Apparatus for concentrating solutions, particularly black liquors
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Fig. 1

Fig. 2

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APPARATUS FOR CONCENTRATING SOLUTIONS, PARTICULARLY BLACK LIQUORS

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Many ways and apparatus have already earlier been proposed for the purpose of evaporating more or less completely such solutions which after evaporation form combustible dry substances, and particularly in order to make use of the combustibles in the so called black liquors, derived in very great quantities as refuse in connection with the sulphite paper pulp industry, great efforts have been made.

The known methods have the disadvantage that at a certain point it is possible only to produce either moist liquid or a dry substance, but it is impossible to produce for the furnace and equipment a combustible product with a high moisture content as well as a low moisture content.

My invention aims to eliminate these disadvantages and troubles in connection with the known methods of black liquor evaporation as touched upon above. Primarily I have invented a method of evaporating the black liquor to a degree of moisture suitable for the heat economy of combustion of the final product. The invention can be used for practically all degrees of moisture, and of course in each particular case that degree of moisture should be calculated which in connection with prevailing circumstances in the plant will give the most economical heat. It might thus happen that in a certain case it would be deemed desirable to evaporate the liquor to practically complete dryness, while in another case it would be deemed desirable to let the remaining moisture-content be greater than the moisture-content in dry wood-combustions, i. e., 15-20%.

In many cases the best choice in this regard depends on the condition of the furnace in which the product is to be burned, but also other conditions matter, such as far instance the heat value of the black liquor, the cost of the installation, etc.

Compared to heretofore known methods for similar purposes the invention lies nearest to the method in which disintegration of the liquor to drops by means of centrifugal force is used. The difference between my invention and the heretofore known methods consists primarily in the fact that after disintegration the liquor is not allowed to freely fall in a drying chamber, but the liquor drops are immediately caught against a wall surrounding the rotating machine for disintegration.

On this wall the liquor drops are collected in order to immediately again be brought towards the rotating axis of the mentioned device and again in form of drops be thrown out against the surrounding wall. This repeated back and forth radial movement of the liquor drops vis-a-vis the rotating axis with corresponding movement of the dry particles derived from the mentioned drops, takes place in a chamber surrounding the disintegration device, which chamber is traversed by warm drying gas, suitably chimney gases.

The advantage of this method according to the invention lies primarily in the possibility to freely choose the speed and frequency whereewith the small liquor drops are thrown alternately back and forth practically perpendicularly to the stream-motion of the hot drying gas. The heat transfer to and simultaneously the evaporation of moisture from the liquor is hereby greatly augmented.

The volume of the mixture of hot gas and liquor contained in the drying device is through the rotation of the disintegration device kept in a violent whirling motion and the liquor particles will be alternately dried and crushed repeatedly. This is contrary to the known method whereby each individual liquor particle, after having once and for all been separated from the rest of the liquor mass, will be surrounded by a practically stable gas which results in a surface drying of each individual particle and consequently forms an isolating coating thereon, which coating makes the further drying more difficult and necessitates a considerable falling distance to complete the process of drying. It is this circumstance which in the known method creates the requirement for a drying chamber of excessive dimensions and corresponding high cost.

Secondly my invention contains an apparatus or machine for the practical use of the method touched upon above. This machine is in the following made easier to understand by references to attached schematic drawing, and as this is described, the closer details of the method should also be made clear.

On the drawing, Fig. 1 represents the machine in longitudinal section, whereas Fig. 2 shows part of a cross-section of the same. According to my invention the machine is equipped with several disintegration-discs, suitably placed on the same axis, which discs are brought into very speedy rotation (for instance 1500 revolutions per minute), giving them considerable power of disintegration as well as centrifugal force. The first disintegration, however, will not be of long duration, because the drops are thrown against a cover surrounding the rotating discs and again collected thereon. From there the liquid or the paste is again brought in towards the discs in order to
again be thrown out and so on, and this movement of the liquid, one time radially outwards in disintegrated form, and the second time radially inwards in disintegrated form, takes place in a hot gas-stream which carries away the evaporated moisture by passing the machine chiefly parallelly to the rotating shaft of the discs.

One shaft 1, which is to be made to rotate with considerable speed by means of suitable motor, is placed on bearings and surrounded by a closefitting housing 2 which at its ends is equipped with end covers 3 and 4 at which are arranged an intake-opening 5 for the incoming warm gases, resp, an outlet opening 6 for the gas mixture which goes out together with the dry substances. The device for introduction of the liquor to be evaporated is not shown on the drawing, and as far as the invention is concerned it is of practically no importance how this liquor is introduced.

