Advances in Engineering Research, volume 210
Conference on Broad Exposure to Science and Technology 2021 (BEST 2021)

The Effect of Air Flow Rate on Oxygen Purity Level in Pressure Swing Adsorption Equipment with Zeolite 13x and Natural Zeolite Bayah

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ABSTRACT
One of the oxygen generators is a Pressure Swing Adsorption (PSA) machine which is intended as a central oxygen-producing source on a smaller scale by a concentrator machine. Oxygen from the PSA device will be flowed to the patient through the terminal on the patient's bed or flowed to an oxygen cylinder as a supply or backup. Given the importance of the Pressure Swing Adsorption (PSA) machine for oxygen therapy, therefore to help purify the oxygen in the machine, zeolite assistance is needed. The methodology used in this study is an experimental method, namely by testing the air flow rate on the level of oxygen purity produced by the PSA device. By doing this research, it is expected to know the effect of air flow rate on the level of oxygen purity produced by the PSA device. With this research, it is also possible to know the optimal air flow rate to be able to produce a high level of oxygen purity. The results obtained from this study are the effect of the flow rate on the purity of oxygen produced by the PSA device, that is, if the flow rate is greater, the purity of oxygen obtained will be smaller. This is because the flow rate that is too large will cause the zeolite to decrease its ability to absorb gas faster because too much gas enters the tube so that too many molecules stick to the pores of the zeolite. The optimal flow rate to produce high oxygen purity for the PSA device used in this study is 20L/min for both types of adsorbents, resulting in an oxygen purity of 82% using Zeolite 13X. Meanwhile, with a mixture of Zeolite 13X and Zeolite Alam Bayah obtained a maximum purity of 73% with the same flow rate.

Keywords: *Zeolite, PSA, Absorption, Oxygen Purity*

1. INTRODUCTION

Oxygen is one of the elements contained in dry air. Living things, namely humans, need oxygen to breathe and survive, especially when oxygen needs are urgently needed, such as during the COVID-19 pandemic that attacks human respiratory organs.

One of the oxygen producers is a Pressure Swing Adsorption (PSA) machine [1] which is designated as a central oxygen-producing source on a smaller scale by a concentrator machine [2]. Oxygen from the PSA device will be flowed to the patient through the terminal on the patient's bed or flowed to an oxygen cylinder as a supply or backup [3][4][5].

Given the importance of the Pressure Swing Adsorption (PSA) machine for oxygen therapy, therefore to help purify the oxygen in the machine, zeolite assistance is needed. [6], is a natural zeolite [7][8] and synthetic zeolite [9][10]. Natural zeolite is used because it is easy to obtain, especially in the Bayah area, Banten Province [11], while the synthetic zeolite commonly used in PSA is 13X zeolite because it has a good ability to adsorb nitrogen compared to other types of synthetic zeolite.[12][13][14].This study aims to determine the effect of air flow rate on the level of oxygen purity in a pressure swing adsorption device using synthetic zeolite 13X and natural zeolite Bayah.

2. METHODS

The methodology used in this study is an experimental method [15][16], namely by testing the air flow rate on the level of oxygen purity produced by the PSA

device. By doing this research, it is expected to know the effect of air flow rate on the level of oxygen purity produced by the PSA device. With this research, it can also be seen the optimal air flow rate to be able to produce a high level of oxygen purity. The variation used is the flow rate variation, namely 20 L/min, 25 L/min, 30 L/min, 35 L/min, 40 L/min. And also using a variety of adsorbent media, namely 13X synthetic zeolite and a combination of 13X synthetic zeolite with Bayah natural zeolite.

The tools and materials used in this study are as follows:

1. PSA

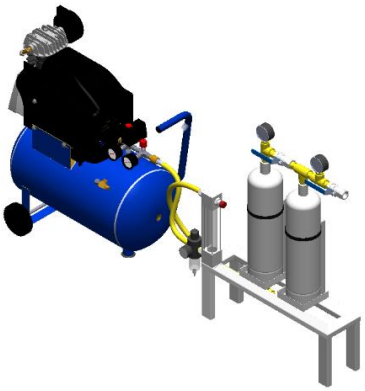

Figure 1. PSA.

The PSA used has a capacity of up to 2.5 kg, a power source, a manual valve mechanism and a single bed type.

2. 13X Zeolite

Figure 2. 13X Zeolite.

Synthetic zeolite uses 13X zeolite because 13X zeolite has a better nitrogen adsorption ability than other synthetic zeolite [12].

3. Bayah Natural Zeolite.

Figure 3. Bayah Natural Zeolite.

Bayah natural zeolite is used because it is easy to obtain and the price is also more affordable, so it can be used in combination with 13X synthetic zeolites which can function to absorb liquids that are mostly produced by the adsorption process in the PSA device.

