

PLANT FOR PROCESSING A SLURRY AND USES OF THE SAME

The invention relates to a plant for processing a slurry according to the preamble of Claim 1 and methods for operating the same, which have the aim of avoiding the so-called thermoplastic phase.

- 5 Such plants are used in sludge dewatering engineering, in particular in food engineering and pharmaceutical engineering, but also in the disposal of sewage sludge and the like for separating the solids portion contained in the slurry from the liquid portion.
- 10 Corresponding plants are also known which, in addition to a chamber filter press, include a heating unit and a suction or vacuum pump (DE-A-3 901 851, EP-A-0 263 197), but the latter only serves for removing the filtrate by suction, that is for accelerating the filtration process.
- 15 None of these patents indicates a method by which the thermoplastic phase can be bypassed.

In many uses, the filter cake, which forms in the chamber filter press from the suspended matter contained in the slurry, is further processed, in particular dried. For
20 this it must, in conventional plants, be removed from the filter press and recharged into a drying plant which, if the necessary cleaning operations and the keeping-sterile of the filter cake, generally required principally in the medical sector, are taken into consideration, represents
25 a highly complex operation.

In particular, the removal of the filter cake from the chamber filter press frequently represents a serious problem: in the filter cake, in the course of drying, the formation of a so-called thermoplastic phase can occur.
30 The cake then appears as a viscous, extremely sticky substance, which can only be detached with the greatest difficulty from the filter cloths possibly used. In US Patent No. 4,999,118, by Beltcho A. Beltchev, Sofia, Bulgaria, of 12th March 1991, this problem is mentioned
35 in the description. A "scraper" is then cited as an

unsuitable means for removing the sticky filter cake. However, only disadvantages of this scraper are quoted. In the entire patent specification there is no further indication of the problems of the thermoplastic phase; as
5 is the case in all other known patents, no solution is offered.

The object therefore underlying the invention is to provide a design of such plants which permits, with little additional expenditure, a relatively extensive
10 processing of the slurry (or of the filter cake) and a combination of methods or processes for its operation which offer particular advantages.

The invention, as characterized in the claims (particular embodiments are cited in the subclaims), creates a plant
15 in which further processing is possible, in particular a specific (by controlling the parameters pressure and temperature in the chamber filter press) and gentle drying of the filter cake without removal of the same from the chamber filter press. By avoiding the
20 thermoplastic phase, the removal of the filter cake can be automated, since there is no longer any risk of it remaining stuck. By this means, the most extensive processing possible of the slurry is made possible in a relatively simple plant. Owing to the simple method of
25 removal, the course of the process is made considerably simpler and cheaper. By this means, the plant can be constructed to be very compact and can be designed to be mobile.

In plants according to the invention, the circumstance
30 that the filter cake in a chamber filter press is in any case produced so that it offers a large surface area - this is also necessary in the interests of a rapid filtration process - is also utilized in subsequent process steps. Thus a chamber filter press for treating
35 the filter cake with reduced pressure is most suitable, but it is also outstandingly suitable for contact heating

of the filter cake (contact drying). Favourable preconditions likewise prevail for heating by hot gas (convection drying), since for a fine distribution of the same, the feed line or the filtrate line with their branches or
5 both can be utilized.

In the following, the invention is described in more detail on the basis of the figures depicting only one embodiment. In the drawings,

10 Fig. 1 shows a diagrammatic side view of a plant according to the invention,

Fig. 2a shows a diagrammatic plan view of the plant as in Fig. 1,

Fig. 2b shows a plan view corresponding to Fig. 2a, but in which the top machinery is removed,

15 Fig. 3 shows a diagrammatic longitudinal section through a part of the plant as in Figs. 1, 2a, 2b,

Fig. 4 shows a diagrammatic representation of the principle of the plant as in Fig. 1, 2a, 2b,

20 Fig. 5 shows the change with time of various parameters during filtration and subsequent drying of the filter cake for, e.g., sewage sludge and

Fig. 6 shows the change with time of various parameters during filtration and subsequent freeze-drying of the filter cake for, e.g., fruit and vegetables.

25 The structure of the plant is described in principle below with reference in particular to Fig. 4, which shows the machinery with its components and the connections between them in all details, while Figs. 1, 2a, 2b are intended chiefly to show the spatial arrangement of the
30 machinery.

