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TECHNICAL PROGRESS REPORT

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Overview of Progress

In order to increase the production rate of the purified gas stream, the length of the time for vacuum desorption part of the cycle was reduced significantly. The system was studied for different periods of vacuum desorption; an optimum value for it was obtained to achieve the minimum CO_2 composition in the purified gas stream with the maximum purified gas production rate. These experiments were carried out using a feed composition of around 10% CO_2 and balance N_2 . The system was also studied with a feed composition of around 5% CO_2 and balance N_2 . Module no. 4 was used for all of the above experiments. The details of the module is provided in Technical Progress Report No. 5. Preparations are now being made to fabricate a more compact module using a plastic casing inside the stainless steel shell with the same number of fibers as in Module no. 4 to study the effect of fiber packing density. A study of the absorption behavior of CO_2 - N_2 gas mixture with a reactive absorbent liquid such as aqueous diethanolamine (DEA) solution will be initiated afterwards.

Experiment

All experiments were carried out in the following manner.

The feed gas was allowed to enter for a certain time through valve no. 1 (Figure 1) until the required pressure was achieved in the module while both valves no. 2 and 3 remained closed. Immediately afterwards, valve no. 1 was closed and simultaneously valve no. 3 was opened for a short time to withdraw the purified front of mixture of gases. Then valve no. 3 was closed and simultaneously valve no. 2 was opened for vacuum desorption.

In this set of experiments the vacuum desorption cycle time was varied to explore its effect while keeping the values of other part of the cycle unchanged. Experiments were carried out with vacuum desorption cycle times of 40, 24, 15, and 10 seconds. For all experiments, steady state purified gas compositions as well as the flow rate of the purified gas stream were determined. That value of the time period for the vacuum desorption was considered optimum which yielded the highest level of gas purification with the maximum

rate of purified gas production. The gas mixture used was 10.28% CO₂ and balance N₂; pure water was used as the absorbent for all of the above experiments.

Using the optimum value of the desorption cycle time, a few runs were carried out to optimize other sections of the time cycle to achieve an even higher purification of the mixture of gases. Then the system was studied for a gas mixture containing 5.24% CO₂ and balance N₂ and pure water as an absorbent.

Results

The durations of the open and close settings of the solenoid valves, the corresponding values of the feed gas pressure and the mode of operation for different experimental runs have been identified in Table 1. The purification results of each such run identified in Table 1 are provided in Table 2. The effect of varying the desorption part of the cycle time while maintaining other parts of the cycle times unchanged was studied using the purification performance and the volumetric flow rate of the purified gas stream identified in Table 3. From the data obtained, 15 seconds was found to be an optimum value for the vacuum desorption part of the cycle time for Module no. 4 for the gas mixture of around 10% CO₂ and balance N₂. A lower length of time (~10 seconds) did not allow achievement of a constant gas composition in the purified product.

In our earlier studies (Technical Progress Report No.4, Tables 3 and 4 and Technical Progress Report No. 5, Tables 2 and 3), the desorption cycle times were maintained at 40 and 24 seconds; a purified gas stream containing a minimum of about 1.5% CO₂ was obtained from a gas mixture of 10.12% CO₂ and balance N₂ using 24 seconds in vacuum desorption cycle. The present set of experiments indicate that without decreasing the purified gas stream composition we could achieve an even lower time for the vacuum desorption part of the cycle so that the overall cycle time is reduced and the rate of production is effectively increased.

Using the optimum value of the vacuum desorption cycle, the system was studied

for possible optimization of other sections of the cycle time to yield even lower levels of CO_2 composition in the purified gas stream from a feed gas mixture of 10.28% CO_2 and balance N_2 and water as an absorbent. The results of the experiments are identified in Table 3. The system was also studied for a feed gas mixture of 5.24% CO_2 and balance N_2 and water as an absorbent. The result is given in Table 3.

Table 1: Duration of Different Settings of Solenoid Valves

Experiment No.	Module No.	Mode of Operation	Pressure in fiber lumen (psig)	Valve # 1		Valve # 3		Valve # 2		Total Cycle Time (Seconds)
				Open (Seconds)	Close (Seconds)	Close (Seconds)	Open (Seconds)	Close (Seconds)	Open (Seconds)	
6-1	4	2	20~25	2	51	5	8	13	40	53
6-2	4	2	20~25	2	35	5	8	13	24	37
6-3	4	2	20~25	2	26	5	8	13	15	28
6-4	4	2	20~25	2	21	5	8	13	10	23
6-5	4	2	20~35	1	26	5	7	12	15	27
6-6	4	2	20~25	2	25	5	7	12	15	27
6-7	4	2	20~25	3	24	5	6	12	15	27
6-8	4	2	20~25	3.2	23	6	5.2	11.2	15	26.2
6-9	4	2	20~25	2	28	7	8	15	15	30
6-10	4	2	20~25	2	24.2	6	5.2	11.2	15	26.2

Table 2: Experimental Results

Experiment No.	Module No.	Mode* of Operation	Feed Pressure (psig)	Feed Gas Composition	Purified Gas Composition
6-1	4	2	20~25	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.3% N ₂ : Balance
6-2	4	2	20~25	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.25% N ₂ : Balance
6-3	4	2	20~25	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.3% N ₂ : Balance
6-4	4	2	20~25	CO ₂ : 10.28% N ₂ : Balance	Constant composition cannot be obtained
6-5	4	2	30~35	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.25% N ₂ : Balance
6-6	4	2	20~25	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.20% N ₂ : Balance
6-7	4	2	20~25	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.20% N ₂ : Balance
6-8	4	2	20~25	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.15% N ₂ : Balance
6-9	4	2	20~25	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.01 N ₂ : Balance
6-10	4	2	20~25	CO ₂ : 5.24% N ₂ : Balance	CO ₂ : 0.8% N ₂ : Balance

* Identified in Technical Progress Report No. 4, dated October 31, 1991.

Table 3: Purified Gas Composition with Purified Gas Flow Rate

Experiment No.	Inlet Gas Composition	Outlet Purified Gas Composition	Vacuum Desorption Cycle Time (Seconds)	Purified Gas Flow Rate (cc/min)
6-1	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.3% N ₂ : Balance	40	5-8
6-2	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.25% N ₂ : Balance	24	8-12
6-3	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.3% N ₂ : Balance	15	15-20
6-4	CO ₂ : 10.28% N ₂ : Balance	Constant composition cannot be obtained	10	20-25
6-5	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.25% N ₂ : Balance	15	15-20
6-6	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.20% N ₂ : Balance	15	15-20
6-7	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.20% N ₂ : Balance	15	15-20
6-8	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.15% N ₂ : Balance	15	15-20
6-9	CO ₂ : 10.28% N ₂ : Balance	CO ₂ : 1.01% N ₂ : Balance	15	8-12
6-10	CO ₂ : 5.24% N ₂ : Balance	CO ₂ : 0.8% N ₂ : Balance	15	15-20

Figure 1: Solenoid Valve Locations in RAPSAB Apparatus

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