(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 095 265**
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **83302532.3**

(22) Date of filing: **05.05.83**

(51) Int. Cl.³: **F 26 B 21/06**
F 26 B 25/22

(30) Priority: **21.05.82 GB 8214951**

(43) Date of publication of application:
30.11.83 Bulletin 83/48

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

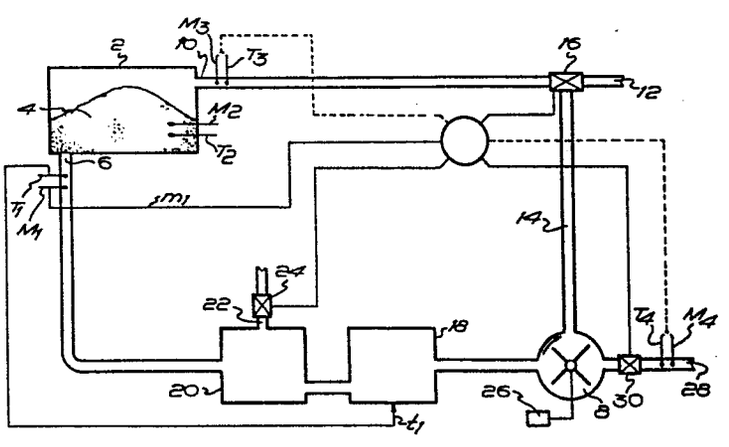
(71) Applicant: **Moisture Control & Mesurement Limited**
Thorp Arch Trading Estate
Wetherby West Yorkshire LS23 7BJ(GB)

(72) Inventor: **Wallis, Bruce**
Thorp Arch Trading Estate
Wetherby West Yorkshire, LS23 7BJ(GB)

(74) Representative: **Denmark, James**
c/o Bailey Walsh & Co. 5 York Place
Leeds LS1 2SD Yorkshire(GB)

(54) **Control of drying operation.**

(57) An improved technique for the drying of materials or otherwise controlling the moisture content thereof consists in passing air over or through the materials, the specific enthalpy of the input air being controlled independently of its drying potential.



EP 0 095 265 A2

Control of Drying Operation.

The invention relates to the control of drying or other moisture control operations by the circulation of air or other suitable gas over or through the material the moisture in or on which is to be controlled.

The ability of relatively dry air to extract water from surfaces with which it makes contact is employed in a wide range of industrial and other drying operations. The drying capacity of air being determined solely by its temperature and existing moisture content, drying operations can be and often are precisely thermally controlled in an attempt to optimise efficiency.

However important the thermal efficiency may be, the prime consideration must always be product quality, and the present invention arose from a consideration of, but is not necessarily confined to, circumstances in which control of drying capacity of the drying air is of supreme importance to the quality of the product.

According to one aspect of the invention there is provided a method of controlling moisture in or on materials when passing gas over or through the materials wherein the specific enthalpy of the gas is controlled independently of the drying potential thereof. The value of specific enthalpy relative to drying capacity may be controlled by monitoring the temperature and moisture content adding heat and moisture as required.

The method may be applied to the drying of material or, alternatively, to the maintenance of a controlled property of moisture on or in materials.

According to a further aspect of the invention there is provided moisture on or in materials when passing gas over or through the materials comprising means for controlling the specific enthapy of the gas independently of the drying potential thereof.

Preferably the addition of heat and moisture is controlled automatically by signals representing temperature and moisture content.

The invention will now be further described by reference to a number of non-limiting examples and the accompanying drawings of which the single figure shows schematically an installation for the drying of material by the circulation of air therethrough.

In the non-limiting example described, the material to be dried consists of green malt, which is a substance which is susceptible to damage if subjected to incremental changes in enthalpy and drying rate greater than predetermined values. It will be assumed that the initial moisture content of the malt is 45% and that it is required to reduce this to something like 4%.

