International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.9, No.03 pp 640-644, 2016

# Treatment of coke oven effluent by coagulation process

**Rajkishore Chaudhary and Parmesh Kumar Chaudhari***

**Department of Chemical Engineering, National Institute of Technology, Raipur, India**

**Abstract:** Coke oven effluent (COE) has been found to one of the highly polluted effluent. It contains high phenol, cyanide and chemical oxygen demand (COD). The effluent was treated by coagulation process using $FeCl_3$. Effect of pH and coagulant doze was studies on removal of COD. With $FeCl_3$ coagulant 47.71%, 48.25%, 49.1%, 52.41%, 50.06%, and 50.08% COD reduction obtained at pH 4, 6, 8, 9, 10, 10.5 and 11, respectively. At optimum pH 9 and coagulant dosages 1.2, 2.4, 3.6 and 4.8 g/dm$^3$, respectively, COD reductions were 36.21%, 52.14%, 56.37 and 52.41. Settling studies show good settability of solid residues.
**Keywords:** Coke oven effluent, coagulation, settling, chemical oxygen demand.

## Introduction

Energy is prime requirement in house hold and in industries. Much amount of energy is fulfilled by coal. In steel making industries coke is used in blast furnace to melt iron ore. Huge amount of coke is required all over the world. This coke is produced from destructive distillation of coal in coke oven. In world about 3000 coke-ovens are in operation to produce coke from coal. In these coke – ovens about 350 million tons of coke are produced, out of this, about 12 million tons are produced in India [1]. One ton of coal produces about 50 gallons of COE which is composed of complex inorganic and organic contaminants such as ammonia, cyanide, thiocyanide, phenolic compound etc [2,3]. Most of these compounds are refractory, toxic, and carcinogenic and very harm full to environmental and ecological system [4]. Therefore, bring it to a recycle or dischargeable limit, efficient and low cost process is needed for its treatment. Biological treatment process is widely used to treat CWW in industries. Some works have been also reported to use these methods [2,4,5]. Exposure of effluent for long period is one of the drawback of this process. Second drawback is, selective and efficient micro-organisms are needed to consume the pollutants. Coagulation procss have been effectively applied to treat various industrial effluents organic in nature [6-10]. Therefore, in present studies coagulation process using $FeCl_3$ is used. $FeCl_3$ has been proved to effective coagulant [6,10].

## Material and methods

### Materials

The coke oven effluent (COW) was obtained from Bhilai Steel Plant Ltd Bhilai, C.G. (India). Analytical reagent (A.R.) grade chemicals were used for the analysis of the parameter during coagulation studies. Laboratory reagent (L.R.) grade $FeCl_3$, obtained from Merk Ltd Mumbai (India). A Watman filter paper was supplied by GE Healthcare Ltd, Buckinghamshire (U.K).

## Experimental method

0.5 $dm^3$ of COW was taken in a 1 $dm^3$ glass beaker. The known amount of coagulant was added to the effluent and mixed with the help of glass stirrer. The pH of effluent was noted and initial pH ($pH_i$) was adjusted by adding aqueous NaOH (1M) or $H_2SO_4$ (1M) solution and kept on jar test apparatus for coagulation process. The coagulant added COE was mixed for 20 minutes with the help of paddle stirrer at 100 rpm, after this it was slowly mixed (40 rpm) for 5 minute. After the mixing process was complete the glass beaker was kept quiescent for about 6 h later on the supernatant liquor was filtrated by Watman filter paper (no 41) and its COD was analysed. The steps were repeated for different coagulant dosages. Settling study was performed in 0.5 $dm^3$ measuring cylinder.

## Analytical procedure

The COD of the sample was determined by the close reflux method [11]. The samples were digested at 148°C then their absorbance was determined at 605 nm. pH of sample was determined by using digital pH meter (EI Made, India).

## Result and discussion

The COE has contains number of organic and inorganic material, organics contains number of functional groups. These groups have negative charge. Most of coagulant used are iron and aluminum salts and is trivalent in nature such as aluminum chloride ($AlCl_3$) and ferric chloride ($FeCl_3$). When metal salts are added in water, the metal ions hydrate and hydrolyse to form $M(OH)^+$, MOH monomeric or polymeric species. At low pH (pH < 7), $Fe^{3+}$ remain in the solution, and form precipitates of $Fe(OH)_3$ as the pH is increased or as the coagulant dosage is raised [12]. The general form of hydrolysis reaction of trivalent metals is given as [13],

$$xM^{3+} + yH_2O \rightarrow M_x(OH)_y^{(3x-y)+} + yH^+$$

The metal hydroxide passes positive charge which adsorb and neutralize the negative ions of COE forms heavy mass and settled down.

