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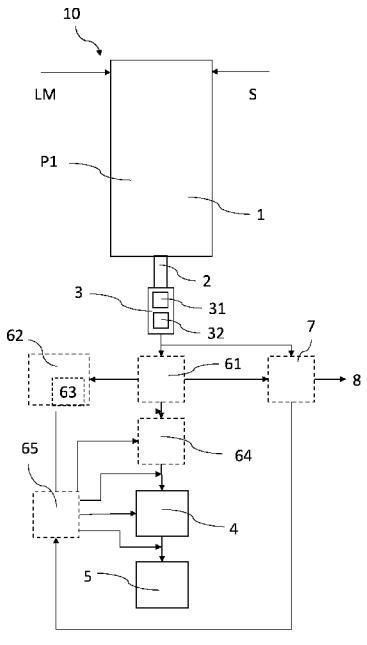

Fig 1

(57) Abstract: The present invention relates to a method for producing fiberboard or glue powder for fiberboard production, comprising - supplying (11) lignocellulosic material (LM) to a reactor (1), - treating (12) the lignocellulosic material (LM) in the reactor (1), - discharging (13) the lignocellulosic material (LM) from the reactor (1) through an outfeed unit (2) to a pressure drop unit (3) that comprises a receiving portion (32) held at a lower pressure for causing steam explosion of the lignocellulosic material (LM) to create steam exploded fibers, and drying and pressing the steam exploded fibers to fiberboard or alternatively providing the steam exploded fibers as a glue powder. The invention also relates to a manufacturing arrangement.

METHOD AND ARRANGEMENT FOR PRODUCING A GLUE POWDER FOR FIBERBOARD PRODUCTION, AND METHOD FOR PRODUCING FIBERBOARD AND FIBERBOARD MANUFACTURING ARRANGEMENT

TECHNICAL FIELD

The present invention relates to the manufacture of fiberboard from a lignocellulosic material, primarily medium-density fiberboard (MDF) and high-density fiberboard (HDF). The invention also relates to producing a glue powder suitable for use in fiberboard production or as a fuel.

BACKGROUND

Fiberboard is a highly versatile material used in a variety of applications such as furniture, roofing, soundproofing and insulation. In particular medium-density fiberboard, MDF, and high-density fiberboard, HDF, are suitable for such applications. However, insulation fiberboard are also suitable.

Typically, fiberboard is manufactured by refining a lignocellulosic material and adding glue to bind the fibers together before pressing to form the finished product. One particular disadvantage of traditional fiberboard manufacturing is the need for large quantities of glue to hold the fibers together, in many applications as much as 10-20 % by weight of the fibers. Apart from the high costs caused by the additional of glue, many types of glue (such as urea-formaldehyde, for instance) contain harmful chemicals (e.g. formaldehyde) that damage both human health and the environment and that are hazardous both during manufacture and during recycling and handling of the fiberboards. There are attempts at replacing them with more environmentally friendly and less toxic glues, but such substances may be less useful in holding the fibers together and also often require a longer curing time so that the manufacturing time is increased.

There is therefore a need for improvements within this area, both with regard to decreasing the use of toxic substances and to creating a more cost-efficient manufacture of fiberboards.

SUMMARY

The object of the present invention is to eliminate or at least to minimize the problems discussed above. This is achieved by a method and arrangement for producing a glue powder for fiberboard production, a method for producing fiberboards and by a fiberboard manufacturing arrangement according to the appended independent claims.

The method for producing glue powder according to the invention comprises

- supplying lignocellulosic material to a reactor,
- treating the lignocellulosic material in the reactor at a pressure of 12 bar – 30 bar for a retention time of 1 min – 30 min,
- discharging the lignocellulosic material from the reactor through an outfeed unit to a pressure drop unit that comprises a receiving portion held at a pressure lower than the pressure in the reactor for causing steam explosion of the lignocellulosic material to create steam exploded fibers with a diameter of 2 mm or less that form a glue powder, and
- receiving (44) the glue powder in a storage unit.

By using steam explosion in this way, a highly suitable glue powder is produced in a very efficient way, thereby providing a cost and energy efficient glue powder that can be used in fiberboard manufacturing and other applications. This in turn decreases or even eliminates the need for other glues, in particular such that contain harmful chemicals or that carry a high cost. The glue powder can also be used as a wood dust for fuel, suitably in a lime kiln, thereby providing a fuel in a highly cost and energy efficient manner.

Suitably, the method thus comprises adding the glue powder in fiberboard production to form fiberboard. Thereby, fiberboard can be manufactured in a cost efficient and reliable manner and harmful chemicals can be avoided.

Also, the method may comprise using the glue powder as fuel, preferably in a lime kiln.

The invention also comprises a glue powder manufacturing arrangement comprising

- a reactor for treating lignocellulosic material at a pressure of 12 bar – 30 bar for a retention time of 1 min – 30 min,
- an outfeed unit for discharging the lignocellulosic material from the reactor,
- a pressure drop unit for receiving lignocellulosic material from the outfeed unit, said pressure drop unit comprising a receiving portion held at a pressure lower than the pressure in the reactor so that the lignocellulosic material is steam exploded at discharge into the receiving portion to form steam exploded fibers with a diameter of 2 mm or less that form a glue powder, and
- a storage unit for receiving the glue powder.

This allows for the cost and energy efficient manufacture of the glue powder as disclosed above.

In some embodiments, the storage unit is connected to a glue applicator for supplying glue in a fiberboard manufacturing arrangement. Thereby, the glue powder can be supplied to an arrangement that produces fiberboard and can be used as glue directly.

In other embodiments, the glue powder is instead supplied as fuel to a remote location on the same site as the glue powder manufacturing arrangement or on another site. Suitably, the glue powder is used in a lime kiln as fuel.

The method for producing fiberboard of the present invention comprises

- supplying lignocellulosic material to a reactor
- treating the lignocellulosic material in the reactor at a first pressure,
- discharging the lignocellulosic material from the reactor through an outfeed unit to a pressure drop unit that comprises a receiving portion held at a second pressure, said second pressure being lower

than the first pressure for causing steam explosion of the lignocellulosic material to create steam exploded fibers,

- drying the steam exploded fibers, and
- pressing at least the steam exploded fibers to form fiberboard.