For the sake of the example, it will also be assumed that the ambient air has a temperature of 15oC and a dew point of 10oC, though if the drying cycle continues into the night, the moisture content may drop to a dew point of 0oC and the temperature, having also dropped to around 0oC may, typically, recover to some 3oC by morning.

In the present example, the method of drying will be described, for the sake of simplicity, as comprising three

distinct phases, though it should be understood that in practice the phases may overlap at least to some extent.

As shown in the figure the installation for drying comprises a chamber 2 for containing a quantity of material 4 to be dried, in this example green malt. Air is passed into the chamber 2 through an inlet 6 by means of a fan 8, and having passed over or through the material 4 the air is exhausted through outlet 10 and either voided to atmosphere at opening 12 or returned to the fan 8 via branch pipe 14 for recirculation. A valve 16 controls the proportion of air recirculated with respect to the proportion voided to atmosphere.

In its passage from the fan 8 to the inlet 6 the air is capable of being heated by means of a heater 18. A mixing unit 20 is also provided in the path between the fan 8 and the inlet 6 providing facility for the introduction of moisture, for example in the form of steam or liquid water through moisture inlet 22 controlled by valve 24.

The rate of air flow produced by the fan 8 is controlled by means of a controller 26, and to the extent that the exhaust side of the fan is not satisfied with recirculated air from branch pipe 14, air is introduced through inlet 28 via valve 30. The air introduced through inlet 28 will normally be moist ambient air but in certain circumstances may be relatively or absolutely dry air.

The temperatures t of the air circulating in the apparatus is determined at various positions by means of sensors T1, T2, T3 and T4. The moisture content m of the circulating air is similarly determined at corresponding locations by moisture meters M1, M2, M3 and M4.

In the first, initiation, phase of drying, ambient air is drawn from inlet 28 through valve 30 by fan 8 and, heated

in heating unit 18 and moistened as required in the mixing unit 20 so as to produce the desired enthalpy and drying potential, is introduced into the material 4 in chamber 2 via inlet 6.

As the initiation phase continues, the enthalpy of the input air is increased gradually whilst controlling the drying potential so as not to damage the material 4.

The warming of the material 4 increases the transpiration of moisture within the material but, although the specific enthalpy of the air is increased, the drying capacity of the air is not allowed to increase in this example. The process in infinitely variable and in other examples the drying capacity may be allowed to increase but not in correspondence with increasing specific enthalpy.

This can be contrasted with with normal drying where, for example, ambient air with a temperature of 15 C and a dew point of 10 C is merely warmed prior to passing through the malt. During the night the dew point may be reduced to 0 C, and under these conditions the control of input temperature alone fails to control the drying process adequately and damage to the product can occur.

The control of drying capacity independently of specific enthalpy is effected by introduction into the air entering the chamber of quantities of moisture controlled by a signal m1 provided by sensor M1. The moisture introduced may originate from the atmosphere, any recirculated exhaust air or, predominantly at this phase, by injection into the mixing unit 20, and the input air moisture signal is therefore used to control the valves 16, 24, and 30.

The initiation phase therefore proceeds with gradual warming of the material without drying. The exhaust air leaving the chamber 2 via outlet 10 may be recirculated or

voided to atmosphere. The process is continued until the conditions recorded by sensors M3 and T3 have reached predetermined values or until the conditions at a predetermined zone within the material 4, as determined by sensors M2 and T2, have reached predetermined values. In practice, the temperature and the moisture content of the air within the material 4 may be determined by a series of probes at different levels, and the sensors T2 and M2 shown in the figure are to be taken as representative of such probes.

The second phase of the process is one of free drying. The specific enthalpy is further increased, but now the drying capacity of the air is also allowed to increase according to the requirements of the process and the material, for example as to whether the main requirement is for thermal efficiency or the safety of the product. It is to be understood that the requirements may vary throughout the process.

