMap analyzer was used for the freeness and the fiber length measurements. Freeness was estimated.

[0121] Altogether five different test runs were performed:

- MPC based SEC control was taken into use and compared to the traditional control structure,
- MPC based freeness control was taken into use and the freeness variation was compared to the situation in which freeness was controlled by a traditional control
- optimization of power splits between the refiners,
- production maximization without violating pulp quality was tested.

[0122] In this example the energy saving potential of different components was altogether approximately about 11.7 per cent.

[0123] In the following some examples are provided.

[0124] According to a first example there is provided a method for manufacturing mechanical pulp in a system comprising a refiner line comprising a first refiner and a second refiner, the first refiner and the second refiner being single disc refiners comprising a rotating disc and a stationary disc, and having a plate gap, wherein the method comprises:

- feeding wood chips to the refiner line, the feeding rate of the wood chips to the refiner line being at least 300 adt/d, and
- refining the wood chips in at least two refining stages using said first refiner and said second refiner in order to manufacture mechanical pulp,
- determining at least two parameters from the refiner line and/or from the mechanical pulp that is refined in the refiner line, and
- controlling at least one parameter of the manufacturing process using said at least two parameters.

[0125] In some embodiments the method comprises:

- controlling the at least two parameters with a multivariable control.

[0126] In some embodiments of the method the refiner line comprises at least three refiners and the wood chips are refined in said at least three refining stages.

[0127] In some embodiments of the method a diameter of the rotating disc of said at least two single disc refiners is between 55 and 75 inches, more preferably between 60 and 70 inches, most preferably 65 inches.

[0128] In some embodiments the determining of said at least two parameters is performed by measuring and/or estimating.

[0129] In some embodiments of the method said at least two measured parameters comprise:

- the power of one or more of the refiners, and/or
- the total power of the refiner line, and/or
- SEC of one or more of the refiners, and/or
- the total SEC of the refiner line, and/or
- refining consistency in one or more of the refiners, and/or
- the feeding rate of the refiner line, and/or
- freeness after the refiner line, and/or
- fiber length distribution after the refiner line, and/or
- shive content after the refiner liner.

[0130] In some embodiments of the method said at least one estimated parameter comprises:

- freeness after the refiner line, and/or
- fiber length after the refiner line, and/or
- shive content after the refiner line, and/or
- fiber length distribution after the refiner line, and/or
- the production rate of the refiner line, and/or

- refining consistency in one or more of the refiners.

[0131] In some embodiments the method comprises:

- pretreating the wood chips in an impregnation stage before conveying the wood chips to the refiner line.

[0132] In some embodiments of the method the impregnation stage comprises

- impregnating the wood chips with water.

[0133] In some embodiments of the method the power of the first refiner of the refiner line is between 0.5 and 1.3 times the power of the second refiner of the refiner line.

[0134] In some embodiments of the method the power of the first refiner of the refiner line is between 0.5 and 1.3 times the power of the second refiner of the refiner line, and the power of the third refiner of the refiner line is between 0 and 1.0 times the power of the second refiner of the refiner line.

[0135] In some embodiments of the method the energy consumption of the refiner line is lower than 2.4 MWh/adt and the freeness of the refined pulp is between 100 and 250 ml, more preferably between 140 and 180 ml.

[0136] In some embodiments of the method the plate gap of said at least two single disc refiners is between 0.1 and 1.0 mm.

[0137] In some embodiments the method comprises:

- using plate gap dilution water in at least one of the single disc refiners.

[0138] In some embodiments the method comprises separating steam from the at least partly refined wood chips between two refiner stages by using an apparatus comprising a feeder and a mechanical steam separator.