## Effect of pH

The COD reduction of COE with $FeCl_3$ coagulants is presented in Fig. 1. The effect of coagulant with pH variation from pH 4 to pH 11 was studied. It was seen that COD reduction of the COE varied with pH. With $FeCl_3$ coagulant 47.71%, 48.25%, 49.1%, 52.41%, 50.06%, and 50.08% COD reduction took placed at pH 4, 6, 8, 9, 10, 10.5, 11, respectively. COD reduction decreased for $pH_i < 9$ and $pH_i > 9$. The amount of COD reduction depends on components present in effluent and on the amount of metal cations, metal hydroxide and methyl hydroxide cations [12]. Due to this COD reductions varied. At high pH $Fe(OH)_3$ forms, while metal hydroxide cation decreased, thus COD reductions also decreased. At low pH COD reductions less, this is due to presence of $Fe^{+++}$ ions in much amount as compare to metal hydroxide which are more effective than $Fe^{+++}$ cations. Reactivity of functional groups present in effluent also varied with pH. COD reductions take place by charge neutralization as well as sweeping.

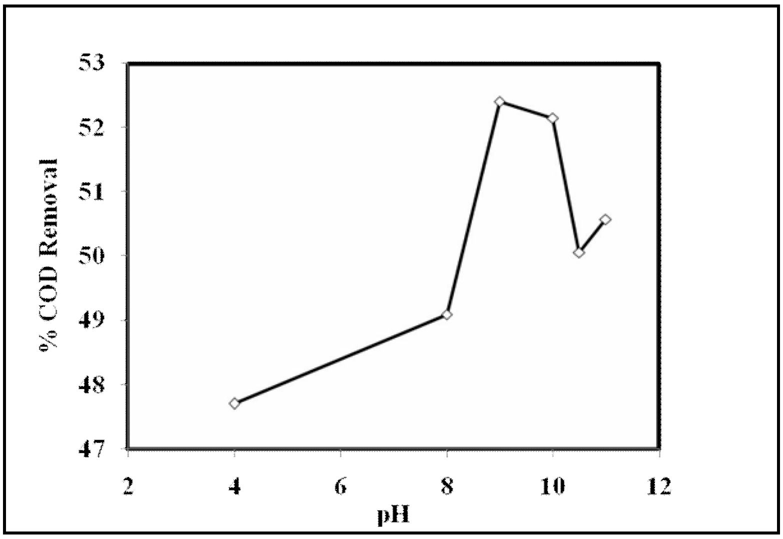


**Figure 1. Effect of pHi COD reduction of coke oven waste water using $FeCl_3$ as a coagulant**

**Effect of coagulant dosage**

To get optimum dosage of $FeCl_3$ coagulant, different dosage of $FeCl_3$ was used in experiment. The results are presented in Fig. 2. Percentage COD reduction increased with increase in coagulant dosage up to certain limit then after it decreased. This is due to restabilization of neutralized organic anions at higher coagulant dosage [14]. With coagulant dosages of 1.2, 2.4, 3.6 and 4.8 g/dm$^3$ , COD reduction was observed to 36.21%, 52.14%, 56.37% and 52.41% at their optimum pH 9. Similar effects were also observed for treatment of pulp and paper effluent by coagulation process [10]. In our case COD reduction of 56.37 % obtained, which is better to earlier work in which 31% COD reduction observed [15].

