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(54) DRYING OF GASES

5 (71) We, BASF AKTIENGESELLSCHAFT, a German Joint Stock Company of 6700 Ludwigshafen, Federal Republic of Germany, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following Statement:-

10 The present invention relates to a process for drying gaseous material.

15 Silica gels are very active amorphous silicic acids which, because of their special process of manufacture, have a large inner surface area and a large pore volume. The large inner surface area explains the excellent ability to adsorb gases, especially water vapor, and the high pore volume is the precondition for the high adsorption capacity of this drying agent.

20 Accordingly, silica gels have been used for many decades for drying gases. The most important fields of use are the drying of compressed air, the treatment of natural gas and the adsorptive drying of oxygen, nitrogen, hydrogen and other industrial process gases.

25 In general, narrow-pore silica gel, as beads or chips, is used for drying compressed air and industrial gases. This type of gel is distinguished by a particularly large inner surface area of from 650 to 850 m²/g and a pore volume - substantial for solid bed adsorbents - of from 0.35 to 0.50 cm³/g.

30 However, such silica gel must be shielded from direct contact with liquid water because the enormous intensity of water adsorption easily causes particles of the gel to disintegrate. Frequently, a small layer of wide-pore silica gel is placed upstream from the main bed of silica gel in the adsorbers, to protect the latter gel from water spray and fine mists of liquid. This wide-pore silica gel has a larger pore volume, of from 0.7 to 1.0 cm³/g, and also a smaller inner surface area, of from 300 to 500 m²/g. Because of these properties, the wide-pore gel is less active and can

therefore take up liquid water, applied in the form of mist or fine droplets, without being destroyed. In accordance with its function, this type of gel is often referred to as contact gel or protective gel. The amount of such gel to be employed depends on the expected entrainment and is normally from 10% to at most 20% of the fixed bed volume.

Summarizing the prior art, it may be said that silica gel adsorbents are operated almost exclusively with the narrow pore type. Whilst this gives very thorough drying of the gas to be treated, the dynamic capacity is limited, because of the relatively low pore volume of the narrow pore silica gel. The dynamic capacity is a measure of the amount of moisture which an adsorptive drying agent takes up in the course of dynamic drying under the prevailing conditions and is always lower than the equilibrium capacity.

We have found that gaseous materials can be dried advantageously by a process which comprises contacting the gaseous material, to effect drying by adsorption, with adsorbent material disposed in a first bed and comprising silica gel particles having a pore volume greater than 0.7 cm³/g, and effecting further drying by adsorption by contacting gaseous material, after treatment in the first bed, with adsorbent material disposed in a second bed and comprising silica gel particles having a pore volume of less than 0.5 cm³/g., the volume of the silica gel particles in the first bed being at least 30% of the total combined volume of the silica gel particles in both beds.

The decisive feature of the process of the invention is that an essential property of wide-pore silica gel, i.e. its high pore volume, is fully employed in the overall process for drying the gas.

Surprisingly, we have found that a first bed of wide-pore silica gel is capable, under the conventional reaction condition, of absorbing virtually the entire water vapor content of

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the moist gas, and that this requires substantially less silica gel, and accordingly less adsorber volume, than when using narrow-pore silica gels. It is therefore advantageous 5 not to restrict the proportion of wide-pore silica gel in the first bed to the low amounts conventionally used, which have hitherto been employed solely to take up water spray at the adsorber inlet, but instead deliberately 10 to choose as high a proportion as possible of wide-pore silica gel in order fully to utilize the advantage of the high pore volume for the adsorption of water vapor. The thoroughness of drying ultimately required is 15 achieved by the narrow-pore silica gel in the second bed.

