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(54) Process and apparatus for drying and/or cooling of a product containing one or more evaporable substances.

(57) Process and apparatus for drying and/or cooling of a product containing one or more evaporable substances.

The invention relates to a process for cooling and/or drying of comminuted products, like granules, powders etc. in a continuous vacuum treatment, wherein the product preferably is subjected to a pre-deaeration. The invention is especially suited for cooling of cattle feed pellets to control odour emission. An apparatus for carrying out the process is indicated in figure 1.

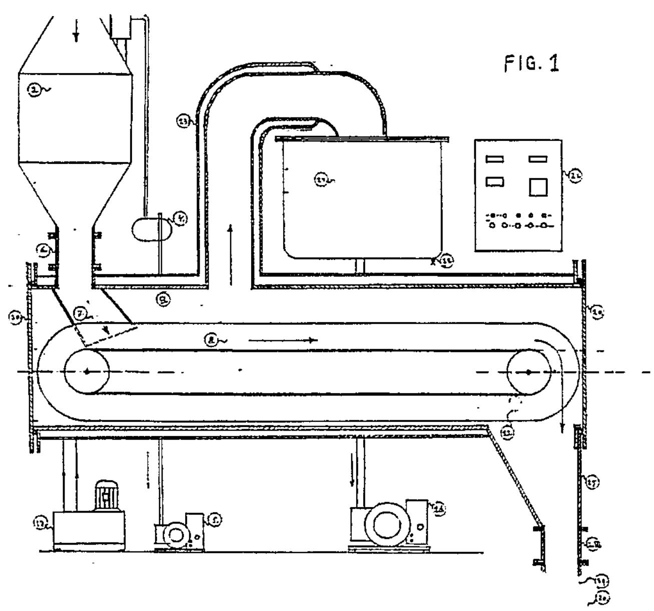

FIG. 1

EP 0 393 777 A2

PROCESS AND APPARATUS FOR DRYING AND/OR COOLING OF A PRODUCT CONTAINING ONE OR MORE EVAPORABLE SUBSTANCES

The invention relates to a process and apparatus for drying and cooling of a product containing one or more evaporable substances by means of pressure reduction which may be combined with energy supply. In particular, the invention relates to the use of a vacuum technique as a means of reducing odour emissions which arise when air is used as a cooling or drying medium. By the use of the invention these emissions are restricted. The process and apparatus are in particular applicable to divided products, like granules, powders, pellets or sludge. Such products which, when formed in hot and/or moist condition, often have to be cooled and/or dried quickly, on the one hand to accelerate the process, on the other hand to prevent deterioration of the quality. A generally used process for cooling said products is by contacting them with colder air. In that case air is carried along the products to extract heat. An undesired side effect of this process is that in many cases odours and dust are carried away which lead to emissions giving rise in some cases to nuisance to the surroundings. This e.g. plays a role for cattle feed works. A generally used drying process is to heat the product in which way drying is effected. A disadvantage of this process is the high energy consumption and possible oxidation of the product.

The problem to be solved by the invention will now be illustrated by means of the cooling of cattle feed pellets, for which the above odour emission problems are very actual, but it is to be understood that the invention is also applicable to other products for which similar problems exist, such as plastic powders and granulates, silicates, dung products, used suspensions or slurries etc.

When preparing cattle feed pellets before the compression process, amongst others water and molasses are added to the starting materials to enable pressing pellets therefrom. The moisture and molasses added are necessary to obtain a good quality pellet. After pressing by means of pressure rolls through a die, holes or in another way the additionally added moisture has to be again withdrawn from the pellets to confer them the necessary hardness and abrasion resistance. In practice one seeks to draw as much moisture during cooling as is added before the compression. In the presently used cool installations in the cattle feed industry air is forced past the pellets. This air stream entrains heat but also other materials. This cooling air in most occasions is untreated vented in the atmosphere. In some cases this gives a serious burden on the surroundings.

It is a principal object of the invention to provide a process or apparatus wherein the cooling and/or drying of the said defined products continuously can take place under vacuum without odour burdening or other undesirable side effects.

It is a further object of the invention to provide a process or apparatus wherein using underpressure cooling and/or drying of the afore mentioned defined products is continuously carried out by extraction of heat from these products by causing volatile components to evaporate. The rate of evaporation is adjustable and in many cases energy savings compared with conventional techniques can be realised.

It is a further object of the invention to provide a process wherein a pre-deaeration is carried out before the product is subjected to a high vacuum.