During this phase, the increase of drying capacity is still controlled independently of the increase of specific enthalpy. At least some of the exhaust air is conveniently recirculated during this process, and the requirement for the injection of moisture through valve 24 is accordingly adjusted. In exceptional circumstances dry air will be introduced through inlet 28. Data used in the control of the valves accordingly may include signals indicative of the moisture content for the time being of both input and recirculated exhaust air.

During the phase of free drying, evaporative cooling generally means that the temperature of the product does not rise to the value of the input air. Conversely, when the temperature of the product as measured by probe T2 begins to increase without any corresponding increase in the moisture content of the air in the material as

determined by M2, the end of free drying is indicated and the inset of the third phase - restricted drying - in which water removal cannot continue at the former rate. At this stage, the moisture content of the material may be, typically, 7%, and in order to reduce this to the 4% required, it is convenient to increase the drying potential of the air so as to shorten the process. This may be effected by:-

(a) increasing the temperature of the circulating air further by operation of the heater 18 whilst maintaining its moisture content;

(b) maintaining the temperature and, for example by introducing dry air through inlet 28, reducing the moisture content; or

(c) varying the temperature, the moisture content, and the flow rate of the circulating air by means of controller 26.

Whilst in the above example the three phases of the operation have been described as being quite distinct from one another, in practice the free drying phase may be integrated with the initiation phase inasmuch as some drying could take place from the outset. Nevertheless, the drying capacity of the air will be controlled together with, but independently of, specific enthalpy.

If the process of free drying continues to a point at which the moisture content of the material is reduced to the required level, the third phase will of course be dispensed with.

The example described above is one of batch drying wherein the three drying phases - distinct or overlapping - take place in the same spatial zone but at different (distinct

or overlapping) periods of time. However, the invention is equally applicable to continuous processing wherein a portion of a material is made subject to the conditions of the first phase in a first zone and is then moved successively to second and third zones maintained at the conditions respectively of the second and third phases. Successive portions of the material follow the first mentioned portion through the three zones. In the continuous process the equivalent of the overlapping of the phases in the batch process can be afforded by providing zones intermediate the above-mentioned zones and providing in the intermediate zones conditions intermediate those of the adjacent zones.

The invention has been described primarily in relation to drying and this is likely to be its major application. However, in the storage of certain products such as fruit or vegetables, it may be required to maintain or even increase the moisture content of the product whilst circulating air or other gas over or through it, and the invention is to be understood as extending to such application.

Again, the above descriptions have related primarily to control of moisture within materials, but it is to be understood that the invention is equally applicable to the control of moisture on the surface of materials.

CLAIMS

1. A method of controlling the moisture on or in materials when passing gas over or through the materials wherein the specific enthalpy of the gas is controlled independently of the drying potential thereof.

2. A method according to Claim 1 wherein the said independent control is effected by monitoring the temperature and moisture content of the gas and adding heat and moisture as required.

3. A method according to Claim 2 wherein the dew point of the gas is monitored as a measure of moisture content.

4. A method of controlling the moisture on or in materials when passing gas over or through the materials whereby drying conditions are infinitely variable, predictable and fully controllable.

5. A method according to any one of claims 1-4 when applied to the drying of the materials.

6. Apparatus for controlling the moisture on or in materials when passing gas over or through the materials comprising means for controlling the specific enthalpy of the gas independently of the drying potential thereof.

