An apparatus for the cooling and drying of powdery and/or granular material such as foundry sand is disclosed. The sand to be cooled is conveyed throughout the length of the apparatus over a perforated plate and a flow of air is directed upwardly through the perforations in the plate to suspend the material in a fluidized state. The material is conveyed throughout the length of the apparatus by moving scrapers or blades passing along the plate whereby the material receives a swirling motion during its travel. The material leaving the apparatus is cooled preferably to room temperature and is absolutely dry.

5 Claims, 6 Drawing Figures
APPARATUS FOR COOLING AND DRYING SOLID MATERIAL IN GRANULAR OR POWDER FORM

This invention relates to apparatus for the continuous cooling of a powdery or granular solid material or product, which could be a food, a chemical or a mineral such as foundry sand. The apparatus is designed to provide absolutely dry products, cooled to room temperature.

Because of modern and increasing, technology, cooling apparatus have become an absolute necessity, especially in smelting procedures and industry generally.

After casting, the sand moulds are subjected to an operation called "stripping" in which the hot sand mould is broken so that the casting may be recovered. The breaking may be done with a pickax, a hammer, a stream of highly compressed air or a shaking grate. The broken pieces of the mould fall into a mixer where they are ground as finely as possible to permit the recovery or regeneration of the sand grains, so that they may be used again for making new moulds.

Before the still hot sand grains are introduced into the recovery or regeneration apparatus, they must be brought to a temperature close to room temperature, which is the only temperature acceptable for sands prepared, for example, with irreversible binders like sodium silicates or organic resins (furan, urea-formol furans, phenolic furans, etc.). This preliminary cooling is obtained by passing the sand continuously through a cooling apparatus.

The first known cooling apparatus were made with plates on which the sand was displaced by means of scrapers. These plates were either heated (German Pat. No. 468,763) or perforated so that an ascending more or less warm gas would cool the sand (British Pat. No. 720,347).

Such installations (even the preferred ones) have two distinct drawbacks:

a. They can only supply wet sand. Yet, the present regenerations require a perfectly dry sand at the outlet of the cooler.

b. They are cumbersome, because they have a first stage for moistening and homogenizing the sand and a second downstream stage where the wet sand brought in by a conveyor is partially dried and cooled to substantially room temperature.

The installation described in German Pat. No. 1,245,047 illustrates perfectly this condition: the second stage, which is made up of a channel through which the sand passes while water is evaporated, is designed for wet sand only, so that its temperature cannot be greater than 100°C. To moisten the sand in such an installation, an additional station is required upstream. In this station, the sand is sprayed with water and at the same time it is mixed so as to be as homogeneous as possible at the entrance of the cooling channel.

As there is no stirring motion in the cooling channel, it is impossible to spray a volatile liquid on the sheet of sand travelling in this channel. If such a liquid was sprayed it would tend to remain on the surface and the buried grains would not be moistened. This is why such an installation lacks control and reliability: if the sand delivered at the outlet of the apparatus is too hot, it must be recycled at the entrance of the cooling channel, which means an additional operation. This type of installation makes it impossible, therefore, to cool sand more efficiently because the spraying of the liquid is limited to the entrance of the installation, at the level of the first mixing stage, and cannot take place directly in the cooling channel. These cooling apparatus have, therefore, many drawbacks, including their cumbrousness and their lack of control on the delivered product.

The object of the present invention is to avoid the above-mentioned drawbacks, since it concerns a cooling apparatus with a simplified inner installation where both stages (mixing and cooling) are brought together in the same section. Moreover, the apparatus which is the subject of this invention comprises control and regulating devices making sure that the delivered sand will, of course, be cooled to room temperature but also that it will be absolutely dry. Another advantage of the apparatus according to this invention resides in the fact that it makes it possible to cool directly (without preliminary steps) a warm and dry sand, not yet moisture or elevated, the temperature of which, after the stripping and crushing operations, varies between 120° and 500°C and is most often about 280°C.

In all cases, the temperature of the delivered sand must be between 30° and 35°C. If the outlet temperature were to be higher than 35°C, either because of an excessive output or because of a too hot sand at the inlet, spray nozzles provided inside the apparatus, would spray on the stirred hot sand a volatile liquid, which would speed up appreciably the cooling effect. The quantity of the liquid thus added must be reasonably limited so that the delivered product will still be perfectly dry.

