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Performance test of PSA-type O_2 separator for efficient O_2 supply to room ventilation system combined with CO_2 adsorption module

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Abstract−High purity O_2 concentrated by the PSA-type O_2 separator was applied to a room ventilation system combined with CO_2 adsorption module to remove the indoor CO_2 for the indoor air quality. And then the room was occupied by several persons to breathe for the O_2 consumption and CO_2 generation. As a result, the indoor air quality was improved by the ventilation system combined with the O_2 supply and the CO_2 adsorption module. It was due to the fact that the CO_2 concentration was not steeply increased, but also even decreased and then the increasing rate of the O_2 concentration with the O_2 supply was simultaneously increased by the CO_2 removal despite the CO_2 generation and O_2 consumption with the four persons' breathing. As a representative result, in the case of supplying the high purity O_2 of 30 L/min under using the CO_2 adsorption module, the best performance with the highest increasing rate of O_2 concentration and the lowest increasing rate of CO_2 concentration was obtained among the various cases, and then the increasing rates of CO_2 concentration and O_2 concentration were −2.3 ppm/min and 33.3%/min, respectively.

Keywords: Indoor Air Quality, Room Ventilation System, Zeolite-based Adsorbent, O_2 Separator, Supply, PSA-type, CO_2 Adsorption Module

INTRODUCTION

CO_2 is a colorless, odorless, tasteless and global warming gas, comprising about 0.04% of the ambient air. Worldwide concern over the generation of CO_2 is increasing concomitant with the use of the fossil fuel, reduction of the energy cost and the improvement of the air quality. One thing is especially noteworthy in that indoor air quality and ventilation condition in terms of O_2 content is recently highlighted in connection with a sanitary criterion for indoor residents concerned with the harmful effect of CO_2 and CO [1]. The CO_2 concentration is used as a criterion of indoor air quality and ventilation condition as well as the amount of O_2 which gets insufficient for breathing, and CO_2 is treated as an important pollutant getting the dirty end of the stick together with CO when the CO_2 concentration is increased. CO_2 is generated by people breathing with the consumption and the fuel combustion, and then the CO_2 concentration is 1,000 ppm as a reference level in the indoor ventilation condition according to the indoor air quality with different countries [2-7]. When the CO_2 concentration is higher than 1,000 ppm as an acceptable standard in the indoor air quality, the breath and the inside ventilation of an alveolus highly increased. And then it leads to difficulty breathing and headaches. On the basis of these facts, there has been interest in CO_2 removal and its related room ventilation system for the efficient O_2 supply [7]. CO_2 can be removed and treated with the various methods such as adsorption, membrane separation, and absorption. A CO_2 treatment method optimized for the reduction of the indoor CO_2 has been developed; however, its suggestion is very difficult due to the diversity and difficulty with the various treatment conditions [8,9]. Among the various CO_2 treatments, CO_2 adsorption via zeolite-based catalyst is regarded as economical and efficient for CO_2 removal with the low energy cost and reusability by the regeneration and then the activated carbon, alumina, zeolite-based molecular sieves, carbon molecular sieves, silica, and so on can be suggested as favorable candidates as an adsorption agent [10-16]. O_2 can be supplied using fresh air, but effective supply of O_2 is necessary using the pure O_2 concentrated after the separation by the effective method. The O_2 supply is influenced by the efficient concentration, separation, storage and production of O_2 content in air. PSA (pressure swing adsorption) can be used as an efficient O_2 separation/concentration via physical adsorption-desorption cycle with adsorbent.

In the present research, a PSA-type O_2 separator was suggested and investigated for the realization and applicability as an effective method to produce and supply pure O_2 for a room ventilation system to improve the indoor air quality. The CO_2 adsorption module was simultaneously combined with the room ventilation system for the treatment of CO_2 generated by people breathing. The operation conditions for the production and supply of O_2 was optimized under the various operation and environmental conditions, and performance tests were carried out. And then the effect of the supply with the O_2 separator and the CO_2 removal with the adsorption module on the indoor air quality was investigated.

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‡This article is dedicated to Prof. Seong Ihl Woo on the occasion of his retirement from KAIST.