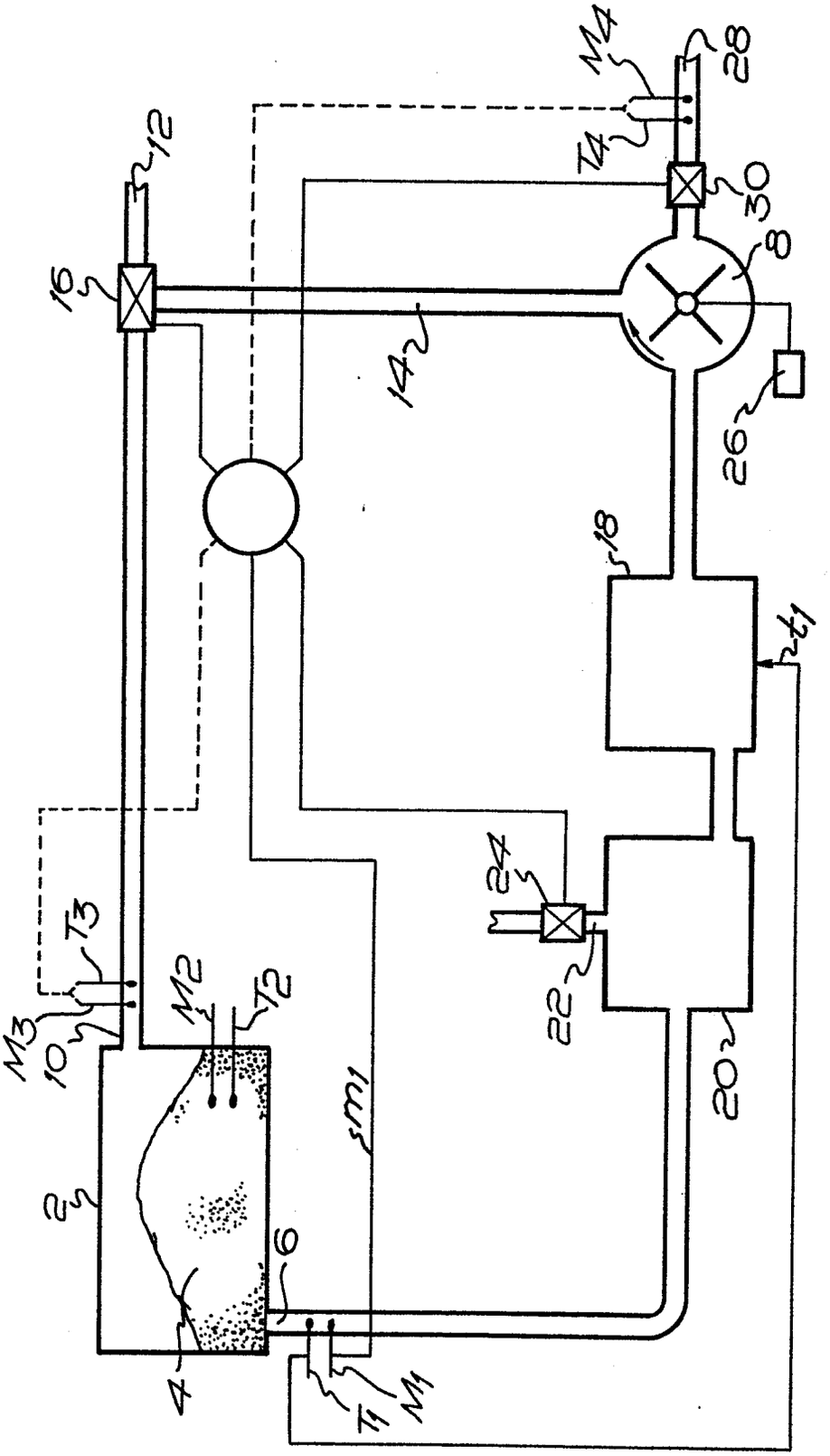
7. Apparatus according to Claim 6 wherein the said control means comprise means for monitoring the temperature and moisture content of the gas and means for adding heat and moisture to the gas in accordance with the results of said monitoring.

8. Apparatus according to either of Claims 6-7 when

applied or for application to the drying of materials.

9. A method of controlling the moisture on or in materials when passing gas over or through the materials substantially as described.

10. Apparatus for controlling the moisture on or in materials when passing gas over or through the materials substantially as described with reference to the drawings.


M4
28
T4
12
30
16
8
14
26
18
21
24
T3
M2
T2
M3
10
22
20
2
M1
9
4
T1
M1