The concept of this invention is to use, inside the cooling channel, the principle of the fluidization bed such as it is described, for example, in French Pat. No. 1,402,633.

According to this invention, an apparatus for the continuous cooling of a powdery and/or granular solid product, which could be a food, a chemical or a mineral such as a foundry sand, comprising a trough equipped, in its upper part, with at least one perforated and nearly horizontal plate, receiving at one end of the trough the hot product on its upper face above which the sheet of the product to be cooled travels from the first end of the trough to the other; a fluidization channel hanging over each plate along its full length, an air compressor distributing from the trough an ascending air stream crossing the perforated plate and keeping in suspension the solid product, and hoods for draining off the heated air are arranged above the fluidized bed. The system for carrying the product from one end of the trough to the other is characterized by the fact that the sheet of the product to be cooled is driven on the fixed plate by solid scrapers fixed at least one endless chain operated by a motor having a variable speed feature. The said scrapers are arranged perpendicularly in relation to the direction of the driving motion above the plate, helping to impart a swirling motion, to the product on the plate insuring the homogeneity of the said product. In addition, a temperature sensor or detector contacts the cooled product, slightly upstream of the product outlet, the said sensor being linked to the variable speed device of the motor to adjust the progress speed of the product so that the temperature of the delivered product will not be greater than the desired temperature.
The inventive concept will now be described in more detail with reference to the accompanying drawings, which illustrate a non-limiting example, and wherein:

FIG. 1 is a side schematic view of one embodiment of the cooling apparatus according to this invention;

FIG. 2 is an end view of the cooling apparatus schematically shown in FIG. 1;

FIG. 3 is a side schematic view of a second embodiment of a cooling apparatus according to the present invention, this embodiment being shown with a protective covering or housing;

FIG. 4 is an end view of the apparatus shown in FIG. 3;

FIG. 5 is a cross-sectional longitudinal view taken along line V—V of FIG. 4;

FIG. 6 is a cross-sectional view taken along line VI—VI of FIG. 5, the protective skin of the latter being shown without the access and inspection gangway.

The cooling apparatus is essentially made up of a trough 1 which is preferably of metal, which has in the example shown one or two perforated fixed plates 2 in its upper part and which are substantially horizontal. Each plate 2 may consist of a filtering metal screen, a porous plate or a perforated metal plate.

The scraping devices 3, which may be made of metal or rubber are fastened to a transmission system 4 which may be at least one endless chain, one chain type or belt type conveyor and driven by a motor 5 which is variable in speed. The devices 3 which will be called scrapers, are arranged perpendicular to the direction of their motion above the upper face of the plates 2. In the example shown, the transmission system 4 may either be a central conveyor moving in a vertical plane between two lateral plates or one or two side conveyors moving in vertical planes close to the longitudinal edges of the single central plate 2. A second embodiment of the inventive concept is illustrated in FIGS. 3 to 6 inclusive.

The hot powdery and/or granular product, particularly a dry foundry sand, is introduced into the apparatus (see arrow 6) as evenly as possible and becomes positioned above one end of the trough 1 on the upper face of the perforated plates 2. The sheet or layer of sand to be cooled, thus positioned, is moved along by scrapers 3 at a speed corresponding to that of the said scrapers. The product is then discharged (arrow 7) at the second end of trough 1 and of plates 2 to fall into a loading container or funnel or to be taken by a conveyor 8 to a storage area or to subsequent transformation, regeneration or recovery apparatus.

Opposite the upper surfaces or faces of the plates 2 are arranged two or four nearly vertical walls 9 which are parallel with each other and follow the direction of the advancing scrapers 3. These walls 9 guide the sand and comprise respectively one or two channels 16 in which the solid product 10, located on the upper face of the filtering or porous plates 2 will be held in suspension by fluidization.

