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(54) **Production process for bio-fuel**

(57) The present invention provides system for controlling a wood particle size distribution in a wood particle manufacturing process. The system comprises a chipper adapted to receive and chip raw wood material into wood chips having crack-formations substantially along a fibre direction, a refiner adapted to receive and refine the chips into wood particles having a predetermined wood particle size distribution, and a refiner control unit connected to the refiner, which unit is adapted to control an operation of the refiner based on a resulting wood particle size distribution in order to obtain the predetermined wood particle size distribution.

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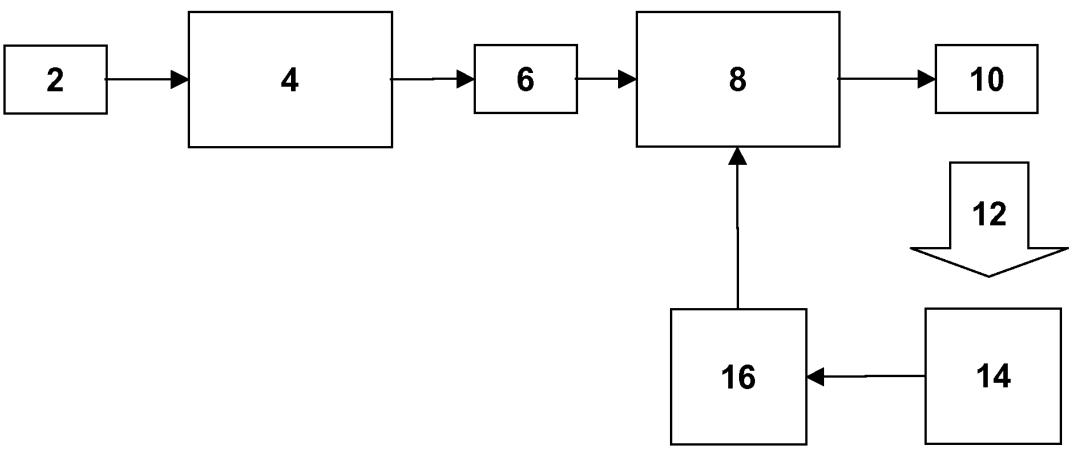

Fig. 1

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Description

Technical field

[0001] The present invention relates to a system for controlling a wood particle size distribution in a wood particle manufacturing process, and a method thereof.

Technical background

[0002] Wood particles are used in many areas for various purposes, e.g. as an essential part of a bio-fuel wood pellet or as reinforcement in plastic composites. Furthermore, ethanol is normally produced by means of a process including fermenting of wood particles.

[0003] Pellets are normally manufactured by pressing small amounts of wooden particles together. In a pellet manufacturing process a set of moulds is filled with wooden particles, which is then packed into pellet. Packing may be done in many ways. For example, a heavy roll may be rolled over the openings of the moulds and compressing particles into the mould, thereby forming a compressed pellet in the mould.

[0004] The herein described pellets are referred to as pellets to be used as bio-fuel. Such pellets are normally used as fuel in a wood-burner or furnace, normally for heating of buildings, such as family houses or office buildings. The heating principle is the same irrespective of the size of the burner. First the pellets are crushed or beaten into particles by grinding or refining for obtaining a more effective burning and thereby a more effective heating. A hammer mill, using hammer means for crushing of the pellets, normally does such a refining. This resulting substance of crushed pellets is then fed to a burner. A parameter of importance for an effective burner is the dimension of the particles. If a particle is too large then such a particle may be burned to slow, causing an incomplete burning. As a result, such incompletely burned particles accompany the outlet gases, so called emissions, i.e. energy losses. On the other hand, small particles that are too light may be sucked into a flow of smoke or exit gas. As a result, such small unburned wood particles is often the origin of unwanted soot, which adheres to the sides of the chimney or pipe conveying the smoke. Soot, in general, is something that needs to be removed for safety reasons

[0005] A wood/plastic composites is a plastic or polymer matrix material with embedded reinforcing wood fibres. These types of composites are often used in areas that are exposed to different kind of weather conditions, especially tough conditions like rain and wind. The wood/plastic composite is suitably used as a complement to various wood materials, which is a commonly used construction material, and such composites may advantageously replace pressure-treated wood, since composites normally have a longer lifetime. The wooden reinforcement is a substance of wood fibres or particles, e.g. sawdust or the like, of a determined distribution. An amount of wood particles are sifted to obtain such commercial wood particles of the determined size, or in other words, the sifted particles only have an upper size limitation. In general, wood fibres of the composite are normally about 40 Mesh, which is about 400 μm. One essential parameter of the fibre is related to the ratio between the length and cross-sectional diameter, herein designated by l/d, it is thus assumed that the fibres have an elongated shape. If the l/d-ratio of the fibres in the commonly used composites is to high, i.e. a long and thin fibre, it may be difficult to disperse or evenly distribute the fibres throughout the embedding polymer matrix. The fibres to be used in composites are normally the same fibres as the paper fibres, i.e. the fibres that constitute the base or reinforcement of a paper. Such paper fibres are generally slim or slender with a high l/d-ratio of about 100 to 250.

