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An Experimental Investigation and Emission Analysis on I.C. Engine with Oxygen Feeding System: Study of Oxygen Enrichment Method

Manish Kumar Kantilal[1], Dr. Ratnesh Shukla[2]
[1]Research Scholar, Rai University & Assistant Professor (GEC, Valsad)
[2]Government Engineering College, Bharuch

Abstract: Combustion efficiency is directly depend upon air fuel ratio, further air fuel ratio depend upon the types of fuel used to generate the energy. Different substance required different air fuel ratio, analytically calculated air fuel ratio for complete combustion is called as stoichiometric air fuel ratio. Combustion efficiency actual depend upon the amount of oxygen available with air. Atmospheric air contain volume based 21% and mass based 23% oxygen, Remaining gases in air participate in combustion process which carried out heat in form of exhaust as well as in form of formation enthalpy. It's required to develop some economical technique which separate the nitrogen and other gases which not required into combustion before entered into combustion process without effect the main combustion process. This paper basically represents different technique which is used to separate oxygen and nitrogen via zeolite.

I. INTRODUCTION

Separation may be defined as a process that transforms a mixture of substances into two or more products that differ from each other in composition. The process is difficult to achieve because it is the opposite of mixing, a process favored by the second law of thermodynamics. Consequently, the separation steps often account for the major production costs in chemical and petrochemical industries. Separation also plays a key role in chemistry and related scientific disciplines. Through the endeavor of human ingenuity, there exist a multitude of industrial separation processes and laboratory separation techniques [1]. The separation of a gas mixture by a zeolite is affected by

(1) Size or steric exclusion of certain components of a gas mixture from entering the zeolite pores, whereas the other components enter the pores and are adsorbed [1].
(2) Thermodynamic selectivity, which is a quantitative measure of the preferential adsorption of certain components over others when all components can enter the pores [1].
(3) Kinetic selectivity, which is a quantitative measure of the ability of certain components to enter the pores (and become adsorbed) faster than other components [1].

A. Production Of Oxygen-Enriched Air With Zeolite [1]

For oxygen enrichment different method is used, apart from that some of the methods are

A large variety of PSA process concepts have been developed for direct production of (23–95) mol % oxygen from ambient air using various ion-exchanged forms of zeolites of type A, X, and mordenite. Some of these concepts are called Vacuum Swing Adsorption (VSA) because the final desorption pressure is sub atmospheric.

*1) VSA (Vacuum Swing Adsorption) [1]*SA process consisting of six steps

a) Pressurizing the adsorber from an intermediate pressure level to the final adsorption level (P_A) by introducing compressed air feed
b) Flowing compressed air feed through the adsorber to produce the oxygen enriched product gas at P_A
c) Counter currently depressurizing the adsorber to ambient pressure and venting the effluent gas
d) Counter currently evacuating the adsorber to a sub atmospheric pressure level (P_D)
e) Counter currently purging the adsorber at pressure P_D with a part of the oxygen enriched product gas while venting the effluent gas

f) Counter currently pressurizing the adsorber from PD to the intermediate pressure level with a part of the oxygen-enriched product gas from step 2.

Produces a 90 mol % oxygen enriched product gas (dry and free of carbon dioxide) with an oxygen recovery of 53% from the air feed. The adsorbent used was LiX and the adsorption

(PA) and desorption pressures were 1.43 and 0.34 atm, respectively. The mean adsorbent temperature was 290 K and the total cycle time was 70 s.

The basic idea of the three-bed vacuum swing adsorption (VSA) process is to desorb the adsorbed nitrogen with a vacuum pump countercurrent to the adsorption. The three-bed VSA process now in commercial use is based on two patents from 1959/1961. In these patents, the evacuation is carried out without purging (with product) and the pressure is built up to approximately 1 atm with air. As these two features do not produce very high oxygen purity levels, the VSA process only became popular at the end of the seventies when certain improvements were made. Most three-bed VSA systems work with an adsorption pressure of 1 atm, and, less often, up to 1.2 bar (abs). The minimum desorption pressure is 15& 300 mbar. The energy requirement of the vacuum pump depends almost proportionally on the oxygen yield, and is also dependent on the desorption pressure and pump quality. Most oxygen VSA processes are carried out at air temperatures between 20 and 40°C. At lower ambient temperatures, the air is heated up [8].

