ROTARY BED FOR DIRECT CAPTURE OF CO_2 FROM AIR AND METHOD THEREOF

FIELD

[0001] Systems and methods are provided for using a rotary bed contactor for direct capture of CO_2 from air.

BACKGROUND OF THE INVENTION

[0002] Capture and sequestration of CO_2 can contribute to efforts for reducing or minimizing the amount of CO_2 introduced into the atmosphere by various commercial, residential, and/or industrial processes. One option is to attempt to capture CO_2 as it is generated at various types of point sources. Another option is to attempt to remove CO_2 directly from air.

[0003] Some of the difficulties with direct air capture are related to the relatively low concentration of CO_2 in the atmosphere. Typical CO_2 concentrations in air are on the order of 400 volume parts per million (vppm). Due to the relatively low concentration of CO_2 in comparison with other air components, achieving a high loading of CO_2 at fast adsorbent rates in an adsorbent can be difficult, leading to increased material costs. Additionally, the amount of energy used per CO_2 molecule captured can also be high, due in part to the relatively low density of CO_2 that can be adsorbed in a typical adsorbent based on the low concentration of CO_2 in the atmosphere. It would be beneficial to have improved systems and methods for capturing CO_2 from air that can reduce or minimize the associated capital costs and/or energy requirements.

[0004] In order to manage the plurality of flows that a sorbent is exposed to, there are two basic strategies. One strategy is to maintain the sorbent in a fixed volume corresponding to a sorbent environment, and then bring the various flow streams sequentially into the sorbent environment for contact with the sorbent. In this strategy, complex process flow management is needed so that the different flow streams do not mix while still reducing or minimizing the time required to switch between the various flow streams. An additional complication is that in order to have a continuous process, where air is continually taken in for CO_2 removal, multiple sorbent beds in parallel are required. Each parallel bed increases the complexity of the piping and manifolds required for managing the process flows.

[0005] The other option is to allow the sorbent to move, so that the piping for the process flows can be fixed. This has the advantage of simplifying the transport of the gas flows for the direct air capture process. However, conventional methods for allowing the sorbent to move to the gas flow have suffered from a variety of mechanical issues and/or difficulties with reliability. What is

CLAIMS

We claim:

1. A system for sorption of CO_2, comprising: a sorbent bed housing; a wheel framework structure within the sorbent bed housing; a sorbent bed comprising: a support material comprising one or more monoliths, the one or more monoliths supported by the wheel framework structure, the support material comprising a first surface, a second surface, and a plurality of channels providing a flow path between the first surface of the support material and the second surface of the support material, and a sorbent with selectivity for sorption of CO_2 supported on the support material, at least a portion of the sorbent being supported on one or more surfaces within the plurality of channels; at least one fan or blower associated with the sorbent bed housing, the at least one fan or blower being in fluid communication with a first portion of the plurality of channels; at least one cover plate; one or more cover plate seals attached to the one or more cover plates, a second portion of the plurality of channels being within a desorption zone volume defined by the at least one cover plate and the one or more cover plate seals, the one or more cover plate seals providing a) a seal between the at least one cover plate and the first surface of the support material, b) a seal between the at least one cover plate and the second surface of the support material, or c) a combination of a) and b); one or more input flow conduits providing fluid communication between at least a source of a one or more gases and the desorption zone volume; and at least one output flow conduit in fluid communication with the desorption zone volume.

2. The system of claim 1, further comprising at least one internal seal within the desorption zone volume, the at least one internal seal providing a seal between an interior surface of the one or more cover plates and at least one of the first surface and the second surface of the support material, the at least one internal seal defining a plurality of sub-zones within the desorption zone volume.

3. The system of claim 2, wherein at least a first input flow conduit of the one or more input flow conduits is in fluid communication with a first sub-zone of the plurality of sub-zones within the desorption zone volume, and wherein at least a second input flow conduit of the one or more input flow conduits is in fluid communication with a second sub-zone of the plurality of separate sub-zones within the desorption zone volume.

4. The system of claim 2 or 3, wherein at least one sub-zone of the desorption zone volume is separated from the first portion of the plurality of channels by at least one internal seal and at least one cover plate seal.

5. The system of any of the above claims, wherein the one or more cover plate seals comprise one or more purged seals, or wherein the one or more cover plate seals comprise one or more inflatable seals.

6. The system of any of the above claims, wherein the one or more input flow conduits are in fluid communication with the desorption zone volume via at least one input manifold; or wherein the at least one output flow conduit is in fluid communication with the desorption zone volume via at least one output manifold; or a combination thereof, the at least one output manifold optionally comprising a liquid collection trough.

7. The system of any of the above claims, wherein the wheel framework structure is supported by a central support, the central support optionally being configured for rotation of the wheel framework structure by a motor.

8. The system of any of the above claims, wherein the wheel framework structure is mechanically engaged by one or more gears configured for rotation of the wheel framework structure.

9. The system of any of the above claims, wherein the first portion of the plurality of channels are in direct fluid communication with the at least one fan or blower.

10. A method of sorbing CO_2 using a system according to any of claims 1 to 9, comprising: rotating the wheel framework structure; exposing a first gas flow comprising 15 vol% to 25 vol% O_2 and 100 vppm to 650 vppm CO_2 to a first portion of the sorbent bed outside of the desorption zone volume, the first gas flow having a temperature of 0°C to 40°C; exposing a plurality of gas flows to a second portion of the sorbent bed within the desorption zone volume, the exposing a plurality of gas flows to the second portion of the sorbent bed comprising sequentially exposing the second portion of the sorbent bed to: a purge gas flow to form a purge exhaust, and a steam flow having a temperature of 80°C to 180°C to form a CO_2-containing output flow, wherein the rotating of the wheel framework structure changes the portions of the sorbent bed that correspond to the first portion of the sorbent bed outside of the desorption zone volume and the second portion of the sorbent bed within the desorption zone volume.

11. The method of claim 10, wherein the desorption zone volume comprises a plurality of sub-zones, each sub-zone comprising at least one of the plurality of gas flows.

12. The method of claim 10 or 11, wherein a temperature of a leading edge of the second portion of the sorbent bed is 70°C or higher after the exposing to the steam flow, and a temperature of a trailing edge of the second portion of the sorbent bed is 60°C or lower prior to being rotated out of the desorption zone volume.

13. The method of any of claims 10 to 12, wherein exposing the plurality of gas flows to the second portion of the sorbent bed further comprises exposing the second portion of the sorbent bed to a temperature adjustment flow after the steam flow, the temperature adjustment flow having a temperature 0°C to 50°C to form a temperature adjustment flow exhaust, the exposing the plurality of gas flows to the second portion of the sorbent bed optionally further comprising exposing the second portion of the sorbent bed to a second purge gas flow after the temperature adjustment flow, the temperature adjustment flow optionally comprising a humidity of 25% or less relative to the temperature of the temperature adjustment flow.

14. The method of any of claims 10 to 13, wherein exposing the second portion of the sorbent bed to the steam flow further forms a liquid output product, or wherein the steam flow comprises substantially no liquid water content, or a combination thereof.

15. The method of any of claims 10 to 14, wherein a pressure inside the desorption zone volume is greater than a pressure outside the desorption volume by 2.0 kPa or more, or wherein a pressure inside the desorption zone volume is lower than a pressure outside the desorption zone volume by 20 kPa or more, or a combination thereof.