

## ***Abstract***

Flue gas desulfurization process has been studied in a fixed bed reactor using Modified Activated Carbon (MAC) catalysts. Activated carbon (AC) was selected as a support due to its availability, low cost, high activity towards sulfur dioxide removal and ability to be regenerated by simple methods.

The experimental set up consists of three sections: SO<sub>2</sub> generation section, test section (reactor) and the analysis section. The reactor was constructed from QVF column of 2.54cm inside diameter and 50cm length. AC particles with mean particle size of ( $d_p$ ) = 1.09 mm were used. All the experiments were conducted at atmospheric pressure, initial SO<sub>2</sub> concentration ( $C_o$ ) = 2500 ppm and bed temperature was ( $T_{bed}$ ) = 90°C, that it was the optimum temperature of *Jabbar*.

MAC was prepared by loading a series of nickel and copper oxides (1, 3, 5, 7, and 10) wt% onto AC. In some of the experimental runs, the original activated carbon was pretreated with two different concentrations of nitric acid of (10 and 45) wt%. The desulfurization performance of the MAC was investigated at flue gas flow rate of 140  $\ell$ /h and bed height of 4 cm.

For metal oxide loading, the results showed that the SO<sub>2</sub> removal efficiency, breakthrough time ( $\tau_{0.05}$ ) and sorption capacity increase with increasing metal oxide loading up to a value of 7 wt% beyond which the desulfurization performance decreases. The chemical state of the 7Ni/45NAC catalyst was characterized using XRD, it was found that NiO phase shows major peaks but minor peaks for Ni, Ni(OH)<sub>2</sub> and Ni<sub>2</sub>O<sub>3</sub> were detected. Moreover the removal efficiency of SO<sub>2</sub> increases with increasing the concentration of HNO<sub>3</sub>. The copper oxide supported catalysts showed higher desulfurization activity as compared to the nickel oxide supported catalysts,  $\tau_{0.05}$  for 7Cu/AC compared to 7Ni/AC increases from 3 to 4 h and sorption capacity increases from 191 to 200 mg/g.

Using 7Ni/AC catalyst, the effect of two process variables: namely flue gas flow rate of  $80 \leq Q \leq 290 \text{ } \ell/\text{h}$  (equivalent to  $263 \leq V_g \leq 955 \text{ cm/min}$ ) and bed height of  $4 \leq H \leq 8 \text{ cm}$  on the desulfurization activity and the characteristics of the mass transfer zone (MTZ) were examined, (MTZ) is the adsorption zone in the bed in which a gradient in adsorbate concentration from zero to equilibrium.

On increasing gas flow rates for all bed heights a similar behavior was observed. As the flue gas flow rate increases, the  $\text{SO}_2$  effluent concentration and breakthrough time decrease and the  $\text{SO}_2$  removal efficiency increases up to a point beyond which any increase in the flue gas flow rate results in an increase in  $\text{SO}_2$  effluent concentration and breakthrough time, and the decrease in the  $\text{SO}_2$  removal efficiency.

The effluent concentration of  $\text{SO}_2$  decreases, the breakthrough time and the removal efficiency increase by increasing the bed height of the catalyst from 4 to 12 cm for all flue gas flow rates studied.

The effect of the pretreatment of the original AC with  $\text{HNO}_3$  on the characteristics of MTZ was investigated. The  $L_{\text{MTZ}}$  decreases and the breakthrough time ( $\tau_{0.05}$ ) and exhaustion time ( $\tau_{0.95}$ ) increase by increasing the concentration of  $\text{HNO}_3$  and bed height. On increasing the superficial gas velocity two regions are developed. In the first region, as the superficial gas velocity increases  $\tau_{0.05}$  and  $\tau_{0.95}$  decrease but the  $L_{\text{MTZ}}$  is prolonged while in the second region,  $\tau_{0.05}$  and  $\tau_{0.95}$ , and  $L_{\text{MTZ}}$  increase as the superficial gas velocity increases. Based on the experimental results the  $L_{\text{MTZ}}$  is correlated in terms of superficial gas velocity ( $V_g$ ) and bed height ( $H$ ) using STATISTICA software as:

$$L_{\text{MTZ}} = \frac{1.58V_g^{0.35}}{H^{1.06}}, \quad \text{Correlation Coefficient (R)} = 0.9800$$