On shaft 1 a number of discs 6 are placed which are perpendicular to the shaft and do not quite extend to the surrounding housing 2. These discs are circular, but also polygonal discs could be considered usable. At the periphery of these discs a number of scrapers 7 are arranged which radially extend to the neighbourhood of the housing 2, yet without touching the same. These scrapers may have different shapes provided they are suitable to scrape away from the housing and convey towards the shaft such parts of the more or less evaporated liquid which tend to adhere to the inner walls of the housing. Since the tendency to adhere will change as the moisture content of the material under treatment is changed during the process of evaporation, these scrapers can be differently formed so that at the intake-end of the machine they have a greater inwardly directing force than at the outlet end. On the drawinging all scrapers 7 on the discs bearing scrapers are shown of the same shape, viz. in the shape of stirlups (see Fig. 1), but naturally it is possible with such a construction to arrange for different scavenging force between the scrapers by changing the angle of inclination of the scrapers towards the tangents of the periphery at the point of attachment. The shape of the scrapers can thus be adjusted to the desired force at each particular point in the machine, and the idea is that the scrapers shall throw out the more or less moist—or maybe purely liquid—products to be treated away from the inside of the housing towards the rotating shaft.

In addition on other discs shovels or paddles 8 are mounted angularly to the scrapers 7 described above. The function of these shovels or paddles 8 is to again while rotating throw out those particles which have been conveyed towards the rotating shaft by the above mentioned scrapers, whether these particles are more or less liquid or form a dry substance. Contrary to the above mentioned scrapers, which extend beyond the periphery of the discs, the shovels or paddles 8 are placed altogether within this periphery. They should, however, not extend fully to the rotating shaft but allow for particles under treatment to be brought by the revolving shaft to fall nearer to the shaft without being influenced by the shovels 8 in the beginning. Also the shape of the shovels may of course be varied, provided they fill the desired purpose, and in the drawing they are simply shown as V-shaped angle-iron clips the extending part of which is placed parallel to the rotating shaft. Other shapes of the shovels may, however, be considered and used to effect the same result, and the invention is not limited to any special shape of either the shovels 8 or the scrapers 7.

Furthermore inwardly directed flanges may be arranged on the inside of the housing which flanges extend along the periphery of the housing and are in close proximity to the side of the scrapers 7 although not touching these. Between the inner edges of these flanges 9 and the outer edges of the discs 6 a free space is formed extending all around the machine, and this space is not meant to be occupied by the liquid. Although the arrows in Fig. 1 show only a gaspassage in the upper end of the machine, it is evident that the same possibilities for passage of the gases exit in the whole circumference. This whole gas-channel or space should be in free connection both with the intake and outlet of the hot gases.

As it may be possible that, especially before a certain degree of dryness has been reached, the liquid under treatment would tend to adhere to the housing and rotate with the discs and shovels without being brought radially towards the rotating shaft, the machine is equipped with a device to prevent such a procedure. This device consists according to the invention of a shaft 10 equipped with shovels or wings 11 and meant to rotate in the housing 2 in the front parts of the wings, which are located nearest the above described shaft, move preferably in opposite direction to the rotating direction of the shovels, which is shown by arrows in Fig. 2.

The shaft 10 is suitably mounted parallel to shaft 1 and the outer edges of the shovels or wings of the first mentioned shaft are located beyond, yet close to the outer motion-range of the shovels on shaft 1. The result of this will be that if a more or less evaporated quantity of liquid tends to circulate along the inner wall of the housing, it will by centrifugal force be directed radially outwards and arrive within the field of action of the wings 11 of shaft 10, after which the pulpy mass is partly halted and made to move inwardly towards shaft 1, i.e., within the influence of the shovels 8. If shaft 10 is made to rotate very quickly as compared to the circumferential speed of the scrapers 7, it may with almost the same result be made to rotate in opposite direction to the one indicated by the arrow on the drawing, but apart from the rotation-direction the result of this device will of course be that it rotates in opposite direction to shaft 1. It may also be possible that more than one such device which halts and re-directs the substance inwardly towards the main shaft will be used on one machine, and the invention is thus not limited to the use of only one such device. Several of these may perhaps with greater gain be placed at suitable angle-distance around the whole circumference of the housing 2, and whether one or more such devices are used, they are placed in separate housings 12, which with their sides facing the shaft have free and open connection with the housing 2.

