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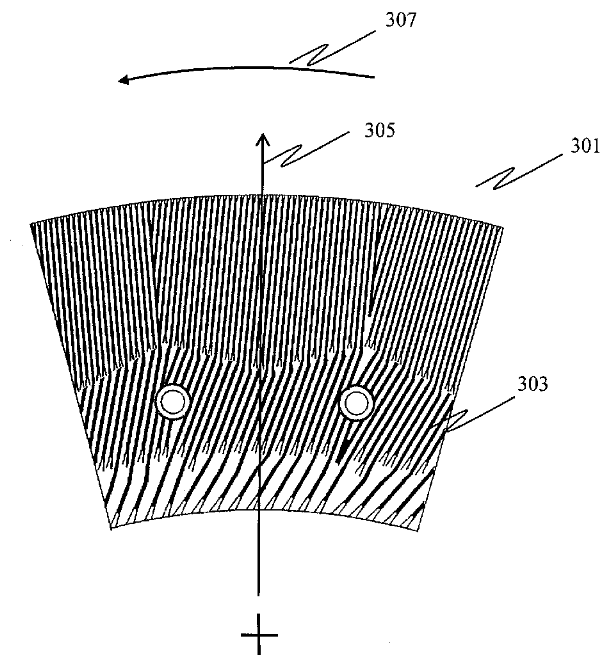

Figure 3

(57) Abstract: A thermo-mechanical or refiner-mechanical method of producing pulp from Pinus Radiata wood chips including the steps of: introducing the Pinus Radiata wood chips into a refiner system including one or more refiners where at least one of the refiners has a set of refining discs with an angled bar unidirectional configuration, grinding the wood chips in between the refining discs within the refiners, wherein the set of refining discs are configured to produce pulp that is further processed to produce a final pulp product that has a final freeness value of between 300 ml (CSF) and 450 ml (CSF), and a final average fibre length of between 1.0 mm and 1.6 mm.

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IMPROVED METHOD OF PRODUCING PULP FROM PINUS RADIATA

FIELD OF THE INVENTION

The present invention relates to a mechanical method of producing pulp from Pinus Radiata wood chips.

BACKGROUND

According to one form of the paper making process, wood chips obtained from trees are refined in between refining plates (made up of several refining segments) to break down the fibres in the wood in order to create paper based products.

Pinus Radiata is one type of wood that is used to make these paper based products. Pinus Radiata is a softwood tree from the Pine family and is also known as the Monterey Pine, Radiata Pine or Insignis Pine.

As with other wood, Pinus Radiata is made of three main constituents. It includes the cellulose fibres that are desired for making paper products. It also includes lignin, which is a complex polymer that helps bind the fibres; and hemicelluloses, which is a mixture of several plant polysaccharides. The refining process attempts to separate the cellulose fibres from the lignin and hemicelluloses. Pinus Radiata is known to have a very long natural fibre length.

Known refining processes for Pinus Radiata generally result in a final pulp product that includes fibres of an excessive average fibre length. On average, the fibre length in the pulp produced after the primary refining stage using known methods is around 2.3 mm with a freeness value of around 630 ml CSF (Canadian Standard Freeness). The freeness value is effectively a measure of how fast water flows through the pulp. These known primary refining stages operate at approximately 55% moisture content, or at 45% consistency.

Following further steps of the pulp process (including secondary refining and screening stages) the final resultant pulp is known to have an average fibre length of approximately 2.0 mm with a freeness value of around 350 ml CSF.

Due to the length of the fibres in the pulp produced using known methods, during the paperboard or paper manufacturing process the fibres interweave so that they tangle together and flocculate to produce paper board or paper with poor formation. This provides a poor quality product with low smoothness and printability properties. Therefore, Pinus Radiata pulp produced that has these parameters is generally considered low quality and not particularly suitable for paper products.

Further, as freeness has a linear relationship with bulk, these known refining processes have produced relatively low bulk pulp values. Bulk is effectively a measurement of the inverted density of the pulp, i.e. the amount of volume per unit weight. Producing pulp having a greater bulk value is advantageous to the paper maker as this enables less resources and energy to be consumed for a particular pulp thickness compared with the resources and energy required for pulp having a lesser bulk value.

These known processes using Pinus Radiata utilise one or more refining plates that have fibre cutting geometries where the bars and grooves on the plates are orientated such that they extend out from the refining plate from the centre along the plate's radius at substantially a zero degree angle. That is, the bars and grooves do not substantially deviate away from the radial path of the plate.

Although refining plates have been developed utilising angled bar configurations, these have been predominantly directed at non Pinus Radiata pulp processing techniques. These configurations were developed to reduce the energy consumption during the pulp process, but were not been able to produce the required quality pulp in terms of fibre length, freeness and bulk.

An object of the present invention is to produce an improved quality pulp made from Pinus Radiata, or to at least provide the public with a useful choice.

The present invention aims to overcome, or at least alleviate, some or all of the afore-mentioned problems.

SUMMARY OF THE INVENTION

It is acknowledged that the terms "comprise", "comprises" and "comprising" may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, these terms are intended to have an inclusive meaning - i.e. they will be taken to mean an inclusion of the listed components that the use directly references, but optionally also the inclusion of other non-specified components or elements.

According to one aspect, the present invention provides a thermo-mechanical or refiner-mechanical method of producing pulp from Pinus Radiata wood chips including the steps of: introducing the Pinus Radiata wood chips into a refiner system including one or more refiners where at least one of the refiners has a set of refining discs with an angled bar unidirectional configuration, grinding the wood chips in between the refining discs within the refiners, wherein the set of refining discs are configured to produce pulp that is further processed to produce a final pulp product that has a final freeness value of between 300 ml (CSF) and 450 ml (CSF), and a final average fibre length of between 1.0 mm and 1.6 mm.

According to a further aspect, the present invention provides a thermo-mechanical or refiner-mechanical method of producing an interim pulp product from Pinus Radiata wood chips including the steps of: i) introducing the Pinus Radiata wood chips into a primary refiner system including one or more refiners where at least one of the refiners has a set of refining discs with an angled bar unidirectional configuration, ii) operating the one or more refiners using an axial force applied to the set of refining discs, iii) providing a mixture of water and wood chips between the refining discs, iv) grinding the mixture in between the refining discs, v) measuring the interim pulp product produced by the grinding step to determine if the interim pulp product has an interim average freeness value of between 400 ml (CSF) and 570 ml (CSF), and an interim average fibre length of approximately 1.3 mm, and, upon a positive determination, vi) outputting the interim pulp product from the primary refiner system for further processing.

According to yet a further aspect, the present invention provides a thermo-mechanical or refiner-mechanical method of producing an interim pulp product from Pinus Radiata wood chips including the steps of: i) introducing the Pinus Radiata wood chips into a primary refiner system including one or more refiners where at least one of the refiners has a set of refining discs with an angled bar unidirectional configuration, ii) operating the one or more refiners using an axial force applied to the set of refining discs, iii) providing a mixture of water and wood chips between the refining discs, iv) grinding the mixture in between the refining discs, v) measuring the interim pulp product produced by the grinding step to determine if the interim pulp product has an interim average freeness value of between 400 ml (CSF) and 570 ml (CSF), and an interim average fibre length of between 1.2 mm and 1.8 mm, and, upon a positive determination, vi) outputting the interim pulp product from the primary refiner system for further processing.