[0006] Manufacturing of ethanol is, as mentioned above, another example where wood particles is used. In such a process wood particles are fermented to produce the ethanol. The dimension, such as the shape and size, is a parameter of importance to obtain an effective process with reference to the content of alcohol. An effective process also affects the speed of the produced volume of alcohol. The wood fibre, which is the primary product in the ethanol manufacturing, suitably has a length of at least 15 mm and a cross-sectional diameter of at least 3 mm. Sawdust particles are the most commonly used particles as the primary product. Fibres that have lesser dimensions than this do not take an active part in such processes. On the contrary, such smaller fibres normally make the ethanol process ineffective.

[0007] In the above-mentioned examples of the use of wooden particles, the dimension of the particle is of relevance. There exist a number of alternative manufacturing methods for producing wood particles. For example, as mentioned above, sawdust is commonly used in the fabrication of both ethanol and pellets. Sawdust is a biproduct at the sawmill in the timber or lumber manufacturing process. However, sawdust may be generated in other ways by another process, such as a paper mill. Since the timber is the primary product and the sawdust residual product. Because of that, the dimension or size distribution, i.e. the frequency of the size or dimension of the particles throughout the sawdust substance, of the particles is impossible, or at least difficult, to control. Of course, the sawdust substance may be filtered for separation purposes, but there will still be an amount of unwanted wood particle, which is useless in many applications, especially in those mentioned above.

[0008] In the bio-fuel pellet manufacturing, sawdust is the most common raw material. During storage or transport from the mill to the pellets manufacturing site, the sawdust very easily exposed to contaminating non-wooden particles, i.e. unwanted substances such as dirt or the like. This is especially of relevant because of a large surface area of the sawdust, i.e. a large surface in comparison to the weight, which could cause a relative large contamination if it is stored for a long time or exposed at long transport distances. In addition, there is an upper limit of the transportation distance due to the cost related thereto and the environmental influence. Moreover, there is a great interest of using pellets as bio-fuel and interest is increasing substantially. As a consequence, an enhanced production of pellets will limit the supply of sawdust.

[0009] Alternatively, round wood may directly be transformed or process into wood particles. One way of doing this is the use of a hammer mill. However, round wood have a relatively high percentage of humidity, compared to for example normal sawdust. When such wet or moisture-containing round wood is subjected to a normal hammer-like treatment of a conventional hammer mill, the moisture results inefficient chipping process. The quality of the resulting chips is low, i.e. a high percentage of too large non-processed wood pieces. Furthermore, the moisture in the round wood causes extensive wearing of the hammer means, which decreases the quality even further. Thus the hammer mills needs to be provided with means to assert these moisture problems, such as heating means. This problem is of coarse even more complex during wet or cold weather conditions, such as wintertime, or when the hammer mill is situated in a humid climate or environment.

[0010] Another problem that relates to hammer mills is that the resulting wood particles, in general, have a relatively high percentage of fine or small particles compared to conventional sawdust. Furthermore, the resulting particles also have a large variation in shape or form, which is disadvantageous with respect to floating properties. At the inlet of particles to the pellet generating device, the wood particles are normally fed to the device by floating on a stream of water, or the like. Thus, it is of importance that the particles have good floating abilities. This non-floating property of the particles resulting from a conventional hammer mill process is thus unfavourable in the pellet manufacturing process. Moreover, the hammer mill process generates particles with an elongated shape, i.e. a non-compact particle having a stretched out shape. Hence, this elongated shape property increases the percentage of non-floating or other small particles even further.

Summary of the invention

[0011] An object of the invention is to provide a novel solution for providing wood particles and controlling the particle size distribution thereof.

[0012] This object and other object are met by the invention as defined in the independent claims. Example embodiments of the invention are defined in the dependent claims. In addition, the present invention has other advantages and features apparent from the description below.

[0013] The present invention is based on the insight that by combining a first chipping process in which wood material is chipped to wood chips having crack-formations substantially along a fibre direction with a second refining process, the resulting particle distribution can be controlled in an efficient and accurate manner.

[0014] According to a first aspect of the present invention, there is provided a system for controlling a wood particle size distribution in a wood particle manufacturing process, the system comprising a chipper adapted to receive and chip raw wood material into wood chips having crack-formations substantially along a fibre direction, a refiner adapted to receive and refine the chips into wood particles having a predetermined wood particle size distribution, and a refiner control unit connected to the refiner, which unit is adapted to control an operation of the refiner based on a resulting wood particle size distribution in order to obtain the predetermined wood particle size distribution.

[0015] According to a second aspect of the present invention, there is provided a method for controlling a wood particle size distribution in a wood particle manufacturing process, the method comprising the steps of: chipping of raw wood material into wood chips, such that crack-formations, substantially along a fibre direction, are formed, refining of the chips into wood particles having a predetermined wood particle size distribution.

