CLAIMS

1. A gas purification apparatus comprising:

an adsorption tower filled with an adsorbent that adsorbs a miscellaneous gas other than a purification target gas from a source gas;

a source gas supply line for supplying the source gas to the adsorption tower;

a product gas recovery line for discharging the purification target gas that has not been adsorbed on the adsorbent as a product gas; and

a miscellaneous gas discharge line for discharging the desorbed miscellaneous gas that has been adsorbed on the adsorbent,

the adsorption tower, the source gas supply line, the product gas recovery line, and the miscellaneous gas discharge line being connected so as to be able to perform a pressure swing operation of alternately performing

an adsorption step of receiving the source gas from the source gas supply line, adsorbing the miscellaneous gas onto the adsorbent, and recovering the product gas, and

a desorption step of depressurizing-desorbing the miscellaneous gas adsorbed on the adsorbent and discharging said miscellaneous gas from the miscellaneous gas discharge line,

wherein a membrane separator that includes a separation membrane impermeable to the purification target gas and permeable to the miscellaneous gas, and that separates the purification target gas and the miscellaneous gas by an exhaust gas pressure of the adsorption tower is provided in the miscellaneous gas discharge line,

a regenerated gas return line for returning, into the source gas supply line, a regenerated gas in which the concentration of the purification target gas has been increased by the separation membrane is provided, and

a regeneration pressure control valve is provided in the regenerated gas return line,

opening degree of said regeneration pressure control valve being adjusted so as to control the pressure for reducing gradually the exhaust gas pressure of the adsorption tower in the desorption step, a regeneration controller that controls a membrane separation pressure of the separation membrane by the regeneration pressure control valve is provided, and the membrane separation pressure of the separation membrane is controlled by the exhaust gas pressure of the adsorption tower with the regeneration pressure control valve.

2. The gas purification apparatus according to claim 1,

wherein a regenerated gas recovery line for recovering a regenerated gas in which the concentration of the purification target gas has been increased by the separation membrane as the product gas is provided.

3. The gas purification apparatus according to claim 1 or 2,

wherein a bypass line for causing the miscellaneous gas flowing through the miscellaneous gas discharge line to bypass the membrane separator so as to be guided to the regenerated gas return line is provided.

4. The gas purification apparatus according to any one of claims 1 to 3,

wherein a buffer tank is provided upstream of the membrane separator in the miscellaneous gas discharge line.

5. The gas purification apparatus according to any one of claims 1 to 4, wherein a vacuum pump is provided on a miscellaneous gas permeable side of the membrane separator in the miscellaneous gas discharge line so as to be operated in a steady state.

6. The gas purification apparatus according to any one of claims 1 to 5,

wherein a regenerated gas tank is provided in the regenerated gas return line.

7. The gas purification apparatus according to any one of claims 1 to 6,

wherein a product gas tank is provided in the product gas recovery line.

8. The gas purification apparatus according to claim 7,

wherein a product gas washing line for flowing the product gas into the adsorption tower from the product gas tank is provided, a product pressure control valve is provided between the product gas tank and the adsorption tower in the product gas washing line, and a washing controller for washing the adsorption tower by flowing the product gas into the adsorption tower from the product gas tank is provided.

9. The gas purification apparatus according to any one of claims 1 to 8,

wherein the source gas is a methane-containing gas, the purification target gas is methane, and the miscellaneous gas is a gas composed mainly of carbon dioxide.

10. The gas purification apparatus according to any one of claims 1 to 9,

wherein the source gas is a methane-containing gas containing at least 40% methane as the purification target gas, and a product gas containing at least 90% methane is obtained.

11. The gas purification apparatus according to any one of claims 1 to 10,

wherein the adsorbent is composed mainly of at least one material selected from the group consisting of an activated carbon, a molecular sieve carbon, zeolite, and a porous metal complex.

12. The gas purification apparatus according to claim 11,

wherein the adsorbent is a molecular sieve carbon having a pore volume ($V_{0.40}$), at a pore diameter of 0.38 nm or more, of not exceeding 0.01 cm^3/g, and a pore volume ($V_{0.34}$), at a pore diameter of 0.34 nm, of 0.20 cm^3/g or more, as measured by the MP method.

13. The gas purification apparatus according to any one of claims 1 to 12,

wherein the separation membrane is composed mainly of at least one material selected from the group consisting of cellulose acetate, polyamide, polyimide, polysulfone, polytetrafluoroethylene, polyether sulfone, a carbon film, a microporous glass composite film, DDR-type zeolite, multibranched polyimide silica, and polydimethylsiloxane.

14. The gas purification apparatus according to any one of claims 1 to 13,

wherein a booster pump is provided in the source gas supply line, and a pressure of supply of the source gas to the adsorption tower by the booster pump is 0.5 MPaG to 2 MPaG.