According to yet a further aspect, the present invention provides a thermo mechanical method of producing pulp from Pinus Radiata wood chips including the steps of: introducing the Pinus Radiata wood chips into a refiner system including one or more refiners where at least one of the refiners has a set of refining discs with an angled bar unidirectional configuration, grinding the wood chips in between the refining discs within the refiners, wherein the set of refining discs are configured to produce pulp that has a final freeness value of between 300 ml (CSF) and 450 ml (CSF), and an average fibre length of between 1.1 mm and 1.7 mm.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a diagrammatic representation of the refiner system according to an embodiment of the present invention;

Figure 2A shows a simple representation of the angle of the bars with respect to the direction of rotation of the plate for a known refiner plate configuration;

Figure 2B shows a simple representation of the angle of the bars with respect to the direction of rotation of the plate for a plate configuration according to an embodiment of the present invention;

Figure 3 shows an example of a refiner plate that may be used in a primary refiner according to an embodiment of the present invention;

Figure 4 shows a graph indicating the fibre length distribution of final pulp product produced using a method according to an embodiment of the present invention; and

Figure 5 shows a graph used to explain how fibre length is measured for pulp produced according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

First Embodiment

The following description describes an embodiment of a process for producing improved thermo-mechanical pulp (TMP) from Pinus Radiata.

It will be understood that, as an alternative, the method described below may also be applied to a process for producing improved refiner-mechanical pulp (RMP) from Pinus Radiata.

The initial stage of producing pulp involves the removal of the bark from the Pinus Radiata logs using a bark removal machine (debarker drum). Once the bark is removed, the logs are transformed into wood chips by a wood chipping machine (chipper).

The wood chips are first screened by removing any oversize and undersize chips.

The chips are then pre-heated with steam in an atmospheric vessel.

The preheated chips are submerged in hot process water to remove any debris. After removal, they are squeezed in a compaction screw to remove moisture and extractives.

Prior to being fed to a series of refiners, the chips are heated in a pressurized vessel.

All the steps prior to the refiner stages use standard process parameters, as will be understood by a skilled person.

The chips are then fed to a refining system, which consists of one or more refiners that are used to turn the wood chips into a pulp mixture.

According to this embodiment of the present invention, the refining system includes multiple refiners. In particular, there are three refiners (R1, R2, R5) in a primary refining stage, two refiners (R3, R4) in a secondary refining stage and a further reject refiner (R6) as explained in more detail below.

However, it will be understood that as an alternative, the refining system may include as a minimum a single primary refiner utilising the herein described refiner plate configuration and having sufficient capacity to produce the required pulp. According to a further alternative, the refining system may include two or more primary refiners utilising the herein described refiner plate configuration. According to yet a further alternative, one or more secondary refiners utilising the herein described refiner plate configuration may be used.

According to this embodiment, each of the refiners (whether primary, secondary or a reject refiner) include a single rotating refining plate (consisting of one or more refining segments) and a fixed refining plate such that the plates oppose each other and rotate relative to each other. The wood chips are fed in to a gap in between the refining plates through a central aperture in one of the plates. The single rotating plate is caused to rotate adjacent the static plate while an axial force is applied to either or both of the rotating and static plates. The applied axial force causes the rotating plate and static plates to move towards each other and so enable the wood chips to be broken down in between the relatively rotating plates into the fibre components.

As an alternative, the system may incorporate a double disc refining system where any of the refiners in any of the refining stages may include two rotating refining plates that oppose each other and rotate in opposite directions to each other. The wood chips are fed in between the refining plates through a central aperture in one or both of the plates. The plates are caused to rotate in opposite directions while they are also forced together.

Each refiner plate may be made from twelve refiner segments that join together to form the complete plate. As is known in the industry, a refiner plate may consist of an inner segment, a four piece (i.e. four segments) ring placed around the inner segment, an eight piece ring placed around the inner ring and an outer ring consisting of twelve segments. It will be understood that, as an alternative, the plate may also be made from a single piece or two or more segments.

According to this embodiment the wood chips are passed through several stages of refining to produce the refined pulp.

A primary refining stage refines the new wood chips.

A secondary refining stage refines the pulp that comes from the primary refining stage. This secondary stage provides a higher quality pulp than that produced solely by the primary refining stage. The secondary refining stage also reduces the shive content (i.e. bundles of unrefined fibre) in the pulp mixture. According to this embodiment, the pulp from the primary refining stage is processed by the secondary refining stage with minimal energy application. That is, the majority of the processing energy is utilised by the primary refining stage.

It will be understood that the amount of the primary refined pulp forwarded to the secondary refiners may depend on the amount of shive content found in the pulp coming from the primary stage. That is, the pulp from the primary stage may be monitored to determine the level of shive content and the system adjusted accordingly to apply the required amount of energy to the secondary refining stage dependent on the amount of shive content found. As a minimum, zero energy being applied to the secondary refining stage means the secondary stage is bypassed.

The pulp output from the secondary stage is fed to a pressure screening stage which screens the secondary pulp to ensure only the high quality pulp is allowed through. That is, only the refined pulp that passes through the pressure screens is passed on to the further processing stages. According to this embodiment, the pressure screens are fitted with screen baskets featuring holes and/or slots for example, upon which the diluted pulp is passed through. Any pulp that does not pass through the basket is directed to the reject refining stage (R6). In this way fibres or bundles of fibres not sufficiently processed are further refined.

The rejected pulp (i.e. the pulp that does not pass through the screens) is fed to a reject refining stage to be refined again. This further refined pulp is then passed back to the screening stage.

According to an alternative method, the secondary refining stage is not used and the pulp from the primary stage is fed from the primary stage direct to the pressure screening stage, where the rejected pulp is fed to the reject refiner. All refined pulp that passes through the pressure screens is passed on to the further processing stages.

According to a further alternative method, a separate reject refiner stage may further refine the rejected pulp before applying the refined pulp to the pressure screening stage.

According to yet a further embodiment, the refining stage may be comprised of just the primary refining stage without any secondary refining. Optionally, pulp from the primary refining stage may be fed back through a reject refiner via a screening system if the pulp is not of sufficient quality.

Figure 1 shows a diagrammatic representation of the refiner system according to this embodiment.

According to this embodiment, the primary refining stage uses three separate primary refiners (R1, R2, R5) all of which process the wood chips in parallel. Refiners R1, R2 and R5 all use a specifically designed refiner disc/segment as described in more detail below. The refiner R5 has slightly more capacity for refining the wood chips than R1 and R2 combined. In particular, according to this embodiment, the outer rings of the refiner plates are specifically designed having a bar and groove configuration as defined below. As an alternative, the two outer rings of the refiner plates may have the configuration defined below.