The plant has in the upper part a chamber filter press 1 having chamber filter plates 3 suspended on bars 2a,b (Figs. 1, 2a), which chamber filter plates can be pressed together by a hydraulic unit 4 having a pump 5 and a pressure sensor 6. It is connected via a feed line 7 and a valve 8 to a feed system 9 which includes a stirred tank 10 and, upstream of the same, a flocculation reactor 11 and, connected downstream of the stirred tank 10, a charging pump 12 which can be designed as a piston membrane pump or a screw centrifugal impeller pump and, for control thereof, a pressure sensor 13 arranged between the charging pump 12 and the valve 8. The feed line 7 is further connected to the stirred tank 10 via a return line having a further valve 14.

So that settling of the solids portion is avoided, the feed line 7, instead of as depicted at a central height, can alternatively open out below or above into the chamber filter press 1 or a plurality of openings can be present between which the flow is switched. Thus, solids suspensions in which the solids portion has a tendency to sedimentation, can be fed from above and those in which it has a tendency to flotation can be fed from below.

The chamber filter press 1 is connected via a filtrate line 15 having a controllable valve 16 to a filtrate vessel 17 (Figs. 1, 2b). Since it has a cavity - which is described in still more detail further below in connection with Fig. 3 - it is also connected to a first branch 18a of a pressure line 18 and to a return line 19. The pressure line 18, which simultaneously represents with its branches a heating line, is monitored by a temperature sensor 20 and is fitted with a vent valve 52. The pressure line 18 leads via a controllable valve 21a to a superheated steam unit 22, more precisely to the outlet of a boiler 23 of the same. The superheated steam unit 22 has, moreover, a temperature controller 24, which controls the output of an electrical heating device 25 for heating the boiler 23 on the basis of the temperature in

the pressure line 18, and a condensate pump 26, which is controlled in a similar manner by a pressure controller 27, and a condenser 28, via which the return line 19 is connected to the inlet of the condensate pump 26 via a controllable valve 29. A water connection 31 is, moreover, connected upstream of the condensate pump 26 via a valve 30 controlled by the pressure controller 27. Instead of the superheated steam unit, a hot water unit or other heat transfer medium unit could be provided. The pressure line 18 has two further branches 18b and 18c which open out via controllable valves 21b and 21c into the feed line 7 and the filtrate line 15, respectively.

Apart from the superheated steam unit 22, the plant has a further heating apparatus, that is a hot air unit 32, which is connected to the chamber filter press 1 via a branch 33a, opening out into the feed line 7, having a valve 34a and a branch 33b, opening out into the filtrate line 15, having a valve 34b of a pressure line 33 which, with its branches, simultaneously represents a heating line. The hot air unit 32 includes a heating apparatus 34, through which flows compressed air, having a heating device 35 which is controlled by a temperature controller 36. The compressed air is generated by a pressure pump 37 which is connected upstream of the heating apparatus 34 and is controlled by a pressure controller 38 so that the hot air unit 32 simultaneously represents a compressed air unit.

Separated from the hot air unit 32 by a valve 39, a vacuum plant 40 is additionally connected to the pressure line 33, so that the pressure line 33 equally serves as an evacuation line. The vacuum plant 40 includes a vacuum pump 41, downstream of which is connected a controllable valve 42 and a pressure controller 43, which controls the vacuum pump 41 in dependence on the pressure prevailing in the pressure line 33.

The plant described is controlled by a controller 44 from

where the valves are opened and closed manually or according to a selectable programme and the individual units and plants are controlled for instance by presetting defined pressures and temperatures. Preferably, pressures from approximately 0.1 mbar to approximately 16 bar should be capable of being established in the chamber filter press 1 by the pressure pumps 37 integrated into the hot air unit 32 and the vacuum pump 41 and, by use of the heating apparatus 34 or the boiler 23, temperatures between -45°C and 250°C should be capable of being established, temperatures beneath the ambient temperature being achieved by the vacuum pump 41 so that a refrigeration unit is not necessary. Obviously, however, the plant described, if required, can also be equipped with such a unit. The vacuum pump 41 is furnished with a condenser in which the vapours taken off are condensed or desublimated to reduce their volume.