Finally at the lower part of the housing 2 and suitably in tangential direction and with the rotation there is arranged an outlet 13 in the end of the machine opposite to the liquor-entrance end, and in this outlet a feeder screw (not indicated) may be arranged, which is made to rotate with suitable speed. Furthermore this outlet 13 may on the outside of the feeder-screw be equipped with a connecting pipe 14, which has connection towards the gas-outlet from the machine and intended to discharge gases which may leak through the feeder-screw.
As described in the above there is obtained in the machine a constant alternating action between the shovels 8 that throw the pulp to one side and the scrapers 7 which again direct it inwards towards the rotating shaft, and during passage through the machine the pulp mass is moving in zig-zag back and forth in a radial direction, which movement mainly is located in the space between the outer periphery of the discharge 2, resp. the inner edges of the flanges 9. The frequency of these alterations or zig-zag flows depends on the rotation speed of the shafts 1 and 18, and each time the mass is moved as indicated mainly radially inwards or outwards, the hot gases will flow through it and thus effect the evaporation, which consequently takes place during a series of processes related to each other, and the repeated disintegration of the liquor particles prevent any surface coating, that might deter evaporation, from forming on said particles.

When the mass is introduced into the machine it contains a considerable degree of moisture (generally around 40%), and in the case of black liquors these may be described as thick liquids, but disintegration takes place at the entrance into the machine. The moisture content is, however, lowered as the machine is passed, and at the exit the mass may be considered as a practically dry fuel as far as water-content concerns, moisture content varying preferably between 4 and 5%. In the case of bleach liquors this substance has a considerable heat-value but of course it does not consist of altogether combustibles, but also chemicals are present therein. At the combustion of the final product these chemicals melt and find their way to the bottom of the furnaces and are discharged in molten form to be used again in the process of pulp fabrication.

The quantity of gas (and herewith the quantity of calories or heat) per unit of time introduced into the machine, suitably by means of a fan, should be suited according to the original moisture-content of the liquor to be treated and also to the quantity of such liquor brought into the machine per unit of time.

Finally in connection with the gas-outlet from the machine there should be arranged a separator in order to extract solid particles from the outgoing gases, but this separator is not influenced by the invention and is not shown on the drawing.

Although as far as the practical use of the invention is concerned it is not necessary (especially by lower degrees of dryness), the above description will have shown that in the apparatus described as an example of the practical use of the invention the evaporation process, contrary to known processes of a comparable kind, takes place with the current in regard to the passage of the drying gases and the liquor through the machine. This contributes to lessen the risk of fire and to eliminate this risk, even if evaporation is driven to almost complete dryness. The result of running the machine as described will namely be that the incoming drying gas, which has the highest temperature, first meets the liquid when its moisture-content is at its greatest and when it is in liquid form, whereby any glowing particles or sparks that might accompany the drying gas immediately will be extinguished on entering the machine. An evaporation to dryness, which earlier has been accompanied by considerable risks of fire, can thus according to the invention be obtained altogether without risk.

Finally it has been shown that contrary to hereof known methods the evaporation to desired dryness according to the invention takes place through a suitable amount of step-wise work-processes, so that the dryness is by and by augmented as these work-processes follow each other. It is thus entirely possible for each individual case to determine the desired degree of dryness where with the machine shall be operated, and in one and the same machine it is possible to obtain various degrees of dryness.

What I claim and desire to secure by Letters Patent is:

1. In a machine, or apparatus, for evaporation of so called black liquor and the like containing combustible ingredients, a shaft means adapted to be set into rotational motion, a plurality of disc members mounted in an axially spaced relation on said shaft means and adapted to be set in motion together with the same, shovel means mounted on said disc members and having portions thereof located between said discs and adapted to effect a centrifugal disintegration of a more or less moist mass fed thereon, a housing surrounding said shaft means and disc members and forming an air-space between itself and the circumference of the disc members, individual scraper means supported on the shaft by means located between the disc members therein, such scraper means extending radially beyond the circumference of the disc members, and a plurality of disc members and disc members arranged to perform an inwardly forcing action towards the axis of rotation on the material to be treated, inlet means at one end of said housing, and outlet means at the opposite end thereof, such inlet and outlet means being adapted, besides of the material to be treated, also to convey a flow of hot gases in axial direction through said housing.