According to this embodiment, all three of the primary refiners R1, R2 and R5 include a modified refiner plate made up of segments that have an angled bar unidirectional configuration. The term unidirectional indicates that the refiner plate is configured to be rotated during a pulp refining operation in a single direction. The bars and grooves on the plate are offset or angled away from the radial path of the refiner plate such that rotation of the plate not only cuts the fibres in the mixture being processed but also allows the mixture to more easily pass from the centre of the plate to its outer radial edge as well as keeping the pulp in the gap between the bars so that it is subjected to impact as the plate is rotated in one direction. This is compared to the known refiner plate configuration that has bars and grooves that are substantially parallel to the radial path of the refiner plate. That is, according to this embodiment, the bars in the refiner plate lie in a direction that is not perpendicular to the angle of rotation, instead the bars are offset so that the direction of the bar (from the outer edge to the centre of the plate) does not pass through the centre of the refiner plate. In other words, they are orientated obliquely in relation to the radius of the segment.

This form of refining plate segment in the primary refining stage provides a refiner plate that reduces energy usage while maintaining the quality of the pulp with respect to fibre length, bulk and shive content. That is, the specific quality requirement for Pinus Radiata is maintained while allowing the pulp mixture to move across the plate surface.

Figures 2A and 2B show a simple representation of the angle of the bars (and so the grooves) with respect to the direction of rotation of the plate for a prior known configuration (Figure 2A) and a configuration according to this embodiment (Figure 2B).

Figure 2A shows a prior known bar configuration in a bi-directional refiner plate used for refining Pinus Radiata. The bars 201 are configured so that they are perpendicular to the direction of rotation of the refiner plate 203. The plate can therefore operate in a clockwise or anti-clockwise manner. The projected line of the bars and grooves passes through the centre of the refiner plate.

Figure 2B shows the bar configuration of an angled bar uni-directional refiner plate according to this embodiment used for refining Pinus Radiata. The bars 205 are configured so that they are offset from an angle which is perpendicular to the direction of rotation of the refiner plate 207. The plate can therefore only operate in an anti-clockwise manner (as indicated by the arrows). The projected line of the bars and grooves do not pass through the centre of the refiner plate. Therefore, the mixture that enters the refiner plate at the centre, marked with a +, can more easily travel from the centre of the refiner plate out to the radial outer edge of the plate.

Figure 3 shows one such example of the configuration of an angled bar unidirectional refiner plate segment that could be used in the primary refiners R1, R2 and R5 according to this embodiment.

The refiner plate segment 301 includes a number of adjacent bars 303 which form grooves in between. As can be seen from figure 3, the bars 303 are not parallel with the radial path 305 from the refiner plate centre to the refiner plate edge. Instead, the bars are oriented obliquely in relation to this radial path.

A skilled person will understand that alternative configurations may also be used where the segment has an angled bar unidirectional configuration. According to this example, the refiner segment has multiple regions (inner, central and outer) where the angle of orientation of the bars varies in each region. However, it will be understood that the bars may be orientated at an angle that is the same in each of these regions.

Referring back to figure 1, the secondary refining stage includes two refiners R3 and R4 which process the pulp from the primary refiners in parallel. According to this embodiment, both R3 and R4 use standard refining segments/discs, as will be understood by a skilled person. However, as an alternative, one or both of the secondary refiners may use an angled bar unidirectional refiner plate as described above with reference to figures 2B or 3.

The pulp from the secondary refiners is fed to a set of pressure screens 101. If the pulp does not pass through the screens it is fed to a reject refining stage.

According to this embodiment, the reject refiner stage includes a single refiner R6, which also uses an angled bar unidirectional refiner plate as described above. The reject refiner according to this embodiment operates using high consistency values, such as between 20% and 35%%. Alternatively, the reject refiner could be modified or replaced to operate using lower consistency values, such as between 3% and 8% %. It will be understood that the lower consistency setup would require less energy and may be more suitable for fibre cutting.

As a further alternative, the reject refiner stage may use standard refining segments discs as will be understood by a skilled person.

In each of the refiners R1 to R6 a single rotating disc is used against a stationary disc. That is, the discs rotate relative to each other with one being stationary. It will be understood that, as an alternative, one or more of the refiners may incorporate a dual disc rotation system as mentioned above.

Each plate generally includes three zones, an inner zone, a central zone and an outer zone. Each zone may have a number of bars and grooves that have defined dimensions and orientations in order to refine the wood chips.

As an example, each zone may have bar widths that range from 3.5 to 1.5 mm, groove widths from 4.5 to 2.0 mm, and a groove depth from 5.0 mm to 10.0 mm. As an alternative, the inlet zone may include dams that are located in between adjacent bars. As a further alternative, these dams may be sub surface dams that have a height less than the height of the bars. For example, the dams may be at a height that is half that of the bar height.

After the secondary refinement stage has taken place, a latency removal stage may be used where twirling is removed from the fibre. The latency removal stage effectively consists of keeping the pulp at a desired temperature for a residence time to remove latency. For example, a latency chest may be used.

After the latency removal stage, the pulp may be passed through a series of pressure screens to screen out any parts of the pulp that are not of the required quality. That is, long and/or coarse fibres and/or stiff fibres and shive (bundles of fibre) are removed (rejected) from the main pulp stream. These rejected components may then be fed through a reject refiner before being fed back through the pressure screens or forward to the next process.

The screened pulp may then be cleaned in hydracyclones to remove debris, bark and shive that have passed through the screening stage.

Extractives are then removed from the diluted pulp using a compaction screw. The extraction screw also increases consistency prior to bleaching.

The pulp is then bleached to increase the pulp brightness using a peroxide/alkali process.

The bleaching process affects the bulk properties of the final pulp product. For example, at 350 CSF the bleaching process may produce a bleached final pulp product that has an ISO brightness of 80 and a bulk value of 2.7 m3/kg x 10^{-3}. Alternatively, the bleaching process may produce a bleached final pulp product that has an ISO brightness of 70 and a bulk value of 3.1 m^3/kg x 10^{-3}. In general, the bulk values of the final pulp product are from 2.7 m^3/kg x 10^{-3} up to 3.3 m^3/kg x 10^{-3} or preferably up to 3.7 m^3/kg x 10^{-3}.

Free water is then removed from the pulp, after which the pulp is then dried in a hot air flash dryer. The dried pulp is then formed into a bale.

The pulp may be tested at this point to provide a final quality measurement in terms of a final average fibre length value and final freeness value. It will be understood that the quality of the pulp may be tested throughout the process steps described above to track the quality of the pulp and to make any necessary adjustments to any of the process steps to ensure the desired pulp quality is maintained.

After the final quality testing, the pulp is packaged by baling, wrapping, and tying with wire prior to it being despatched.

The pulp bale that is produced by the above described process may then be used to form various types of product, such as paper and paperboard products.

The properties of the final pulp product produced using the above described method were measured as follows to test the final quality.

Using an optical fibre analyser on a Pulp Expert (an automated analyser) the average fibre length of the final pulp product at 350 CSF was measured as 1.25 mm. According to this embodiment, the analyser was configured to measure the average fibre length using length weighted averages as is well known in the art.