To reduce investment costs, the three-bed VSA system has been reduced to a two-bed VSA system. Since here, as in the two-bed PSA system, the product flow is not continuous; a product buffer is required in the oxygen product stream. In order to achieve a product pressure of at least 1 atm, the air must be compressed in all cases, and the usual pressure is 1.1-1.5 bar (abs). It is for this reason that the system is called the PVSA (pressure vacuum swing adsorption) process [8].

2) *PSA (Pressure Swing Adsorption) [1]:* Zeolitic PSA processes have also been designed to produce relatively low-purity oxygen enriched gas (23–30 mol % oxygen) directly from ambient air (23). One of these processes is a three-step cycle:

a) Pressurizing the adsorber co currently with compressed air to pressure PA without any withdrawal of gas.

b) Cocurrently depressurizing the adsorber to an intermediate pressure level while producing an oxygen-enriched product gas.

c) Counter currently depressurizing the adsorber to ambient pressure and venting the effluent gas.

3) *Rapid pressure swing adsorption (RPSA) [1]:*Rapid pressure swing adsorption (RPSA) has been developed for the production of low-purity oxygen enriched air (25–50 mol % oxygen). RPSA processes with a total cycle time of seconds can increase the oxygen productivity per unit amount of zeolite by orders of magnitude compared to the conventional cycles. Figure 2 shows a schematic diagram of an RPSA process design that uses two or more layers of a zeolitic adsorbent inside a single adsorption vessel. The layers are separated by a flow-restricting screen. The steps of this RPSA cycle are:

a) Simultaneous pressurization to a pressure of PA with compressed air and adsorption of nitrogen.

b) Simultaneous depressurization to ambient pressure and back purge with a part of the oxygen-enriched product gas generated by the companion layerFigure 1.shows the performance of this RPSA process using NaX zeolite (0.5- mm) beads at feed air pressure of 2.2–3.1 atm. The total cycle time was 12 s. Very high oxygen production capacities and recovery from air can be achieved when the oxygen product purity is less than 40 mol %. This process was found to be superior in performance over other RPSA process designs for low-purity oxygen product even though the other processes were operated at a faster frequency. Low-purity oxygen-enriched air is useful for enhanced combustion in metallurgical furnaces and cupolas.RPSA cycles require smaller zeolite particles to achieve faster adsorption kinetics. However, large pressure drops are developed when the gas flow rates are high. Zeolite monoliths offer very low pressure-drops and are resistant to attrition. Recent air separation studies with square lattice channel monoliths prepared from 5A zeolite powder and Na-bentonite binder exhibited inferior separation performance compared to a packed bed due to channeling at high flow rates and early breakthrough of nitrogen

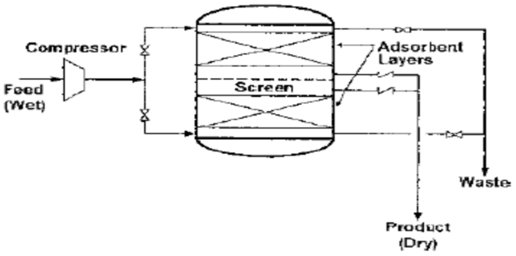


Fig 1. RPSA process using NaX Zeolite [1]

II. LITERATURE REVIEW ON OXYGEN SEPARATION

Zenzi Hagiwaraet. et. al [2] had developed a process for separating oxygen more than 90% pure from a raw material gas, for example air, containing oxygen and nitrogen as main components, includes at least two adsorption zones, each having an inlet and a discharging end, and containing therein a bed of an adsorbing agent having sieving action which is capable of selectively adsorbing nitrogen from said raw material gas and resister there innovative idea under United States Patent having patent number [4,519,813]. And stated that The process can be performed having adsorbing agent is selected from the group consisting of zeolite 4A, zeolite 5A, zeolite X, molecular sieve 4A, molecular sieve 5A, molecular sieve 13X, mordenite and mixtures thereof [2].