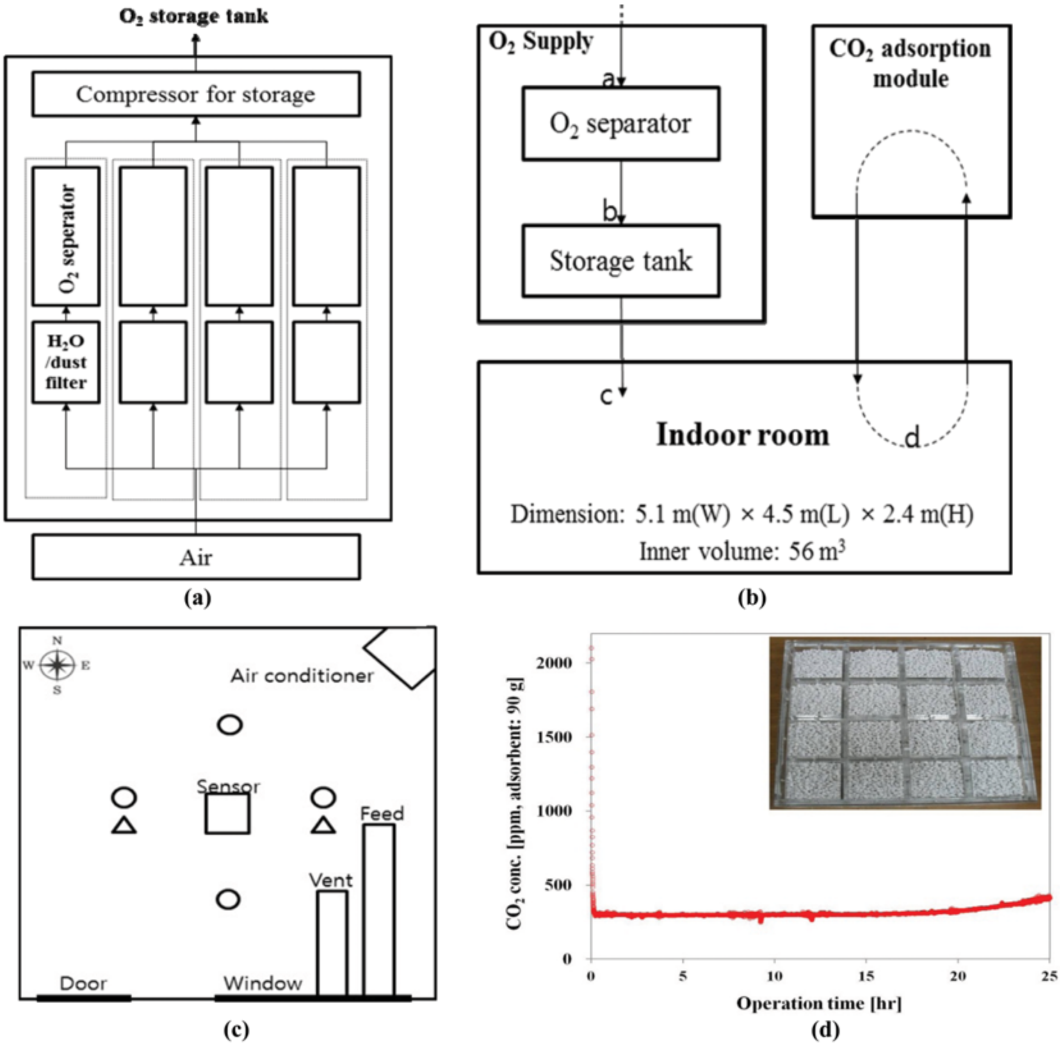

Fig. 1. Schematic diagram of the O_2 separator and ventilation system with CO_2 adsorption module for the improvement of the indoor air quality.
((a) O_2 separator, (b) ventilation system with O_2 separator and CO_2 adsorption module, (c) specification of indoor room for the ventilation system and the position of person (○: Position of 4 persons, △: Position of 2 persons), (d) picture of adsorption module and CO_2 breakthrough curve of adsorbent for CO_2 removal)

EXPERIMENTAL

Fig. 1 shows a diagram of the O_2 separator (Dimension: 60 cm (W)×60 cm (L)×150 cm (H)) used in the room ventilation system combined with CO_2 adsorption module. The O_2 separator, which is in parallel composed of four adsorbent-packed beds, was operated by the inflow of air into the adsorbent-packed bed through the filter for moisture/dust removal. The O_2 thus separated and concentrated was discharged into the air-conditioned test room. In the O_2 separation/concentration process, the flow rate for the inflow into the bed packed by the adsorbent of 1.5 kg was about 60 L/min, and the internal pressure of the bed was automatically controlled by the discharged outflow in the range of 2-12 L/min.

A storage tank was constructed with quality aluminum in order to efficiently supply the flow rate and concentration of concentrated O_2 from the O_2 separator. The storage tank module consisted of four unit-tanks of 22 L individual capacity and the total volume was about 88 L and could be individually operated by each unit tank in case of necessity. Concentrated O_2 by the O_2 separator was charged with the compressed pressure of 6-8 kg_f/cm^2 into the storage tank installed with digital pressure gauge. After the storage step into the tank, the concentrated O_2 was discharged with the flow rate controlled by MFC (mass flow controller, Linetech Co. Ltd.) and was supplied to the indoor room.