[0139] According to a second example there is provided a system for manufacturing mechanical pulp, the system comprising

- a refiner line comprising a first refiner and a second refiner for refining wood chips into pulp in at least two refining stages, the first refiner and the second refiner being single disc refiners comprising a rotating disc and a stationary disc, and having a plate gap, and the system further comprises
- an apparatus for feeding wood chips to the refiner line, the feeding rate of the wood chips to the refiner line being at least 300 adt/d, and
- at least one device for determining at least two parameters from the refiner line and/or from the mechanical pulp that is refined in the refiner line, and
- an apparatus for controlling at least one parameter of the manufacturing process using said at least two parameters.

[0140] In some embodiments the system comprises:

- means for controlling the at least two parameters with a multivariable control.

[0141] In some embodiments of the system the refiner line comprises at least three refiners and the wood chips are refined in said at least three refining stages.

[0142] In some embodiments of the system a diameter of the rotating disc of said at least two single disc refiners is between 55 and 75 inches, more preferably between 60 and 70 inches, most preferably 65 inches.

[0143] In some embodiments the at least one device for determining of said at least two parameters comprises means for measuring and/or estimating said at least two parameters.

[0144] In some embodiments of the system said at least two measured parameters comprise:

- the power of one or more of the refiners, and/or
- the total power of the refiner line, and/or
- SEC of one or more of the refiners, and/or
- the total SEC of the refiner line, and/or
- refining consistency in one or more of the refiners, and/or
- the feeding rate of the refiner line, and/or
- freeness after the refiner line, and/or
- fiber length distribution after the refiner line, and/or

- shive content after the refiner liner.

[0145] In some embodiments of the system said at least one estimated parameter comprises:

- 5 - freeness after the refiner line, and/or
- fiber length after the refiner line, and/or
- shive content after the refiner line, and/or
- fiber length distribution after the refiner line, and/or
- the production rate of the refiner line, and/or
- 10 - refining consistency in one or more of the refiners.

[0146] In some embodiments the system comprises:

- 15 - means for pretreating the wood chips in an impregnation stage before conveying the wood chips to the refiner line.

[0147] In some embodiments of the system the impregnation stage comprises

- means for impregnating the wood chips with water.

20 **[0148]** In some embodiments of the system the power of the first refiner of the refiner line is between 0.5 and 1.3 times the power of the second refiner of the refiner line.

[0149] In some embodiments of the system the power of the first refiner of the refiner line is between 0.5 and 1.3 times the power of the second refiner of the refiner line, and the power of the third refiner of the refiner line is between 0 and 1.0 times the power of the second refiner of the refiner line.

25 **[0150]** In some embodiments of the system the energy consumption of the refiner line is lower than 2.4 MWh/adt and the freeness of the refined pulp is between 100 and 250 ml, more preferably between 140 and 180 ml.

[0151] In some embodiments of the system the plate gap of said at least two single disc refiners is between 0.1 and 1.0 mm.

[0152] In some embodiments the system comprises:

- 30 - means for using plate gap dilution water in at least one of the single disc refiners.

[0153] In some embodiments the system comprises an apparatus comprising a feeder and a mechanical steam separator between two refiner stages for separating steam from the at least partly refined wood chips.

35 **[0154]** According to a third example there is provided mechanical pulp that is obtainable by the process defined in any of the method claims.

[0155] One skilled in the art readily understands that the different embodiments of the invention may have applications in environments where optimization of the mechanical pulp is desired. It is also obvious that the present invention is not limited solely to the above-presented embodiments, but it can be modified within the scope of the appended claims.

Claims

45 1. A method for manufacturing mechanical pulp in a system comprising a refiner line comprising a first refiner and a second refiner, the first refiner and the second refiner being single disc refiners comprising a rotating disc and a stationary disc, and having a plate gap, wherein the method comprises:

- 50 - feeding wood chips to the refiner line, the feeding rate of the wood chips to the refiner line being at least 300 adt/d, and
- refining the wood chips in at least two refining stages using said first refiner and said second refiner in order to manufacture mechanical pulp,

wherein the method further comprises

- 55 - determining at least two parameters from the refiner line and/or from the mechanical pulp that is refined in the refiner line, and
- controlling at least one parameter of the manufacturing process using said at least two parameters.