4. *Furnace*.

Figure 4. Furnace.

The furnace in this study was to calcinate 13X zeolite and Bayah natural zeolite with the calcination process temperature of 300^{o}C and carried out for 60 minutes.

3. RESULTS AND DISCUSSION

Table 1 is the oxygen quality test data with the pressure used is 20 Psi with a variation of 13X zeolite adsorbent media and a combination of zeolite 13 with Bayah natural zeolite. And using flow rate variations, namely 20 L/minute, 25 L/minute, 30 L/minute, 35 L/minute and 40 L/minute. The results obtained are that the smaller the flow rate, the better or higher the oxygen quality level.

Table 1. Testing Data.

Times (s)	Flow rate (L/minutes)	Concentration O2 (%)	
		13X Zeolite	13X Zeolite + ZAB
20	20	82	73
40		81	72
60		80	71
20	25	80	71
40		78	69
60		76	67
20	30	78	69
40		76	67
60		74	64
20	35	76	65
40		73	62
60		70	59
20	40	72	61
40		69	57
60		65	53

In the adsorption process with PSA technology, not only pressure affects the level of purity of oxygen produced. In this study, what is considered is the air flow rate of the oxygen production equipment used. During the adsorption process, gas molecules that match the size of the pores of the adsorbent will enter the pores and molecules that are not suitable will pass. The flow rate can also affect the adsorption process [17].

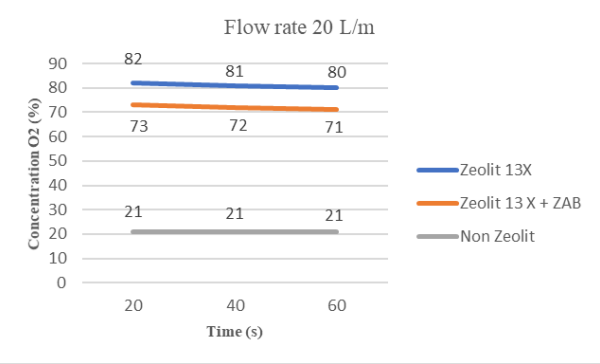

Figure 5. Oxygen Purity Graph with Flow Rate 20 L/min.

The graph in Figure 5 is the data obtained from the operation of the PSA device with a flow rate of 20 L/min. From the graph it can be concluded that: In operation for 20 seconds, it produces 82% purity us-ing Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 73% oxygen puri-ty. In operation for 40 seconds, it produces a purity of 81% using Zeolite 13X , while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 72% oxygen purity. At 60 seconds of operation it produces 80% purity using Zeolite 13X , while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 71% oxygen purity.

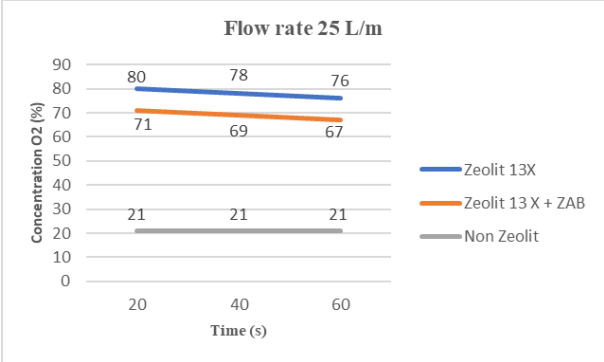

Figure 6. Oxygen Purity Graph with Flow Rate 25 L/min.

The graph in Figure 6 is the data obtained from the operation of the PSA device with a flow rate of 25 L/min. From the graph above, it can be concluded that: Operation for 20 seconds produces 80% purity using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 71% oxygen purity. In operation for 40 seconds, it produces a puri-ty of 78% using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 69% oxygen purity. At 60 seconds of operation it produces 76% purity using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 67% oxygen purity.

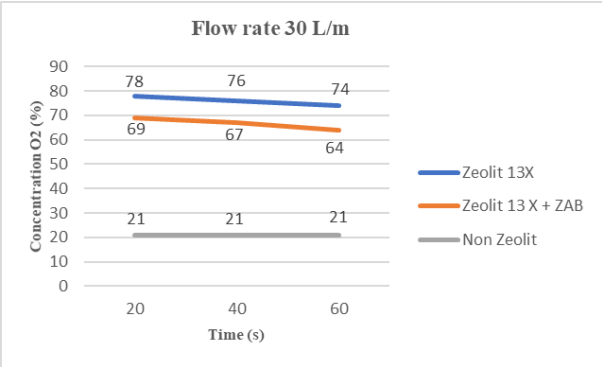

Figure 7. Oxygen Purity Graph with Flow Rate 30 L/min.