Fig. 3 shows in longitudinal section the principal item of the chamber filter press 1, that is the chamber filter plates 3, which are covered by liquid-permeable filter cloths 45 and are pressed together by the hydraulic unit 4. The chamber filter plates 3 are furnished centrally with continuous orifices 46 forming a continuation of the feed line 7 and have recesses 47 on both sides, at the base of each of which is arranged a cavity 48. The recesses 47 form chambers connected by the orifices 46, into the bottom region of which chambers open out branches 15' of the filtrate line 15. The chambers are completely lined by the filter cloths 45. The chamber filter plates 3 additionally have pressure channels 18 which open out behind the cavities 48 and are connected to the branch 18a of the pressure line 18 and to the return line 19.

The chamber filter press 1 can alternatively be equipped with chamber filter plates without a membrane, in which case the pressure channels open out into cavities in the same, which for example are formed by cast-in hollow

bodies and through which, via the branch 18a of the pressure line 18 and return line 19, a steam circulation can flow, which is closed by the condenser 28, the condensate pump 26 and the boiler 23. In both cases, steam introduced can achieve a heating of the filter cake 50 by direct or, at any rate since the filter cloths 45 form only a thin intermediate layer, almost direct contact, in one case contact with the cavities 48, in the other with the chamber filter plates themselves, which at least in the latter case should be composed of metal because of the higher heat conductivity of this material, which is also to be preferred because of its heat resistance, although in this regard plastic plates are also adequate for many applications. Of course electric heating of the filter plates can be provided as well.

Beneath the chamber filter press 1 is arranged a trough 51 (Fig. 1) for receiving the filter cake 50 after opening the chamber filter press 1. The plant is accommodated in a relatively small volume of approximately $2 \times 1.4 \times 0.8 \text{ m}^3$ and is transportable.

The plant can (Figs. 5, 6) be used to produce a filter cake 50 and further treat the same, in particular for the production of a material which is pourable or in pieces depending on circumstances - colourants, pharmaceuticals, soup and drink powders, vegetable and fruit snacks and many others are suitable -, various combinations being possible for the further treatment. The plant is particularly highly suitable for processes which include the filtration A of the filter cake 50 with subsequent drying B of the same in the chamber filter press 1. A slurry is first produced in the flocculation reactor 11 and is continuously passed into the stirred tank 10 and is there stirred as long as necessary. The valve 8 is then opened and the feed pump 12 is turned on. As a result, slurry is transported into the chamber filter press 1 until (see below) only little filtrate exits because a solid filter cake has formed in the chamber

filter press 1. The valve 8 is then closed and the valve 14 and the valves 39 and 34a are opened and the feed line 7 is blown out by the pump 37. While the chamber filter press 1 is being filled, the majority of the filtrate drains by gravity through the filtrate line 15 into the filtrate vessel 17. Opening the valve 21a and turning on the condensate pump 26 passes water or alternatively steam through the first branch 18a of the pressure line 18 into the pressure channels 49 of the chamber filter press 1, so that the cavities 48 heat up. Water or steam is then discharged via the return line 19.

The further treatment depends, just as do certain parameters in the filtration A, on the type of the slurry and the intended final result; two selected examples are intended to document this.

In the example of Fig. 5, the slurry is a chemical suspension, mineral sludge, sewage sludge or flue gas scrubber sludge of between 0.5% and 35% (by weight) - approximately 5% in the example shown - dry matter (DM). The pressure a in the interior of the chamber filter press 1 is increased in the filtration to 15 bar and maintained for approximately 2.5 h.

When the filtrate flow has fallen below a defined limit, the drying B begins, more precisely, vacuum drying of the filter cake in the chamber filter press 1. For this purpose, the vacuum plant 40 is put into operation and the pressure a in the interior of the chamber filter press 1 is reduced to a value between 5 and 100 mbar, in the example indicated 50 mbar, and maintained. In addition, heating is carried out by the heating device 25 of the boiler 23 and steam is generated and finally the valves 21a are opened, so that, by steam flowing into the pressure channels 18 via the cavities 48 of the chamber filter plates 3, their plate temperature b is brought to between 140°C and 200°C, in the present case 160°C and the filter cake 50 is thus heated.