The indoor room has dimensions of 5.1 m (W)×4.5 m (L)×2.4 m (H) and inner volume of 56 m^3 and its indoor temperature was controlled and maintained by an air conditioner. The feed and vent pipes for the circulation between the outdoor and indoor air were wall-mounted and located at a height of 1.8 m from the ground as shown in Fig. 1(c).

The O_2 supplying part, which was composed of the O_2 separator and the storage tank, was constructed outdoors and then concentrated O_2 by O_2 separator from outdoor air was supplied into the indoor.

To remove the indoor CO_2 generated by people breathing, the CO_2 adsorption module packed with the commercial Li-based adsorbent (Anytech Co. Ltd., Model: ACE-04, CO_2 adsorption capacity $=0.896\ mmol_{CO_2}/g_{adsorbent}$) of 0.8 kg (volume: 1.5 L) was constructed outdoors. The picture and adsorption breakthrough curve of the adsorption module for indoor CO_2 removal are shown in Fig. 1(d). The indoor CO_2 was removed by the circulation of the indoor air of about 3.4 N/m^3 through the adsorbent bed of the outdoor CO_2 adsorption module.

In each step for the inflow and discharge of O_2, the flow rate and concentration of O_2 were quantitatively controlled and monitored by MFC and O_2 analyzer (Omega Instruments, Model: s3520), respectively. The indoor concentration of CO_2 was analyzed by the CO_2 sensor calibrated with proofreading process.

We conducted the experimental process for the indoor air quality of the room in accordance with the operation conditions of O_2 separator combined with the storage tank of high purity O_2. And then the effect of the CO_2 removal with the CO_2 adsorption module operated on the indoor air quality of the room was investigated. The indoor air quality, such as the concentration of indoor CO_2 and O_2, was monitored with the flow rate of O_2 supplied, the operation of CO_2 adsorption module and the person number occupying the room. The monitoring time was different in accordance with the operation cases because the variation of the concentration of CO_2 and O_2 was limited by the originating condition and then was almost maintained after the monitoring time. In addition, the internal pressure of the storage tank was monitored because the supply of high purity concentrated O_2 from the storage tank into the room was confirmed by the variation of the internal pressure of the storage tank.

In the case of the persons' breathing, the number of individuals in the room varied from 2 to 4 in accordance with the experimental conditions. The results, such as the concentration of CO_2 and O_2, were mainly influenced by the number of persons. However, we confirmed that the positions of persons in the room did not have an effect on the indoor air quality such as the concentration of CO_2 and O_2 because the inner space volume of the room ($56\ m^3$) might be simulated as a small space such as an office room to be occupied by 2-4 persons and cannot be influenced by their position. The persons were composed of two men (weight: 65-75 kg, age: 30-35) and two women (weight: 48-53 kg, age: 27-32); their positions are referentially presented in Fig. 1(c). In addition, the humidity of the room was varied in the range of 40-80%; however, its variation did not have an effect on the experimental results such as the concentration of CO_2 and O_2.

RESULTS AND DISCUSSION

Fig. 2 shows the indoor concentration of CO_2 and O_2 with and without supplying O_2 which was produced by the outdoor O_2 separator and filled in the storage tank. The room with the two persons' breathing was about $56\ m^3$ and the concentration and flow rate of O_2 supplied into the room were about 88% and 20 L/min, respectively. In the case of without O_2 supply, the indoor concentration of CO_2 was maintained until 10 min. However, the indoor concentration of CO_2 was raised from about 1,125 ppm after 10 min

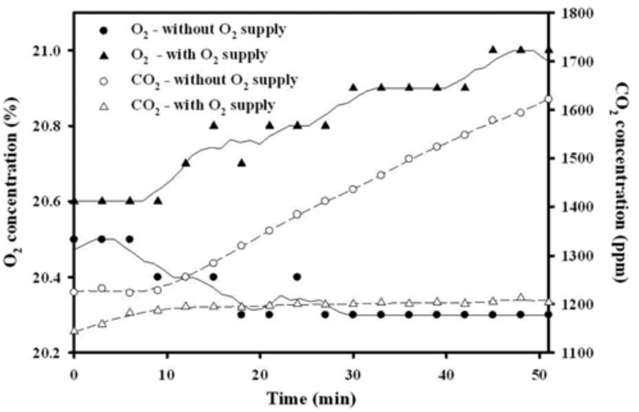

Fig. 2. Indoor concentration of CO_2 and O_2 with and without supplying O_2 into the room having two persons' breathing.