2. The method according to claim 1, wherein the method comprises:

- controlling the at least two parameters with a multivariable control.

3. The method according to claim 1 or 2, wherein the refiner line comprises at least three refiners and the wood chips are refined in said at least three refining stages.

4. The method according to any of the preceding claims, wherein the determining of said at least two parameters is performed by measuring and/or estimating.

5. The method according to claim 4, wherein said at least two measured parameters comprise:

- the power of one or more of the refiners, and/or
- the total power of the refiner line, and/or
- SEC of one or more of the refiners, and/or
- the total SEC of the refiner line, and/or
- refining consistency in one or more of the refiners, and/or
- the feeding rate of the refiner line, and/or
- freeness after the refiner line, and/or
- fiber length distribution after the refiner line, and/or
- shive content after the refiner liner.

6. The method according to claim 4 or 5, wherein said at least one estimated parameter comprises:

- freeness after the refiner line, and/or
- fiber length after the refiner line, and/or
- shive content after the refiner line, and/or
- fiber length distribution after the refiner line, and/or
- the production rate of the refiner line, and/or
- refining consistency in one or more of the refiners.

7. The method according to any of the preceding claims, the method comprising:

- pretreating the wood chips in an impregnation stage before conveying the wood chips to the refiner line.

8. The method according to claim 7, wherein the impregnation stage comprises

- impregnating the wood chips with water.

9. The method according to any of the preceding claims, the method comprising:

- using plate gap dilution water in at least one of the single disc refiners.

10. The method according to any of the preceding claims, wherein the method comprises separating steam from the at least partly refined wood chips between two refiner stages by using an apparatus comprising a feeder and a mechanical steam separator.

11. A system for manufacturing mechanical pulp, the system comprising

- a refiner line comprising a first refiner and a second refiner for refining wood chips into pulp in at least two refining stages, the first refiner and the second refiner being single disc refiners comprising a rotating disc and a stationary disc, and having a plate gap, and the system further comprises
- an apparatus for feeding wood chips to the refiner line, the feeding rate of the wood chips to the refiner line being at least 300 adt/d, and
- at least one device for determining at least two parameters from the refiner line and/or from the mechanical pulp that is refined in the refiner line, and
- an apparatus for controlling at least one parameter of the manufacturing process using said at least two

parameters.

12. The system according to claim 11, wherein the system comprises:

- means for controlling the at least two parameters with a multivariable control.

13. The system according to the claim 11 or 12, wherein the refiner line comprises at least three refiners and the wood chips are refined in said at least three refining stages.

14. The system according to the claim 11, 12 or 13, wherein a diameter of the rotating disc of said at least two single disc refiners is between 55 and 75 inches, more preferably between 60 and 70 inches, most preferably 65 inches.

15. The system according to any of the claims 11 to 14, wherein the at least one device for determining of said at least two parameters comprises means for measuring and/or estimating said at least two parameters.

16. The system according to any of the claims 11 to 15, the system comprising:

- means for pretreating the wood chips in an impregnation stage before conveying the wood chips to the refiner line.

17. The system according to any of the claims 11 to 16, wherein the power of the first refiner of the refiner line is between 0.5 and 1.3 times the power of the second refiner of the refiner line.

18. The system according to claim 13, wherein the power of the first refiner of the refiner line is between 0.5 and 1.3 times the power of the second refiner of the refiner line, and the power of the third refiner of the refiner line is between 0 and 1.0 times the power of the second refiner of the refiner line.

19. The system according to any of the claims 11 to 18, wherein the energy consumption of the refiner line is lower than 2.4 MWh/adt and the freeness of the refined pulp is between 100 and 250 ml, more preferably between 140 and 180 ml.

20. The system according to any of the claims 11 to 19, wherein the plate gap of said at least two single disc refiners is between 0.1 and 1.0 mm.