The percentage subdivision of the total tap 20 volume of silica gel as between that of the upstream first bed and that of the downstream second bed, depends on the condition 25 of the gaseous material to be dried, that is to say on the relative humidity, temperature and pressure of the moist gas, and on the desired degree of drying of the gaseous material. At least 30% of the total tap volume is 30 employed as wide-pore silica gel in the first bed. This percentage may be as high as, but will in general not be greater than, 90%. In general terms, the proportion of wide-pore 35 silica gel can be the higher, the lower is the initial moisture content and temperature of the gaseous material to be dried and the higher is the pressure of the latter. In general, the temperature of the gas to be dried should not exceed 40 - 50°C.

The advantages obtainable by the process 40 of the invention are not confined to the already mentioned reduction in the amount of silica gel employed, and reduction in the adsorber volume (though the latter feature is of substantial importance in the case of pressure vessels of an adsorber unit) since additionally the process of the invention can achieve a saving in operating costs.

45 Since, for a given volume of the bed, a larger amount of water can be taken up in the process of the invention than when narrow-pore silica gel is used exclusively, the cycle time is increased for given gas conditions, i.e. 50 fewer adsorption and regeneration cycles are needed in the course of the total period of use of the silica gel. Since, when regenerating the silica gel, at most one-third of the amount of heat to be employed is usually utilized in 55 expelling the water adsorbed - the remainder being consumed in heating the apparatus and the silica gel - a significant saving in energy and hence in operating can be obtained.

A further advantage of the process of the 60 invention is that regeneration of the adsorbent can be carried out at lower temperatures than when using predominantly narrow-pore silica gel. The regeneration can be carried out with gases which are at about 65 120°C, these being passed through the adsorber in the opposite direction to that of the gas to be dried, whereas temperatures of about 140°C, or above, are conventionally used for the regeneration.

Example

a) A horizontal adsorber having a length of 450 cm and a diameter of 200 cm is filled with a 40 cm high, loose packing of silica gel beads having a pore volume of 0.8 cm³/g and an inner surface area of 400 m²/g, over which is placed a further, 60 cm high, loose packing of silica gel beads having a pore volume of 0.4 cm³/g and an inner surface area of 750 m²/g. 75

Per hour, 20,000 m³ of air to be dried are passed upwards through the adsorber in the direction of the transverse axis. The air is at 16°C and under a pressure of 5 bars, has a relative humidity of 100% and in addition contains from 2 to 3 g/m³ of liquid water in the form of droplets. The flow rate is 14 cm/sec, based on the internal cross-section; the pressure loss in the packing is 10 mbars. 80

The final dew point of the dried air is from -60°C (at the start of the adsorption stage) to -25°C (at the end of the stage). The dynamic capacity of the two beds is 20%. 90

b) For comparison, a 10 cm high bed of silica gel beads having a pore volume of 0.8 cm³/g and an inner surface area of 400 m²/g is introduced into an adsorber of the same dimensions, and above this bed is placed a 90 cm high bed of silica gel beads having a pore volume of 0.4 cm³/g and an inner surface area of 750 m²/g. 95

Under otherwise identical conditions (i.e. identical throughput and final dew points attained) a dynamic capacity of only 12% is achieved. 100

WHAT WE CLAIM IS:

1. A process for drying gaseous material which process comprises contacting the gaseous material, to effect drying by adsorption, with adsorbent material disposed in a first bed and comprising silica gel particles having a pore volume greater than 0.7 cm³/g. and effecting further drying by adsorption by contacting gaseous material, after treatment in the first bed, with adsorbent material disposed in a second bed and comprising silica gel particles having a pore volume of less than 0.5 cm³/g., the volume of the silica gel particles in the first bed being at 110 least 30% of the total combined volume of the silica gel particles in both beds. 115

2. A process as claimed in claim 1 wherein the two beds are provided in a single vessel. 120

3. A process as claimed in claim 1 or claim 2 wherein the gaseous material to be dried is moist air. 125

4. A process as claimed in any one of claims 1 to 3 wherein the volume of the silica gel particles in the first bed constitutes 130

approximately 40% of the total combined volume of the silica gel particles in both beds.

5. A process as claimed in claim 1 and substantially as hereinbefore described in the specific Example.

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