according to the time stream and reached at about 1,518 ppm after 52 min. Also, the indoor concentration of O_2 was decreased from about 20.5 to 20.28%. It was estimated that these results might be due to the fact that the O_2 consumption and the generation of CO_2 were simultaneously carried out in the room with the two persons' breathing. On the other hand, in the case of the supply of O_2 with the flow rate of 20 L/min and the concentration of about 88%, the CO_2 concentration was slightly increased until 12 min and was maintained after 12 min. Also, the O_2 concentration was maintained until about 6 min and was rapidly increased from about 20.6 up to 21.9%. From these results, it was due to the dramatic increase of the O_2 concentration with the O_2 with the sufficient supply of O_2 concentrated in spite of the O_2 consumption and CO_2 generation with two persons' breathing. As a result, it was known that the improvement of the O_2 concentration and the suppression of the CO_2 concentration could be caused by the supply of O_2 from the storage tank after the concentration by PSA-typed O_2 separator.

Fig. 3 shows the variation of the O_2 concentration with the flow rate of O_2 supplied into the room having the two persons' breath-

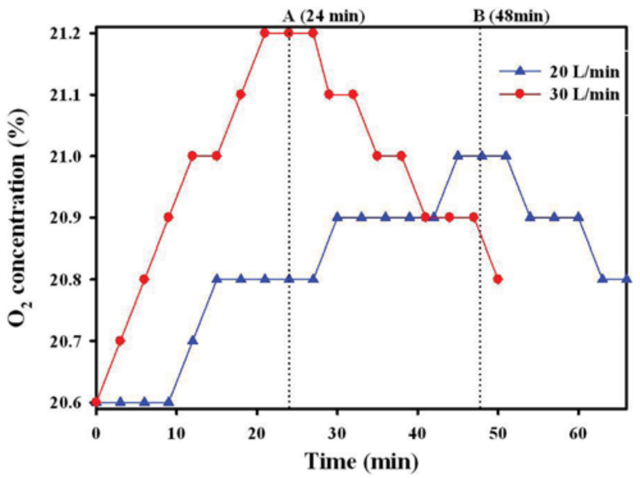

Fig. 3. The variation of the O_2 concentration with the flow rate of the high purity O_2 supplied into the room having the two persons' breathing from the storage tank.

ing from the storage tank. The flow rate of O_2 was varied from 20 to 30 L/min and the O_2 concentration was about 88%. The inner volume of the room was about 56 m^3. Regardless of the flow rate variation of O_2 supplied, the monitoring time section was separated and then the points of A and B of Fig. 3 were retention time separated according to before and after interruption of the O_2 supply. In the case of supplying the O_2 flow rate of 20 L/min, the O_2 concentration was maintained until about 9 min and increased from about 20.6% up to 21% after 48 min. However, after 66 min, the O_2 concentration was reduced to about 20.8% during about 18 min of the O_2 supply interruption. In the case of supplying the O_2 flow rate of 30 L/min, the O_2 concentration was rapidly increased up to about 21.2% until 24 min and dramatically decreased to about 20.8% during 26 min with the interruption of O_2 supply after 24 min. As compared with the case of supplying O_2 of 20 L/min, the increasing rate and decreasing rate of the O_2 concentration were increased with the increase of the O_2 flow rate, and this result was caused by the sufficient supply of O_2 concentrated. It was known that the flow rate of O_2 concentrated and supplied into the room from the storage tank has an influence on the indoor air quality such as the concentration of O_2.

In this section, to investigate the relationship between the indoor air quality and the supply of O_2 from room the outside of the room more carefully, the number of the person presented in the room was more than about four. Fig. 4 shows the concentration of O_2 and CO_2 without the O_2 supply in the room of the four persons' breathing. The CO_2 concentration proportionally increased with the time stream and reached from about 1,380 up to 1,820 ppm after 20 min. On the other hand, the O_2 concentration was maintained at about 20.2% until 9 min, but gradually decreased to about 20.0% after 20 min. As compared with the case of the room having the two persons' breathing in Fig. 4, with the number of the persons present in the room, the increasing rate of the CO_2 concentration and the decreasing rate of the O_2 concentration were increased with the increase of the O_2 consumption and the CO_2 generation.

On the basis of these results, the effect of the O_2 supply and the CO_2 adsorption module on the indoor air quality like the concentration of O_2 and CO_2 monitored will be investigated under the various conditions.

