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직렬 및 병렬 반응기를 이용한 염색공장 유출수의 전기화학적 산화에 관한 연구

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Investigation on Electro-chemical Oxidation of Dye-house Effluent using Series and Parallel Reactors

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ABSTRACT

An electrochemical method is going to be investigated in treating dye-house effluent. For this purpose a cylindrical electrochemical reactor is used. Three different flow setups such as, batch reactor, batch recirculation system and once through process are used to carryout the process. The whole apparatus is kept clean to avoid any contamination. After treating the effluent, samples are collected at the outlet for analysis. The color in the effluent sample is determined by spectrophotometer. The Chemical Oxygen Demand of the feed, treated sample is determined. From that, percentage reduction of COD is calculated. The effect of various operating parameters such as voltage, current density and flow rate removal efficiency is also investigated. The power consumption, mass flux and Rate constant of the process is determined. For the batch recirculation setup values of Electro Oxidation Demand and Degree of Oxidability are calculated

Key Words : Electrochemical Treatment, Electrochemical oxidation, dye house effluent, Chemical Oxygen Demand, Color reduction, Residence time, Energy consumption

Ⅰ. INTRODUCTION

In the past ten years there has been a growing concern about environment. Rapid industrialization causes unwanted pollution in the environment. Among different types of pollutions, water pollution is the major problem

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since water is essential to lead daily life. But because of the modern process industries mainly textile industries,water is polluted in many ways. The textile industry uses 75,000 liters of water daily.

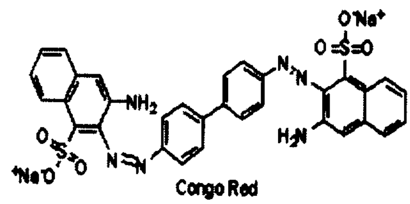
The textile industries pollute water in a major way. They not only add organic pollutants, but they impart color to water. The effluent discharged by this industry contains chemicals, starch, dyestuffs, alkalis,acids, detergents, etc. Various approaches have been made to treat the effluents. Dry process includes opening, blending, mixing, carding, combing, spinning, weaving and knitting operations. The wet process consists of sizing, de-sizing, bleaching, dyeing and finishing operations. Dyeing is an integrated part of the textile process. The nature of dyeing process varies with the nature of fiber and color. The large variety of chemicals used in the dyeing process makes the effluent as complex one to treat. Dyes used in textile industries are vat, sulphur, azoic and reactive dyes [1]. Azoic dyes are banned worldwide since they are proven carcinogens. Reactivedyes are used in dyeing cotton fibers. They are economical, offer wide variety of colors and can be easily applied. Only 70% of applied dyes are fixed with fiber. Remaining portion is discharged with process water. They get hydrolyzed and cause severe problem to treat.

The electrochemical methods are based on principles of electrochemistry. Such as anodic oxidation, cathodic reduction, electro-deposition, ionic transport through membrane etc. The commonly used electro chemical methods are electro-oxidation, electro-reduction, electro filtration, and electro-dialysis. The basic principle of electro-oxidation is that, any species that can be oxidized chemically can be oxidized even more efficiently at an anode [2].

Three different flow set ups such as, batch reactor, batch recirculation reactor and once through process are used to carryout the process. The whole apparatus is kept clean to avoid any contamination. After treating this effluent, samples are collected at the output for analysis. The color in the effluent sample is determined by spectrophotometer. The COD of the feed and treated sample are determined.

II. EFFLUENT SPECIFICATION

Commercial Name Congo Red
Color Index – 20505 CI Reactive Red
Number of –N=N– in structure – 2 in Chromogenic system.
Chemical Structure –



Congo Red

Molecular Wt. of one molecule – 992 g/mol
pH of effluent –10.5
Density of effluent – 989.04 kg/m^3
Initial COD – 1000 ppm
TDS – 82.4 mg/l
Chloride (as Cl) – 4920 mg/l
Initial Absorbance Maximum wavelength – 597.4 nm