By using a steam explosion method for manufacturing fiberboard rather than traditional methods, it has surprisingly been found that fiberboard may be made in a reliable and cost-effective way significantly decreasing or even eliminating the need for adhesives or glues. This is achieved by the steam exploded fibers having an increased ability to adhere to each other so that a stable fiberboard is achieved. Significant improvements with regard to both efficiency of manufacturing, a cost-effective process and a less hazardous fiberboard are achieved due to this method.

Suitably, the steam exploded fibers may be refined before drying and pressing. Thereby, the fibers may be adjusted as desired to improve the fiberboard manufactured in this way. Also, by refining the fibers after steam explosion a highly efficient refining may be performed at a lower energy consumption than in traditional refining where lignocellulosic material is refined without prior treatment to disintegrate the fibers.

In some embodiments, the method may comprise adding a glue to the steam exploded fibers before drying, wherein the added glue is less than 10 % by oven dry weight, preferably less than 5 % by oven dry weight and more preferably less than 3 % by oven dry weight of the steam exploded fibers. Thereby, the amount of glue can be kept significantly lower than in traditional fiberboards, rendering the fiberboard both cost effective and environmentally friendly.

In embodiments comprising both refining and adding glue, the glue may be applied before refining or alternatively during refining. This is advantageous in providing the glue where a thorough mixing with the fibers during refining takes place.

Suitably, the method also comprises separating steam from the steam exploded fibers and removing volatile organic compounds, VOC, from the

steam. Thereby, volatile organic compounds, VOC, present in the lignocellulosic material before steam explosion takes place may be reduced in a secure and reliable way to reduce emission of compounds and decrease the content of such compounds in the exhaust air after drying. Also, the method may comprise transforming the removed volatile organic compounds, VOC, to liquid form. This renders them more easily handled to facilitate further treatment of valuable biological chemicals and transport or burning of the compounds.

The method may also suitably be used to continuously produce fiberboard. This is particularly advantageous since the benefits of a continuous process as compared with a batch process (mainly a higher throughput and a more uniform quality of the finished fiberboard) may be achieved.

However, the invention may in other embodiments be used in a batch process if desired.

Suitably, the method also comprises removing steam exploded fibers to form a glue powder and using said glue powder when adding glue to the steam exploded fibers. Thereby, a highly energy efficient and suitable glue is produced, decreasing or even eliminating the need for adding glues containing harmful chemicals.

Alternatively, the method also comprises removing steam exploded fibers to form a wood dust and using said wood dust as fuel. Thereby, a highly energy efficient and environmentally friendly fuel is achieved. In some embodiments, the wood dust may be used in a lime kiln at a remote location at the same site where the wood dust is produced, or at a different site.

The present invention also comprises a fiberboard manufacturing arrangement that comprises

- a reactor for treating lignocellulosic material at a first pressure,
- an outfeed unit for discharging the lignocellulosic material from the reactor,

- a pressure drop unit for receiving lignocellulosic material from the outlet, said pressure drop unit that comprises a receiving portion held at a second pressure lower than the first pressure so that the lignocellulosic material is steam exploded at discharge from the outlet to form steam exploded fibers,
- a dryer for removing moisture from the steam exploded fibers, and
- a press assembly for pressing at least the steam exploded fibers to form fiberboard.

This arrangement achieves the advantages of manufacturing fiberboard with a significantly reduced or even eliminated need for adding adhesives such as glue, due to the use of steam explosion that both disintegrates the fibers of the lignocellulosic material and increases their ability to adhere to each other when pressing to form fiberboard.

Suitably, the arrangement also comprises a refiner for refining the steam exploded fibers, wherein the refiner is arranged in the fiberboard manufacturing arrangement between the receiver and the dryer. Thereby, the fibers may be adjusted as desired to achieve an improved fiberboard.

Also, by arranging the refiner after the outlet where steam explosion takes place, the refiner requires significantly less energy for refining the fibers as compared with refiners operating with lignocellulosic material that has not undergone steam explosion.

In some embodiments, the arrangement also comprises a glue applicator for applying a glue to the steam exploded fibers, wherein the glue applicator is arranged in the fiberboard manufacturing arrangement before the press assembly and optionally also before the dryer or configured to supply glue to the dryer, and wherein further the glue applicator is configured to add less than 10 % by oven dry weight, preferably less than 5 % by oven dry weight and more preferably less than 3 % by oven dry weight to the steam exploded fibers. This enables the addition of glue in embodiments where it is desired to have an adhesive present in the fiberboard but it is particularly advantageous that less than 10 %, and preferably less than 5 % or even less

than 3 % by oven dry weight is added since this causes the fiberboard to be both cost-effective and environmentally friendly as well as less toxic for humans.

In some embodiments comprising both a refiner and a glue applicator, the glue applicator is arranged before the refiner or the glue applicator is configured to supply glue to the refiner. Thereby, a thorough mixing of the glue and the steam exploded fibers is achieved.

Also, the arrangement may comprise a steam separator for separating steam from the steam exploded fibers, wherein the steam separator is arranged in the fiberboard manufacturing arrangement after the outlet of the reactor. This allows for the removal of steam from the steam exploded material. Also, the arrangement may comprise a VOC treatment unit for treating volatile organic compounds, VOC, wherein the VOC treatment unit is operatively connected to the steam separator for receiving separated steam. Thereby, volatile organic compounds, VOC, present in the lignocellulosic material may be treated to prevent emissions from the fiberboard manufacturing arrangement, in particular from exhaust air from the dryer.

Furthermore, in embodiments comprising the VOC treatment unit there may be a transformation device for transforming the recovered volatile organic compounds, VOC, to liquid form. This is particularly advantageous in facilitating handling and further treatment and transport of the volatile organic compounds, VOC.

Suitably, the fiberboard manufacturing arrangement is configured for continuous manufacture of fiberboard. This enables a highly efficient operation with a uniform quality of the finished fiberboard.

In some embodiments, however, the fiberboard manufacturing arrangement may instead be configured for batch operation.

Suitably, the fiberboard manufacturing arrangement comprises a storage unit for storing steam exploded fibers. Thereby, steam exploded fibers may be removed after steam explosion and stored for further use.

In some embodiments, the storage unit is operatively connected to the glue applicator for supplying stored steam exploded fibers as a glue powder to the glue applicator. Thereby, the removed steam exploded fibers may be used as a glue powder in the fiberboards.

In other embodiments, the stored steam exploded fibers may instead be removed and used as fuel, preferably in a lime kiln.

Many additional benefits and advantages of the present invention will be readily understood by the skilled person in view of the detailed description below.