Figure 4 shows a distribution of the fibre lengths in the sample measured. It can be seen from this distribution that the longest fibre is approx 4.0 mm and the shortest fibres are approx 0.4 mm. This measurement takes into account and disregards the fines content of the sample being measured. The fines content is the debris that is generated during the refining process.

Referring to Figure 5, an explanation of how the average weighted fibre length is calculated is provided. An example distribution of pulp produced according to the described embodiment is provided as a graphical representation, where the fibre length was measured using a weighted fibre distribution including the fines portion of the pulp. Fines are fibres or fibre particles less than 0.2 mm in length. The weighted distribution shows how the fibre lengths are distributed within a pulp sample on a weighted scale. The arrow 501 indicates the "Average Weighted Fibre Length" for the distribution in question. Each point on the graph indicates what percentage of the fibre length class represented on the X axis, is present in the pulp sample by weight. The arrow 503 points to the percentage of fibres "by weight" in the 0.125 mm class, for example.

If one adds up all the percentages for the whole distribution, it will add up to 100%.

The fines (<0.2 mm fibre length) is an essential part of the pulp.

Each point on the weighted by fibre length distribution is a calculation using the actual fibre length and the class that the fibre resides in.

In general the final average fibre length of the final pulp mixture was found to be between 1.15 and 1.3 mm. Even more generally, the average fibre length of the final pulp mixture was found to be between 1.1 and 1.7 mm. That is, by adjusting the consistency of the pulp during the refining process along with other parameters, such as the disc force, the freeness values, fibre length values and bulk values of the final pulp may be adjusted accordingly. Further quality and energy consumption adjustments can be made by altering the throughput (production rate) through the refining plates.

Importantly, the freeness of the pulp is also controlled in the refining stages and measured using a standard Tappi drainage test (T227 om-92). The freeness value of the final pulp product measured was between 300 ml and 500 ml (CSF).

More specifically, the freeness value obtained may be between 330 ml (CSF) and 470 ml (CSF), or more specifically between 340 ml (CSF) and 460 ml (CSF).

According to this embodiment, the consistency of the pulp within the refiner may be adjusted to be within the range 25% to 35%, which is equivalent to a moisture content range of between 70% and 75%. One way of controlling the consistency is to control the mixture of wood chips and water content provided to the refiner. Further, consistency may be adjusted by altering the refiner production rate and energy application, for example by adjusting the plate gap.

Effectively the plate gap is adjusted at the primary refining stage by adjusting one or more of the axial force being applied to the one or more refining plates and adjusting the amount of water being added with the woodchip between the plates (to adjust consistency), which effectively changes the plate gap between the plates. For example, a predefined axial force may be set for operating the primary refiner plates. During an initial setup, an amount of water is added to the wood chips at the plates. Following this setup, analysis of the resultant pulp is performed to determine the quality (e.g. the average fibre length, average freeness and average bulk values). Following the quality analysis, if the pulp output from the primary refiner is not within the desired range, the plate gap may be adjusted by controlling the amount of axial force applied to the plates or the amount of water being added to the mixture. Further analysis steps and adjustments may be performed until the interim pulp product is within the desired range.

During processing, the refined pulp mixture produced from the primary refiner may be analysed on a regular basis to monitor the average fibre length and average freeness values of the pulp being processed by the primary refiner as described below. Also, bulk characteristics may be monitored and adjustments to processing parameters made accordingly to ensure the interim and final pulp product's bulk characteristics are within a desired range. For example, the desired interim pulp product (i.e. after primary refining) target bulk values may be between 4.0 and 6.0, to produce a final product having a desired bulk value of between 2.7 and 3.7.

It will be understood that in some systems the speed of the rotating refiner plates may not be easily adjustable as the speed usually depends on the electricity supply being used to run the synchronous motors driving the rotating plates, where the electricity supply is dependent on the country in which the process is being run. However, speed may be adjusted using gearboxes if desired.

A standard Tappi procedure is used to determine the bulk value of the final pulp product. A Tappi meter T220 om – 88 was used to make a sheet made out of pulp (i.e. a hand sheet, which is a round disc of the pulp). A micrometer is then used to make a physical thickness measurement. Based on this thickness measurement, a calculation is performed using the known weight, size and volume of the round disc to determine the bulk value. The pulp produced using the herein described method has a value of between 2.7 and 3.3 m3/kg x 10-3. More specifically, the pulp produced may have a bulk value of between 2.9 and 3.2 m3/kg x 10-3.

A further measurement used to test the quality of the final pulp product is a strength measurement.

A standard Tappi procedure is used to determine the strength of the final pulp product. The Tappi procedure used for measuring tensile strength is T494: Tensile Breaking Properties of Paper and Paperboard. The pulp produced using the herein described methods produces a final product pulp that has a tensile strength range of between 1900 and 2800 meters.

A further parameter that may be taken into account is the throughput of the pulp product through the refining stages. That is, by adjusting the size and amount of refiners, the throughput is adjusted. It will be understood that, by changing the throughput, different energy levels will be required at the different refiners to produce the desired interim and final pulp characteristics.

A table of the various approximate process parameters used in the above described method is now provided.

	Consistency	Freeness	Temp	Disc Speed	Disc force	Chip Flow
		–ml CSF	°C	RPM	Tonnes	Oven Dry Tonnes/hr
R1	25-30%	400 - 570		1500	40	6.0 to 16 (e.g. 6.756)
R2	25-30%	400 - 570		1500	40	6.0 to 16 (e.g. 6.756)
R5	25-30%	400 - 570		1500	50 - 90	6.0 to 16 (e.g.15.765)
Pre Heater			0 to 110 (e.g.110)			

It will be understood that other parameters may also vary the quality of the final pulp product. For example, the age of the refining plates, the quality of the wood chip and how stable the machines are during operation.

As mentioned herein, during the primary refining stage, the process aims include having a freeness value in the ranges described above. The freeness value may be controlled by adjusting the plate gap between the refining plates by adjusting the axial load applied to the refining plates directly and adjusting the consistency, both of which cause the plate gap to change.

For example, in the primary refining stage, according to this embodiment, the freeness value of the pulp exiting this stage may be monitored to check the average freeness values. For example, R1 and R2 refiners may be set to produce a pulp having a freeness value of up to 600 ml (CSF), whereas the R5 refiner may be controlled so that the pulp produced by R5 has a freeness value of 400 ml (CSF), or possibly lower. As a further example, the R5 refiner may be controlled so that the pulp produced by R5 has a freeness value of 600 ml CSF, and the R1 and R2 refiners are controlled so that the pulp produced by R1 and R2 is 400 ml CSF. By combining the pulp from these refiners, depending on the volume produced by each of the refiners, the average freeness value is configured to be around 500 ml (CSF). By adjusting the various parameters, the CSF values can be adjusted up and down so that they fall in range of the desired quality of the end product pulp.