[0016] According to a third aspect of the present invention, there is provided a computer program product, which when executed on a computer, performs steps in accordance with the method according to the second aspect.

[0017] An advantage of the present invention is that the wood material in a raw condition may be processed directly without pre-treating the wood material or using supplementary or auxiliary devices, such as heating devices, to compensate for the rawness of the wood material. Thus, the system according to the present invention is capable of processing wood material having different degrees of moisture, from 0-80 %, thus including wood having a high degree of moisture, or wood material being wet or bibulous, or material which is frozen or the like. Furthermore, the system is also suitable to be used in practically all weather conditions from -50 °C to 100 °C. Consequently, the system in present invention has the advantage of being operable in the winter with snow and rain, and still being able to process cold or frozen wood material without the need for additional equipment. Moreover, the system according to the present invention is also energy efficient in comparison to known techniques.

[0018] In addition to the advantages above, any suitable raw wood material may be used, such as round wood. Due to the large supply of thinning wood, i.e. wood material sorted out from a forest when thinning thereof, this will enhance the supply of the primary product for manufacturing pellets, and secure the future production of bio-fuel, such as pellets, bio-diesel, methanol, tall oil, pyrolysis oil, and other types of liquid bio-energy.

[0019] Conventional sawmills have a limitation regarding the dimension of the log to be saw-processed into a timber material, in other words, conventional sawmills are unable to process too large logs or other wood material. Thus, logs or stems having a too large diameter cannot be used at sawmill. Another advantage of the system according to present invention is that the system may process any wood material, such as raw wood, with a large diameter. For example, such thick stems or logs may be suitable to be processed by the system of the present invention. Other raw wood material, such as rest products from any wood refining, or the like, may also be used by the system. Consequently, the system is able to process wide range raw wood materials or other wood materials, and is hence capable of processing wood material that would have been rejected by the known systems.

[0020] Moreover, the wood particle manufacturing process of the system of the present invention achieves a controlled wood particle size distribution. This distribution may be controlled for reducing unwanted wood particles, such as too small or too large sized wood particles. For example, in a process of burning bio-fuel pellets that comprises wood particles, too small wood particles are often left unburned, causing disadvantageous soot along a chimney of the burner. Furthermore, too large particles are often left unburned, causing disadvantageous ashes. Consequently, an advantage of the system of the present invention, contrary to conventional hammer mills in which, in general, are difficult or impossible to control the particle size distribution, is that the size of the manufactured particles may be controlled.

[0021] In addition to the advantages above, due to the fact that the system according to the present invention may use raw wood material, a storing or transportation process step may be eliminated. The system may be arranged at a final wood particle refinement apparatus, such as a bio-fuel pellet apparatus. As a consequence, the wood particles resulting from the system of the present invention may directly be processed into pellets. Conventionally, sawdust normally needs to be stored and/or transported to further processes. Such storing or transportation usually contaminates the wood particles, such that the amount of ash-forming substances is increased.

[0022] A further advantage of the system of the present invention is that the system may produce wood particle having an advantageous shape or form. For example the particle may have a small value of the length/diameter relation (l/d), i.e. a short length compared to the diameter of a wood fibre or particle. Wood particles or fibres having such a small value of the l/d is especially advantageously as constituting reinforcement in composites, which is a suitable material to withstand wind and weather. Composites are a complementary material to wooden materials, such as pressure-treated wood.

[0023] In an embodiment of the system according to the present invention, the system further comprises monitoring means connected to the refiner control unit, which monitoring means is adapted to collect at least one first set of monitoring data related to parameters of the resulting distribution of wood particle sizes, and wherein the refiner control units controls the refiner by comparing the first set of monitoring data with reference data of a calculated calibration model, the model being based on previously collected monitoring data.

[0024] Such a refiner control unit ensures that the wood particles that result from the system of the present invention have the particle size distribution of the predetermined parameters. If the monitored size distribution deviates from the preset parameters, i.e. the pre-setup of the refine device, the refiner control unit is adapted to adjust the refiner in a regulating manner, such that wood particles having a determined size distribution are produced. Additionally, monitoring means may also be used for detection of unpredictable malfunctions of the refining process of the refiner, such that the refiner may be turned off.

[0025] According to another embodiment of the present invention, the monitoring means is adapted to collect data by means of a spectrometric method. In a further embodiment of the present invention, the spectrometric method uses ultra-violet, infrared, near-infrared, or visible light. A spectroscopic method is an accurate and well-known method suitable for monitoring a wood particle size distribution, especially a method that uses ultra-violet, infrared, near infrared, or visible light.

