CHAPTER VI
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In this work, the activated alumina and molecular sieve zeolite 4A were deactivated by the hydrothermal steaming process.

The specific surface area of deactivated alumina, analyzed from BET method, was decreased linearly with the adsorption capacity. The average crystal size of deactivated molecular sieve zeolite, obtained from SEM images, was decreased non-linearly with the adsorption capacity. The deactivation range studied in this work is shown in Table 6.1.

Table 6.1 The deactivation range studied in this work

Adsorbent	**%loss of specific surface area**	**%loss of adsorption capacity**
Alumina	0 – 38.0	0 – 88.3
Adsorbent	**%loss of average crystal size**	**%loss of adsorption capacity**
1/8" Molsiv	0 – 54.0	0 – 15.1
1/16" Molsiv	0 – 53.2	0 – 14.1

Freundlich model fitted the data, and can explain the adsorption behavior of fresh and deactivated alumina, and Aranovich-Donohue (A-D) for Toth equation fitted the data and can explain the adsorption behavior of fresh and deactivated molecular sieve zeolite.

The modified mathematical model with fresh and deactivated adsorption isotherms can efficiently predict the breakthrough of the fresh and deactivated beds at 25°C, 1 atm, and 30%RH feed concentration. The differences of the experimental and theoretical breakthrough times are shown in Table 6.2.

In addition, the bed voidage was found to be sensitive to the predicted breakthrough time of deactivated bed.

The molecular sieve zeolite is the most sensitive to the change of breakthrough time of all layers in the multi-layer adsorber, and the least effected layer is the alumina.

Table 6.2 The differences of the experimental and theoretical breakthrough times of fresh and deactivated bed

Multi-layer packed-bed	Breakthrough time (h)		
	Experiment	Model	Error (%)
Fresh (Al,1/8" molsiv,1/16" molsiv)	27.8	26.0	6.5
Deactivated (42.5% Al, 15.13% 1/8" molsiv, 14.10% 1/16" molsiv)	24.0	22.0	8.3

6.2 Recommendations

In this work, two approaches were proposed to develop the deactivation model. Because the first approach needs the deactivation of each adsorbent along the operating time but it takes a long time to deactivate each adsorbent, this approach is recommended to further study. For second approach, the adsorption isotherm equations of fresh and deactivated adsorbents were examined, and used in the mathematical model to predict the breakthrough time of various combinations of beds. However, the range of deactivation for the molecular sieve zeolite was too narrow. The higher extent of deactivation needs to be studied further.

In addition, from this work it was discovered the change of molecular sieve size along with the deactivation which can affect the parameters in the mathematical model such as void fraction, mass transfer coefficient, velocity profile, and axial dispersion coefficient. So, these parameters should be changed upon deactivation in each layer for the future work. In addition, the change of the molecular sieve size may lead to the pressure drop in the packed bed, so the pressure drop needs to be taken into account in the mathematical model.