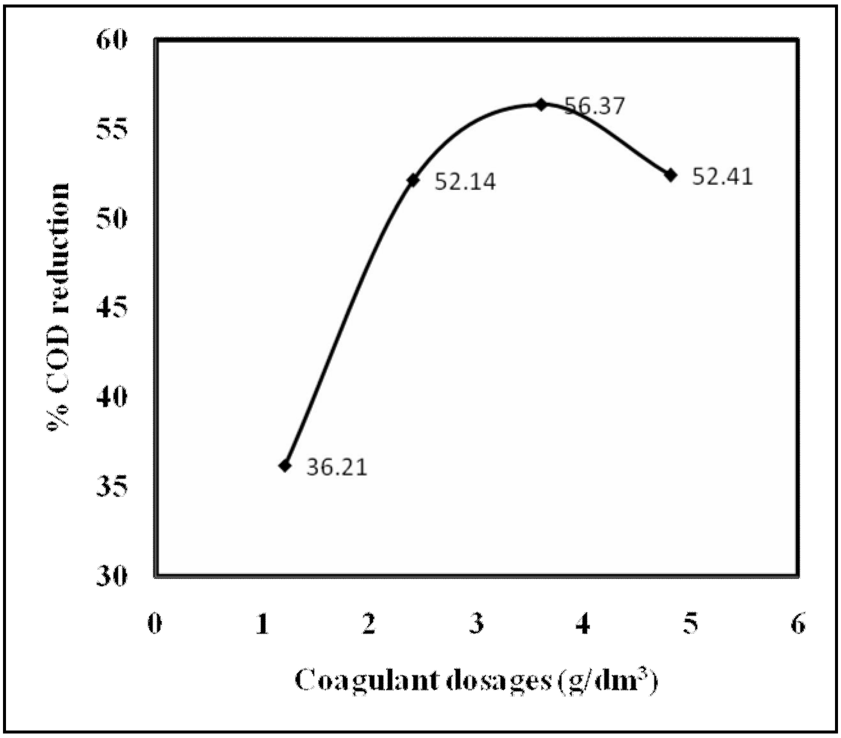


**Figure 2. Effect of coagulant doze on COD reduction of coke oven effluent at optimum pH**

**Settling study of the treated effluent**

It is necessary to separate the sludge and liquid contents in treated effluent, therefore, sedimentation process was used. Sedimentation is the most economic method compared to other separation processes. To study the separation characteristic by settling, the COE after coagulation process was slowly mixed and taken in $0.5dm^3$ cylinder having diameter 4.6 cm. The supernatant and solid interphase was noted with time. Figure 3 show the time Vs height graph of settling sludge of at different pH. It is seen that the settling of the solids is faster initially and after some time, it decreased. The portion in which settling is faster is known as zone-settling region and the portion where a compressed layer begins to form at the bottom of the cylinder is called compression settling region. The settling rate was found in order of pH 10> pH 4> pH 11> pH 7> pH 5> pH 9. pH 10 showed best settling as compare to other pH. Settling depends on size and shape of solid suspended mass. Several methods have been presented for the evaluation of compression zone depth. Using the batch sedimentation data a continuous thickener may be designed [16,17]. Method proposed by Recherdson at al. [16] is common to design a continuous thickener based on batch studies