The graph in Figure 7 is the data obtained from the operation of the PSA device with a flow rate of 30 L/min. From the graph above, it can be concluded that: In operation for 20 seconds, it produces a purity of 78% using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 69% oxygen purity. In operation for 40 seconds, it produc-es a purity of 76% using Zeolite 13X , while using a mixture of Zeolite 13X and Zeolite Alam Bayah pro-duces 67% oxygen purity. In operation for 60 sec-onds, it produces a purity of 74% using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 64% oxygen purity.

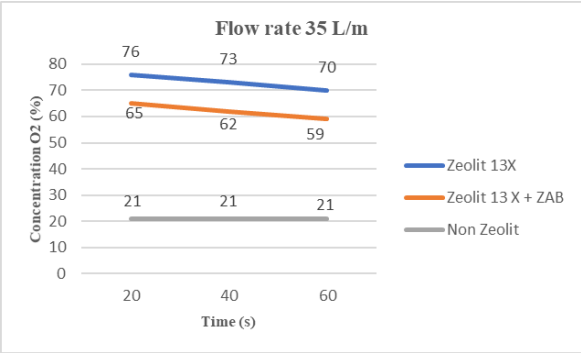

Figure 8. Oxygen Purity Graph with Flow Rate 35 L/min.

The graph in figure 8 is the data obtained from the operation of the PSA device with a flow rate of 35 L/min. From the graph above, it can be concluded that: In operation for 20 seconds, it produces a purity of 76% using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 65% oxygen purity. In operation for 40 seconds, it produc-es a purity of 73% using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah pro-duces 62% oxygen purity. At 60 seconds of operation it produces 70% purity using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 59% oxygen purity.

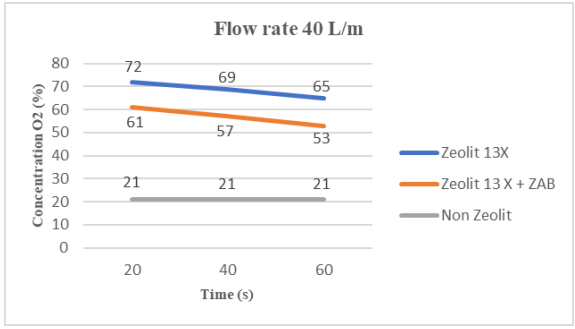

Figure 9. Oxygen Purity Graph with Flow Rate 40 L/min.

The graph in figure 9 is the data obtained from the operation of the PSA device with a flow rate of 40 L/min. From the graph above, it can be concluded that: Operation for 20 seconds produces a purity of 72% using Zeolite 13X, while using a mixture of Zeo-lite 13X and Zeolite Alam Bayah produces 61% oxy-gen purity. In operation for 40 seconds, it produces 69% purity using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 57% oxygen purity. In operation for 60 seconds, it produces a purity of 65% using Zeolite 13X, while using a mixture of Zeolite 13X and Zeolite Alam Bayah produces 53% oxygen purity.

From the data above, it can be seen that the flow rate affects the oxygen content produced by the PSA device. From the data obtained, it can be seen that the greater the air flow rate on the PSA device, the faster the decrease in the level of purity produced. This is because the longer the adsorbent will experience saturation due to the fact that the pores are al-ready filled with adsorbed gas molecules and the flow rate is too large, making it difficult for gas molecules to be absorbed by the adsorbent. The large flow rate also results in less gas being adsorbed by the adsorbent. The flow rate affects the adsorption ability of the adsorbent in the adsorption column.

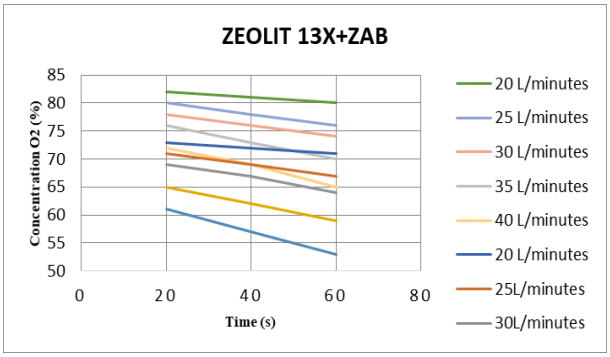

Figure 10. The Effect of Flow Rate on Oxygen Purity with Zeolite 13X.

The graph in figure 10 shows that the most op-timal flow rate to produce high purity oxygen is 20 L/min with the highest purity of 82%. While the low-est level of purity is at a flow rate of 40 L/min with the highest purity of 73%. If the greater the air flow rate used in the PSA device, the purity level of the oxygen produced will decrease. The magnitude of the flow rate also affects the saturation level of the ad-sorbent. The greater the flow rate, the faster the ad-sorbent will saturate and result in a decrease in the adsorption power of the adsorbent.