Cheng-tung et.al.[4] were investigated A single-bed rapid pressure swing adsorption process packed with 60-80 mesh zeolite 5A for enriching oxygen. For an adsorption bed of length 50.8 cm, the influence of the feed time, delay time, exhaust time, production rate and feed pressure were studied. There exists an optimal time for the feed step with a corresponding optimal exhaust time of twice the time of the feed step, and the optimal delay time is about 0.5 s. Oxygen purity depends upon the values of the feed pressure and production rate used. They were used column of length 100 cm, O.D. 6 cm and I.D. 5.5 cm, and the surge tank is of volume 600 ml. The top of the column is packed with silica gel, and the bottom was packed with 60-80 mesh powder of zeolite 5A, of length 50.8 cm. Two 300 mesh sieves and two glass filters were inserted before and after the adsorbent, and Teflon supports are also used. The 60-80 mesh powder of the MOLSIV adsorbent 5A of UOP was obtained by crashing the 1/16 in pellets through a grinder. In the experiments, 884 g of the zeolite powder were packed into the bed and the bed void fraction is 0.34. The timing of the inlet valve T1 and the exhaust valve T2 were controlled by the logic programmable controller. They were conclude that for a single-bed rapid pressure swing adsorption process packed with 60-80 mesh zeolite 5A at an adsorption bed length of 50.8 cm for enriching oxygen from feed air, the optimal cycle time components are 3, 0.5, 6 s (feed, delay, exhaust) for a feed pressure of 20 psig. This optimal cycle time components give the maximum product purity and adsorbent productivity for a production rate, and are nearly independent of the production rate. When the production rate increases, the product purity decreases, and the adsorbent productivity and recovery increases. When the feed pressure increases, the product purity and adsorbent productivity increases, but the recovery is not very sensitive to the change of the feed pressure.

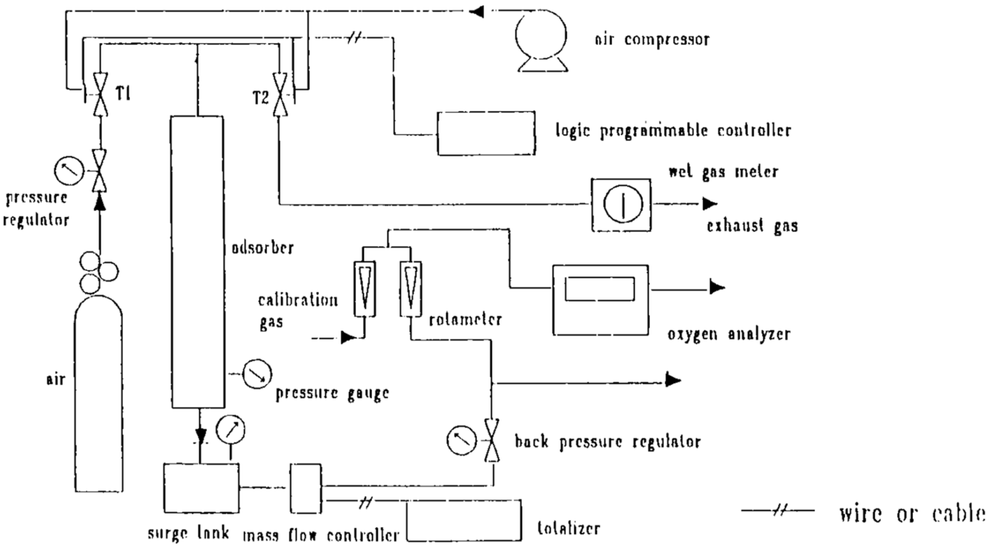


Fig. 2 Experimental apparatus of single-bed RPSA[4]

S. Hayashi et.al. [5] have conducted a series of experiments to optimize the high purity O_2 PSA process and have found various factors that affect the economics of the high purity O_2 generator. Method comprises two-stage concentration process using CMS (carbon molecular sieves) for the first stage and zeolite for the second. In the first stage, Ar of a non-adsorbing component passes onto the CMS bed together with N_2 and a few 0_2, and a mixture gas of O_2 and N_2 that is adsorbed onto CMS is taken out from CMS bed. This mixed gas is sent to the zeolite bed of the second-stage adsorption column: N_2 is removed by selective adsorption, and high purity O_2 remains. It is also possible to use zeolite in the first stage and CMS in the second. The function of each adsorbent in this arrangement remains the same as the former arrangement. In this case, the O_2 recovery ratio is affected by the first stage O_2 recovery ratio, because $0_2/N_2$ selectivity of the zeolite is not good. Therefore this arrangement is not preferable. They have carried out research with the aim of efficiently getting a high purity of O_2 of over 99% from air by a PSA process. The process that uses CMS and zeolite as the adsorbents is a cascade system with complicated operation factors, and optimization is required for each stage. Zeolite used in this experiment is an l/16-in Ca-A type adsorbent, manufactured by Tosoh Corporation. Its adsorption isotherm is shown in Figure 4. The experimental time chart is shown in Table 1. They finally conclude that a high O2 recovery ratio and high productivity of adsorbent was achieved with the Ca-X zeolite system.

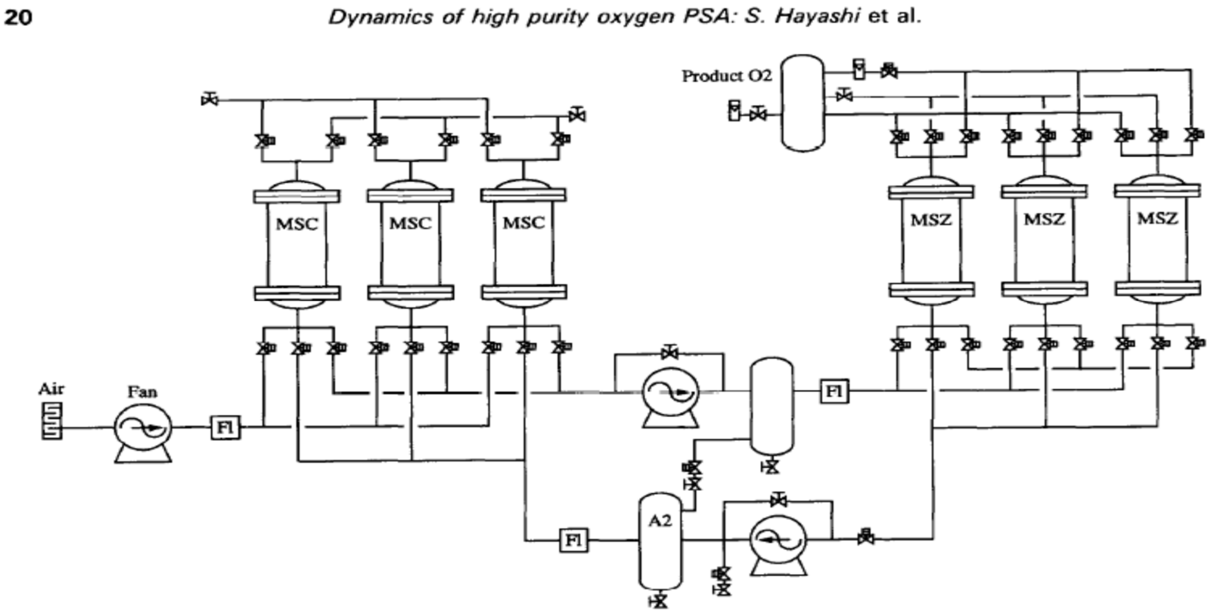


Fig.3 Flow sheet of experiment apparatus [5]