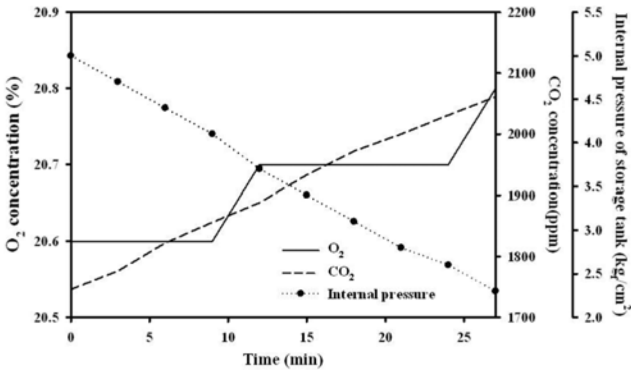

Fig. 5. The indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 10 L/min O_2 concentrated from the O_2 storage tank after the O_2 separation without the CO_2 adsorption module.

Fig. 5 shows the indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 10 L/min O_2 concentrated from the O_2 storage tank after the O_2 separation without the CO_2 adsorption module. The initial concentration of O_2 and CO_2 was about 20.6% and 1,746 ppm, respectively. The number of the persons present in the room was four and the concentration of O_2 supplied to the room was about 88%. Also, the initial internal pressure of the O_2 storage tank was about 5 kg_f/cm^2. With supplying 10 L/min O_2 concentrated from the storage tank to the room having three persons' breathing, the internal pressure of the storage tank was proportionally decreased and reached to about 2.3 kg_f/cm^2 after 27 min. In addition, the concentration of O_2 and CO_2 was gradually increased up to about 20.8% and 2,080 ppm, respectively. Unlike the case of two persons' breathing with the supply of 20 L/min O_2 concentrated to 88% shown in Fig. 5, the CO_2 concentration was increased despite the O_2 supply, because the CO_2 generation may be dramatically increased by the increase of the number of persons present in the room and an insufficient O_2 supply. As compared to the decrease of the O_2 concentration in the case without the supply of O_2 shown in Fig. 5, the O_2 concentration was increased and the increasing rate of CO_2

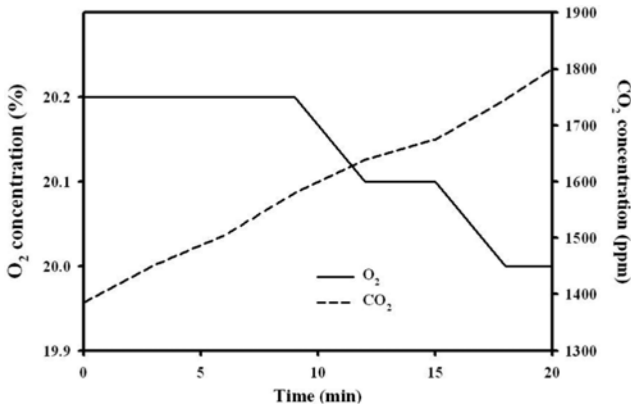

Fig. 4. The concentration of O_2 and CO_2 without the O_2 supply in the room of the four persons' breathing.

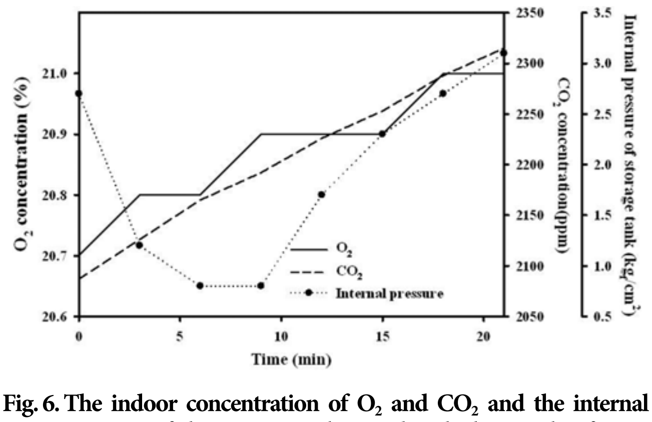

Fig. 6. The indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 20 L/min O_2 concentrated without CO_2 adsorption module.

concentration was decreased because the increase of CO_2 concentration was suppressed with the O_2 supply of 10 L/min.