The cake temperature c constantly remains below 50°C in this case because of the evaporation. The filter cake foams and becomes finely porous, which it remains also in further course with suitable direction of the parameters pressure a and plate temperature b. If the evaporation decreases, the temperature of the chamber filter plates 3 can, for example, be reduced to approximately 70°C. The cake temperature c must not increase above 60°C for as long as the content of dry matter d is between 65% and 85%, since the filter cake 50 otherwise enters into the thermoplastic phase - also termed the glue phase - and assumes a pasty consistency so that it becomes lumpy and also sticks to the chamber filter plates 3. After exceeding the limit of, for example, 85% DM, the plate temperature can be increased, for example, to 140°C and, after approximately 2 h, the heating can be turned off. The filter cake 50 is further dried by the reduced pressure and the latent heat contained in the plates and the product itself for a further 2 h as far as approximately 95% DM, while the cake temperature c decreases to approximately 70°C. The pressure a is then made atmospheric and the chamber filter press 1 is opened.

In an additional method (Fig. 6), a maximum pressure of 2-6, in the present case 3.5, bar is not exceeded in the filtration lasting only approximately 15 min of a solids suspension from food, pharmaceutical or chemical production, e.g. of fruit pieces or vegetable pieces in a 5-fold to 20-fold liquid excess. For the subsequent freeze-drying, the pressure a is decreased to 0.5 to 2 mbar, here 1 mbar - in any case beneath the triple point pressure of water - and the filter cake 50 is intensively cooled as a result. The cake temperature c decreases to approximately -20°C, so that the water portion, if it has not already evaporated, changes over into the solid phase. Thus, also here the filter cake remains loose and further dewatering is not prevented.

The plate temperature b is then increased to 80 to 110°C

and later reduced to approximately 70°C, thus the cake temperature c is also slowly increased so that the water portion in the filter cake 50 is progressively sublimated and the content of dry matter d increases to 98 to 99%.

- 5 The reduction of the plate temperature b to approximately 70°C is carried out to protect the filter cake at least when the evaporation is no longer sufficient to prevent an elevation of the cake temperature c to above 50°C.

10 The boundary between vacuum drying and freeze-drying is essentially given by the pressure course; strictly it is at the triple point pressure of water which is 6.3 mbar for distilled water, but can also be beneath this to a greater or lesser extent, depending on the salt or sugar content. Subjecting also sludges and the like to a
15 freeze-drying is obviously not excluded, but this higher expense is conventionally not necessary, whereas it is usually worthwhile in the case of more sensitive products, which obviously, vice versa, can alternatively be subjected to a vacuum drying.

- 20 In both methods, the drying of the filter cake 50 can be monitored and pressure and temperature can be controlled according to the degree of drying. Said monitoring is possible, for example, by one or more of the following measures:

- 25 - measuring the temperature in the interior of the filter cake 50,
- measuring the amount of condensate which is formed in the condenser of the vacuum pump 41,
- monitoring the pressure course during the drying.

- 30 As an additional step, for example, principally in an application in the pharmaceutical sector and with the plant suitably equipped, sterilization by superheated steam can be carried out after the filtration A. For this

purpose, with the valves 21b and 21c open, steam is pumped through the branches 18b,c of the pressure line 18 from the condensate pump 26 into the chamber filter press 1. After the valves 21b,c are closed, the filter cake 50
5 can be predried by hot air from the hot air unit 32 which flows into the chamber filter press 1 via the branches 33a,b of the pressure line 33 when the valves 34a,b are open. The drying B can then be completed as described by vacuum drying or freeze-drying.



Patent Claims

1. Plant for processing a slurry having a chamber filter press (1) for the filtration of the same and a feed line (7) for feeding the slurry and a filtrate line (15) for discharging the filtrate, characterized in that the plant is provided with means for avoiding the thermoplastic phase of the filter cake by producing a controlled reduced pressure and controlled temperatures in the interior of the chamber filter press (1).
2. Plant according to Claim 1, characterized in that the means are suitable for producing a controlled reduced pressure as far as 100 mbar in the interior of the chamber filter press (1).
3. Plant according to Claim 2, characterized in that the means are suitable for producing a controlled reduced pressure as far as 7 mbar in the interior of the chamber filter press (1).
4. Plant according to Claim 3, characterized in that the means are suitable for producing a controlled reduced pressure as far as 0.5 mbar in the interior of the chamber filter press (1).
5. Plant according to one of Claims 1 to 4, characterized in that the means for producing a controlled reduced pressure include a vacuum pump (41) which is connected via an evacuation line to the interior of the chamber filter press (1).
6. Plant according to Claim 5, characterized in that the evacuation line opens out into the feed line (7).
7. Plant according to one of Claims 5 or 6, characterized in that the evacuation line opens out into



the filtrate line (15).