To bring about this fluidization multiple air inlets 11 are provided in the lower part of the trough 1 under the plates 2. Preferably, the inlets 11 are connected to only one air compressor 12 (FIG. 3) through pipes 13, each having a valve 14, and a header pipe 15 connected to the compressor outlet. A stream of ascendant clean air passes through each of the perforated plates 2 and comes into contact with all of the surfaces of the sand 10 to be cooled and holds it in fluidized suspension, which brings about, according to heat exchange principles, a rapid cooling of the sand mass.

The scrapers 3 serve to maintain the even, continuous output of the apparatus. As a matter of fact, the fluidized sand 10 carried by the scrapers 3 advances slowly in the fluidization channel 16 and is continuously being cooled due to the fluidization air stream. Suction hoods 17 provided above the plates 2 serve to cover completely the fluidized bed, draw the air heated by contact with the sand and discharge it out through upper parts 18.

The simultaneous presence of the fixed plates 2 and the solid scrapers 3 and the fluidized bed effect provided according to the main characteristic of the invention, has the advantage of imparting a swirling motion to the sand on the plates. This swirling motion, which insures the homogeneity of the sand is illustrated at 19 in FIG. 5. Each grain moved by the ascending clean air stream goes up and remains there for a short period while in suspension. This equilibrium is ended when the next advancing scraper contacts the grains which then fall slightly downstream in the apparatus before being lifted up again by the ascending air stream to start a new cycle of periodic swirling motion.

The present apparatus is also provided with a control device which insures a perfect efficiency for the sand cooling. This device comprises a probe or sensor 20 for measuring the temperature of the pulmonary and/or granular product located inside the apparatus slightly upstream of the outlet 7. The probe or sensor 20 is connected to the mechanisms controlling the speed of motor 5 which drives the scrapers 3, and it is possible in this way to adjust the progress speed of the sand on the plate so that the temperature of the delivered product will not be higher than a desired temperature (such as 30° to 35°C). If the temperature measured by the probe 20 is too high, the speed of movement of the sand is decreased. On the other hand, if the temperature is too low, the speed is slightly increased.

The probe or sensor 20 may for example be a thermocouple of iron-constantan.

Additional control and safety devices may be provided in the event that the sand does not cool down to the desired temperature, even if the speed of the sand were drastically reduced. These additional devices may include:

Several (4 in principle) thermometric probes in the shape of thermoellectic couples of iron-constantan. Such probes 22 may be fastened to a support 23 integral with an element of the apparatus, the hood 17 for example, are located above the fluidized sand, in the upstream part of the channel 16. The probes 22 are placed at four different depths and on four levels with different widths so that they may monitor substantially all of the sand sheet. Because the probes 22 are located near the sand vortex, they must be placed high enough not to be prematurely disabled due to abrasive action.

The temperature recorded by the probes 22 correspond to the temperature of the heated air and the sand temperature is derived by extrapolation. Each probe 22 acts individually on a spraying nozzle with a flat jet 24 located above the fluidized bed in the first half of the fluidization channel 16. As the sand 10 is subjected on the full length of the plate 2 to an even stirring, a volatile liquid may be sprayed in a very fine spray by the nozzles 24 to douse the full width of the sand sheet in order to moisten the sand homogeneously. The draw-
4. Apparatus according to claim 2, further including a humidity tester positioned in the proximity of the outlet of the apparatus, the said humidity tester being connected to the said variable speed motor and/or the said nozzles to ensure dryness of the material discharged from the apparatus.

5. Apparatus according to claim 1, wherein said air compressor means is connected through a main duct to a number of pipes with the outlets of the pipes being positioned under the said perforated plate, each of the pipes including a valve the opening and closing of which is controlled by the said temperature sensor whereby the useful length of the fluidization channel located above the perforated plate is adjustable.