DRAWINGS

The invention will now be described in more detail with reference to the appended drawings, wherein Fig. 1 discloses schematically the fiberboard manufacturing arrangement according to a first embodiment;

Fig. 2 discloses schematically the method according to the first embodiment of the invention;

Fig. 3 discloses schematically the glue powder manufacturing arrangement according to a first embodiment; and

Fig. 4 discloses schematically the method for producing glue powder according to the first embodiment.

All the figures are schematic, not necessarily to scale, and generally only show parts which are necessary in order to elucidate the respective embodiments, whereas other parts may be omitted or merely suggested. Any reference number appearing in multiple drawings refers to the same object or feature throughout the drawings, unless otherwise indicated.

DETAILED DESCRIPTION

The term lignocellulosic material is used herein to mean materials containing lignin, cellulose and hemicellulose. One example of such material is wood, others include other agricultural or forestry residues.

The terms upstream and downstream as used herein refer to how lignocellulosic material passes through the defibration system. Thus, a downstream direction will be a direction along which a flow of lignocellulosic material passes, whereas an upstream direction will be a direction against the flow of lignocellulosic material. Also, when it is stated that a component is arranged "before" another, this is to be understood as that component being upstream. Similarly, a component arranged "after" another is to be understood as being downstream.

It is also to be noted that features from the various embodiments described herein may freely be combined, unless it is explicitly stated that such a combination would be unsuitable.

The steam explosion process is a known way of disintegrating lignocellulosic material and will not be described in detail herein but rather outlined in general terms before the invention as such is described with reference to the embodiments of the Figures.

Thus, before undergoing steam explosion, a lignocellulosic material may undergo a pre-treatment such as a screening for removal of unwanted parts such as sand or gravel that could cause wear and blockages. There may also be an initial treatment to soften the material such as steaming. The lignocellulosic material is then inserted into a reactor and treated there at an elevated temperature, typically in the range 170-215 °C, and elevated pressure, typically in the range 10-25 bar, so that the lignocellulosic material undergoes a hydrolysis. The selection of temperature and pressure as well as the treatment time in the reactor and other operational parameters may depend on properties of the lignocellulosic material and desired parameters of the hydrolysis inside the reactor.

After treatment, the lignocellulosic material is discharged through an outfeed unit to a pressure drop unit where there is a significantly lower pressure than

inside the reactor, typically around 4-5 bar. By the lignocellulosic material being subjected to a pressure drop in the pressure drop unit, the lignocellulosic material expands suddenly causing a disintegration of fibers in the lignocellulosic material. This expansion is known as steam explosion.

The pressure drop in the pressure drop unit takes place by the lignocellulosic material passing through an orifice or valve into a conduit, pipe or vessel at a lower pressure. If a valve is used, the valve may be a blow valve, a ball valve (such as a segmented ball valve), or a rotating valve. Other kinds of valves or discharge components may also be used as long as a controlled discharge of the lignocellulosic material can be achieved, and the steam explosion can take place.

After the steam explosion has taken place, steam may be separated from the steam exploded fibers and the fibers may be transported to other components for further treatment such as washing, drying, or similar. Typically, steam explosion is used for making bioethanol, for producing biochemicals, or for making pellets.

The invention will now be described in detail with reference first to Fig. 1 that schematically shows the fiberboard manufacturing arrangement 10 and then to Fig. 2 that schematically shows the method for manufacturing fiberboard. Subsequently, the glue powder manufacturing arrangement 10' will be described with reference to Fig. 3 and then the method for producing the glue powder will be described with reference to Fig. 4.

The invention is particularly useful for producing MDF or HDF, but also for producing insulation board. It may also be used for other kinds of fiberboard.

Thus, Fig. 1 discloses the fiberboard manufacturing arrangement 10 with optional features of the invention disclosed in dashed boxes. Lignocellulosic material LM and steam S are fed into a reactor 1 and treated there at a first pressure P1 that may be in the range 10-25 bar but may optionally be higher or lower than that. In order for steam explosion to take place, the first pressure P1 should be higher than a second pressure P2 of a pressure drop unit 3 but the magnitude of both the first pressure P1 and the second pressure P2 may

be selected depending on features of the lignocellulosic material or of the treatment in the reactor 1, or other factors. The first pressure P1 and second pressure P2 may be constant or may alternatively vary as long as a difference between them is large enough for steam explosion to take place. Suitably, the second pressure P2 is in the range 4-5 bar

Optionally, there may be pre-treatment of the lignocellulosic material LM before it enters the reactor 1 such as screening, steaming, or other pre-treatments that are suitable depending on any given application of the present invention.

When the lignocellulosic material LM in the reactor 1 has been treated, it is discharged through an outfeed unit 2 into the pressure drop unit 3. The discharge is controlled in that it takes place through an outfeed unit 2 to ensure a desired flow of material into the pressure drop unit 3. The outfeed unit 2 may comprise any components that are known in the art to be suitable for discharging lignocellulosic material from a reactor.

The pressure drop unit 3 is connected to the outfeed unit 2 and comprises an orifice or valve 31 that serves to feed the lignocellulosic material in a controlled manner to a receiving portion 32 that may comprise a conduit, pipe, vessel or bin and that is held at the second pressure P2. The orifice 31 may be an opening of a controlled size and optionally a variable size so that a known volume of lignocellulosic material is able to pass through the orifice. Alternatively, a valve 31 such as a blow valve, a ball valve (such as e.g. a segmented ball valve), or a rotating valve, or any other suitable type of valve or discharge means, may alternatively be used as long as a controlled discharge of lignocellulosic material LM may be achieved.

The receiving portion 32 of the pressure drop unit 3 may, as mentioned above, be any suitable component that may be held at the second pressure P2 and that may receive the lignocellulosic material LM from the reactor 1 through the orifice or valve 31. As the lignocellulosic material LM passes through the outfeed unit 2 and passes the orifice or valve into the receiving portion 32 of the pressure drop unit 3, the pressure drop from the first pressure P1 of the

reactor 1 to the second pressure P2 of the receiving portion causes steam explosion of the lignocellulosic material LM to form steam exploded fibers.

After passing through the pressure drop unit 3, the steam exploded fibers are transported to a dryer 4 for reducing moisture content in the steam exploded fibers, and afterwards to a press assembly 5 where at least the steam exploded fibers are pressed to form fiberboard. The fiberboard may be made from the steam exploded fibers created by the fiberboard manufacturing arrangement of the invention but may alternatively also be made from such steam exploded fibers mixed with other fibers. Such other fibers may be recycled MDF/HDF fibers, steam exploded fibers from other sources than the present invention, or refined fibers from a conventional refining process. Other fibers may also be included in the fiberboard formed in the fiberboard manufacturing arrangement 10 according to the invention. Thus, when it is said that the press assembly 5 is configured to press at least the steam exploded fibers to fiberboard, this is to be understood as the press assembly 5 being configured to press the steam exploded fibers and optionally also other fibers to form a fiberboard.

In some embodiments, a steam separator 61 may be provided after the outfeed unit 2 or suitably also after the pressure drop unit 3 but before the dryer 4 for separating steam and gas such as volatile organic compounds VOC from the steam exploded fibers. The steam and gas may in such embodiments be operatively connected to a VOC treatment unit 62 configured to gain volatile organic compounds VOC. The steam and gas are thus transported to the VOC treatment unit 62 and may be separated there so that the steam is removed from the gas. Advantageously the VOC treatment unit 62 may comprise a transformation device 63 that transforms the gained volatile organic compounds, VOC, to liquid form. This is beneficial in facilitating the further treatment of liquid biological chemicals from the volatile organic compounds, VOC, and also transport and handling of the volatile organic compounds, VOC. The volatile organic compounds, VOC, typically comprise volatile wood resins, volatile hemicellulose and terpene. Optionally, the volatile organic

compounds, VOC, may be transported in gas form or liquid form to a destruction site for burning or other destruction.

Also, in some embodiments the fiberboard manufacturing arrangement 10 comprises a refiner 64 that is arranged after the pressure drop unit 3 but before the dryer 4, and that may be operated to refine the steam exploded fibers to adjust them by e.g. separating any fiber bundles that may be present after steam explosion. This is advantageous in situations where it is desired to manufacture fiberboard from fibers that are different than achieved by the steam explosion alone. Adjusting the fibers in this way is suitable for some kinds of fiberboard and may also be beneficial depending on the raw material used to form the lignocellulosic material LM and the extent to which the lignocellulosic material LM has undergone hydrolysis in the reactor 1.

Compared with conventional refining, it requires significantly less energy to refine fibers that have already been disintegrated by steam explosion. Thus, even when a refiner 64 is added to the fiberboard manufacturing arrangement 10 this is more energy efficient than when fiberboard is manufactured by a conventional refining process without also undergoing steam explosion.

In some embodiments, the fiberboard manufacturing arrangement 10 also comprises a glue applicator 65 that is arranged before the press assembly 5 in order to supply an adhesive such as glue to the steam exploded fibers. The glue applicator 65 may in some embodiments be arranged to add the glue before the dryer 4 so that the steam exploded fibers are mixed with glue already before drying commences. In other embodiments, the glue may optionally also be added during the drying in the dryer 4. In yet other embodiments, the glue may be added before the refiner 64 or during refining in the refiner 64. The glue applicator 65 may comprise at least one nozzle for spraying glue but may optionally comprise other ways of supplying the glue to the steam exploded fibers. The glue used with the present invention may be any adhesive suitable for producing fiberboard, such as urea-formaldehyde (UF) or melamine urea-formaldehyde resin (MUF). It is however to be noted that the present invention is not limited to any particular kind of adhesive or glue.

In some embodiments, the glue applicator 65 may be configured to add glue in more than one part of the fiberboard manufacturing arrangement 10. For instance, glue may be supplied both before the dryer and directly into the dryer.

In some embodiments, as much glue as 10 % by oven dry weight of the steam exploded fibers may be added, but in most applications less glue will be required. Suitably, less than 10 % glue and preferably less than 5 % or even less than 3 % by oven dry weight of the steam exploded fibers is supplied by the glue applicator 65. As the steam exploded fibers are of hydrophobic nature the adding of wax which is used in known prior art arrangements and methods for manufacturing fiberboard may be reduced or even eliminated.

In embodiments where glue is to be added to the steam exploded fibers, a desired amount of glue may be determined before manufacture begins but alternatively the amount of glue may be adjusted during use of the fiberboard manufacturing arrangement 10. Thus, glue may be adjusted depending on a quality of manufactured fiberboard after pressing in the press assembly 5 or alternatively depending on properties of the lignocellulosic material LM, the steam exploded fibers, or properties or operational parameters of the reactor 1.

The fiberboard manufacturing arrangement 10 of the embodiment of Fig. 1 is configured for continuous manufacture of fiberboard. In other embodiments, the invention may instead be used in batch manufacturing requiring only minor modifications typically associated with the adjustment from continuous to batch manufacture using steam explosion. Such modifications comprise ensuring that the reactor 1 is pressure sealed and this may be achieved in a number of known ways.

The finished fiberboard may thus be completely free from glue or may alternatively comprise a small quantity of glue. In particular, the fiberboard of the present invention comprises less than 5 % by oven dry weight and more preferably less than 3 % by oven dry weight of glue. In this fiberboard, the steam exploded fibers themselves contribute to the adherence of fibers to each

other which is highly beneficial since it reduced both toxicity and environmental impact of the fiberboard during manufacture, use and recycling or disposal.

In some embodiments, at least a portion of the steam exploded fibers are led to a storage unit 7 from the steam separator 61 or directly from the pressure drop unit 3 where steam explosion takes place. This portion of steam exploded fibers forms a wood dust or glue powder that can be used in the glue applicator 65 as glue in the fiberboards or that can alternatively be led from the storage unit 7 to a remote location 8 to be used as fuel. The remote location 8 may be a location at the same site that produces fiberboard according to the present invention or may alternatively be another site. In one particularly advantageous embodiment, the wood dust is used as fuel in a lime kiln. Using steam explosion as disclosed herein to produce glue powder for use as fuel is a highly advantageous an energy efficient way of producing fuel when compared with known prior art methods such as hammer mills.

The terms wood dust and glue powder are used interchangeably herein to denote a material comprising steam exploded fibers with a diameter of 2 mm or less. This material can be used either as fuel (primarily denoted as wood dust) or as glue (primarily denoted as glue powder).

In embodiments where the glue powder is to be used as glue in the fiberboards, the storage unit 7 may be integrated with the glue applicator 65 or may alternatively be connected to the glue applicator 65 by a connection or conduit so that glue powder is transported to the glue applicator 65 continuously or in batches.

In order to produce glue powder from the steam exploded fibers, it is advantageous to select operational parameters in the reactor 1 to ensure that the steam exploded fibers are small (suitably with a diameter of 2 mm or less) in order to form a powder. A pressure in the reactor 1 is in such embodiments suitably in the range 12 bar – 30 bar and a retention time in the reactor is suitably 1 min – 30 min. A suitable amount of steam is in the interval 100 kg/ton to 800 kg/ton. When using these parameters, an expected production

of furfural as a volatile organic compound, VOC, is in the range 1 kg/ton to 15 kg/ton of lignocellulosic material used. In some embodiments, the pressure is instead in the range 15 bar – 30 bar and the retention time is 5 min – 30 min.

In one advantageous setup, a pressure of 18 bar and a retention time of 15 min was used to produce glue powder from steam exploded fibers in accordance with the present invention.

When the resulting glue powder is mixed into fibers for making fiberboard, it acts as a natural glue and minimizes or even eliminates the need for adding conventional glue that often contains harmful chemicals. In some embodiments, the glue powder may also be mixed with other types of glue if suitable. When using the glue powder in fiberboard, the amount of glue powder is suitably 1.5 % - 15 % of a total weight of the fiberboard when no other types of glue are used. The so produced glue powder can be the only glue used in the fiberboards or can be in mixture with other glues, either biobased or based on oil, in various percentage splits as suitable for each application.

Using the glue powder as disclosed herein is particularly advantageous when fiberboard is produced from steam exploded fibers mixed with other fibers as disclosed herein, since such other fibers typically require addition of a glue to form the fiberboards. Also, in some embodiments, operational parameters of the reactor 1 may be changed to produce steam exploded fibers small enough to form glue powder or wood dust at certain times while at other times producing larger steam exploded fibers to form fiberboards, and to which larger fibers the glue powder may be supplied as glue. In such embodiments, a batch of glue powder may be produced as desired when the amount present in the storage unit 7 is small or running out, so that a stock of glue powder may then be used for a length of time during continuous production of fiberboard as disclosed herein.

Fig. 2 discloses schematically a method according to the present invention, with dashed steps indicating optional steps of the method. As in Fig. 1,

optional pre-treatments of the lignocellulosic material LM are not included in the drawing but are already well-known in the prior art.

According to the method of the present invention, lignocellulosic material LM is supplied 11 to the reactor 1 and treated 12 there in the manned described above. The lignocellulosic material LM is then discharged 13 through the outfeed unit 2 and into the pressure drop unit 3 so that the lignocellulosic material LM undergoes steam explosion there. Then, the steam exploded fibers are dried 14 before being pressed 15 to form fiberboard. The fiberboard formed according to the inventive method may comprise only the steam exploded fibers or may optionally also comprise other fibers that are mixed with the steam exploded fibers before the fiberboard is pressed.

The method may be performed continuously or may optionally be used in batch manufacture of fiberboard.

Optionally, steam may be separated 21 from the steam exploded fibers after discharge 13 from the outfeed unit 2 of the reactor 1 and steam explosion in the pressure drop unit 3. In embodiments where some steam is separated 21, there may also be an optional step of removing 24 volatile organic compounds, VOC, and optionally also of transforming 25 volatile organic compounds, VOC, to liquid form. It may then be transported to further treatment or destruction, as desired.

In some embodiments, the method may also comprise refining 22 the steam exploded fibers before drying 14 and pressing 15 to form fiberboard.

There may also be an optional step of adding 23 glue, either before drying 14, before refining 22, or before pressing 15, or even during drying 14 or refining 22. This is indicated by dashed boxes with numeral 23 inserted between steps of the method and also into the boxes indicating the steps of refining 22 and drying 14. When adding glue, less than 10 % by oven dry weight of the steam exploded fibers is added, and preferably less than 5 % by oven dry weight or even less than 3 % of oven dry weight.

Furthermore, there may be an optional step of removing 26 steam exploded fibers to form a wood dust or glue powder, either directly after the steam exploded fibers are discharged 13 or after steam is separated 21 from the steam exploded fibers. The steam exploded fibers removed is suitably a portion of the total amount of steam exploded fibers that are discharged 13, so that the remaining steam exploded fibers are used to form fiberboard as disclosed herein.

Optionally, the wood dust or glue powder formed by removing 26 steam exploded fibers may be used when adding 23 glue as disclosed above, or in other embodiments the wood dust may instead be transported 27 to a remote location and be used as fuel, preferably in a lime kiln.

Fig. 3 discloses the glue powder manufacturing arrangement 10' according to the invention. Since this arrangement also uses steam explosion, those components that are identical or similar to the fiberboard manufacturing arrangement 10 disclosed above are denoted by the same reference numerals followed by a prime, '. Thus, lignocellulosic material LM and steam S are introduced into the reactor 1' and treated before being discharged through the outfeed unit 2' to the pressure drop unit 3' with the orifice or valve 31' that feeds the lignocellulosic material LM to the receiving portion 32' that is at a lower pressure so that steam explosion can take place. The steam exploded fibers are then collected in the storage unit 7 in the form of the glue powder or wood dust (hereinafter referred to collectively as glue powder).

In order for the steam exploded fibers to be useful as a glue powder or wood dust for fuel, the fibers should be very small (i.e. having a diameter of 2 mm or less) and this is achieved by treating the lignocellulosic material LM in the reactor 1' at a pressure of 12 bar – 30 bar for a retention time of 1 min – 30 min. In some embodiments, the pressure is instead in the range 15 bar – 30 bar and the retention time is 5 min – 30 min.

A suitable amount of steam is in the interval 100 kg/ton to 800 kg/ton. When using these parameters, an expected production of furfural as a volatile

organic compound, VOC, is in the range 1 kg/ton to 15 kg/ton of lignocellulosic material used.

In one advantageous setup, a pressure of 18 bar and a retention time of 15 min was used to produce glue powder from steam exploded fibers in accordance with the present invention.

After reaching the storage unit 7, the glue powder is in some embodiments supplied to a glue applicator 65' to be used as glue in a fiberboard production arrangement or in any other process where glue is needed. Alternatively or additionally, the glue powder may be supplied to a remote location 8 to be used as fuel. The remote location may be at the same site as the glue powder is produced but be a different component or arrangement, or alternatively the remote location may be at another site that is at a distance from where the glue powder is being produced. This means that the glue powder may be supplied continuously or in batches to be used as fuel depending on the distance from the production of glue powder to the remote location 8. In one highly advantageous embodiment, the glue powder is used as fuel in a lime kiln where it replaces more cost and energy intensive fuels to provide a cheap and easily manufactured fuel.