[0026] Moreover, in a further embodiment, the refiner is adapted to shear the chips into wood particles. Alternatively, the refiner is a disc mill comprising a first fixed flat disc, a second movable disc arranged opposite to the first fixed flat disc, the second disc comprises a set of various ramp-shaped protrusion on a surface facing the first disc, wherein the second disc is arranged to spin at its centre axis and exert a milling force such that intermediate wood chips are exposed to shearing forces. An advantage of using a disc mill, in comparison to a common hammer mill, is that such a machine may be around-the-clock-operated, which increases the production rate.

[0027] Furthermore, the system of the present invention may also be provided with an embodiment, the system further comprises conveying means adapted to translate the wood chips from the chipper to the refiner.

[0028] Additionally, according to an embodiment of the present invention, the step of refining further includes the steps of: monitoring of the wood particle size distribution, collecting at least one first set of monitoring data related to parameters of the resulting distribution of wood particles, and comparing the first set of monitoring data with reference data of a calculated calibration model, the model being based on previously collected monitoring data, and controlling of the refiner on basis of said comparing.

[0029] Furthermore, in yet another embodiment of the present invention, the step of monitoring includes the step of monitoring by means of a spectrometric method. In an alternative embodiment, the step of monitoring by means of a spectrometric method includes the step of using ultra-violet, infrared, near-infrared, or visible light in the spectrometric method.

[0030] Additionally, in a further embodiment, the step of refining includes the step of shearing the chips into wood particles. The shearing is preferentially done by a method, wherein the step of refining includes the step of disc milling, wherein the disc mill comprises a first fixed flat disc, a second movable disc arranged opposite to the first fixed flat disc, the second disc comprises a set of various ramp-shaped protrusion on a surface facing the first disc, wherein the second disc is arranged to spin at its centre axis and exert a milling force such that intermediate wood chips are exposed to shearing forces.

[0031] Furthermore, the method of present invention may be provided with an embodiment, the step of chipping includes the step of translating the wood chips from the chipping step to the refining step.

Brief description of the drawings

[0032] Embodiments of the present invention will now be described, by way of example, with reference to the accompanying schematic drawings, in which

Fig. 1 is a block diagram for schematically representing a system according to an embodiment of the present invention.

Fig. 2 is a flowchart for schematically representing the general principles of a method for manufacturing wood particles according to an embodiment of the present invention.

Detailed description of preferred embodiments of the invention

[0033] In Fig.1, a block diagram is shown, which schematically represents a system according to an embodiment of the present invention. The system 1 of Fig. 1 is suitable for controlling a wood particle size distribution in a wood particle manufacturing process according to the present invention. According to the embodiment of Fig. 1, the system comprises a chipper 4, which receive raw wood material 2 and which is adapted to chip this raw wood material into wood chips 6. The arrows in Fig. 1 represent the direction of the manufacturing process. The chipper 4 is further adapted to chip the raw wood 2 such that crack-formations, substantially along a fibre direction of the wood chips 6, are formed. A refiner 8 then receives the chipped wood substance 6 and refines it into small wood particles 10, where the particles 10 have a predetermined wood particle size distribution. A refiner control unit 16, which is connected to the refiner 8, is adapted to control the operation of the refiner 8 in order to manufacture particles 10 of a specific size. Furthermore, the refiner control unit 16 uses earlier information of the wood particle size distribution of previously manufactured particles 10, to control the refiner 8 in order to obtain a predetermined wood particle size distribution.

[0034] The system 1 of Fig. 1 further comprises monitoring means 14, which is connected to the refiner control unit 16. The monitoring means collects information or data 12 of the resulting wood particle distribution. Preferable, the monitoring means 14 may collect at least one first set of monitoring data 12, which is related to parameters of the resulting distribution of wood particle sizes. This distribution information 12 is then used by the refiner control units 16, which compares this first set of monitoring data with reference data, to control the refiner 8. Reference data is here based on a calculated calibration model, wherein the model is based on previously collected monitoring data. Any suitable model may be used. Monitoring may be done by means of a wide range of devices and methods. For example, the system 1 according to the present invention may use a spectrometric device or method, and which method preferable uses ultraviolet, infrared, near-infrared, or visible light, such as a NIR spectroscope. Furthermore, the system 1 may use a picture or image scanning device adapted to obtain pictures or images of the resulting wood particles for use in the characterization of wood properties and the modulation. This can be utilized as an alternative to the NIR spectroscope or as a complement to the NIR spectroscope. Further alternatives for characterizing the properties of the wood particles and for modulation includes Raman spectroscopy and FTIR spectroscopy (Fourier Transform Infra-Red spectrocscopy).

[0035] The refiner 8 may preferable refine the chips 6 into wood particles 10 by means of shearing. Using a disc mill may do this. A disc mill may generally be described as two flat discs, oppositely arranged to each other, wherein one of the discs is fixed and the other one is movable. The movable disc is adapted to spin around its centre axis. This movable disc is then forced towards the fixed disc such that a milling effect is achieved on intermediately positioned wood chips 6. Preferably, the fixed disc has flat opposing surface and the movable is arranged with a non-flat surface such that when these two surfaces are forced together, in a milling manner, the non-flat surface exerts a knife-like effect on the intermediate substance, such as the wood ships 6. Preferably, the non-flat surface is set of various ramp-shaped protrusion such that the intermediate wood chips are exposed to shearing forces.