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Claims:

1. Apparatus for the continuous cooling of a powdery and/or granular solid material, such as foods, chemicals, minerals and foundry sand, to preferably room temperature and in a dry state, comprising:

a trough provided with at least one horizontal or substantially horizontal perforated plate,

a conveyor means to move material deposited on one end of the said perforated plate along the perforated plate throughout the length thereof, the conveyor means including scrapers secured to an endless conveyor mechanism,

a fluidization channel extending throughout the length of the perforated plate,

an air compressor means to direct an ascending flow of air upwardly through the perforations in the plate, the flow of air maintaining the said material in fluid suspension above the plate in the fluidization channel,

a spray nozzle means for spraying a liquid onto the said material in fluid suspension to dissipate heat thereby;

a variable speed motor to drive said conveyor means, the said scrapers being positioned perpendicular to their direction of movement with the scrapers and flow of air imparting a whirliging motion to the material during travel to provide uniform cooling,

an outlet for the discharge of the material positioned adjacent one end of the said plate, and

a temperature sensor positioned upstream of said outlet to determine the temperature of the material, the temperature sensor being connected to the variable speed motor to regulate the speed of travel of the material as a function of its temperature.

2. Apparatus according to claim 1 further including a number of thermometric probes positioned above the fluidized material in an upstream portion of the fluidization channel, each of the thermometric probes being connected to said spray nozzle means, said means comprising spray nozzles for spraying a volatile liquid onto the material, the spray nozzles being positioned above the fluidized material in an upstream portion of the channel for spraying the complete width of a layer of material, and a regulator for each nozzle to actuate the nozzle to spray as the temperature of the material as determined by the thermometric probes exceeds a predetermined value.

3. Apparatus according to claim 2, wherein the thermometric probes are positioned at various locations within the apparatus to provide sensing of temperature over as much area as possible.

4. Apparatus according to claim 2, further including a humidity tester positioned in the proximity of the outlet of the apparatus, the said humidity tester being connected to the said variable speed motor and/or the said nozzles to ensure dryness of the material discharged from the apparatus.

5. Apparatus according to claim 1, wherein said air compressor means is connected through a main duct to a number of pipes with the outlets of the pipes being positioned under the said perforated plate, each of the pipes including a valve the opening and closing of which is controlled by the said temperature sensor whereby the useful length of the fluidization channel located above the perforated plate is adjustable.

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Claims:

1. Apparatus for the continuous cooling of a powdery and/or granular solid material, such as foods, chemicals, minerals and foundry sand, to preferably room temperature and in a dry state, comprising:

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a conveyor means to move material deposited on one end of the said perforated plate along the perforated plate throughout the length thereof, the conveyor means including scrapers secured to an endless conveyor mechanism,

a fluidization channel extending throughout the length of the perforated plate,

an air compressor means to direct an ascending flow of air upwardly through the perforations in the plate, the flow of air maintaining the said material in fluid suspension above the plate in the fluidization channel,

a spray nozzle means for spraying a liquid onto the said material in fluid suspension to dissipate heat thereby;

a variable speed motor to drive said conveyor means, the said scrapers being positioned perpendicular to their direction of movement with the scrapers and flow of air imparting a whirliging motion to the material during travel to provide uniform cooling,

an outlet for the discharge of the material positioned adjacent one end of the said plate, and

a temperature sensor positioned upstream of said outlet to determine the temperature of the material, the temperature sensor being connected to the variable speed motor to regulate the speed of travel of the material as a function of its temperature.

2. Apparatus according to claim 1 further including a number of thermometric probes positioned above the fluidized material in an upstream portion of the fluidization channel, each of the thermometric probes being connected to said spray nozzle means, said means comprising spray nozzles for spraying a volatile liquid onto the material, the spray nozzles being positioned above the fluidized material in an upstream portion of the channel for spraying the complete width of a layer of material, and a regulator for each nozzle to actuate the nozzle to spray as the temperature of the material as determined by the thermometric probes exceeds a predetermined value.

3. Apparatus according to claim 2, wherein the thermometric probes are positioned at various locations within the apparatus to provide sensing of temperature over as much area as possible.

4. Apparatus according to claim 2, further including a humidity tester positioned in the proximity of the outlet of the apparatus, the said humidity tester being connected to the said variable speed motor and/or the said nozzles to ensure dryness of the material discharged from the apparatus.

5. Apparatus according to claim 1, wherein said air compressor means is connected through a main duct to a number of pipes with the outlets of the pipes being positioned under the said perforated plate, each of the pipes including a valve the opening and closing of which is controlled by the said temperature sensor whereby the useful length of the fluidization channel located above the perforated plate is adjustable.

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Claims: