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A NEW ECO-FRIENDLY METHOD FOR REMOVAL OF COLOUR FROM PULP MILL EFFLUENTS

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Key words : Rayon Factory, Effluents, Organic load, Lignin content, Kakatiya Electro Cluster Method.

ABSTRACT

The present investigation is aimed to reduce organic load could due to the presence of lignin content in the Rayon Factory Effluents. An attempt has been therefore made to develop a new and low cost, eco-friendly method. This new method was named as Kakatiya Electro Cluster (KEC) method, which is based on the principle of Electro Chemistry. In the present study the operating variables studied were TSS, TDS, BOD, COD, Colour and TS, the results were tabulated. After series of trials made with this method it was found that there was a significant reduction in TSS, TDS, BOD, COD, Colour and TS values which indicates that the efficacy of the method in removal of colour content of the effluents caused due to the presence of lignin and organic load is considerably reduced in the effluents. It is proposed that this method has a greater potential and cost effective method to treat the pulp mill effluents.

INTRODUCTION

The Indian paper industry has made remarkable progress in recent years with growing literacy and standards of living. The paper consumption will certainly increases pollution load to a greater extent and this industry will have deleterious effect in future. Environmental problems associated with pulp and paper industries vary with the size and category of the mill. Although all the large-scale pulp and paper mills have adequate treatment systems but still some of the problems like colour in the treated effluent still persists (Charles Clayton, 1980). The colour problem is basically due to spoilage of black liquor during its handling which ultimately joins the effluents streams. In the small-scale agro-based pulp and paper mills (Sven A. Rhdholum, 1956), major cause for the pollution is due to discharge of black liquor, which is otherwise taken to chemical recovery plant in large scale pulp mills (Minar, 1978). The absence of chemical recovery plant in small scale unit is due to its high cost and heavy expenditure in its installation (Blosser, 1963). In the water based paper mills zero discharge is possible through recycling of waste water after suitable treatment but due to poor treatment methods and old fiber recovery technologies the industries are unable to recycle the effluents (Trivedy, 1998).

The above study indicates colour is the major pollutant which is present in the pulp and paper mill effluents. These effluents are highly coloured mainly due to lignin and its derivatives (Goring, 1971; Sankaran *et al*. 1971; Sundman *et al*. 1981). These were causing adversely effect on aquatic ecosystem. Thus, it is important to have an eco-friendly method to treat the effluents (Saravanan and Krishna, 2005). The present investigation is aimed to reduce organic load

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and removal of colour from the Rayon factory effluents. Therefore an attempt has been made to develop a new eco-friendly method/technique. This method developed in the laboratory was based on the principle of electro-chemistry. Therefore it was named as Kakatiya Electro Cluster (KEC) method.

MATERIALS AND METHODS

The present work carried out at AP Rayon's factory situated at Kamalapur, Warangal district. The sample (effluent) collected at the site where the effluents are being sent to the treatment plant (Al-Qodah, 2000). These samples were collected in one liter sample bottles and kept in the refrigerator for further studies.

Principle of the basic design

As already mentioned this method was initially designed at the laboratory to test the efficacy of the method and developed on the basis of Faraday laws.

Faraday Equation W = i t e / 96500 coulombs has been applied here to calculate removal of lignin present in the form of colour, power consumed in the process and reaction time.

Where as I = power T = time E = equivalent

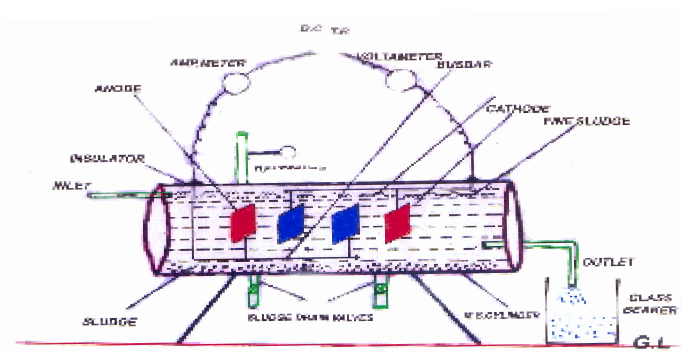
This principle narrates that when electricity is passed through a solution oxygen ions are liberated at Anode (+) and hydrogen ions are liberated at Cathode (–). After a certain period the high molecular weight compounds of the effluents (lignin) get converted into low molecular weight compounds would get them associated with existing hydrogen ions (H^+). The H^+ will be moved to the surface and thus the effluents get decolorized (Saravanan *et al.* 2005; Ramesh *et al*. 2005; Subhas Chandra Bhat *et al*. 2005; Weber and Chakravarthi, 1978; Renu Bala *et al*. 2003; Rajeev Jain *et al*. Pala and Torat, 2002; Bond, 1980; Albery, 1984; Allen and Larry, 1981; Silverstein, 1991). There is a need to apply this design to enable to adopt and use this technique at a large-scale by any industry which discharges considerably good amount of effluents. Therefore through the following mathematical derivatives this method can be applied to any industry that releases 22,000 gallons of effluents per day. The electrolytic cell developed in the present investigation is for the removal of lignin content from the effluents.

Basic Laboratory Design of the device

As MS pipe of 150-millimeter diameter and 400 millimeter of length had taken and formed as a reactor. In this reactor a Titanium plate of 2mm thickness and 6 x 6 inches width and length and an Iron plate of 2mm thickness and 6 x 6 inches width and length were arranged. There are a total of 2 Titanium and 2 Iron plates were arranged alternatively. These plates act as Electrodes and discharges electrons. Both the plates were connected to transformer rectifier, which supplies direct current to the plates. The reactor connected to the circuits that contain amp meter and voltmeter to measure the voltage of the effluents, which were there in the reactor. The reactor was fitted with 1 inches MS pipe at the upper region connected to the pressure gauge. The reactor was also fitted with 2 inches MS pipes at right and left side in which one was the inlet and another was outlet. However the inlet pipe was placed at the upper side of the reactor and the outlet pipe was at the lower side of the reactor. There are 2 inches MS pipes were fitted at the bottom of the reactor that act as drainpipes. The entire reactor was stood on a stand.

Trial Experiments

Several electrodes have been choosed and trials have been made in the combination of these electrodes considering them one as anode (+) and another one as cathode (–) and conducted trials to test the efficacy of the metal plates that have been used as anodes and



KAKATIYA ELECTRO- CLUSTER METHOD [LABORATORY DESIGN]

Table 1. Trial experiments made for colour removal with different combinations of electrodes and their specifications.

Trial experiments	I	II	III	IV	V	VI	VII	VII	IX	X
Sample Quantity	2	2	2	2	2	2	2	2	2	2
Name of selective electrodes	Al and Al	Ti and Al	Fe and Fe	Ti and Mild steel	Ti and Ti	Fe and Al	Zr and Fe	Zr and Al	Fe and Al	Cu and Fe
Number of selective electrodes	2+2	2+2	2+2	2+2	2+2	2+2	2+2	2+2	2+2	2+2
Size of selective electrodes	8.8″ * 8.8″	8.8″ * 8.8″	8.8″ * 8.8″	8.8″ * 8.8″	8.8″ * 8.8″	8.8″ * 8.8″	8.8″ * 8.8″	8.8″ * 8.8″	8.8″ * 8.8″	8.8″ * 8.8″
Time taken for reaction in a solution in minutes	15	8	15	5	3	5	7	8	18	15
Direct current consumption in amps	9	8	10	5	6	5	6	9	10	10
Electrolytic solution voltage in volts	12	11	12	11	12	11	12	11	12	12
Time taken for sludge setting in a reactor in minutes	15	15	20	15	10	10	15	18	25	20
Colour intensity (Before treatment) in Pt. Co.	1600	1800	2000	2800	2500	2000	1500	1200	1200	1400
Colour intensity (After treatment) in Pt. Co.	160	144	250	80	40	100	105	72	168	168

cathodes. The trials have been made by using both sacrificial electrodes as Iron, Aluminum, Stainless Steel, Copper and non sacrificial electrodes (I–X) were conducted by choosing different combination of metals however the cost effectiveness was also taken into consideration. The results obtained by the experiments run on pilot basis were presented in Tables 1. The following combinations of metal plates have been used as trials to understand the efficiency of the metals drawn in removal of the colour and the final conclusion, which are:
1. Aluminum & Aluminum; 2.Titanium & Aluminum; 3.Iron & Iron; 4.Titanium & Mild steel; 5.Titanium & Titanium; 6.Iron & Aluminum; 7.Zirconium & Iron; 8.Zirconium & Aluminum; 9.Iron & Aluminum; 10.Copper & Iron.

RESULTS AND DISCUSSION

Pulp and paper mill effluents are highly cloured mainly due to lignin and its derivatives as described by Goring (1971), Sankaran *et al*. (1971, Sunderan *et al*. 1981). The wood of various plant species consisting of lignin in indifferent quantities (Berchuland, 1957) lignin in wood is light yellow or cream colour, but owing to its reactivity and tendency to form chromophores configuration, it will easily impact objectionable colour to the pulp and in fact, a large part of the pulp processing deals with the colour reactions of lignin and the remove of lignin chromophores. Earlier several authors have made their efforts to remove various toxic substances from the pulp mill effluents. (Carpente, 1966; Parson *et al*. 1967; Rohan and Haas, 1971; Williard, 1973; Herald, 1975; Casey, 1978; Sedobolskil, 1979; Beatson *et al*. 1990; Pallerla and Chambers, 1997; Koyuncuel et al., 2000). Hamonda and Adams, (1989) Measured lignin degradation ranging from 17% to 53% in grass, hay and straw during 100 days of composting and Torrijos (2003) measured a 70% reduction in the lignin content of olive waste compost after 23 days under high moisture (65–83%) thermophilic conditions. Lignin degradation in alder pulp increased from 5.2–29.8% (Zhang, 2000).