[0036] Alternatively, the system 1 may further include conveying means for translating the wood chips 6 from the chipper 4 to the refiner 8 (not shown in Fig. 1). Also, conveying means may also be used for feeding raw wood material 2 to the chipper 4. Furthermore, the system may also include a cooling device adapted to applying a cooling liquid to the wood material, the cooling device being arranged downstream the chipper or downstream the refiner. For example, the cooling device may be adapted to spray water over the conveyed wood material. This improves the chipping and/or the refining process, in particular, if the moisture degree of the wood material is below 50 %. The system described above is adapted to process wood material, however, as the skilled person realizes, the system may also be adapted to process chemicals and other type of biological material such as vegetable fibres.

[0037] In Fig. 2, a flowchart for schematically representing the general principles of a method for manufacturing wood particles according to an embodiment of the present invention, is shown. The different steps in Fig 2. are presented in the direction (indicated by arrows) of the manufacturing process flow according to one embodiment. This method is suitable for controlling a wood particle size distribution in a wood particle manufacturing process. First, the method comprises the step of chipping S20 raw wood material into wood chips such that crack-formations, substantially along a fibre direction, are formed. Secondly, these wood chips are then refined S22 into wood particles with a predetermined wood particle size distribution. Primarily, the wood particle size distribution is then monitored S24. Other parameters of the resulting wood particles may also be monitored, for example the shape or form of the wood particle. The collected data of the monitored wood particle size distribution is then compared S26 with a reference data by means of a calculated calibration model S28. This model is based on earlier data from previously monitored wood particle size distribution. The refiner is then controlled S30 on the basis of the comparison of the monitor data with the calibration model, thereby forming a feedback loop such that wood particles with a predetermined wood particle size distribution is manufactured.

[0038] In an alternative embodiment, the monitoring step may alternatively be done by means of a spectrometric method, and preferable by using ultra-violet, infrared, near-infrared, or visible light, such as a NIR spectroscopy.

[0039] The NIR spectroscopy technique has gained widespread acceptance in recent years as a powerful diagnostic tool, particularly for assurance and on-line process control purposes in harsh industrial environments (Antti et al. Journal of Chemometrics, 10, 591-603 (1996), Pope J.M. "Near-Infrared Spectroscopy of Wood Products" (1995), Conners T.E. and Banerjee S Ed., "Surface Analysis of Paper", 142-151). Normally, in NIR spectroscopy, wavelengths between 400-2500 nm are used. The fundamental principles of NIR spectroscopy have been summarized in a large number of articles, for example, in Barton Spectroscopy Europe 14, no. 1, 12-18 (2002). One major reason for the success of NIR spectroscopy is the development of multivariate analysis techniques, which have made it possible to handle the huge amount of data created in such NIR measurements, for example, principal component analysis (PCA) and partial least square projection to latent structures (PLS), see inter alia, P. Geladi "Partial least-Squares Regression: A tutorial", Anal. Chim. Acta, 185, 1-32 (1986). Another technique may be principal components regression (PCR). In recent years, other techniques suitable for handling large amounts of data have been developed, such as neural networks.

[0040] In an alternative embodiment, the step of refining includes the step of shearing the chips into wood particles, and alternatively by means of disc milling, i.e. a first fixed flat disc and a second movable disc, arranged opposite to the first fixed flat disc, wherein the second disc spins at its centre axis, thereby achieving a disc milling effect such that intermediate wood chips are exposed to shearing forces. Alternatively, the second disc may be arranged with a set various ramp-shaped protrusion on a surface facing the first disc, such that a knife-like shearing force is exerted on the intermediate chips. In an alternative embodiment the method includes translation of the wood chips from the chipping step to the refining step. The raw wood material may also be translated to the chipping step.

[0041] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

Example experiments - manufacturing of pellets

[0042] In an experiment pellets where manufactured using two different manufacturing methods: a conventional hammer mill, hereinafter also referred to as process A, and a system according to the present invention (hereinafter also referred to as process B). Both processes are based on raw wood material and are otherwise performed with the same conditions, such as temperature, to obtain as comparable result as possible. Furthermore, the energy has been measured using conventional energy measuring instruments. In Tab. 1, the energy cost or the amount of used energy (in kWh) per ton raw wood material that needs to be supplied to the respective process A and B, is shown. This example clearly demonstrates the advantage of the system of the invention having a lower energy cost than a conventional hammer mill. Fig. 1 schematically shows a comparison of the particles from the two processes A and B.

Table 1 - Energy cost comparison. The values are per ton raw wood material.