Fig. 6 shows the indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 20 L/min O_2 concentrated without CO_2 adsorption module. The initial concentration of O_2 and CO_2 was about 20.7% and 2,080 ppm, respectively. The number of persons present in the room was four and the concentration of O_2 supplied was about 88%. Also, the initial internal pressure of the O_2 storage tank was about 2.8 kg_f/cm^2. The internal pressure of the tank was decreased and reached to 0.8 kg_f/cm^2 until 9 min with supplying O_2 to the room. However, the internal pressure of the tank rapidly increased after 9 min and reached 3.1 kg_f/cm^2 after 21 min because the O_2 separator was operated by an insufficient storage amount of O_2 as compared with the O_2 amount required for the O_2 supply, and O_2 was generated and stored in the tank. Under this internal pressure variation with the operation of the O_2 separator, the O_2 concentration rapidly increased with higher increasing rate due to the higher amount of O_2 than that of the case of the O_2 supply of 10 L/min and arrived at about 21.0% after 21 min. In addition, the CO_2 concentration increased with lower increasing rate than that of case of the 10 L/min because the increase of CO_2 was suppressed by the high amount of O_2 supplied despite the CO_2 generation with four persons' breathing. From these results, with increasing the O_2 supply, the increasing rate of the O_2 concentration was raised and that of CO_2 concentration was suppressed in the indoor air quality.

Fig. 7 shows the indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 30 L/min O_2 concentrated without CO_2 adsorption module. The initial concentration of O_2 and CO_2 was about 21.1% and 2,350 ppm, respectively. The number of persons present in the room was four and the concentration of O_2 supplied was about 88%. Also, the initial internal pressure of the O_2 storage tank was about 3.4 kg_f/cm^2. The internal pressure of the tank decreased and reached 1.4 kg_f/cm^2 until 3 min with supplying O_2 to the room. However, the internal pressure of the tank rapidly increased after 3 min and reached 3.5 kg_f/cm^2 after 6 min because the O_2 separator combined with the tank pressure was automatically operated by an insufficient storage amount of O_2 as compared with the O_2 amount required for the O_2 supply, and O_2 was generated and stored in the tank. As compared with the case of the supply of 20 L/min O_2, the decreasing rate with the O_2 supply and the increasing rate with the operation of the O_2 separator were increased by the supply and generation of the O_2 amount increased from the viewpoint of the internal pressure of the tank. The O_2 concentration was more rapidly increased and the CO_2 concentration was more slightly increased than those of the cases of 10 and 20 L/min due to the sufficient amount of O_2 supply as compared to the cases of 10 and 20 L/min.

From these results without CO_2 adsorption module, it was concluded that the indoor air quality with the improvement of the O_2 concentration and the suppression of CO_2 concentration could be improved by the increase of the O_2 supply.

In this section, the CO_2 adsorption module was applied in order to improve the indoor air quality more than the case of only O_2 supply. To investigate the effect of the O_2 supply system combined with CO_2 adsorption module on the indoor air quality of the room, the concentration of O_2 and CO_2 was monitored with the amount variation of the O_2 supplied with the operation of the CO_2 adsorption module. The amount of CO_2 adsorbent packed in the module having the inner volume of 1.5 L was about 0.8 kg. Also, the flow rate of the indoor air circulated for the CO_2 removal was about 3.3 Nm^3/min.

Fig. 8 shows the indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 10 L/min O_2 under the operation of the CO_2 adsorption module. The initial concentration of O_2 and CO_2 was about 20.7% and 1,700 ppm, respectively. The number of persons present in the room was four and the concentration of O_2 supplied to the room was about 88%. Also, the initial internal pressure of the O_2 storage tank was about 5.0 kg_f/cm^2. With the O_2 supply to the room, the internal pressure of tank was continuously decreased and reached to about 1.6 kg_f/cm^2. The O_2 concentration was increased after 15 min and arrived at about 20.9% with the O_2 supply, and then its increasing rate was higher than that of the case without CO_2 adsorption module. This result may be due to the sufficient O_2 supply as compared to the amount of O_2 required despite the O_2 consumption and CO_2 generation with four persons' breathing. The CO_2 concentration increased by CO_2 generated with the four persons; however, its rate

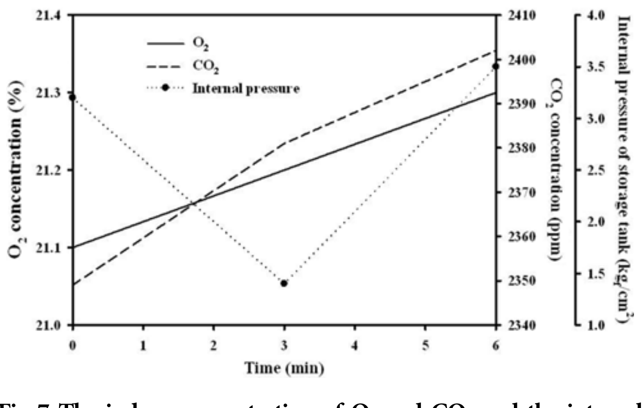

Fig. 7. The indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 30 L/min O_2 concentrated without CO_2 adsorption module.