2. In a machine, or apparatus, according to claim 1, the additional feature that separate disc members are provided for the scraper means.

3. In a machine, or apparatus, according to claim 1, the additional feature that the interior of the housing is provided with circumferently positioned and inwardly extending flanges the edges of which are positioned at a distance from the circumferences of the disc members, when counted in radial direction, so as to form an axially extending annular channel therewith, the scraper means extending with a little clearance between said flanges.

4. In a machine according to claim 1, the additional feature that the scraper means are mounted on separate disc members from those supporting the shovel means and in a position intermediate and alternating with said shovel means, the angular distance between the scraper and shovel means being substantially the same all around the circumference of the disc members.

5. In a machine according to claim 1, the additional feature that the outlet end of the same is provided with two separate outlets one of which is adapted to convey the hot gaseous fluid and the solids conveyed by said fluid, whereas the other one is adapted to convey the treated material from the machine.

6. In a machine, or apparatus, for evaporation of so called black liquor and the like containing combustible ingredients, a shaft means adapted to be set into rotational motion, a plurality of centrifugally acting disintegration means mounted in a spaced relation along said shaft means and adapted to be set in motion together with the same, a main housing surrounding.
ing said shaft and disintegration means and mounted so as to form a space between itself and the disintegration means, scraper means mounted intermediate the disintegration means on said shaft means and adapted to perform an inwardly forcing action towards the axis of rotation of the material to be treated, one or more secondary housings positioned at the circumference of said main housing and extending in the longitudinal direction of the latter, each of said secondary housings communicating with the main housing by means of a longitudinally extending slot, a secondary shaft means mounted in each of said secondary housings and adapted to be set into rotational motion therein, shovel members mounted on each of said secondary shaft means and adapted to be set in motion together with the latter, inlet means at one end of the main housing, and outlet means at the opposite end thereof, such inlet and outlet means being adapted, besides of the material to be treated, also to convey a flow of hot gases in axial direction through the main housing.

7. In a machine, or apparatus, according to claim 6 the additional feature that the outlet end of the same is provided with two separate outlets one of which is adapted to convey the hot gaseous fluid and the solids conveyed by said fluid, whereas the other one is adapted to convey a more or less pulpy mass resulting from an incomplete evaporation of the moisture.

8. In a machine, or apparatus, for evaporation of so called black liquor and the like containing combustible ingredients, a main shaft means adapted to be set into rotational motion, a plurality of disc members mounted in an axially spaced relation on said shaft means and adapted to be set in motion together with the same, shovel means mounted on said disc members and adapted to perform a centrifugal disintegration of the material fed thereon, a main housing surrounding said shaft means and disc members and forming an inter-space between itself and the circumference of the disc members, scraper means supported by the main shaft means in a position intermediate the disc members thereon, such scraper means extending radially beyond the circumference of the disc members and being adapted to perform an inwardly forcing action towards the main shaft means on the material to be treated, one or more secondary housings positioned at the circumference of the main housing and extending in the longitudinal direction of the latter, longitudinally extending communication means between each of said secondary housings and the main housing, a secondary shaft means mounted in each of the secondary housings and adapted to be set into rotational motion therein, shovel members mounted on each of the secondary shaft means and adapted to be set in motion together with the same, inlet means at one end of the main housing, and outlet means at the opposite end thereof, such inlet and outlet means being adapted, besides of the material to be treated, also to convey a flow of hot gases in axial direction through the main housing.

9. In a machine, or apparatus, according to claim 8, the additional feature that the scraper means are mounted on separate disc members.

10. In a machine or apparatus according to claim 8, the additional feature that the main housing is provided circumferentially with inwardly extending flanges the edges of which are positioned at a distance from the circumferences of the disc members, when counted in radial direction, so as to form an axially extending angular channel therebetween, the scraper means extending with a little clearance between said flanges.

11. In a machine according to claim 8, the additional feature that the outlet end of the same is provided with two separate outlets one of which is adapted to convey the hot gaseous fluid and the solids conveyed by said fluid, whereas the other one is adapted to convey a more or less pulpy mass resulting from an incomplete evaporation of the moisture.

12. In a machine, or apparatus, according to claim 8, the additional features that the outlet end of the machine is provided with two separate outlets one of which is adapted to convey the hot gaseous fluid and the solids conveyed by said fluid, whereas the other one is adapted to convey a more or less pulpy mass.

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