In the present study the effluents were sent into the reactor through inlet pipe and when the reactor was filled with the effluents then the electrodes are charged with the direct current. We should allow to get reaction to occur for 5 minutes, after 5 minutes the uncoloured effluents starts flow out from the outlet pipe. The effluent has been collected to test further and also analyzed to understand the efficiency of the fabricated device in removal of the colour from the effluents and to draw further conclusions on the efficacy of the device. Table 1 shows the comparative account of energy utilization with time and percentage of colour removed in trial experiments I–X. It is observed that the optimum electrodes were Titanium and Mild steel for the effective colour removal in the effluent for which analytical data shows in experiment–IV (Table 1). Thus we selected Titanium and Mild steel as electrodes in KEC method.

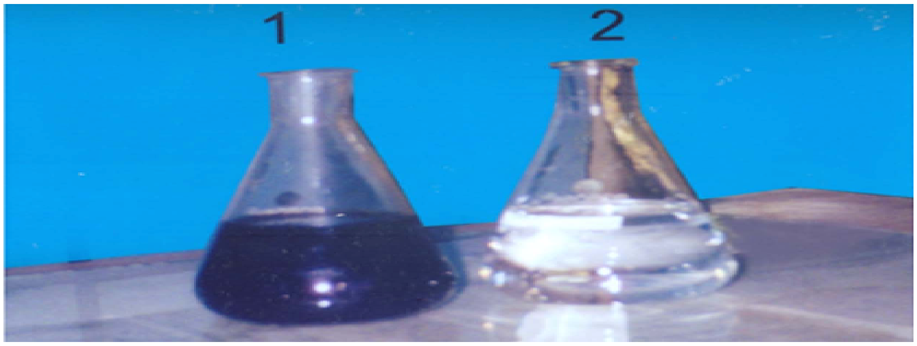
The reactions inside the reactor

It is assumed that there is several chemical reactions might have occurred to the effluents, which are there in the reactor, after passing the current. The chloro-lignin present in the effluents is split into chloride ions and lignin ions. Similarly, water molecules of the effluents are split into hydrogen ions (H^+) and hydroxyl ions (OH^-). And Sodium Chloride is split into Chloride ions (Cl^-) and Sodium ions (Na^+), Sodium Sulphate is spilt into Sulphate ions and Sodium ions, similarly Calcium Chloride and Calcium Sulphate. The chloride ions combine to form chlorine and the hydrogen ions combine to form hydrogen gas (Saravanan and Sreekrishnan, 2005; Goring, 1971; Sankaran *et al*. 1971; Sundman *et al*. 1981; Paice and Jurzek, 1984; Bajpai and Bajpai, 1984; Clarck *et al*. 1994; Diez *et al*. 1999; Gorg *et al*. 2004 ;Arunima *et al*. 2005). The sodium ions and hydroxide ions combine to form sodium hydroxide. In the same way, hydrochloric acid is formed. All salts settled at bottom of the proto type reactor and organic substances like lignin floats at the surface of the effluents as a fine sludge due to low density where the hydrogen gas called as carrier gas.

Table 2. Quality of effluents treated with Kakatiya Electro Cluster Method

Parameters (in ppm)	Before treatment	After KEC treatment	A.P.P.C.B (standards recom mended)
Colour (Pt.Co)	2100±50	63±2	350±10
COD	850±10	15±2	350±2
BOD	250±10	NIL	30±2
TDS	2200±10	100±5	2100±5
TSS	200±5	2±0.05	100±2
TS	2400±10	102±5	2200±10

By this method we could reduce the colour content due to lignin of the effluents as well as we can improve water quality. The reduction of Colour, COD, BOD, TDS, TSS, TS values of the effluents are indicates the efficiency of the KEC treatment. The operating variables were highly decreased after KEC treatment, in that the colour of effluents was highly decreased from 2100±50 to 63±2, this indicates that the lignin content is highly reduced in the KEC treated effluents. COD value also decreased from 850±10 to 15±2 and the BOD content in the effluents fall down to zero level. In the same way TDS, TSS, TS values were also completely reduced. All these parameters were noticed lower than APPCB prescribed standard values this shows the potentiality of KEC method



(1- Non-treated effluent; 2-treated effluent with KEC method)

which is very eco-friendly and most economical for the treatment of pulp and paper mill effluents.

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