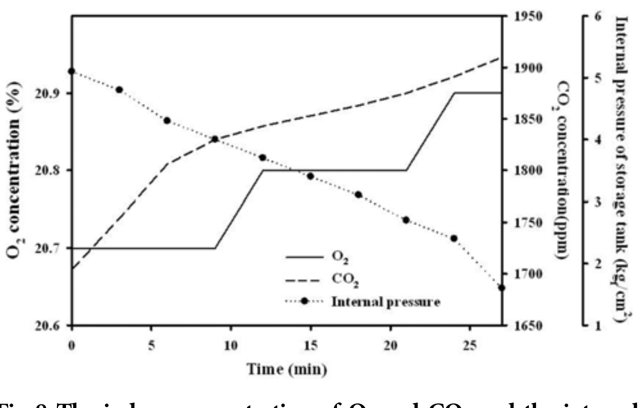

Fig. 8. The indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 10 L/min O_2 under the operation of the CO_2 adsorption module.

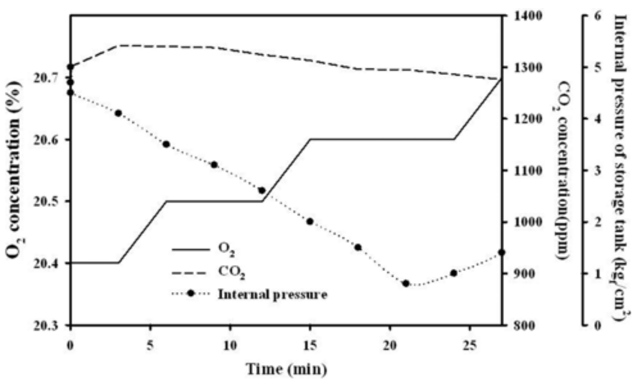

Fig. 9. The indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 20 L/min O_2 under the operation of the CO_2 adsorption module.

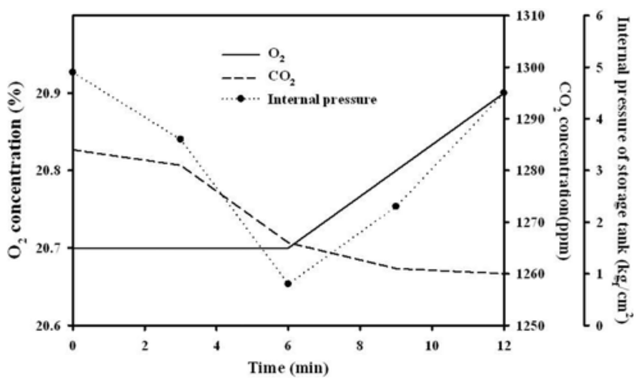

Fig. 10. The indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 30 L/min O_2 under the operation of the CO_2 adsorption module.

of increase was lower than that of the case without the CO_2 adsorption module. Consequently, it was concluded that the indoor air quality was improved by the CO_2 removal with the CO_2 adsorption module as compared with the O_2 supply without the CO_2 adsorption module.

Fig. 9 shows the indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 20 L/min O_2 under the operation of the CO_2 adsorption module. The initial concentration of O_2 and CO_2 was about 20.4% and 1,300 ppm, respectively. The number of persons present in the room was four and the concentration of O_2 supplied was about 88%. Also, the initial internal pressure of the O_2 storage tank was about 4.5 kg_f/cm^2 and the amount of the indoor air circulated for the CO_2 removal was about 3.3 Nm^3/min. The internal pressure of the tank was decreased and reached 0.8 kg_f/cm^2 until 21 min with supplying O_2 to the room. However, the internal pressure of the tank was increased after 9 min and reached 1.4 kg_f/cm^2 after 21 min because the O_2 separator was operated by an insufficient storage amount of O_2 as compared with the O_2 amount required for the O_2 supply, and then concentrated O_2 was generated and stored in the tank. With the O_2 supply of 20 L/min combined with the CO_2 adsorption module, the O_2 concentration was increased to about 20.7% after 27 min and then its increasing rate was higher than that of the case of the supply of 10 L/min. However, the CO_2 concentration was slightly increased in the initial time and was maintained in the short range of 1,280 and 1,340 ppm after 3 min. These results may be due to the fact that the CO_2 concentration was not increased by the CO_2 removal with the adsorption module despite the CO_2 generation with four persons' breathing as compared to the case without the CO_2 adsorption module.