21. The system according to any of the claims 11 to 20, the system comprising:

- means for using plate gap dilution water in at least one of the single disc refiners.

22. The system according to any of the claims 11 to 21, wherein the system comprises an apparatus comprising a feeder and a mechanical steam separator between two refiner stages for separating steam from the at least partly refined wood chips.

23. Mechanical pulp that is obtainable by the process defined in any of the method claims 1 to 10.

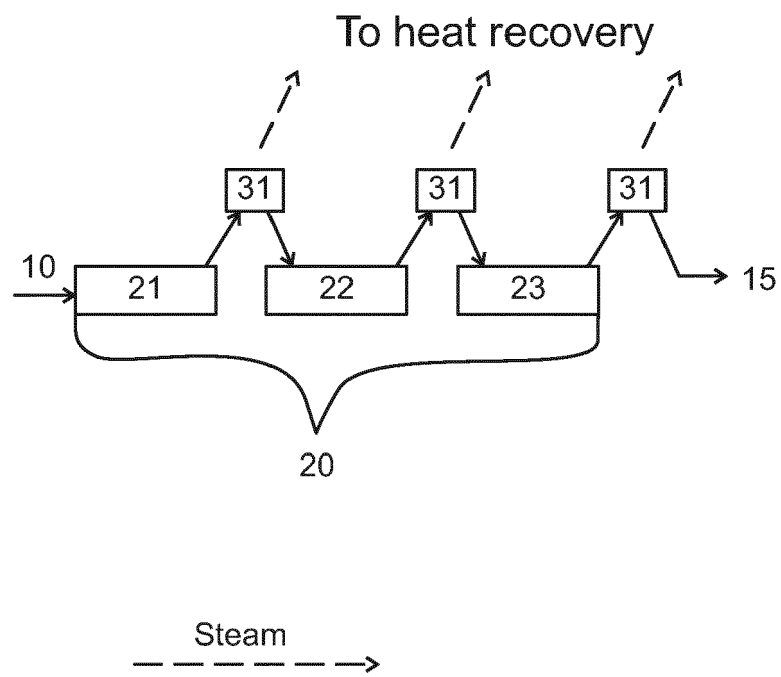


Fig. 1

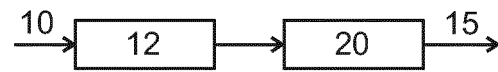


Fig. 2

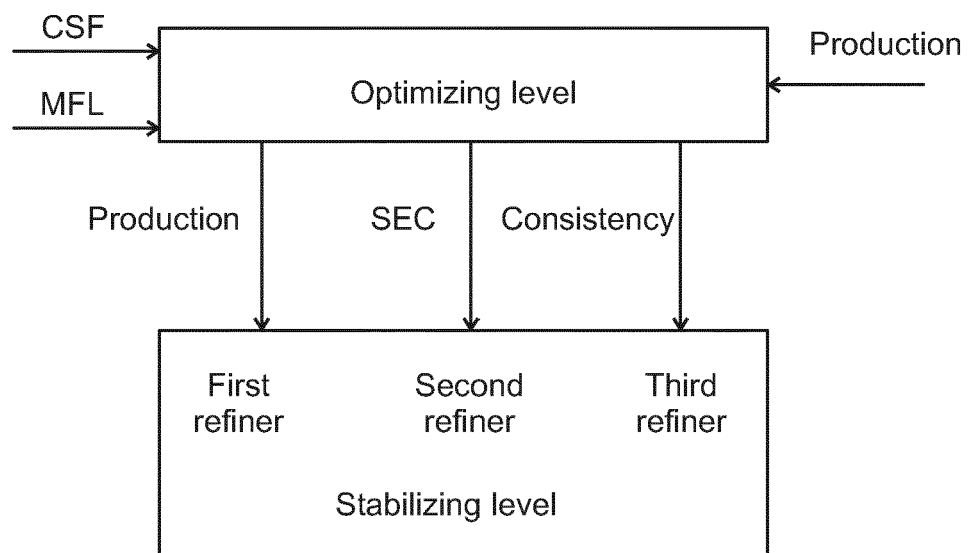


Fig. 3

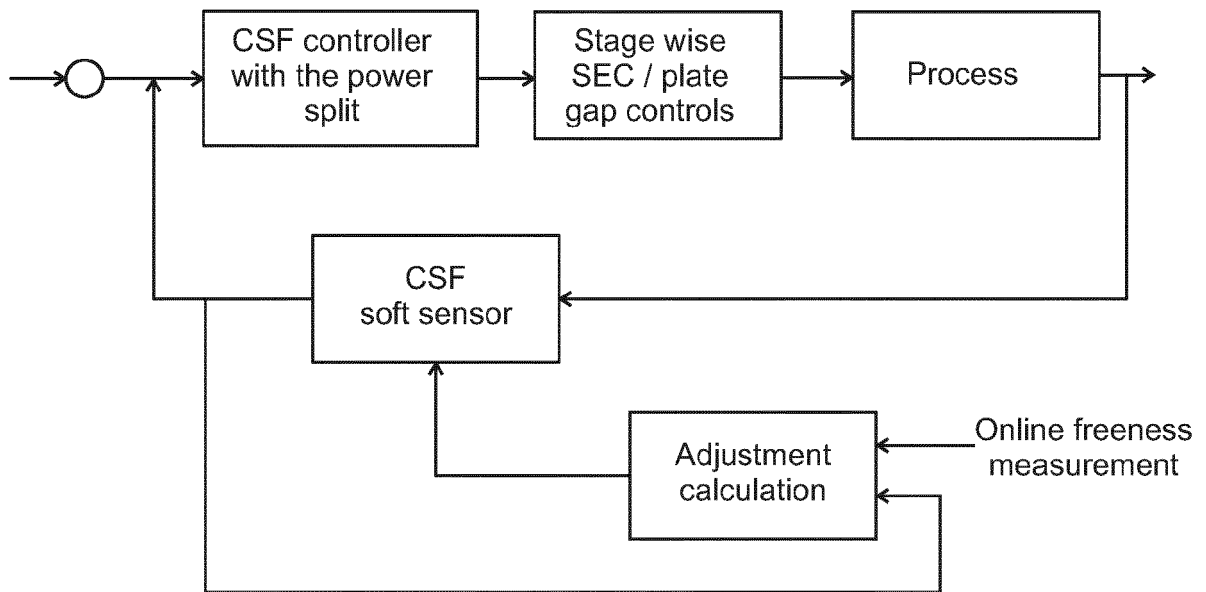


Fig. 4

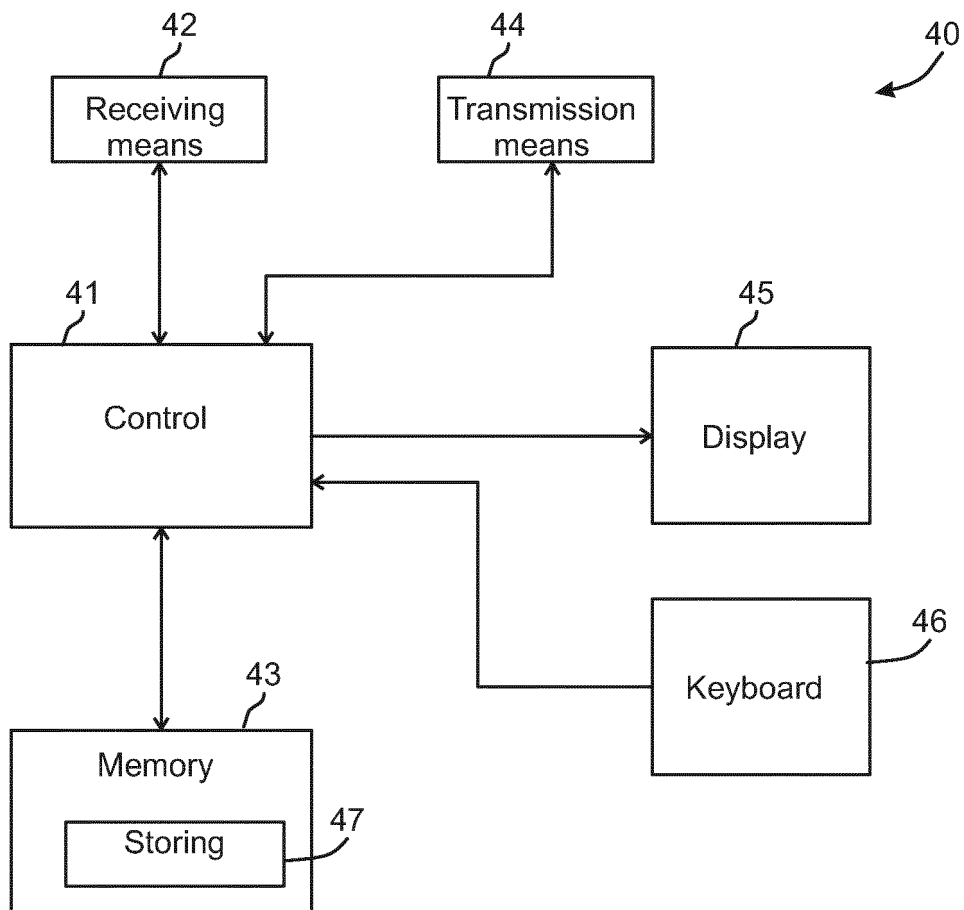


Fig. 5