Further, the pulp quality may be monitored after the primary refining stage to determine the average fibre length at this stage. A target average fibre length may be, for example, 1.3 mm. After the secondary refining and additional processes, the final product pulp average length will then fall within the desired range as described above. Alternatively, the target average fibre length may be between 1.2 and 1.8 mm for the interim pulp product (i.e. after primary refining), with a freeness value of between 400 ml and 500 ml CSF. Alternatively, the target average fibre length may be between 1.25 and 1.45 mm for the interim pulp product.

Further Embodiments

It will be understood that the embodiments of the present invention described herein are by way of example only, and that various changes and modifications may be made without departing from the scope of invention.

It will be understood that the primary refining stage may be modified to include a single refiner utilising one of the refining segment forms as described herein. Further, the primary refining stage may be modified to include two refiners with one or both utilising one of the refining segment forms as described herein. For example, two large refiners may be utilized instead of three smaller refiners as described in the specific embodiment. Optionally the secondary refining stage may be as described above in the preferred embodiment. Alternatively, the refining system may only utilise the primary refining stage without any secondary refining.

Further, it will be understood that the primary refining stage may be modified to include more than three refiners, with one or more of those refiners utilising an angled bar unidirectional refining segment form as described herein. In each case, the output of the primary refining stage (i.e. the interim pulp product) is monitored and the parameters (e.g. the plate gap, by virtue of plate axial force and consistency) are adjusted until the desired quality values (e.g. the average fibre length, the freeness value and the bulk characteristics) are achieved. For example, an average number of measurement values may be taken to determine whether the pulp characteristics are within the desired target range. Therefore, it will be understood that any number of primary refiners may be used to achieve the desired result. The number of primary refiners may depend on the whether the operator wishes to operate a system of low intensity refining or high intensity refining.

Further, it will be understood that the secondary refining stage, if used, could be modified to include a single refiner, or three or more refiners.

Further, it will be understood that the secondary and/or reject refining stages may implement low consistency refining techniques for the refining process. For example, the secondary and/or reject refining stages may use up to or greater than 90% moisture content.

Further, it will be understood that any of the refiners may use a combination of two differently configured refining segments for each plate. For example, one or more of the primary refiners may use an angled bar unidirectional refiner plate that opposes a standard (i.e. bi-directional parallel bar) refiner plate.

CLAIMS:

1. A thermo-mechanical or refiner-mechanical method of producing pulp from Pinus Radiata wood chips including the steps of:

introducing the Pinus Radiata wood chips into a refiner system including one or more refiners where at least one of the refiners has a set of refining discs with an angled bar unidirectional configuration,

grinding the wood chips in between the refining discs within the refiners,

wherein the set of refining discs are configured to produce pulp that is further processed to produce a final pulp product that has a final freeness value of between 300 ml (CSF) and 450 ml (CSF), and a final average fibre length of between 1.0 mm and 1.6 mm.

2. The method of claim 1, wherein the freeness value is between 315 ml (CSF) and 400 ml (CSF).

3. The method of claim 2, wherein the freeness value is between 330 ml (CSF) and 390 ml (CSF).

4. The method of claim 1, wherein the freeness value is between 350 ml (CSF) and 450 ml (CSF).

5. The method of claim 1, wherein the final average fibre length is between 1.1 mm and 1.6 mm.

6. The method of claim 1, wherein the final average fibre length is between 1.0 and 1.45 mm

7. The method of claim 6, wherein the final average fibre length is between 1.15 and 1.3 mm.

8. The method of claim 7, wherein the final average fibre length is substantially 1.25 mm.

9. The method of claim 1, wherein the final average fibre length is between 1.3 and 1.6 mm.

10. The method of claim 1, wherein the bulk value of the final pulp product is between 2.7 and 3.7 $m^3/kg \times 10^{-3}$.

11. The method of claim 1, wherein the bulk value of the final pulp product is between 2.7 and 3.3 $m^3/kg \times 10^{-3}$.

12. The method of claim 11, wherein the bulk value of the final pulp product is between 2.9 and 3.2 $m^3/kg \times 10^{-3}$.

13. The method of claim 1, wherein the one or more refiners are primary refiners.

14. The method of claim 1, wherein the refiner system includes one or more primary refiners and a reject refiner.

15. The method of claim 1, wherein the refiner system further includes one or more secondary refiners.

16. The method of claim 1, wherein the further processing step includes passing the pulp through one or more pressure screens.

17. The method of claim 16, wherein the pulp is passed though one or more pressure screens after passing through a primary refiner or a reject refiner.

18. The method of claim 1, wherein the pulp is further processed in one or more hydracyclones.

19. The method of claim 1, wherein the refining discs are rotated relative to each other at a speed of between 1400 and 1600 rpm.

20. The method of claim 1, wherein an axial force is applied to the refining discs at a force of between 50 and 90 tonnes.

21. The method of claim 1, wherein the wood chips are processed in the refiner system with a moisture content of between 70% and 75%.

22. The method of claim 1, wherein the at least one refiner includes a set of refiner discs including two different types of disc.

23. The method of claim 1, wherein the at least one refiner includes a set of refiner discs of the same type.

24. A thermo-mechanical or refiner-mechanical method of producing an interim pulp product from Pinus Radiata wood chips including the steps of:

i) introducing the Pinus Radiata wood chips into a primary refiner system including one or more refiners where at least one of the refiners has a set of refining discs with an angled bar unidirectional configuration,

ii) operating the one or more refiners using an axial force applied to the set of refining discs,

iii) providing a mixture of water and wood chips between the refining discs,

iv) grinding the mixture in between the refining discs,

v) measuring the interim pulp product produced by the grinding step to determine if the interim pulp product has an interim average freeness value of between 400 ml (CSF) and 570 ml (CSF), and an interim average fibre length of approximately 1.3 mm,

and, upon a positive determination,

vi) outputting the interim pulp product from the primary refiner system for further processing.

25. The method of claim 24, whereupon a negative determination, one or more of the plate gap between the refining discs, axial force and amount of water are adjusted, and steps iv) and v) are repeated.

26. The method of claim 24 wherein the interim average fibre length is between 1.2 mm and 1.4 mm.

27. The method of claim 24 wherein the interim average fibre length is between 1.25 mm and 1.55 mm.

28. The method of claim 24 wherein the interim average freeness value is between 400 ml (CSF) and 550 ml (CSF).

29. The method of claim 24 wherein the interim average freeness value is approximately 500 ml (CSF).

30. The method of claim 24 further including the steps of processing the interim pulp product using further process steps to produce a final pulp product.

31. The method of claim 30, wherein the further process steps include one or more of secondary refining, pressure screening, reject refining, latency removal, cleaning, compacting, bleaching and drying.

32. A thermo-mechanical or refiner-mechanical method of producing an interim pulp product from Pinus Radiata wood chips including the steps of:

i) introducing the Pinus Radiata wood chips into a primary refiner system including one or more refiners where at least one of the refiners has a set of refining discs with an angled bar unidirectional configuration,

ii) operating the one or more refiners using an axial force applied to the set of refining discs,

iii) providing a mixture of water and wood chips between the refining discs,

iv) grinding the mixture in between the refining discs,

v) measuring the interim pulp product produced by the grinding step to determine if the interim pulp product has an interim average freeness value of between 400 ml (CSF) and 570 ml (CSF), and an interim average fibre length of between 1.2 mm and 1.8 mm,

and, upon a positive determination,

vi) outputting the interim pulp product from the primary refiner system for further processing.