Process step	Process A (kWh)	Process B (kWh)
Chipping by a chipper	75	85
Hammer milling	120 - 150	
Refining by a refiner	-	10 - 25
Total	195 - 225	95-110

[0043] The manufactured pellets were then compared by some parameters, which result is summarized in Tab. 2. Pellet density is the density of a dry pellet measured in kg/ m^3. Bulk density is a property of particulate materials, such as a substance of wood particles, and is here measured as the mass of an amount of particles divided by the occupying volume thereof. Coke reactivity is a property of special interest for bio-fuel, which is the time (in seconds) from when the flames of a burning sample stops until the sample cease to glow, in other words, it is how long the sample glows, without flames, before it goes out. Pyro-time, which stands for pyrolysis time, is here the lightning time (in seconds) of a sample, i.e. the time until the sample shows flames. Ash content is the amount (in percent) of unburned substance remaining from a complete burning of a material, here pellets. As can be seen from the table, a pellet using the process B is an advantageous pellet compared to a pellet from process A. Consequently, pellets made of wood particles that are manufactured by the system of the present invention, are more suitable as bio-fuel than pellets of particles from a conventional hammer mills.

Table 2 - Some pellet parameters of the two processes A and B.

Parameter	Process A (kWh)	Process B (kWh)
Pellet density (kg/m^3)	1100 - 1250	1150 - 1325
Bulk density (kg/m^3)	630 - 670	703 - 670
Coke reactivity (s)	-	290 - 350
Pyro-time (s)	-	40 - 42
Ash content (%)	0,46 - 0,68	0,34-0,41

[0044] The ash content dependence of the particle size and contamination time was also investigated in an experiment. The results indicate that the ash content increases with the amount of small particles in the primary product of wood particles, despite the fact that the contamination time, from decomposition of the raw wood material to the pellet manufacturing, is equally short for all three siftering graphs. Although the difference is small, the correlation is unambiguous. Contrary, the correlations between the ash content and the size of particles, which are manufactured according to process A, is not as clear. A probable hypothesis is that storing of small particles increases the ash content due to the increasing time of contamination. The particle size is thus, for a process A particle, is of less importance compared with the amount of exposure to contamination. Consequently, the ash content of pellets that comprises particles, manufactured by the system according to the present invention, may be controlled.

Example experiments - manufacturing of particles

[0045] According to an embodiment of present invention, the refiner may be controlled by NIR, making it possible to determine a preferential particle size distribution. This means that that amount of refined small particles may be decreased. In an experiment, the weight of an amount sawdust, resulted from a hammer mill process, was measured. Particles having lengths less than 1 mm, were sieved and measured with a result of about 40 weight percentage. There are about 60.000 particles in 1 gram. For comparison, the same experiment was made on particles from process B, with a result of about 5 weight percentage and less than 3.500 particles per gram.

[0046] In another experiment, adjustments were made to a refiner, such as a disc mill. This was also compared with a conventional hammer mill. The refiner according to the present invention was fed with spruce chips having a length of about 4 mm and a moisture content of about 40 %. The temperature during the experiments was about 20 °C. At the first experiment, the disc mill was arranged with a gap between the two discs of the disc mill. The gap was set with a gap of about 1,10 mm. The energy consumption of the first experiment was measured to 18 kWh per ton raw wood material. At the second experiment, the gap was set to 0,20 mm and the disc were modified according to the invention. Now, the energy consumption became 40 kWh per ton. The particle size distribution differs significantly between the first and second experiment. As consequence of these two experiments, it is thus possible to determine the particle size distribution of the resulting particles by varying the gap between the opposing discs of the disc mill and/or modifying the discs. The number of particles per gram varies greatly. The first experiment resulted in about 4000 particles per gram; meanwhile the second experiment gave 40.000 particles per gram. The two experiments with a disc mill were compared with an experiment with a hammer mill. Grinding of the hammer mill give more than 60.000 wood particles per gram and the possibilities of adjusting or controlling the hammer mill in any way are small, if not impossible.

[0047] In a further experiment, the length and the cross-sectional diameter were measured on particles that had a length less than 1 mm. The experiment was performed on both particles processed from a hammer mill (A) and from a system according to present invention (B). First the length of the particles in question were measured, then the cross-sectional diameter thereof was calculated, and thus the length/diameter (l/d) relationship. The material was divided into classes, whereby the class that comprised most particles was selected. The result is shown in Fig. 6, which significantly shows that the particles manufactured by process B have a lower l/d-value, than those particles of the process A.

Claims

1. A system for controlling a wood particle size distribution in a wood particle manufacturing process, the system comprising a chipper adapted to receive and chip raw wood material into wood chips having crack-formations substantially along a fibre direction, a refiner adapted to receive and refine the chips into wood particles having a predetermined wood particle size distribution, and a refiner control unit connected to the refiner, which unit is adapted to control an operation of the refiner based on a resulting wood particle size distribution in order to obtain the predetermined wood particle size distribution.