Table 1 experiment time chart for Ca-A zeolite

		Step 1			Step 2			Step 3	
Step time (s)		60			60			60	
CMS packed column									
Column 1		Adsorption			Purge			Desorption	
Column 2		Desorption			Adsorption			Purge	
Column 3		Purge			Desorption			Adsorption	
Step time (s)	5	15	40	5	15	40	5	15	40
MSZ packed column									
Column 4		Adsorption		P.E.	Evacuation	E.P.	P.E.	Pressurization	
Column 5	P.E.	Pressurization			Adsorption		P.E.	Evacuation	E.P.
Column 6	P.E.	Evacuation	E.P.	P.E.	Pressurization			Adsorption	

P.E.—pressure equalization
E.P.—evacuation with purge

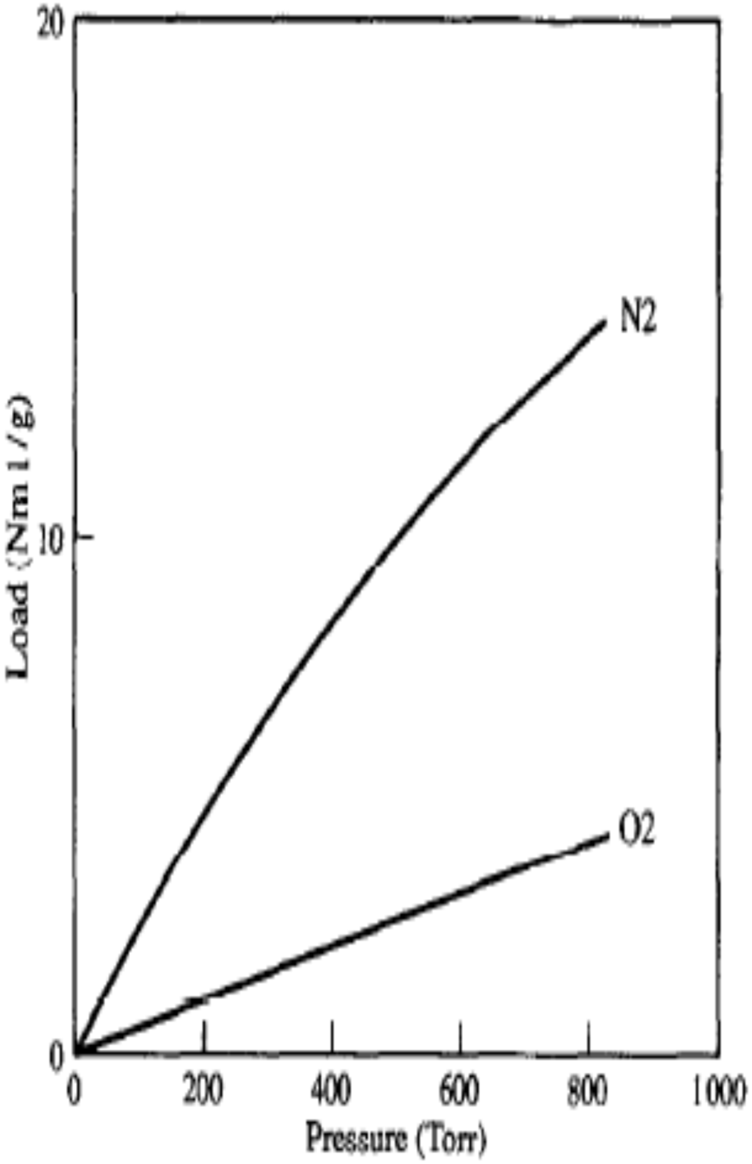


Fig.4 Adsorption isotherm for N_2 and O_2 on Ca-A zeolite at 25^0 C [5]

Y. Y. Li, et.al. [6] carried out experiments on two individual idealized steps in a pressure swing cycle in order to compare the performance of a novel adsorbent monolith with that of a packed bed of commercial pellets containing the same weight of adsorbent. They were conducted experiment for oxygen-enriched air using 5A zeolite. From an experiment for feed pressures up to 3.8 bar, maximum oxygen compositions in the constant pressure production step up to 100% and 52%were achieved for the monolith with the previous step being carried out (1) by purging the column with pure oxygen at 1 bar, and (2) by evacuating the column, respectively. For virtually all experimental conditions studied, the separates performance of the monolith was found to be somewhat inferior to that of the bed of pellets, this being due largely to the former' s poorer film mass transfer coefficient together with the virtual independence of this coefficient on velocity. To its advantage, however, the pressure drop through the monolith was found to be 3-5 times lower than that through the equivalent packed bed and consequently the time to pressurize the monolith was found to be 3-5 times faster than for the bed of pellets. This experimental feasibility study has demonstrated that the novel zeolite monolith configuration shows good potential for the production of oxygen-enriched air of low-to-medium purity, in a low energy, short cycle time, pressure swing process. From experiments they were concluded that benefits of the monolith over a bed packed with pellets include (1) no temperature rise on pressurization which should lead to an improved performance during the feed step of a PSA process, and (2) a low attrition resistance which could extend the life of the adsorbent.

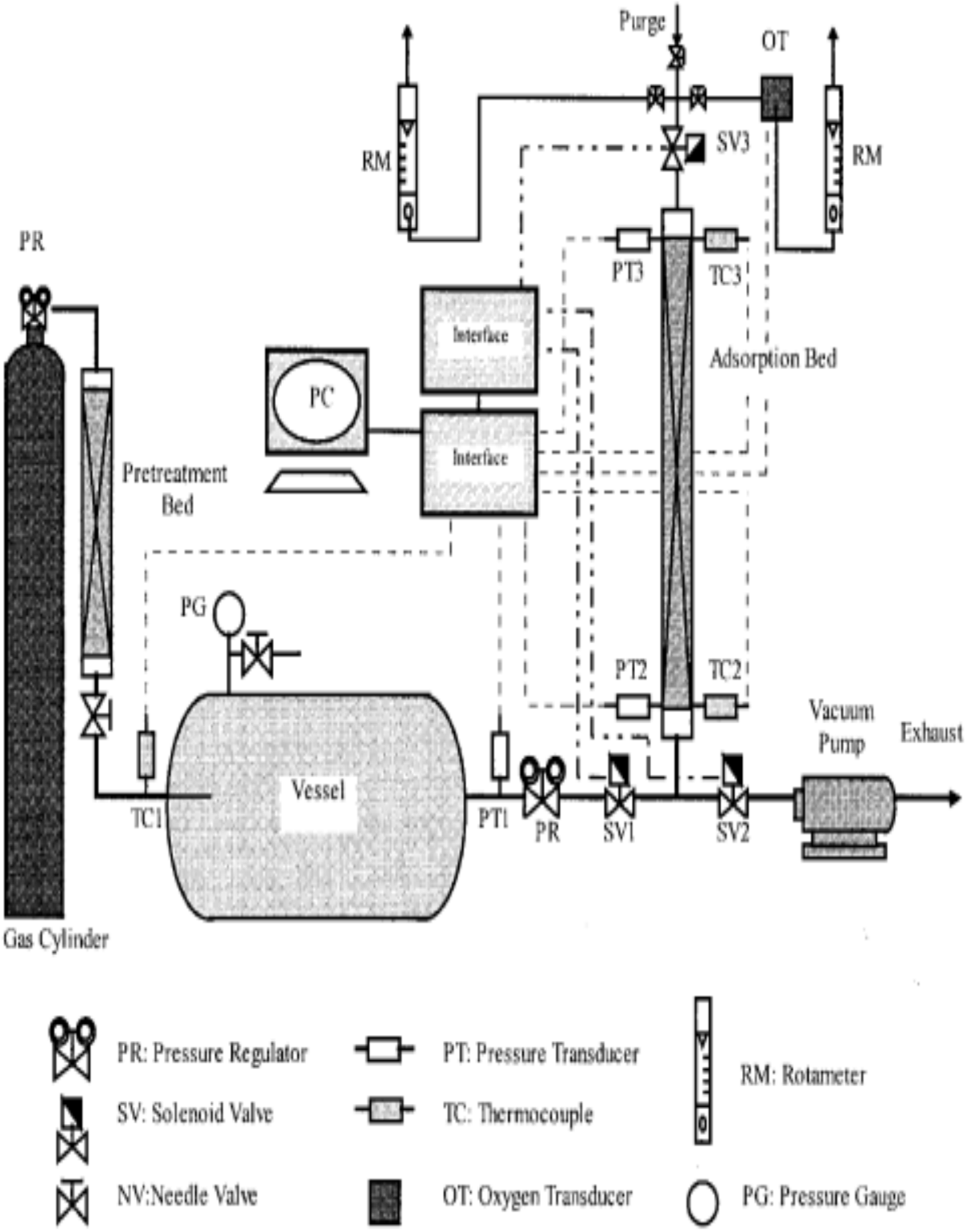
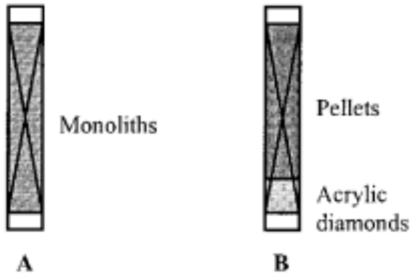
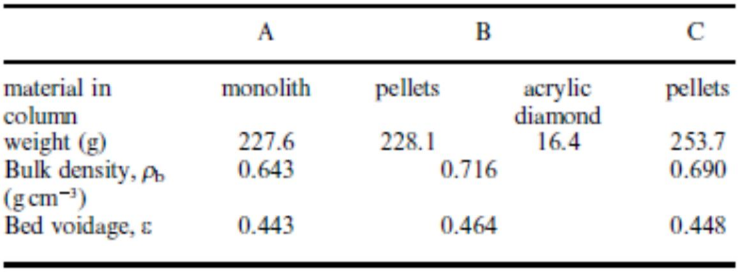