Thus the invention comprises a process for cooling and drying of a product containing one or more evaporable components which is characterized in that product is continuously cooled and/or dried at a vacuum of 0-300 mbar (absolute). The proper adjustment of the pressure depends on the product to be treated, but a suitable range is 0-150, especially 0-100 mbar, while for other products, especially cattle feeds a range of 0-20 mbar (absolute) is suitable.

In a prefered embodiment the invention comprises a process of the type described, wherein the product to be treated is subjected to a pre-deaeration at a lower pressure, preferably not lower than 300 to 900 mbar (absolute) before it is subjected to the continuous treatment. Here again the pressure is dependent on the product to be treated, especially the air content (or other gas). A suitable range is 300-500 mbar (absolute).

The invention also comprises an apparatus for carrying out this process comprising a pre-aeration room working at subpressure and coupled therewith through valves a main vacuum room, working under vacuum, which room possesses a continuously circulating conveyor, arranged to take up the product from the pre-aeration room, which preferably has double walls and to release it through locks in an after- aeration room which preferably has double walls, which apparatus further comprises a condensor for taking up the evaporable substances, control and driving means for the conveyor as well as prevacuum and main vacuum pumps. The under pressure in the pre-deaeration room as indicated is in the range of 300 to 900 mbar (absolute) while the under- pressure in the high-vacuum room has the above indicated values and is much lower than that in the deaeration room.

The pressure applied in the pre-aeration room is so chosen that for a particular product just no evaporation of components takes place. This can be determined by means of arranged detectors. In practice preferably a prevacuum of 300-400 mbar is used in case of evaporation of water. The pre-deaeration step therefore is carried out until the desired pre-vacuum as above mentioned is adjusted, whereafter this step can be finished by opening a valve arrangement, which is commanded by a control device. This treatment preferably takes place without external cooling. The treatment is carried out batch-wise in such a way that the pre-deaeration room is filled with the moist products, next sealed with a valve arrangement and connected to the pre-vacuum. This connection takes place through an air filter and condensor. The product entering in the high-vacuum room through the valve arrangement which functions as a lock, is distributed on a driven endless conveyor, which conveyor is arranged within the high-vacuum room which at the ends is closed by blind covers. The high-vacuum room preferably has double walls so that possible cooling and/or evaporation by means of tap water or another heat carrier is possible. The conveyor and the brush are driven by a hydraulic unit which is outside the main vacuum room and thus their r.p.m. can easily be varied. The releasing vapours are conveyed to a condensor by means of one or more pipes, preferably with double walls, which condensor is cooled by normal tap water or another heat carrier. The liquid which is formed, is then at intervals carried away by means of a lock system. The condensor and the main vacuum room are kept under vacuum by the main vacuum pump. The cooled product is running from the conveyor in a hopper, wherein a valve arrangement takes care that the product alternatively is taken up into after-aeration rooms, which are provided at the bottom part of the valve arrangement. These after-aeration rooms are pre-evacuated by the same pre-vacuum pump as the pre-deaeration rooms so that there are no big differences in the main vacuum room. Further various level and pressure detectors are present which assure by their control a good functioning of the process. Preferably there are two or more pre-deaeration rooms which alternatively feed the main vacuum room, so that the process in the second step will function continuously.

The invention is now illustrated by the drawing wherein figure 1 schematically indicates an apparatus according to the invention, figures 2 and 3 are graphs which indicate the course of the pressure and the temperatures against the cooling time and the weight decrease velocity against the course of the pressure in a laboratory test arrangement respectively.

The apparatus according to figure 1 comprises the following parts:
a pre-deaeration room (2) wherein product is introduced through a valve (1). Connected to the pre-deaeration room are an air filter (3) and condensor (4), which are in communication with the pre-vacuum pump (5). (6) schematically indicates the valve arrangement by which the feed treated in the deaeration room is carried in the high-vacuum room (9), which has double walls. The product is flattened on the conveyor (8) by means of the distributor (7). This conveyor is driven by the hydraulic unity (12) in the direction of the arrow and is provided with a brush (11) at the end of the course. The double wall of the high-vacuum room is indicated with (13). The main vacuum room (9) further contains blind covers (10) on both sides. The main vacuum room is connected to the condensor (14) wherein the vapour (indicated with a vertical arrow) is condensed, the condensate being carried away through lock system (15). The main vacuum room is evacuated with the main vacuum pump (16). The product leaves the main vacuum room through hoppers (17) and valve arrangement (18) and is taken up in after-aeration room (19) through a valve (20). One will notice that in use mainly two or three after-aeration rooms as well as two or three pre-deaeration rooms are used. The apparatus is commanded by a controller which generally is indicated by reference numeral (21).