33. A thermo mechanical method of producing pulp from Pinus Radiata wood chips including the steps of:

introducing the Pinus Radiata wood chips into a refiner system including one or more refiners where at least one of the refiners has a set of refining discs with an angled bar unidirectional configuration,

grinding the wood chips in between the refining discs within the refiners,

wherein the set of refining discs are configured to produce pulp that has a final freeness value of between 300 ml (CSF) and 450 ml (CSF), and an average fibre length of between 1.1 mm and 1.7 mm.

34. Pulp made from the method of any one of claims 1 to 33.

35. A method of producing pulp from Pinus Radiata wood chips substantially as herein described with reference to figures 1, 2B, 3 and 4.

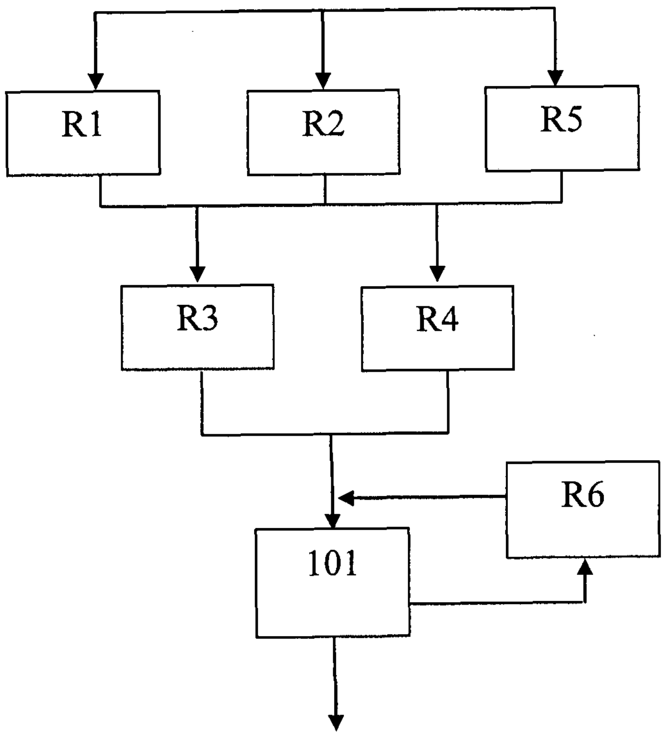

FIGURE 1

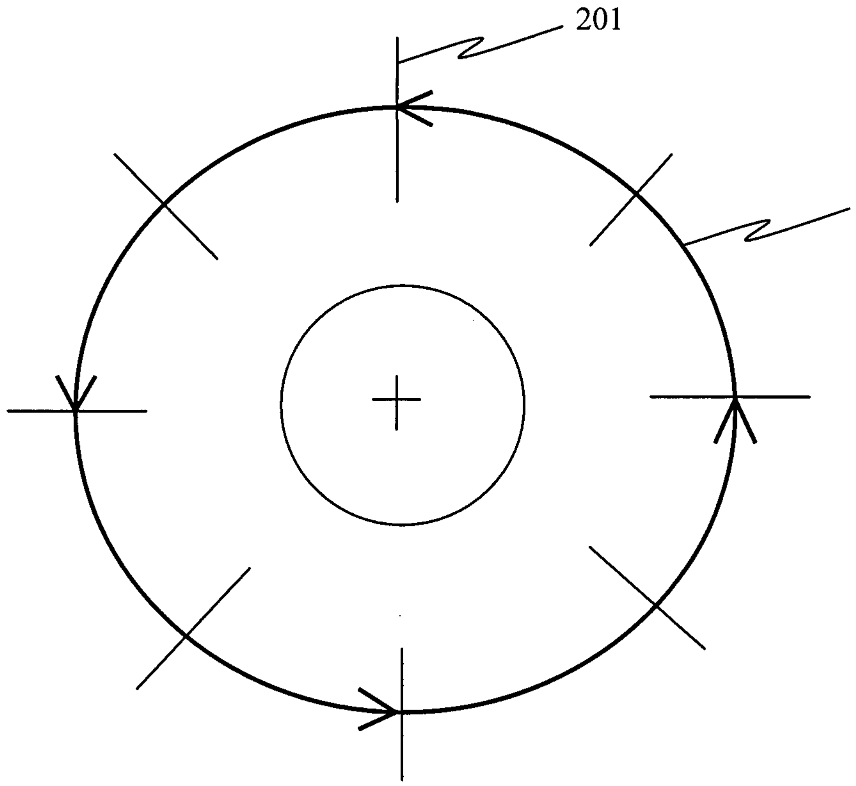

FIGURE 2A

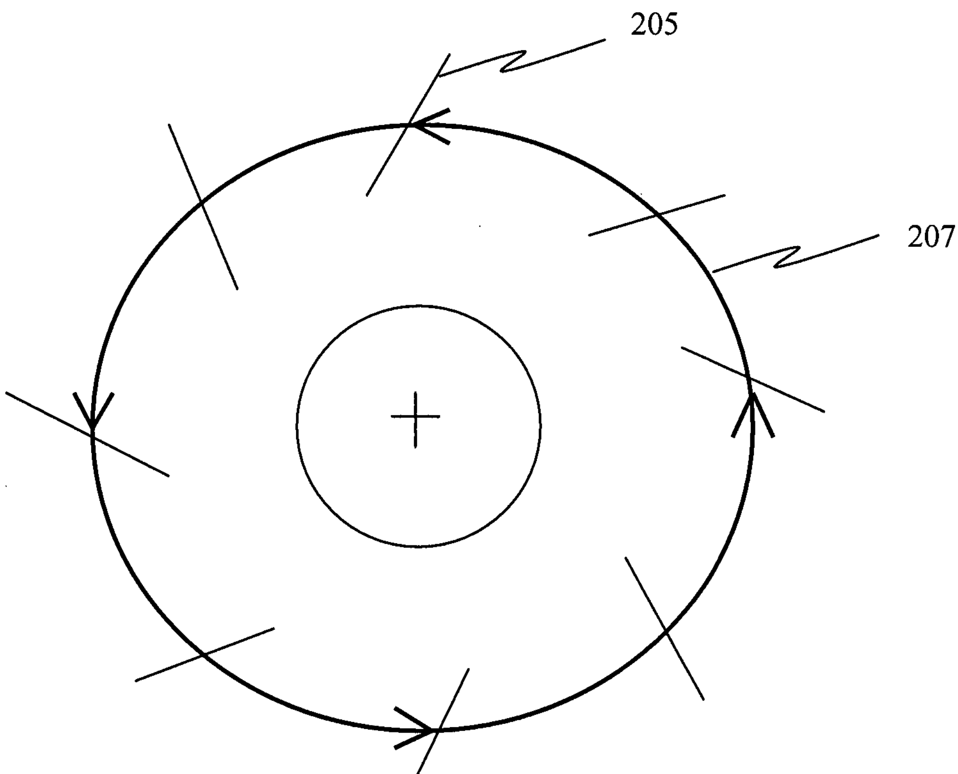

FIGURE 2B

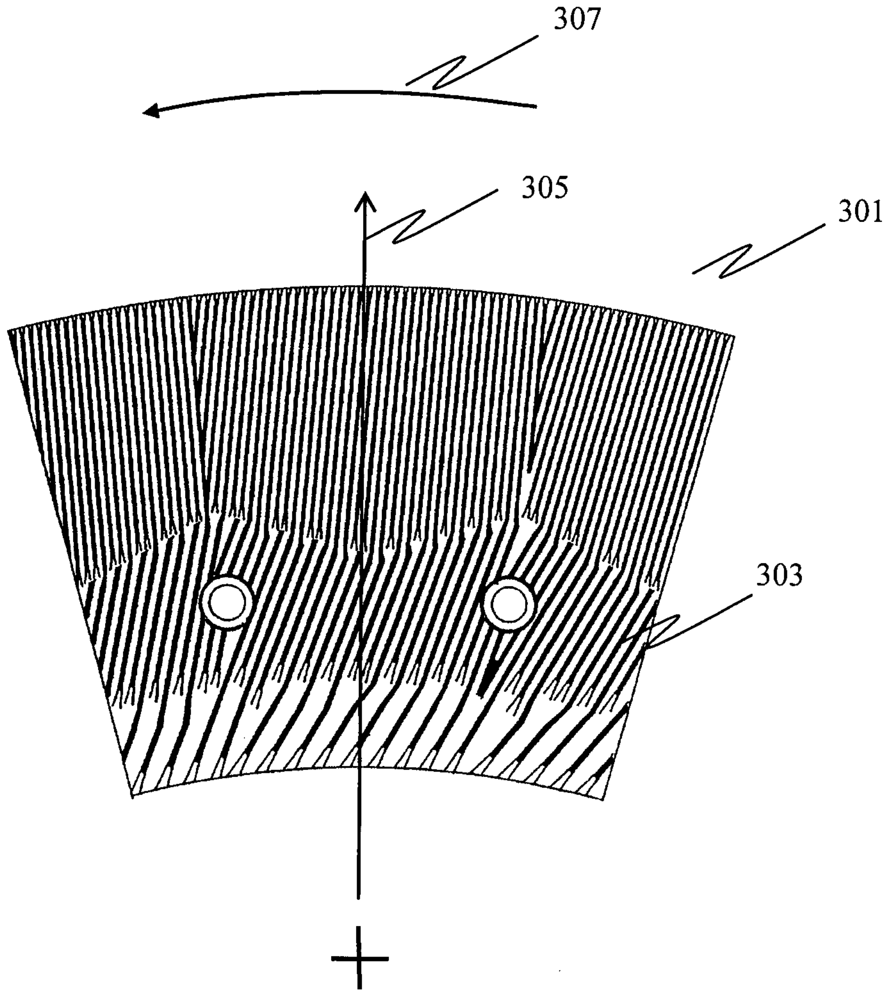

Figure 3

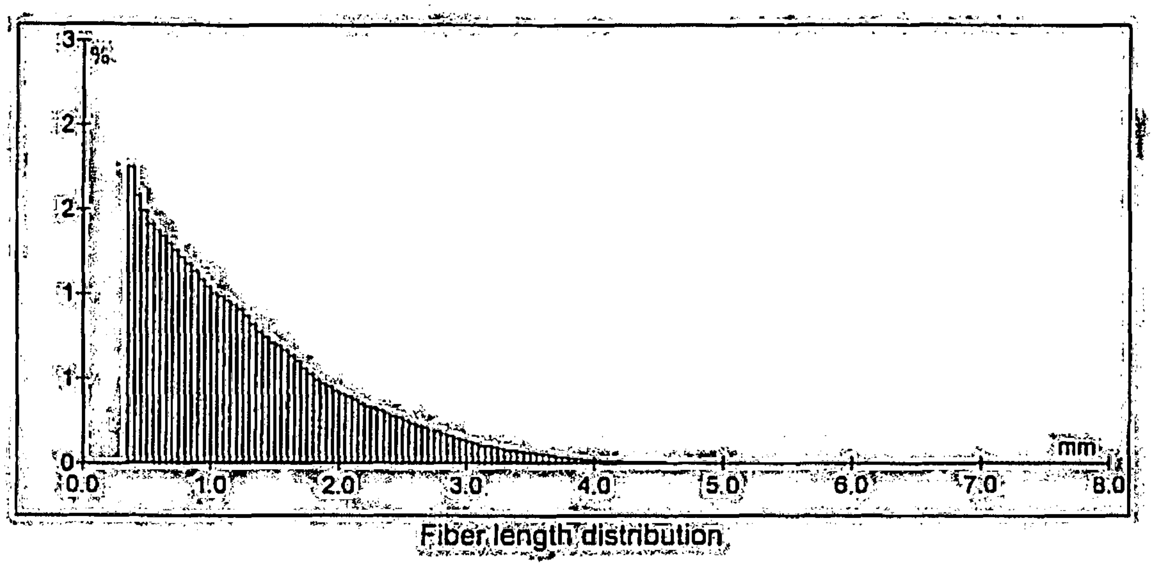

FIGURE 4

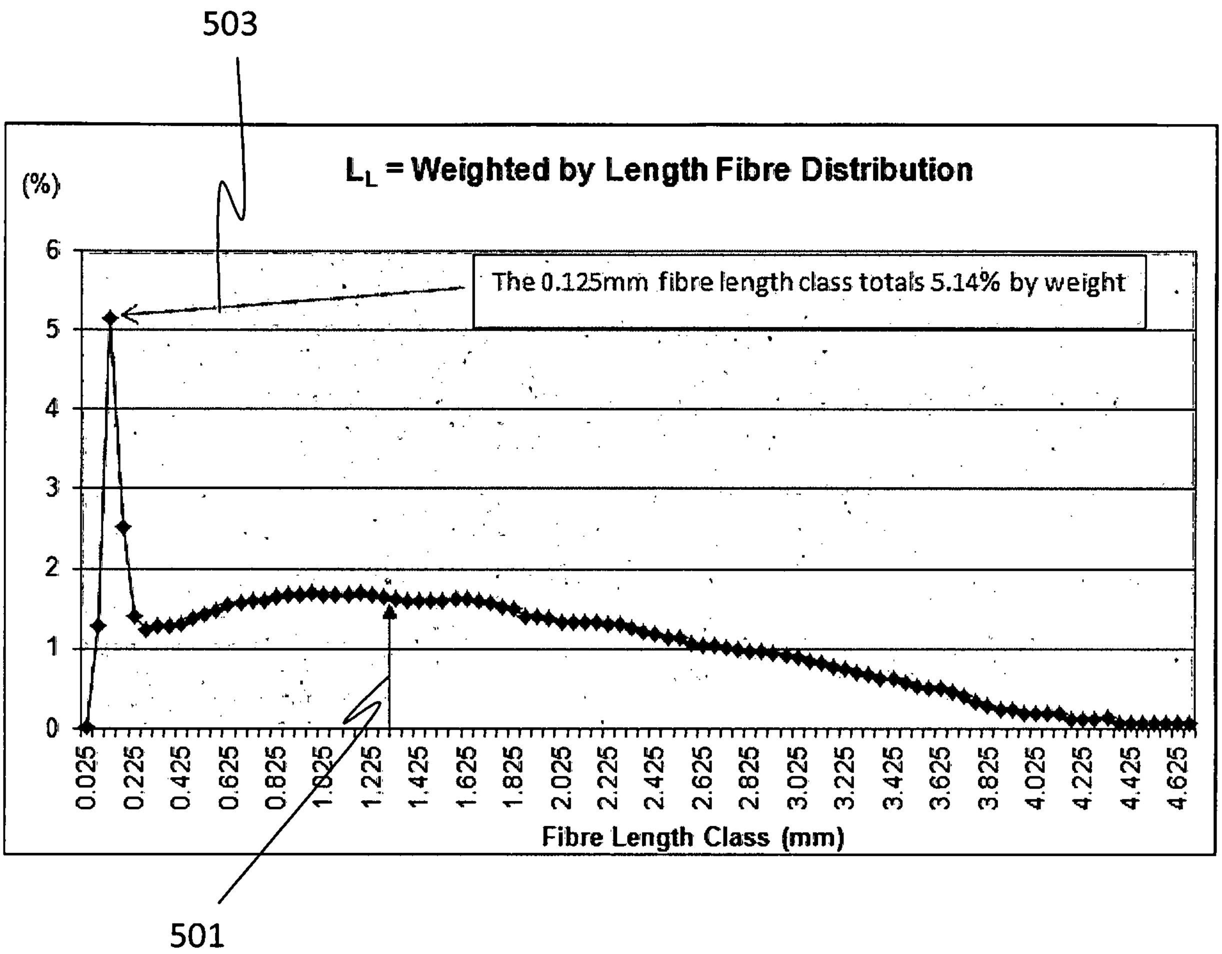
503
L_L = Weighted by Length Fibre Distribution
(%)
The 0.125mm fibre length class totals 5.14% by weight
6
5
4
3
2
1
0
0.025
0.225
0.425
0.625
0.825
1.025
1.225
1.425
1.625
1.825
2.025
2.225
2.425
2.625
2.825
3.025
3.225
3.425
3.625
3.825
4.025
4.225
4.425
4.625
Fibre Length Class (mm)
501

FIGURE 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2012/000021

A. CLASSIFICATION OF SUBJECT MATTER

B02C 7/12 (OCT 2005) D21D 1/30 (OCT 2005) D21B 1/14 (OCT 2005)

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)

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)