Fig. 4 discloses the method for producing glue powder, showing the steps of supplying 41 the lignocellulosic material to the reactor 1', treating 42 the lignocellulosic material LM at the pressure and retention time given above, discharging 43 the lignocellulosic material LM from the reactor 1' through the outfeed unit 2' to the pressure drop unit 3' that comprises the receiving portion 32' so that steam explosion takes place at the pressure drop from the orifice or valve 31' to the receiving portion 32', and receiving 44 the steam exploded fibers that form the glue powder in the storage unit 7. The figure also discloses the optional steps of adding 23 the glue powder to a fiberboard production arrangement and of using 45 the glue powder as fuel, preferably in a lime kiln.

It is to be noted that embodiments disclosed herein may freely be combined, in particular that the method and arrangement for producing the glue powder may take place in the arrangement and according to the method for producing

fiberboard. The glue powder is a powder made from very small steam exploded fibers, and these fibers may be manufactured according to the arrangement for producing fiberboard and the fiberboard manufacturing method if the operational parameters are selected to be suitable for producing very small fibers through steam explosion. Also, any details and parameters given for the production of glue powder in the method or arrangement for producing fiberboard may freely be implemented in the method and arrangement for producing glue powder, and vice versa.

CLAIMS

1. Method for producing glue powder, the method comprising
- supplying (41) lignocellulosic material (LM) to a reactor (1'),
- treating (42) the lignocellulosic material (LM) in the reactor (1') at a pressure of 12 bar – 30 bar for a retention time of 1 min – 30 min,
- discharging (43) the lignocellulosic material (LM) from the reactor (1') through an outfeed unit (2') to a pressure drop unit (3') that comprises a receiving portion (32') held at a pressure lower than the pressure in the reactor for causing steam explosion of the lignocellulosic material (LM) to create steam exploded fibers with a diameter of 2 mm or less that form a glue powder,
- receiving (44) the glue powder in a storage unit (7).

2. Method according to claim 1, further comprising
- adding (23) the glue powder in fiberboard production to form fiberboard.

3. Method according to claim 1, further comprising
- using (45) the glue powder as fuel, preferably in a lime kiln.

4. Glue powder manufacturing arrangement comprising
- a reactor (1') for treating lignocellulosic material (LM) at a pressure of 12 bar – 30 bar for a retention time of 1 min – 30 min,
- an outfeed unit (2') for discharging the lignocellulosic material (LM) from the reactor (1'),
- a pressure drop unit (3') for receiving lignocellulosic material (LM) from the outfeed unit (2'), said pressure drop unit (3') comprising a receiving portion (32') held at a pressure lower than the pressure in the reactor so that the lignocellulosic material (LM) is steam exploded at discharge into the receiving portion (32') to form steam exploded fibers with a diameter of 2 mm or less that form a glue powder, and
- a storage unit (7) for receiving the glue powder.

5. Glue powder manufacturing arrangement according to claim 4, wherein the storage unit (7) is connected to a glue applicator (65) for supplying glue in a fiberboard manufacturing arrangement.

6. Method for producing fiberboard, comprising
   - supplying (11) lignocellulosic material (LM) to a reactor (1),
   - treating (12) the lignocellulosic material (LM) in the reactor (1) at a first pressure (P1,
   - discharging (13) the lignocellulosic material (LM) from the reactor (1) through an outfeed unit (2) to a pressure drop unit (3) that comprises a receiving portion (32) held at a second pressure (P2), said second pressure (P2) being lower than the first pressure (P1) for causing steam explosion of the lignocellulosic material (LM) to create steam exploded fibers,
   - drying (14) the steam exploded fibers, and
   - pressing (15) at least the steam exploded fibers to form fiberboard.

7. Method according to claim 6, further comprising
   - refining (22) the steam exploded fibers before drying (14) and pressing (15).

8. Method according to claim 6 or 7, further comprising
   - adding (23) a glue to the steam exploded fibers before pressing (15), preferably before drying (14), wherein the added glue is less than 10 % by oven dry weight, preferably less than 5 % by oven dry weight and more preferably less than 3 % by oven dry weight of the steam exploded fibers.

9. Method according to claim 8 when dependent on claim 7, wherein the glue is added (23) before or during refining (22).

10. Method according to any of claims 6-9, further comprising
   - separating (21) steam from the steam exploded fibers

- removing (24) volatile organic compounds (VOC) from the steam.

11. Method according to claim 10, further comprising
- transforming (25) the removed volatile organic compounds, VOC, to liquid form.

12. Method according to any of claim 6-11, wherein fiberboard is produced continuously according to the steps of the method.

13. Method according to any of claims 6-12, further comprising removing (26) steam exploded fibers to form a glue powder and using said glue powder when adding (23) glue to the steam exploded fibers.

14. Method according to any of claims 6-12, further comprising removing (26) steam exploded fibers to form a wood dust and using said wood dust as fuel.

15. Fiberboard manufacturing arrangement comprising
- a reactor (1) for treating lignocellulosic material (LM) at a first pressure (P1),
- an outfeed unit (2) for discharging the lignocellulosic material (LM) from the reactor (1),
- a pressure drop unit (3) for receiving lignocellulosic material (LM) from the outfeed unit (2), said pressure drop unit (3) comprising a receiving portion (32) held at a second pressure (P2) lower than the first pressure (P1) so that the lignocellulosic material (LM) is steam exploded at discharge into the receiving portion (32) to form steam exploded fibers,
- a dryer (4) for removing moisture from the steam exploded fibers, and
- a press assembly (5) for pressing at least the steam exploded fibers to form fiberboard.

16. Fiberboard manufacturing arrangement according to claim 15, comprising

- a refiner (64) for refining the steam exploded fibers, wherein the refiner (64) is arranged in the fiberboard manufacturing arrangement between the pressure drop unit (3) and the dryer (4).

17. Fiberboard manufacturing arrangement according to claim 15 or 16, further comprising

- a glue applicator (65) for applying a glue to the steam exploded fibers, wherein the glue applicator is arranged in the fiberboard manufacturing arrangement before the press assembly (5) and optionally before the dryer (4) or configured to supply glue to the dryer (4), and wherein further the glue applicator (65) is configured to add less than 10 % by oven dry weight, preferably less than 5 % by oven dry weight and more preferably less than 3 % by oven dry weight to the steam exploded fibers.