Example

The invention will now be illustrated by the following example, which specifically relates to the cooling of cattle feed pellets (pig recipe with a pellet diameter of 5 mm) with a continuous vacuum cooling installation with a capacity of 10 ton per hour.

Production process before cooling

In the process treatment of cattle feed the following process steps can be distinguished. In the first place the starting materials according to table A are comminuted in the mills. Then the flour obtained is conditioned by adding more steam and molasses to it. After conditioning the flour is pressed to pellets. The pellets have a temperature between 60 and 90 °C and a moisture content which is between 3 and 5%

higher than the moisture content of the raw materials used. In the vacuum cool installation the hot pellets are cooled to about room temperature.

Table A

Composition pig feed	
Wheat	23%
Wheat flour	19%
Peas	10%
Corn feed meal	10%
Tapioca	10%
Soybean flour 50%	10%
Fish meal	5%
Lactose	4%
Fat	3%
Animal meal	3%
Minerals	2%
Premix	1%
Moisture content	11,8%

Cooling

The two pre-deaeration rooms are intermittently filled in the manner as indicated in the afore mentioned installation description. When the pre-deaeration room is filled with about 170 kg hot pellets the air pressure is reduced by means of the pre-vacuum pump from 1.000 mbar to about 350 mbar within about 5 seconds. After the pre-vacuum treatment the pellets are brought in the main vacuum room. Here flattening takes place via a distributor on a conveyor band with a width of 1,5 meter and a total length of 10 meter, to a layer thickness of about 17 cm. The velocity of the conveyor band is so adjusted that the residence time is maximally 12 minutes. From the graph wherein the course of the pressure and temperature, based on laboratory tests, the pressure being gradually reduced, is indicated against the time it appears that the pellets are then at room temperature (about 20° C).

In the above described continuous vacuum cooler the cooling time will be shorter because the underpressure to which the pellets are exposed is not gradually lowered, such as with the laboratory experiment, but the pellets after the pre-vacuum treatments are immediately brought into the high-vacuum room where there is a pressure between 20 and 25 mbar.

The cooling of the pellets is effected by evaporation of a part of the moisture content of the hot pellets. This evaporation process is indicated in figure 3, wherein the weight decrease of the pellets, based on laboratory tests, is a measure for the evaporation of moisture from the pellets. For the continuous vacuum cooler the weight decrease in the high-vacuum room will be quicker because the driving force is greater.

The evaporated moisture is condensed in a condensor wherein the condensate is carried away through a lock system. This condensate contains a number of volatile components evaporated from the mixed feed, such as amino acids and fatty acids. From the laboratory tests it appears that the CVZ content of the condensate amounts to 2080 mg N2/l, the BZV content 650 mg N2/l and the Kjeldahl-N content 9,4 mg N/l. This condensate is drained in the sewer or it is reused as process water. The difference between the moisture content before and after the cooling amounts to about 3 to 4%. This is substantially equal to the amount of moisture which is added in the conditioning process, so that the moisture content of the cooled pellets will not be lower than that of the starting materials.

The air to be carried away is contaminated with odour substances. The total emission of odour substances in the laboratory vacuum cooling is however only 10% of the emission in case of the usual air cooling. In the continuous vacuum cooling installation as described, this reduction will be more than 99%. By this reduction the possible nuisance to the surroundings is greatly reduced.

At the end of the conveyor the cooled pellets are brought in one of the two intermittently acting after aeration rooms via a valve arrangement. Here the air pressure is raised to 1000 mbar. After the aeration room the product is ready for packaging or bulk shipment.

Quality

To judge cattle feed pellets in the mixed cattle feed industry two parameters are of importance. The abrasion resistance which is measured by a Holmen tester and the hardness which is measured by a Kahl hardness meter. In table B the results of the pellet quality to he expected based on laboratory-wise vacuum cooled pellets in relation to the traditionally air cooled pellets is indicated.

Table B

Table relating to pellet quality of laboratory vacuum cooled pellets compared to air cooled pellets (pig recipe)		
	Air cooled	Vacuum cooled
Kahl hardness (after 24 hours)	5,0 kg	6,2 kg
Abrasion resistance (Holmen test)	91,4%	92,6%

It appears that the quality of the vacuum cooled pellets matches that of the air cooled pellets.

The hardness is measured by the Kahl hardness meter. In this case a pellet fixed in a claw has to withstand increasing pressures. The pressure at which the pellet breaks is a measure for the hardness. The abrasion resistance is measured by the Holmen-granule tester. This tester immitates pneumatic transport in a bulk carrier.