WPI & EPODOC: IPC B02C7/00 and below, D21B1/14 and below, D21D1/30 and Keywords (refine, disc, bar, angle and like terms); Google Patents: Keywords: refine pulp (pine OR "pinus radiata") freeness fibre length

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 June 2012	02 July 2012

Name and mailing address of the ISA/AU	**Authorized officer**
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2012/000021

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: **35**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
The claim does not comply with Rule 6.2(a) because it relies on references to the description and/or drawings.

3. ☐ Claims Nos:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	PCT/NZ2012/000021

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 6336602 B1 (MILES) 08 January 2002	
X	Abstract	34
Y	Abstract; column 3, lines 48-59; column 5, lines 25-30; column 6, lines 16-22; column 8, lines 47-65; figures 3, 11-12, 18	1-33
	US 3910511 A (LEIDER et al) 07 October 1975	
X	Abstract	34
Y	Abstract; figures 2, 6; column 2, lines 60-64	1-33
	EP 0611599 B2 (SUNDS DEFIBRATOR INDUSTRIES AKTIEBOLAG) 24 August 1994	
Y	Abstract; figure; para 5-6, 9	1-33
	US 5683048 A (VIRVING) 04 November 1997	
X	Abstract	34
Y	Abstract; figures 1-2; column 1, lines 41-65	1-33
	US 2005/0252625 A1 (LINDSTROM et al.) 17 November 2005	
X	Abstract; para 12	34

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/NZ2012/000021**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 6336602 B1	08 Jan 2002	AU 747752 B2	23 May 2002
		AU 3923199 A	13 Dec 1999
		BR 9910733 A	13 Feb 2001
		CA 2333047 A1	02 Dec 1999
		EP 1082487 A1	14 Mar 2001