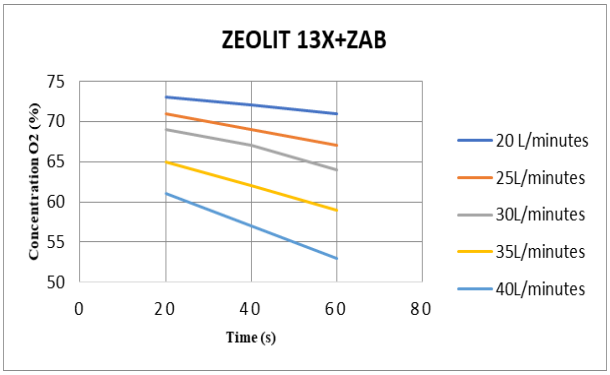

Figure 11. The Effect of Flow Rate on Oxygen Purity with Zeolite 13X and Zeolite Alam Bayah.

The graph in Figure 11 shows the difference with the previous graph, namely the graph above shows a lower level of oxygen purity than the previous graph with the highest purity level of 73% with a flow rate of 20L/min, while the lowest purity is at a flow rate of 40 L/min. This is caused by the different types of adsorbents used. In Figure 4.7 above the type of ad-sorbent used is a mixture of Zeolite 13X with Zeolite Alam Bayah where Zeolite 13X is a synthetic zeolite while Zeolite Alam Bayah is a zeolite obtained direct-ly from mining in nature. From the results of the re-search above, it can also be seen that the longer the adsorption process, the saturation of the adsorbent will occur which results in a decrease in the adsorption power of the adsorbent. Therefore, the optimal flow rate in this PSA device is 20 L/min to produce a high level of purity with a mixture of Zeolite 13X and Alam Bayah Zeolite as adsorbent.

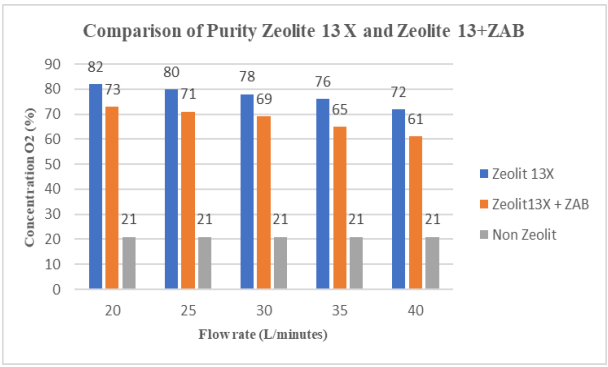

Figure 12. Comparison of Purity Zeolite 13X and Zeolite 13X + ZAB

From the graph in Figure 12 it can be seen that the level of purity produced using Zeolite 13X is greater than the mixture of Zeolite 13X and Zeolite Alam Bayah (ZAB). In the graph above there are five variations of the flow rate used. The difference in oxygen purity is also caused by the different flow rates used. Based on the graph above, the greater the flow rate, the lower the level of purity produced. Oxygen produced by using Zeolite 13X adsorbent and flow rate of 20 L/min has the highest purity of 82%. If you use a mixture of Zeolite 13X and Zeolite Alam Bayah, a lower level of purity is produced than using Zeolite 13X alone. The optimal purity obtained from the mixture of the two zeolites is 73%.

This research shows that Zeolite 13X is a suitable adsorbent material to produce oxygen with a high enough purity. Zeolite 13X has a higher adsorption power than Alam Bayah Zeolite, it is proven by the high purity produced. Zeolite 13X is generally used as an adsorbent used by oxygen-producing devices with PSA technology because the zeolite has a high ability to select and adsorb gases other than oxygen. The graph above also shows that the higher the flow rate used, the lower the purity of the oxygen produced. This is because the flow rate that is too large will cause the zeolite to decrease its ability to absorb gas faster because too much gas enters the tube so that too many molecules stick to the pores of the zeolite.

4. CONCLUSION

The conclusion that can be obtained from the research that has been carried out is the effect of flow rate on the purity of oxygen produced by the PSA device as

follows: The effect of the flow rate on the purity of the oxygen produced by the PSA device is that if the flow rate is greater, the purity of oxygen obtained will be smaller. This is because the flow rate that is too large will cause the zeolite to decrease its ability to absorb gas faster because too much gas enters the tube so that too many molecules stick to the pores of the zeolite. The optimal flow rate to produce high oxygen purity for the PSA device used in this study is 20L/min for both types of adsorbents, resulting in an oxygen purity of 82% using Zeolite 13X. Meanwhile, with a mixture of Zeolite 13X and Zeolite Alam Bayah obtained a maximum purity of 73% with the same flow rate.

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