8. Plant according to one of Claims 1 to 7, characterized in that it has means for changing the temperature of the chamber filter plates (3).
- 5 9. Plant according to Claim 8, characterized in that the means for changing the temperature include at least one heating apparatus.
- 10 10. Plant according to Claim 9, characterized in that at least one heating apparatus is suitable for heating a fluid medium and a heating line is present by means of which the medium can be passed to the chamber filter press (1).
- 15 11. Plant according to Claim 10, characterized in that the heating line opens out into cavities of the chamber filter plates (3).
12. Plant according to Claim 10 or 11, characterized in that a heating apparatus is designed as a superheated steam unit (22), as a hot water unit or as a thermal transfer medium unit.
- 20 13. Plant according to Claim 10 or 11, characterized in that a heating apparatus is designed as a hot air unit (32).
- 25 14. Plant according to one of Claims 10 to 13, characterized in that the chamber filter press (1) has a pressure line (18a) which opens out to the cavities 48 between chamber filter plates (3) and in that the heating line opens out into the pressure line (18a).
- 30 15. Plant according to ~~Claim (sic)~~ one of Claims 11 to 13, characterized in that the chamber filter plates (3) are cast and the cavities are enclosed by cast-



in hollow bodies of metal.

- 5 16. Plant according to one of Claims 1 to 15, characterized in that the feed line (7) proceeds out from a feed system (9) which includes a stirred tank (10).
17. Plant according to Claim 16, characterized in that a flocculation reactor (11) is provided upstream of the stirred tank (10).
- 10 18. Plant according to one of Claims 1 to 17, characterized in that a charging pump (12) having a screw centrifugal impeller is provided for charging the chamber filter press (1).
19. Plant according to one of Claims 1 to 18, characterized in that it is designed to be mobile.
- 15 20. Method for the operation of a plant according to one of Claims 1 to 19, characterized in that, for producing and drying a filter cake, a suspension is fed into the chamber filter press (1) and filtered and then the filter cake is dried by the pressure in the interior of the chamber filter press (1) being reduced beneath an upper limit pressure of at most 200 mbar and the temperature of the chamber filter plates (3) being brought above a lower limit temperature of at least 40°C, and, by controlling pressure and temperature, the thermoplastic phase of the filter cake is avoided.
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- 30 21. Method according to Claim 20, characterized in that the pressure in the interior of the chamber filter press (1) and the temperature of the chamber filter plates (3) are controlled by the degree of drying of the filter cake (50).
22. Method according to Claim 20 or 21, characterized in



- 5 that, in the drying, the pressure in the interior of the chamber filter press (1) is maintained above a lower limit pressure of 5 mbar and the temperature of the chamber filter plates (3) is maintained between a lower limit temperature of 70°C and an upper limit temperature of 200°C.
- 10 23. Method according to Claim 22, characterized in that the suspension comprises a chemical suspension, a mineral sludge, a sewage sludge or a flue gas scrubber sludge.
- 15 24. Method according to Claim 20 or 21, characterized in that, in the drying, the pressure in the interior of the chamber filter press (1) is maintained beneath an upper limit pressure of 7 mbar and the temperature of the chamber filter plates (3) is maintained between a lower limit temperature of 40°C and an upper limit temperature of 160°C.
- 20 25. Process according to Claim 24, characterized in that the suspension is a solids suspension from food production, preferably of vegetables or fruit, from pharmaceutical production or chemical production.
- 25 26. Method according to one of Claims 20 to 25, characterized in that, in the drying, the pressure in the interior of the chamber filter press (1) and the temperature of the chamber filter plates (3) are directed so that the temperature of the filter cake does not exceed 60°C as long as the dry matter content lies between 65% and 85%.
- 30 27. Method according to Claim 25 or 26, characterized in that, in the drying, the pressure in the interior of the chamber filter press (1) and the temperature of the chamber filter plates (3) is directed so that the temperature of the filter cake does not exceed 50°C.