Fig. 10 shows the indoor concentration of O_2 and CO_2 and the internal pressure of the storage tank varied with the supply of 30 L/min O_2 under the operation of the CO_2 adsorption module. The initial concentration of O_2 and CO_2 was about 20.7% and 1,280 ppm, respectively. The number of the persons in the room was four and the concentration of O_2 supplied was about 88%. Also, the initial internal pressure of the O_2 storage tank was about 4.5 kg_f/cm^2 and the amount of the indoor air circulated for the CO_2 removal was about 3.3 Nm^3/min. The internal pressure of the tank was decreased and reached 0.8 kg_f/cm^2 until 6 min with supplying O_2 to the room. However, the internal pressure of the tank was increased after 6 min and reached 4.5 kg_f/cm^2 after 12 min because the O_2 separator was operated by an insufficient storage amount of O_2 as compared with the O_2 amount required for the O_2 supply and then concentrated O_2 was generated and stored in the tank. The O_2 concentration was maintained until 6 min and rapidly increased after 6 min. And then its increasing rate was higher than that of the case without the CO_2 adsorption module and with the O_2 supply of 10 and 20 L/min. Also, the CO_2 concentration was slightly decreased to about 1,260 ppm after 12 min. In this case, the increasing rate of

Table 1. Effect of the CO_2 adsorption and O_2 flow rate on the variation of the indoor air quality

Usage of CO_2 adsorption (--)	w/			w/o		
Flow rate of O_2 supplied (L/min)	10	20	30	10	20	30
ΔCO_2 concentration (ppm)	341	228	53	206	−37	−21
ΔO_2 concentration (%)	0.1	0.3	0.2	0.2	0.2	0.3
Increasing rate of CO_2 concentration (ppm/min)	11.4	10.9	8.8	7.6	−2.1	−2.3
Increasing rate of O_2 concentration (%/min, $\times 10^{-3}$)	3.3	14.3	33.3	7.4	16.7	33.3

*ΔCO_2 concentration (ppm)=CO_2 concentration$_{after\ ventilation}$−CO_2 concentration$_{before\ ventilation}$

*ΔO_2 concentration(ppm) = O_2 concentration$_{after\ ventilation}$−O_2 concentration$_{before\ ventilation}$

*Increasing rate of CO_2 concentration (ppm/min)=ΔCO_2 concentration/Duration time for ventilation

*Increasing rate of O_2 concentration (ppm/min)=ΔO_2 concentration/Duration time for ventilation the O_2 concentration and the decreasing rate of the CO_2 concentration were increased by the simultaneous O_2 supply and CO_2 removal as compared to the case without the CO_2 adsorption module and with O_2 supply of 10 and 20 L/min. As a result, it was concluded that the indoor air quality could be improved by the increase of the O_2 supply and the CO_2 removal with the CO_2 adsorption module.

To discuss synthetically about the various results above mentioned, the effect of CO_2 adsorption and O_2 flow rate on the variation of the indoor air quality was listed in Table 1. Regardless of the usage of CO_2 adsorption, the concentration increasing rate of CO_2 and O_2 was respectively and simultaneously decreased and increased with the increase of the amount of O_2 supplied into the room, and then it was known that the indoor air quality was improved by the supply of high purity concentrated O_2 from outside. In addition, without reference to the amount of O_2 supplied, the CO_2 concentration was not steeply increased but also slightly decreased and then the increasing rate of O_2 concentration was increased in accordance with using the CO_2 adsorption module despite four persons' breathing under the supply of the identical O_2 amount. As a result, it was concluded that the indoor air quality was improved by both the artificial CO_2 removal with the CO_2 adsorption module and the supply of high purity O_2 concentrated from outside.

CONCLUSIONS

In a room ventilation system with CO_2 adsorption module to improve the indoor air quality, a PSA-type O_2 separator combined with the storage tank was used to control the concentration of O_2 and CO_2. The O_2 separator, which was combined with the storage tank to supply O_2 efficiently through the preservation, was used for the production of O_2. Also, the CO_2 adsorption module was used for the removal of CO_2 generated by the people breathing. O_2 consumed by the people breathing was replenished by the supply of the concentrated O_2 which was produced by the O_2 separator outside of the room. And then CO_2 generated by the people breathing was removed by the CO_2 adsorption module. Therefore, these processes lead to the improvement of the concentration of O_2 and CO_2. It was concluded that the indoor air quality of the room deteriorated by O_2 consumed and CO_2 generated by the people breathing could be improved by the artificial O_2 supply and CO_2 removal, and then these process can be realized through a room ventilation system composed of the O_2 separator with the storage tank and CO_2 adsorption module.

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