Per test about 100 gram granules are necessary. The tester is blowing the pellets during a fixed time (1 minute for 5 mm pellets and 0,5 minutes for 3 mm pellets) through the pipe of the tester. The parts which thus get free are sieved, whereafter the remaining quantity of the pellets is again weighed. The difference is equal to the abrasion resistance expressed in percentage.

The invention is of special importance for mixed feeds which are obtained in the form of pellets and are given to animals, like cattle, pigs, poultry etc. As already mentioned these products after their preparation at 60-80°C have to be cooled to room temperature. It is also possible to treat other solid or semi-solid products according to the invention like Lacta (a side product of penicillin preparation), manures, protein concentrates, sludges, molasses etc. Of course other temperatures will be present as far as other materials than water, for instance solvents are present, which, however, at the used lowered pressures are not higher than about 120°C and not lower than about 60°C. One will generally cool to room temperature, which is about 15-25°C. It has appeared that this two-step process has also a sterilizing effect and disease causing germs, such as especially Salmonellae can be made harmless.

Thus the invention comprises a two-steps process wherein in the first step batch-wise is deaerated at a lower pressure and in the second continuously is cooled and/or dried at a very low pressure, wherein by adjustment of the under-pressure in step one and the under-pressure and residence time (adjustment velocity conveyor) in step two, desirable end properties for a particular treated product are obtained.

Claims

1. Process for cooling and/or drying of a product containing one or more evaporable components, characterized in that the product is cooled and/or dried by a continuous vacuum treatment.

2. Process according to claim 1, characterized, in that the product to be treated is subjected to a pre-deaeration at a lower temperature, preferably not lower than 300 mbar (absolute) before it is subjected to the continuous treatment.

3. Process according to claims 1-2, characterized, in that the product to be cooled and/or dried is continuously transported through the main vacuum room at a pressure of 0-300 mbar (absolute).

4. Process according to claims 1-3, characterized, in that the products are mixed feed pellets and they are cooled from temperatures of 60-80°C to room temperature.

5. Process according to claim 4, characterized, in that the pellets before pressing are wetted and the

process conditions are so chosen, that after drying and cooling, the moisture content is at least about equal to the starting moisture content.

6. Process according to claim 2, characterized, in that during the pre-deaeration the pressure is so adjusted that there is just no evaporation of components for the particular product.

7. Process according to claim 6, characterized, in that the pressure is adjusted in the range of 300-500 mbar (absolute).

8. Apparatus for carrying out the process according to one of the preceding claims, characterized, in that it comprises a pre-deaeration room with an inlet and outlet for the product, arranged to work under pressure, as well as a main vacuum room which is coupled to the deaeration room by a valve arrangement, which is arranged to give a vacuum and is provided with a conveyor arranged to transport the deaerated product continuously from the inlet to the outlet of the main vacuum room under substantially constant vacuum, as well as one or more storage silos connected to the main vacuum room through a valve system.

9. Use of vacuum technique for reducing odour emission in case air is used as a cooling or drying medium, characterized, in that the process and apparatus according to one of the preceding claims is used.