		EP 1082487 B1	06 Apr 2005
		NO 20005528 A	02 Nov 2000
		NO 320529 B1	19 Dec 2005
		NZ 507723 A	29 Apr 2003
		US 6336602 B1	08 Jan 2002
		WO 9961696 A1	02 Dec 1999
US 3910511 A	07 Oct 1975	CA 1021617 A1	29 Nov 1977
		DE 2522349 A1	04 Dec 1975
		GB 1461057 A	13 Jan 1977
		JP 51004303 A	14 Jan 1976
		JP 54020022 B	19 Jul 1979
		SE 7505745 A	21 Nov 1975
		US 3910511 A	07 Oct 1975
EP 0611599 B2	24 Aug 1994	AU 651933 B1	04 Aug 1994
		BR 9400060 A	09 Aug 1994
		CA 2109125 A1	15 Jul 1994
		EP 0611599 A1	24 Aug 1994
		EP 0611599 B1	18 Sep 1996
		EP 0611599 B2	22 Dec 1999
		FI 934587 A	23 Jul 1994
		FI 98227 B	31 Jan 1997
		JP 6240592 A	30 Aug 1994
		JP 3414813 B2	09 Jun 2003
		NO 933749 A	25 Jul 1994
		NO 305197 B1	19 Apr 1999
		NZ 248981 A	26 Oct 1994
		PH 30910 A	23 Dec 1997
		SE 470566 B	29 Aug 1994
		SE 9300078 A	23 Jul 1994

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/NZ2012/000021**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
		US 5362003 A	08 Nov 1994
		ZA 9308905 A	02 Aug 1994
US 5683048 A	04 Nov 1997	AU 678908 B2	12 Jun 1997
		AU 3088895 A	14 Mar 1996
		BR 9508806 A	23 Dec 1997
		CA 2196298 A1	29 Feb 1996
		EP 0776248 A1	04 Jun 1997
		EP 0776248 B1	08 Dec 1999
		FI 970658 A	17 Feb 1997
		FI 113630 B1	31 May 2004
		JP H10510009 A	29 Sep 1998
		NO 970729 A	17 Feb 1997
		NO 313408 B1	30 Sep 2002
		NZ 290214 A	19 Dec 1997
		SE 9402747 A	19 Feb 1996
		US 5683048 A	04 Nov 1997
		WO 9605911 A1	29 Feb 1996
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		EP 1513981 A1	16 Mar 2005
		SE 0201679 A	04 Dec 2003
		US 2005252625 A1	17 Nov 2005
		WO 03102296 A1	11 Dec 2003

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.