III. EXPERIMENTAL SETUP

There are two cylindrical cells. The reactor is shown in Figure.1. Anode is made of RuO_2

coated titanium and cathode is made of stainless steel [3]. The reservoir is connected to a rotameter for varying different flow rates. The rotameter outlet is connected to the input of the one cylindrical cell in series setups and to two cells in the parallel setup. The output of the first cell is sent as the output to the 2nd cell in the series setup Figs.2 and 3. But in the parallel setup, the outputs of the first and 2nd cell are sent to the output tank. The output of the cell placed second is sent as output to the output tank Figs.4 and 5. In the horizontal set-up same thing is followed, but the cells are placed horizontally. Thus the cells are placed. The anode and the cathode are connected in the same cell in the series and parallel flow setup. But in dipolar setup anode in first cell and cathode in another cell are connected from the main. The parameters used are voltage 8V, and current 40A. The motors put on, and the samples are collected for every flow rates such as 20, 40, 60, 80,100 l/h.

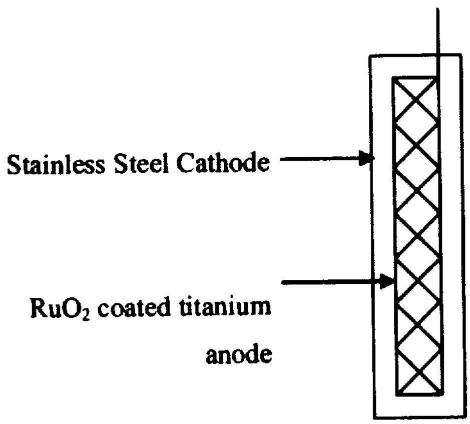


Fig. 1. Reactor

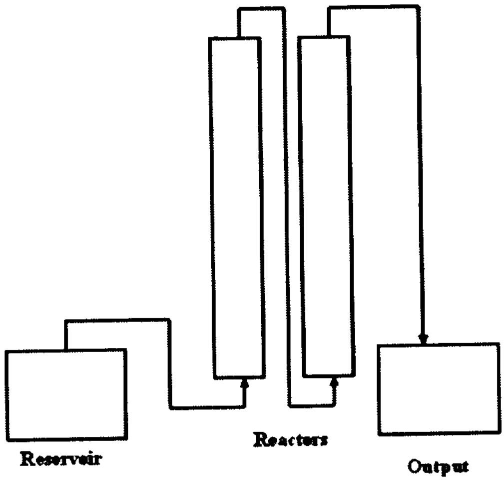


Fig. 2. Vertical series setup

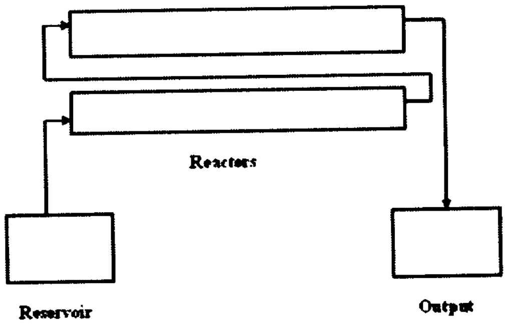


Fig. 3. Horizontal series setup

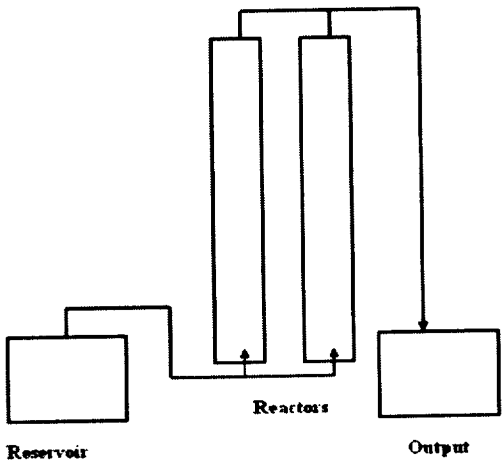