2. The system according to claim 1, wherein the system further comprises monitoring means connected to the refiner control unit, which monitoring means is adapted to collect at least one first set of monitoring data related to parameters of the resulting distribution of wood particle sizes, and wherein the refiner control units controls the refiner by comparing the first set of monitoring data with reference data of a calculated calibration model, the model being based on previously collected monitoring data.

3. The system according to claim 2, wherein the monitoring means is adapted to collect data by means of a spectrometric method.

4. The system according to claim 3, wherein the spectrometric method uses ultra-violet, infrared, near-infrared, or visible light.

5. The system according to any one of the claims 1 to 4, wherein the refiner is adapted to shear the chips into wood particles.

6. The system according to any one of claims 1 to 5, wherein the refiner is a disc mill comprising a first fixed flat disc, a second movable disc arranged opposite to the first fixed flat disc, the second disc comprises a set of various ramp-shaped protrusion on a surface facing the first disc, wherein the second disc is arranged to spin at its centre axis and exert a milling force such that intermediate wood chips are exposed to shearing forces.

7. The system of any one of claims 1 to 6, wherein the system further comprises conveying means adapted to translate the wood chips from the chipper to the refiner.

8. The system of any one of claim 1 to 7, wherein the system further comprises a cooling device adapted to applying a cooling liquid to the wood material, the cooling device being arranged downstream the chipper or downstream the refined.

9. The system of any one of claim 1-8, wherein the monitoring means is adapted to collect data by means of a image or picture scanning.

10. A method for controlling a wood particle size distribution in a wood particle manufacturing process, the method comprising the steps of: chipping of raw wood material into wood chips, such that crack-formations, substantially along a fibre direction, are formed, refining of the chips into wood particles having a predetermined wood particle size distribution.

11. The method of claim 10, wherein the step of refining further includes the steps of: monitoring of the wood particle size distribution, collecting at least one first set of monitoring data related to parameters of the resulting distribution of wood particles, and comparing the first set of monitoring data with reference data of a calculated calibration model, the model being based on previously collected monitoring data, and controlling of the refiner on basis of said comparing.

12. The method according to claim 11, wherein the step of monitoring includes the step of monitoring by means of a spectrometric method.

13. The method according to claim 12, wherein the step of monitoring by means of a spectrometric method includes the step of using ultra-violet, infrared, near-infrared, or visible light in the spectrometric method.

14. The method according to any one of the claims 10 to 13, wherein the step of refining includes the step of shearing the chips into wood particles.

15. The method according to any one of claims 10 to 14, wherein the step of refining includes the step of disc milling, wherein the disc mill comprises a first fixed flat disc, a second movable disc arranged opposite to the first fixed flat disc, the second disc comprises a set of various ramp-shaped protrusion on a surface facing the first disc, wherein the second disc is arranged to spin at its centre axis and exert a milling force such that intermediate wood chips are exposed to shearing forces.

16. The method of any one of claims 10 to 15, wherein the step of chipping includes the step of translating the wood chips from the chipping step to the refining step.

17. The method of any one of claims 10 to 16, further comprising the step of applying a cooling liquid over the wood material, downstream the chipping step or downstream the refining step.

18. The method according to claim 11, wherein the step of monitoring includes the step of monitoring by

means of a picture or image scanning.

19. A computer program product, which when executed on a computer, performs steps in accordance with any one claim 10 to 18.