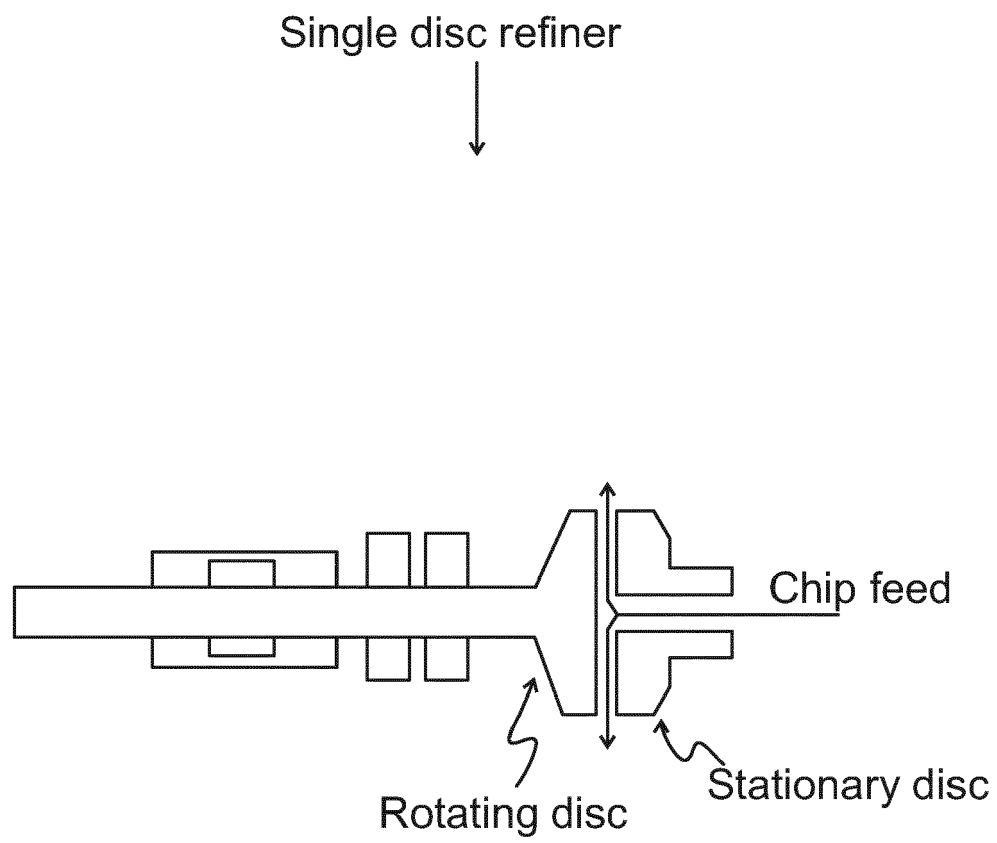


Fig. 6

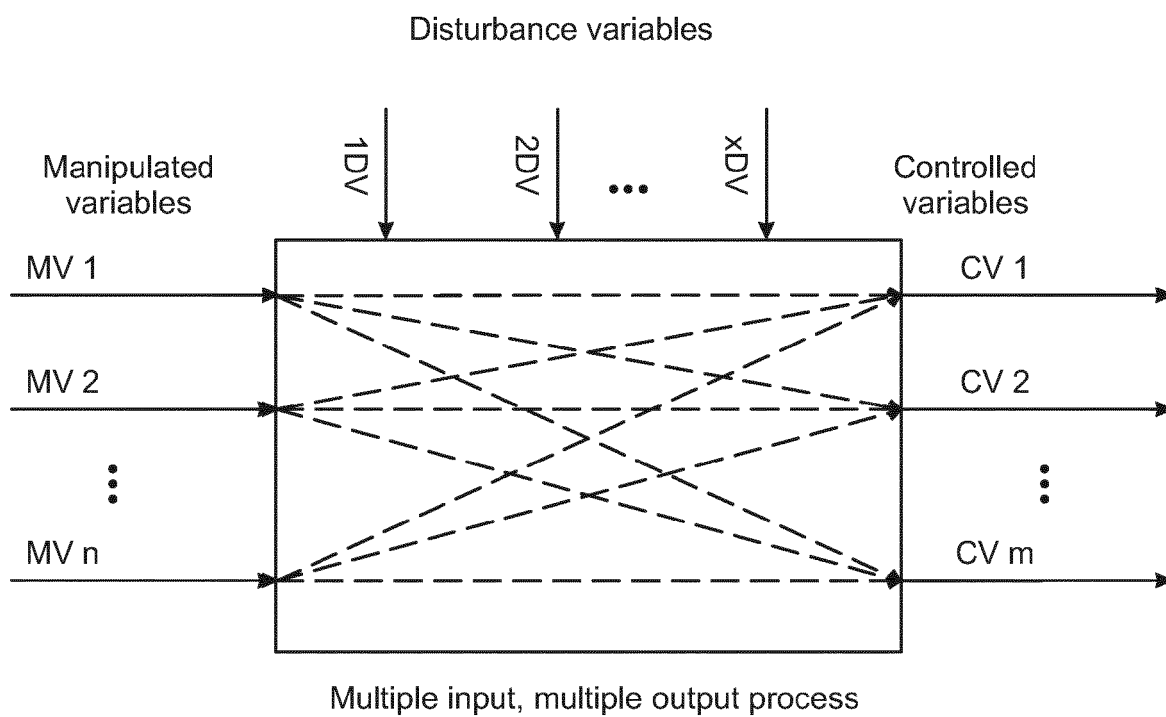


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
EP 13 39 7544

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	Huaijing Du: "Multivariable predictive control of a TMP plant", The University of British Columbia (Vancouver, Canada), October 1998 (1998-10), XP055107302, ISBN: 978-0-61-234520-1 Retrieved from the Internet: URL: http://search.proquest.com/docview/304490974 [retrieved on 2014-03-17]	1,2, 4-12, 14-17, 19-23	INV. D21D1/00 D21D1/20 D21D1/30
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Place of search Munich		Date of completion of the search 17 March 2014	Examiner Maisonnier, Claire
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