Fig.4. Vertical parallel setup

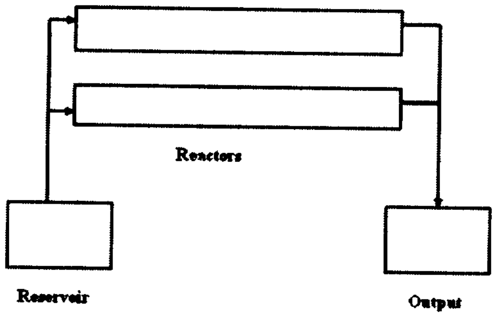


Fig. 5. Horizontal parallel setup

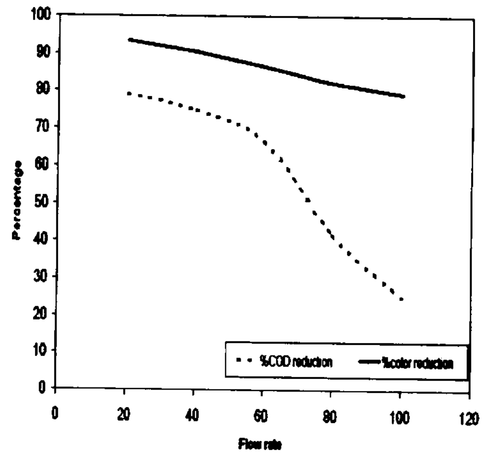


Fig. 7. Horizontal series setup

IV. RESULTS AND DISCUSSION

4.1 Effect of flow rate on % COD reduction and % color reduction

The color and COD gradually decrease as the flow rate increases when the electrical series there is a maximum COD and color Reduction than when the electrical is parallel. When the cylinders are kept vertically there is slightly higher % COD and color reduction than when the cells are placed horizontally. This is given in Figs. 6 and 7.

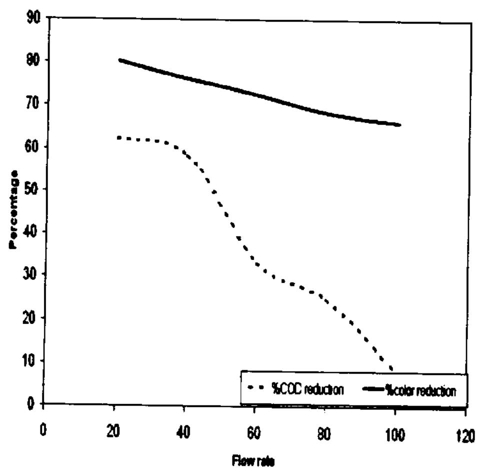


Fig. 6. Vertical series setup

4.2 Effect of flow rate on energy consumption

As the flow rate increases, the energy consumed decreases to certain low point and then gradually increases. The energy consumption is almost same in both horizontal and vertical, series and parallel setups. This is clearly shown in Figs. 8 and 9.

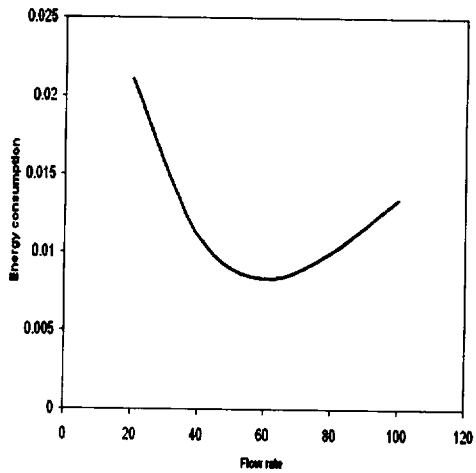


Fig. 8. Vertical series setup

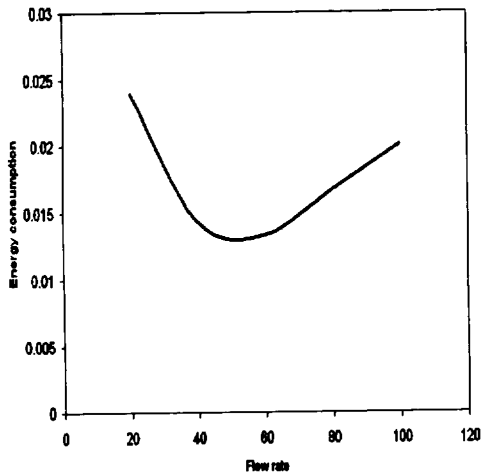


Fig. 9. Horizontal series setup

4.3 Effect of flow rate on average flux

As the flow rate increases the average flux also increases up to a certain point and then decreases. In some cases there is also an increase then decrease and again increases.