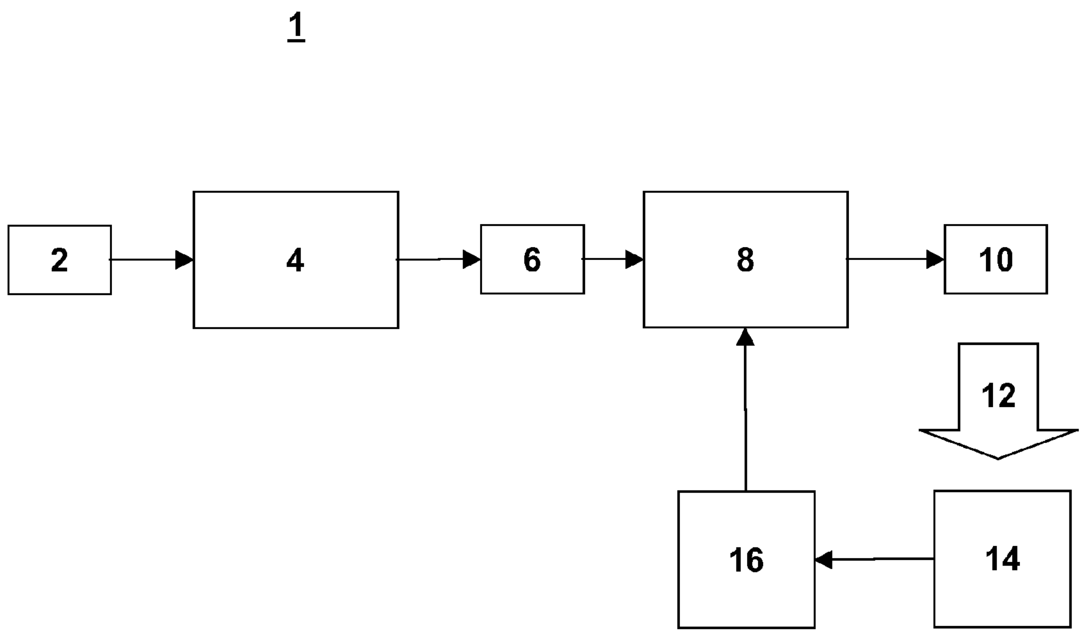

Fig. 1

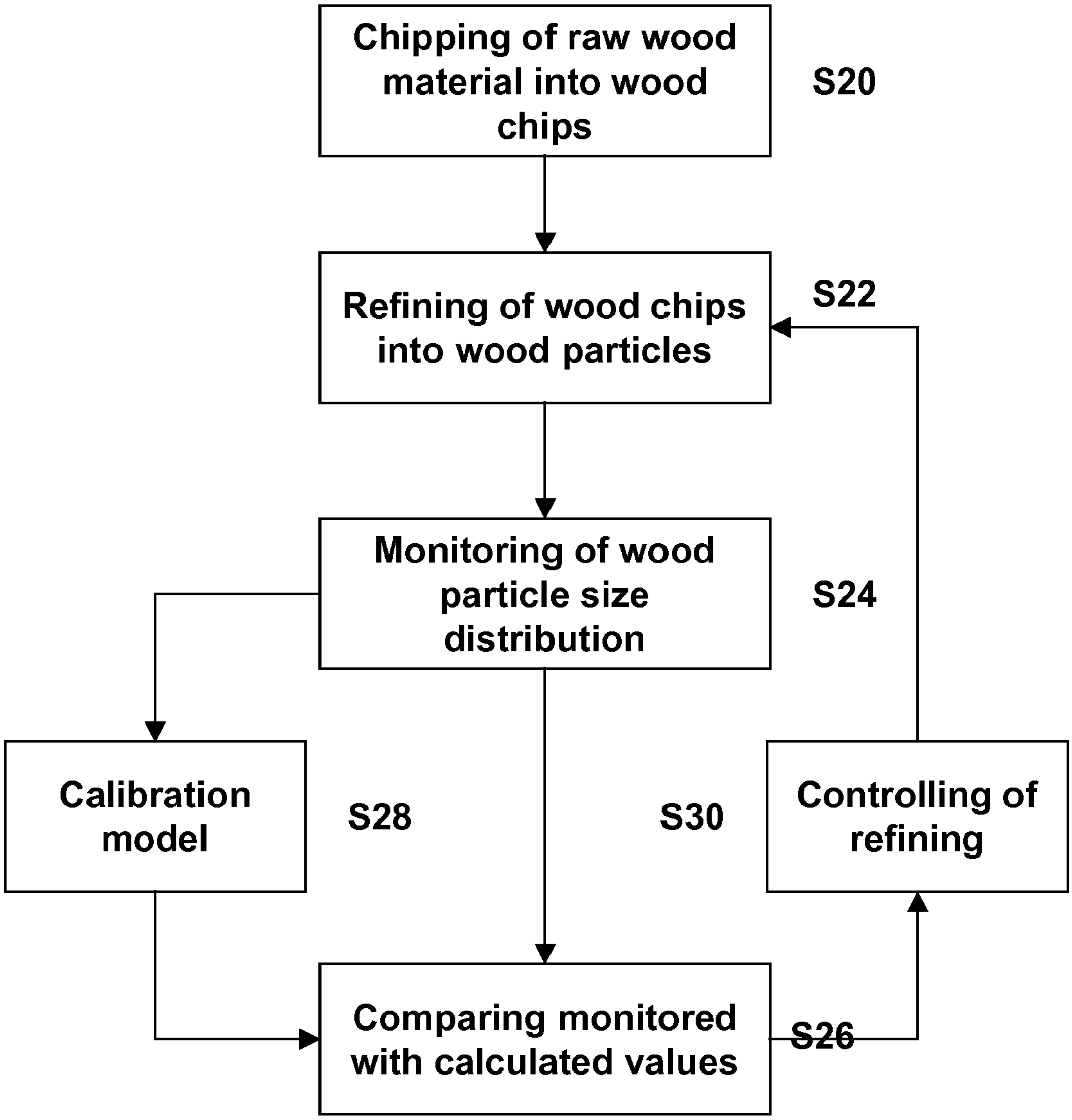
Chipping of raw wood material into wood chips
S20
Refining of wood chips into wood particles
S22
Monitoring of wood particle size distribution
S24
Calibration model
S28
S30
Controlling of refining
Comparing monitored with calculated values
S26

Fig. 2

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Application Number
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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	5 March 2008	Hamel, Pascal

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

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The Hague	5 March 2008	Hamel, Pascal

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