Fig.5 Schematic diagram of experiment apparatus [6]

Table 2. Characteristic of packing material

Material	Monolith	Pellets	Acrylic diamon
Shape	Lattice cube	Cylinder	Parallel hexahedra
Density (gm/cm3)	1.154	1.306	1.176





	A	B		C
material in column	monolith	pellets	acrylic diamond	pellets
weight (g)	227.6	228.1	16.4	253.7
Bulk density, ρ_b (g cm^{-3})	0.643	0.716		0.690
Bed voidage, ε	0.443	0.464		0.448

Fig.6 Packaging status in adsorption column [6]

III. CONCLUSION

This study is carried out with PSA and VSA system. PSA and VSA techniques are very old technique for separation of air via adsorption process, still different technique and methodology are developing to improve efficiency of process. Selection of absorber is primary factor for obtaining desire output. Purity and percentage of separation of gases is depends upon pressure being applied, types of molecular sieves used and method used for separation.

REFERENCES

[1] R. Yang, Gas Separation by Adsorption Processes, Butterworths, Boston, MA, 1987

[2] Zenzi Hagiwaraet, Developed a process for separating oxygen more than 90% pure from a raw material gas, Patent number [4,519,813] United States Patent

[3] R. Arvinda, S. Farooqa, D. M. Ruthvenb. Analysis of a piston PSA process for air separation. Chemical Engineering Science 57 (2002) 419 – 43