10. Use according to claim 9 for mixed feed pellets.

FIG. 1

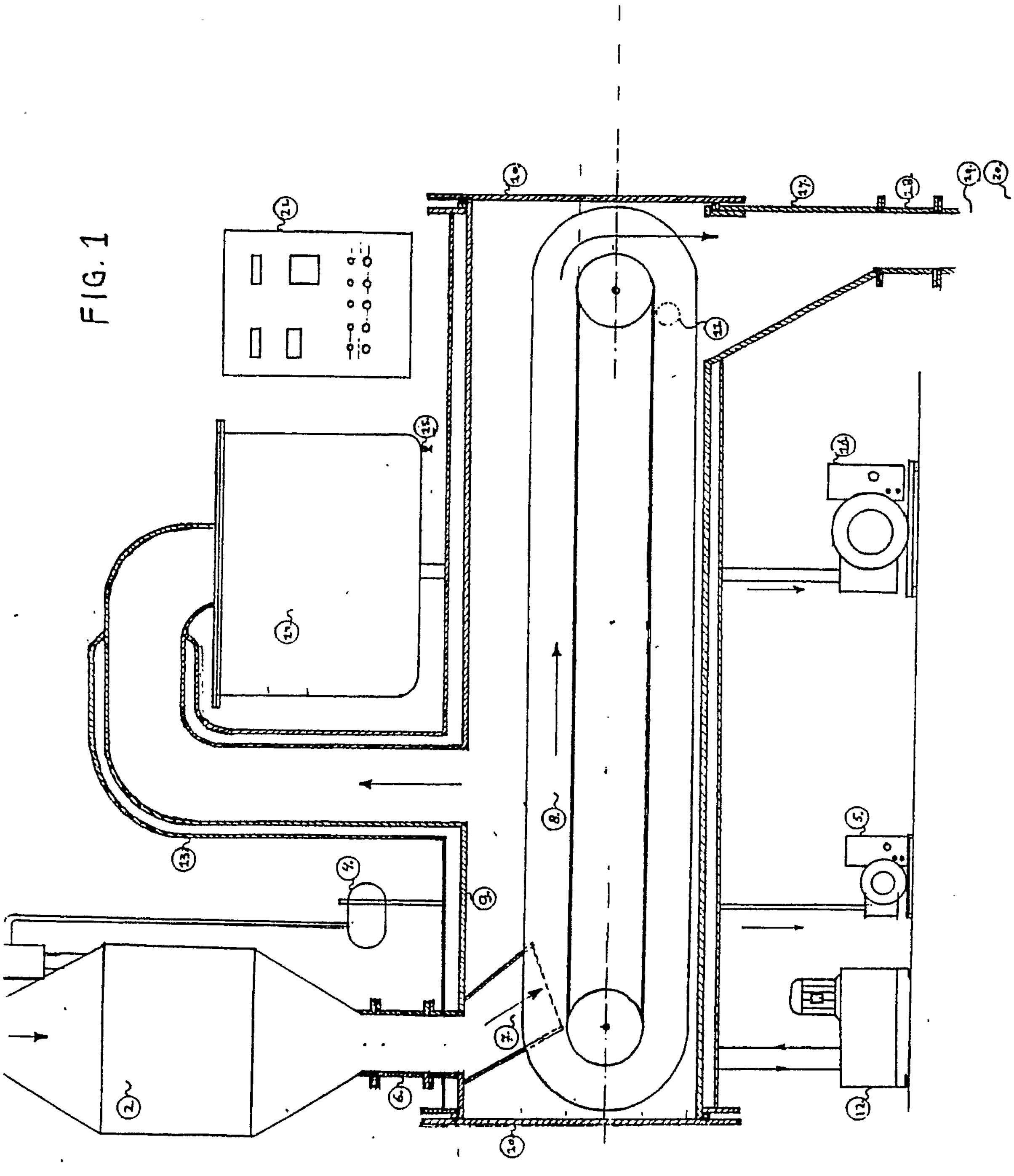

Figure 2: course of pressure and temperature versus cooling time in a test arrangement

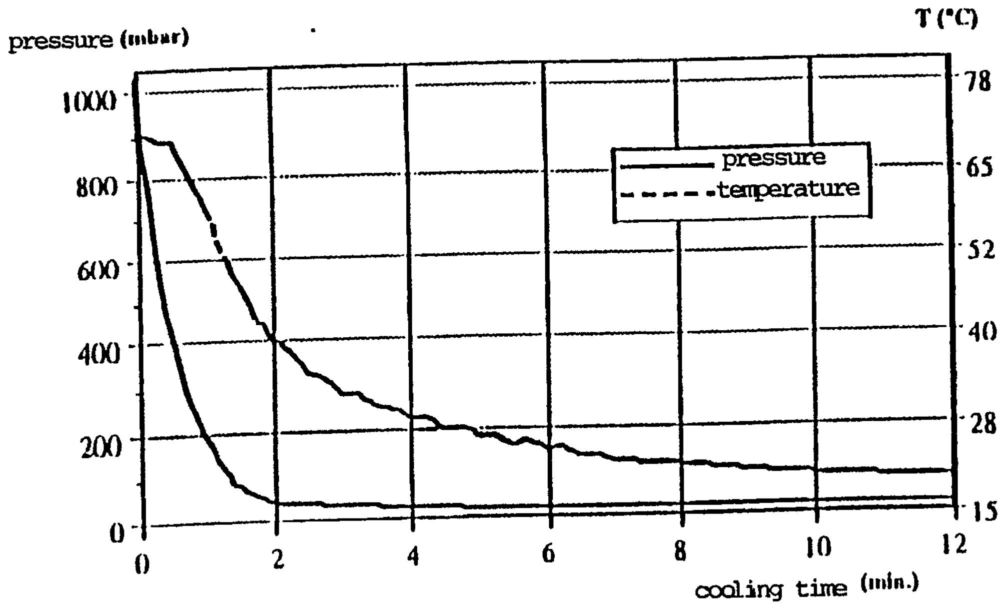

Figure 3: rate of weight reduction versus course of pressure in a test attangement