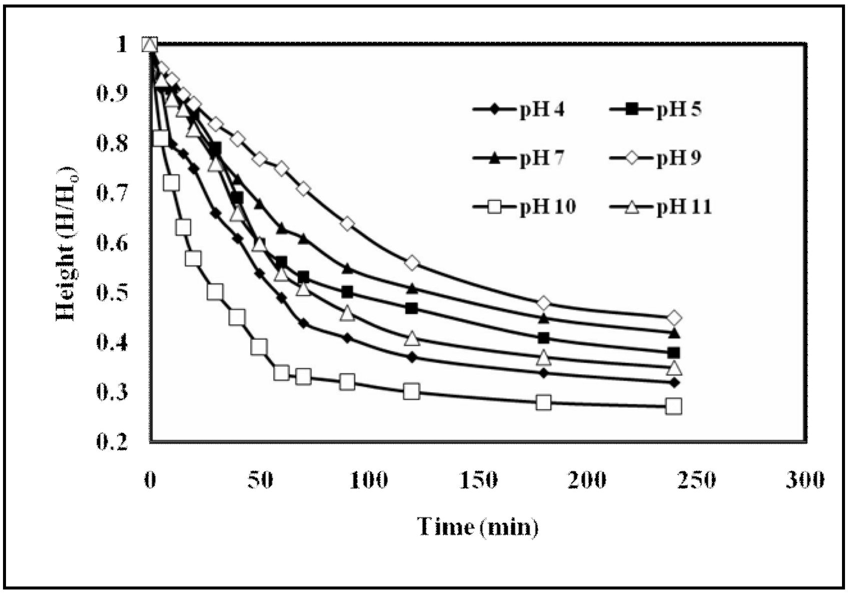


**Figure 3. Settling characteristic of the coagulated slurry at different pH.**

## 4. Conclusion

Coagulation process for treatment of COE can be an effective treatment method as primary treatment. $FeCl_3$ provided 56.37% COD reduction at their optimum pH 9. The COD reduction was also varied with coagulant mass. The reduction increased with increase in the dosages of coagulants up to 3.6 $g/dm^3$. Reduction of COD was not found to increase with further increase in coagulant mass. The settling characteristic of $FeCl_3$ treated COE at pH 10 was found best among effluents treated at pH 4, 5, 7, 9, 10, 11. Complete removal of COD from the COW was not possible by Coagulation, thus, further treatment required.

## References

1. Luthy, R.G., Stamoudis, V.C, Cambell, J.R., Harrison, W., Removal of organic contaminants from Coal conversion process condensates, Journal of Water Pollutant Control Federation, 1983, 55(2), 196 – 207.
2. Masanon, F., Vazquez, I., Rodfiguez, J., Castrillon, L., Fernadzed, Y., Loopez, H., Treatment of coke wastewater in a sequential batch reactor (SBR) at pilot plant scale. Bioresource Technology, 2008, 99, 4192-4198.
3. Chang, E.E., Hsing, H. S., Chiang, P.C., Chen, M.Y., Shyngn, J.Y., The chemical and biological characteristics of coke-oven waste water by ozonation, Journal of Hazardous Materials, 2008, 156, 560-567.
4. Lim, B.R., Hu, H.Y., Fujic, K., Biological degradation and Chemical oxidation characteristics of coke – oven wastewater, Water Air Soil Pollution, 2003, 146, 23 – 33.

5. Lai, P., Zhang, H., Zeng, Wang, C., Ni, J., Study on treatment of coking wastewater by biofilm reactors combined with zero-valent iron process, Journal of Hazardous Materials, 2009, 162, 1423-1429.
6. Chaudhari, P.K., Majumdar, B., Choudhary, R., Yadav, D. K., Chand, S., Treatment of paper and pulp mill effluent by coagulation, Environmental Technology, 2010, 31, 357– 363.
7. Randtke, S.J., Organic Contaminant Removal by Coagulation and Related Process Combinations, Journal of American Water Works Associations, 1988, 80, 40-56..
8. Sabur, M.A., Khan, A.A., Safiullah, S.; Treatment of Textile Wastewater by Coagulation Precipitation Method, Journal of Science and Research, 2012, 4(3), 623-633.
9. Semmens, M. J., and Field, T. K., Coagulation: Experiences in Organics Removal, Journal AWWA 1980, 72, 476-483.
10. Prajapati, A., Choudhary, R., Verma, K., Chaudhari, P.K., Dubey, A., Decolorization and removal of chemical oxygen demand (COD) of rice grain–based biodigester distillery effluent (BDE) using inorganic coagulants, Desalination and Water Treatment, 2015, 53, 2204-2215.
11. APHA. American Public Health Association, Standard Methods for Examination of Waste and Wastewater, APHA-AWWA-WEF, Washington, DC, 2013.
12. Bratby, J., Coagulation and Flocculation in Water and Wastewater Treatment, 2nd ed, Water Intelligence Online, IWA Publishing: London, 2006.
13. Ching, H.W., Tanaka, T.S., Elimelech M., Dynamics of Coagulation of Kaolin Particles with Ferric Chloride, Water Research, 1994, 28, 559-569.
14. Peavey, S., and Rowe, R., Environmental Engineering, McGraw-HILL International, New York, 1985.
15. Lai, P., Zhan, H., Zeng, Wang, C., Ni, J., Advanced treatment of coking wastewater by coagulation and zero valent iron processes, , Journal of Hazardous Materials, 2007, 147, 232-239.
16. Richardson, J.F., Harker, J.H., Backhurst, J.R., Coulson and Richardson's Chemical Engineering, Particle Technology & Separation Processes vol. 2, 5th ed., Elsevier, a division of Reed Elsevier, India Pvt. Ltd., 2003
17. R. Font, Calculation of the compression zone height in continuous thickeners, AIChE J., 1990, 3 36.

*****