18. Fiberboard manufacturing arrangement according to claim 17 when dependent on claim 11, wherein the glue applicator is arranged before the refiner (64) or wherein the glue applicator is configured to supply glue to the refiner (64).

19. Fiberboard manufacturing arrangement according to any of claims 15-18, further comprising

- a steam separator (61) for separating steam from the steam exploded fibers, wherein the steam separator (61) is arranged in the fiberboard manufacturing arrangement (10) after the pressure drop unit (3).

20. Fiberboard manufacturing arrangement according to claim 19, further comprising

- a VOC treatment unit (62) for treating volatile organic compounds, VOC, wherein the VOC treatment unit (62) is operatively connected to the steam separator (61) for receiving separated steam.

21. Fiberboard manufacturing arrangement according to claim 20, wherein the VOC treatment unit (62) comprises a transformation device (63) for transforming the volatile organic compounds, VOC, to liquid form.

22. Fiberboard manufacturing arrangement according to any of claims 15-21, wherein the fiberboard manufacturing arrangement (10) is configured for continuous manufacture of fiberboard.

23. Fiberboard manufacturing arrangement according to any of claims 15-22, further comprising a storage unit (7) for storing steam exploded fibers.

24. Fiberboard manufacturing arrangement according to claim 23, wherein the storage unit (7) is operatively connected to the glue applicator (65) for supplying stored steam exploded fibers as a glue powder to the glue applicator (65).