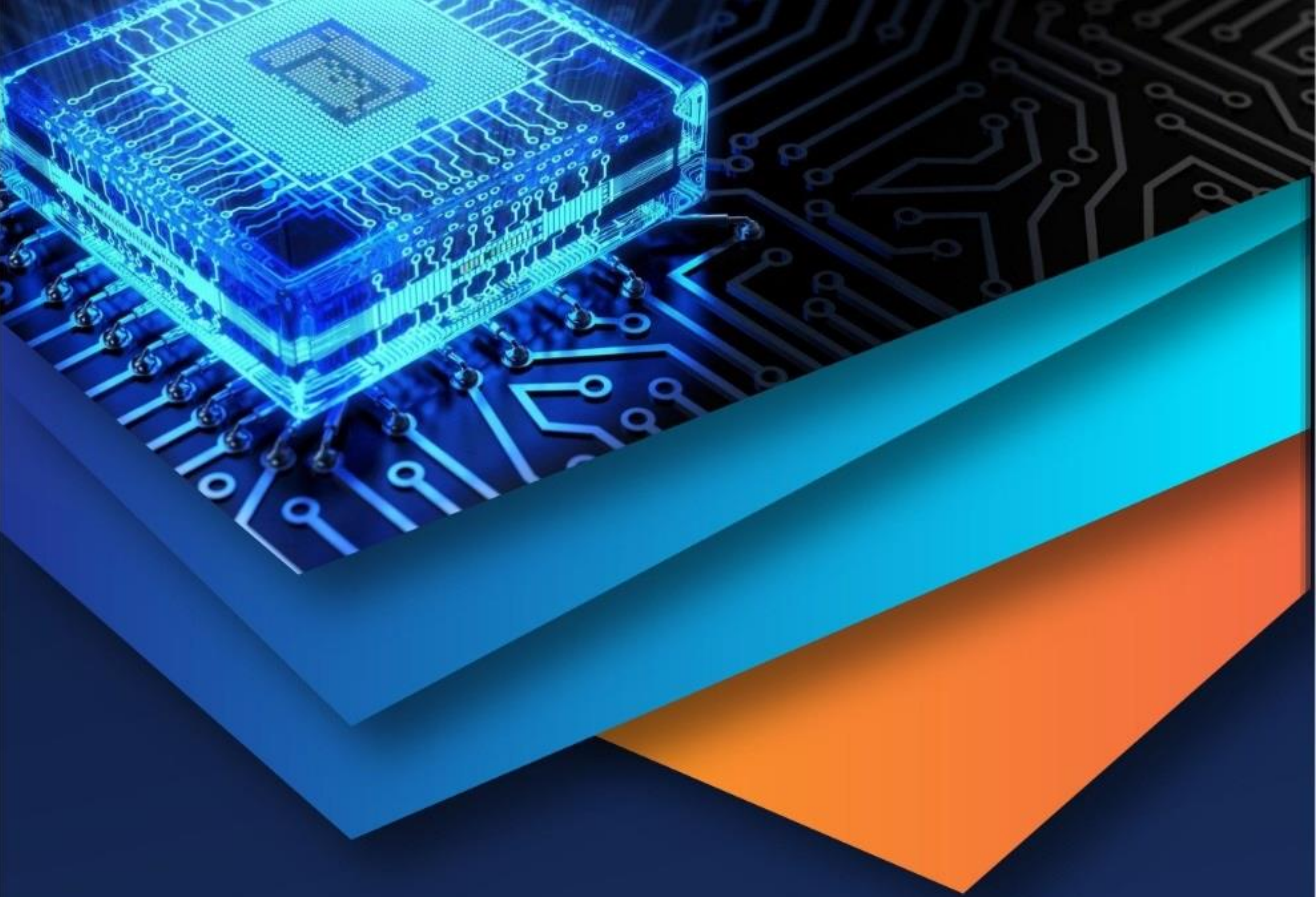
[4] Cheng-tung Chou and Hsiu-Cha Wu , Oxygen Enrichment over Zeolite 5A by a Rapid Pressure Swing Adsorption Process, State of the Art 1994 ,Studies in Surface Science and Catalysis, Vol. 84.

[5] S. Hayashi, M. Kawai and T. Kaneko, Dynamics of high purity oxygen PSA, Gus. Sep. Purif. Vol. 10. No. 1, pp. 19-23, 199

[6] Y. Y. Li, S. P. Perera, B. D. Crittenden , Zeolite Monoliths For Air Separation Part 2: Oxygen Enrichment, Pressure Drop and Pressurization , Trans I ChemE, Vol 76, Part A, November 199

[7] Douglas M. Ruthven , Diffusion Of Ox

[8] ygen And Nitrogen In Carbon Molecular Sieve, Chemical Engineering Science, Vol. 47, No. 17/l & pp. 43054308, 1992Bayer AG, Status and development of oxygen generation processes on molecular sieve zeolites, Gas Separation & Purification 1994 Volume 8 Number 2



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