Thus the average flux is varying as the flow rate increases. This is shown clearly in Figs. 10 and 11.

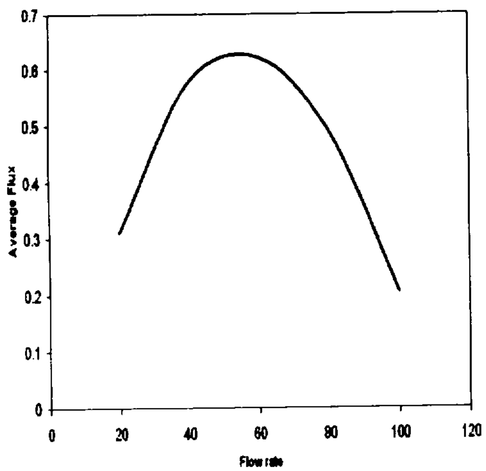


Fig. 10. Horizontal series setup

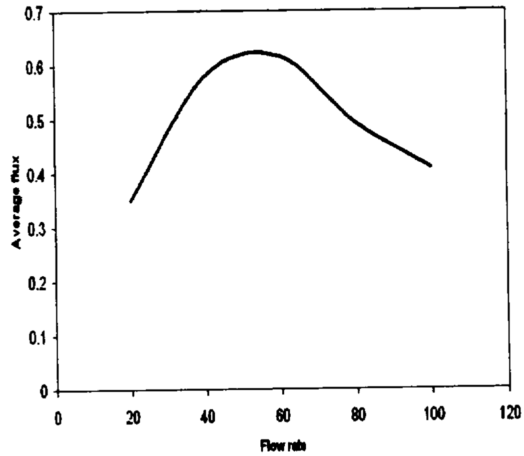


Fig. 11. Vertical series setup

4.4 Effectsof flow rate on residence Time

The residence time decreases as a flow rate increases. The residence time is found out to be highwhen flow rate is low. The residence time remains constant for vertical and horizontal, series and parallel setup as shown in Fig.12.

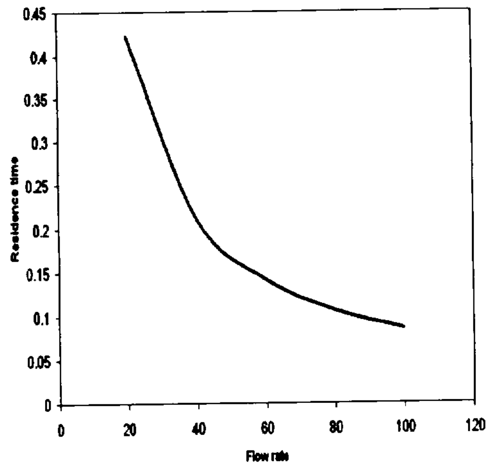


Fig. 12. Flow Rate vs. Residence Time

4.5 Effects of residence time on % COD and % Color Reduction

The residence time for all flow rates in the series and parallel setup remains constant. As the residence time decreases the % COD and % Color reduction also decreases. Thus the residence is directly proportional to the COD and Color reduction.

V. CONCLUSIONS

The electrochemical reactors are connected in series and parallel for vertical and horizontal positions. The results show the percentage COD and percentage color reduction. The efficiency of reduction is much higher than the other methods such as electro coagulation, electro flocculation and biological methods [4]. Treatment using physiochemical method produces more sludge, high cost and lower efficiency. In Biological treatments the process takes longer time and lower efficiency. Thus this electro chemical are best suited for treating the dye house effluent [5]. The electro chemical oxidation method is efficient compared to other electro chemical methods. The COD and Color reduction is up to 80 to 90%. Thus, this method is also economical. In the series and parallel, series gives more efficiency than the parallel method. Thus the dye house effluent is treated in the more efficient and economical manner using the electro oxidation technique.

Acknowledgement

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