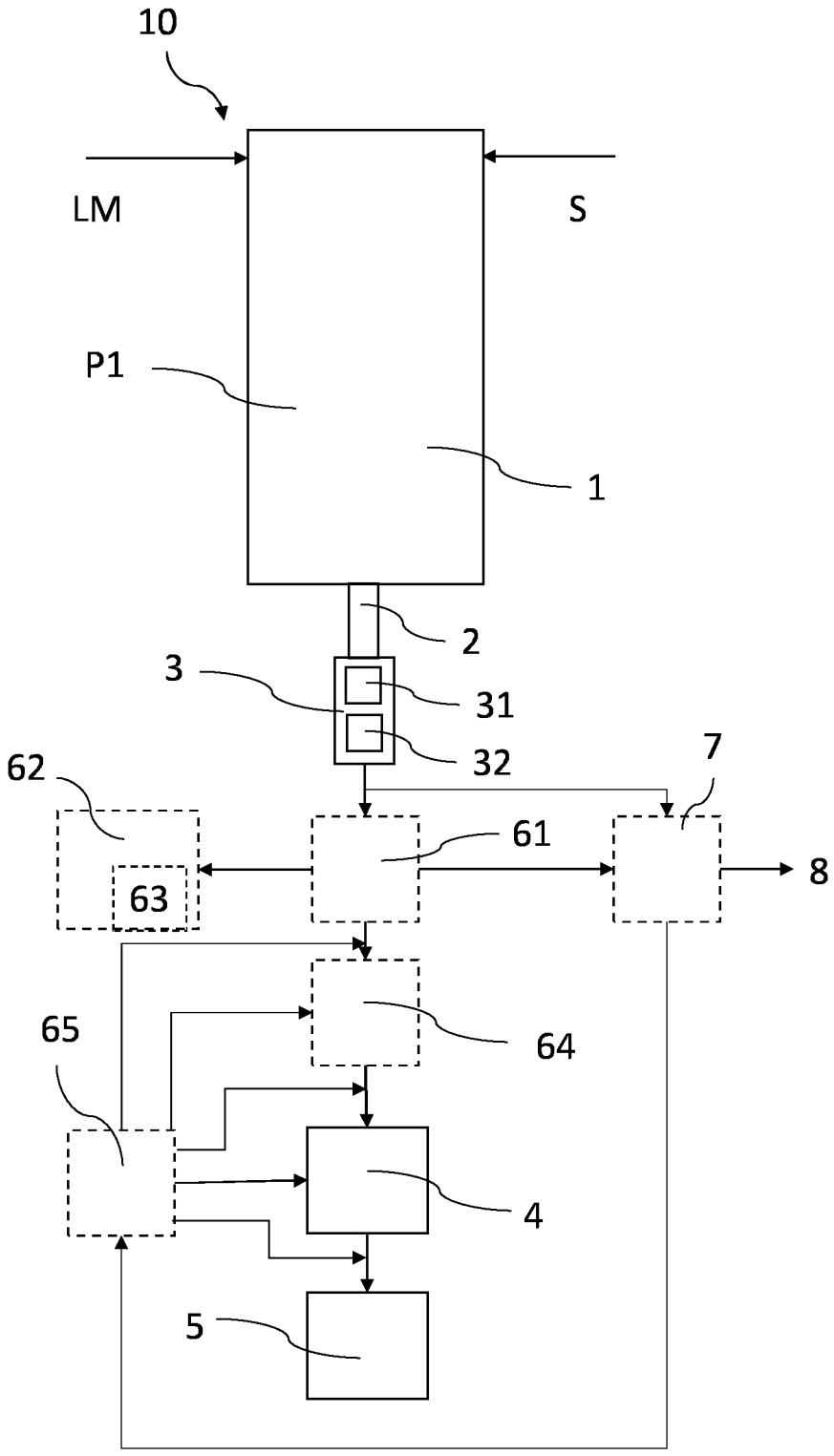

Fig 1

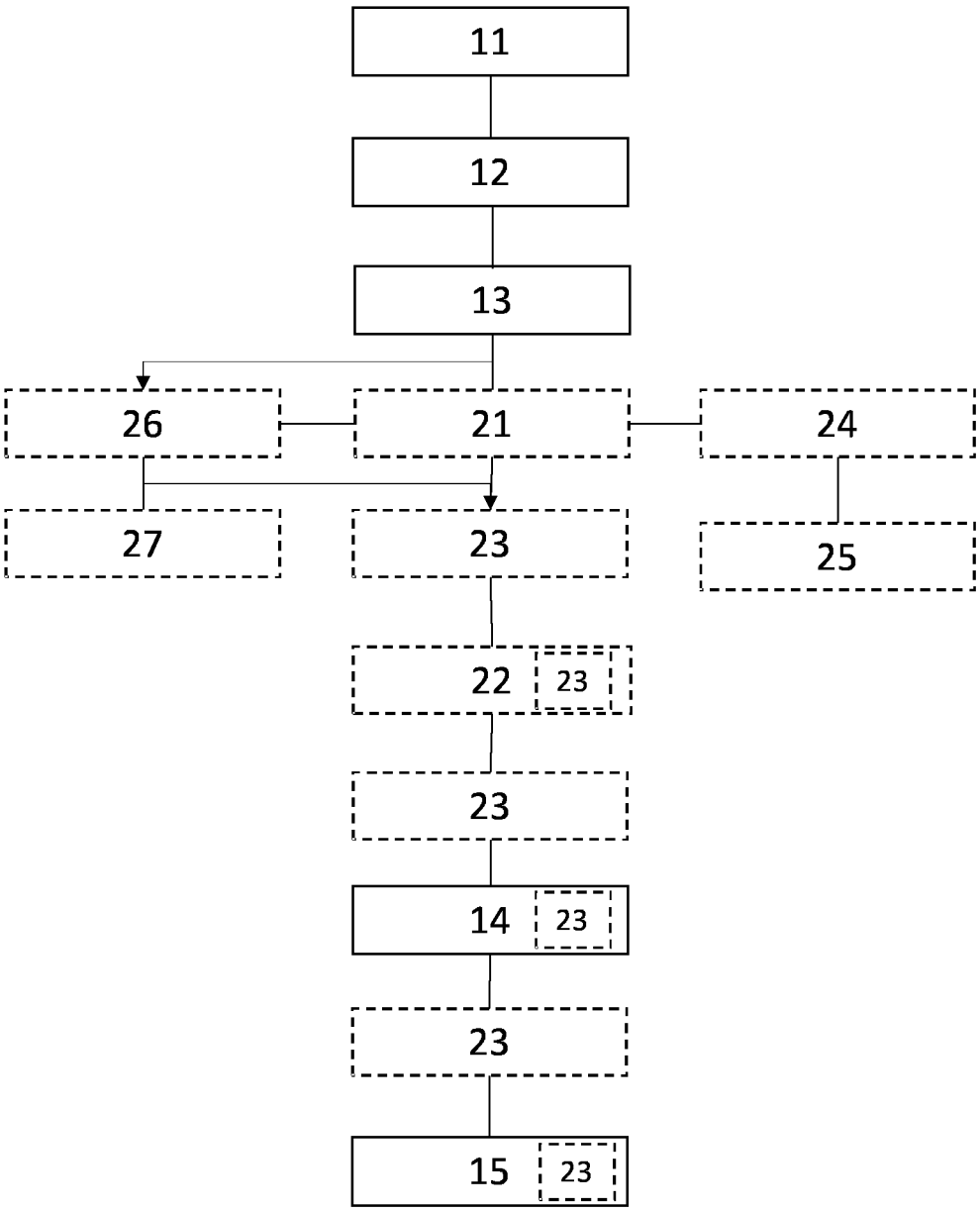

Fig 2

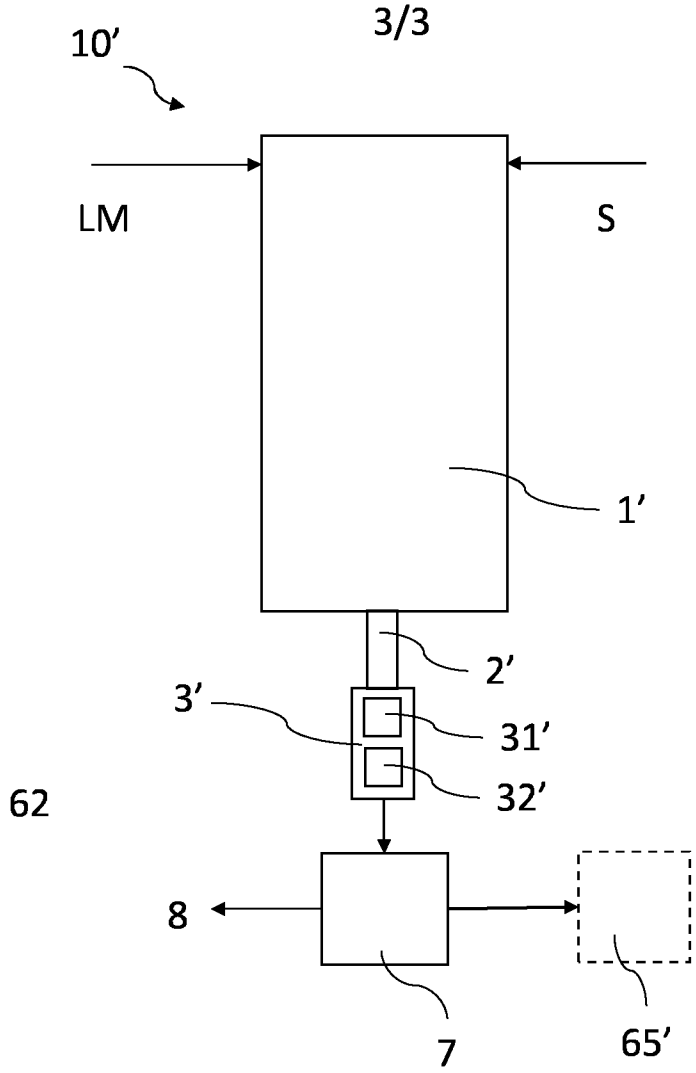

Fig 3

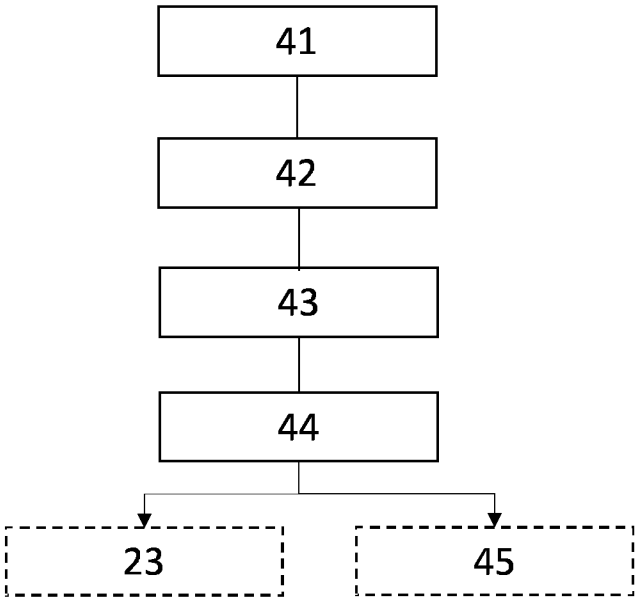

Fig 4