REMOVAL OF WOOL DYES FROM INDUSTRIAL WASTEWATER BY REVERSE OSMOSIS PROCESS

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ABSTRACT

The influence of feed PH in the range of 2-10, feed temperature in the range of 10- 40 °C and the working pressure in the range of 2-6 bar on the performance of reverse osmosis in removal the wool dyes from industrial waste water with polyamide spiral- wound membrane type TFC- 8822 HR were investigated..

Reverse osmosis experiments were carried out under controlled operating parameters using dye (Lanacron Red-SG) - water system as feed.

The experimental results show that the percentage productivity of reverse osmosis unit increases as (a) the working pressure is increasing for various feed pH and feed temperatures (b) the values of feed pH goes from acidic side towards alkaline side for various working pressures and feed temperatures (c) the feed temperature increases for various working pressure and feed pH. The results show also that the permeability of dye- water system decreases as the working pressure is increasing and also that the percentage increase in productivity decreases as working pressure is increasing and having a minimum value at pH around 5.

INTRODUCTION

In the last decade, government and industry have become increasingly aware on the need of clean up industrial and reduce river pollution.

The standards for quality of wastewater effluent are gradually becoming more rigid and methods of treatment are continuously being investigated and developed. Several methods have been used to treat a dilute wastewater. These include biological treatment, stripping and carbon adsorption [1, 2]. Ozonation has also been found to be effective in oxidizing some hazardous organics[3, 4] to less toxic compounds. Membrane processes can be used to purify wastewater and produce a 20 to 50 fold decrease in waste volumes that must be treated with other processes and therefore greatly reducing energy cost.

Many dyes used in the textile industries are difficult to remove by conventional waste treatment methods. Since they are stable to light, oxidizing agent and are resistance to aerobic digestion. With such kind of problems membrane technology has been made. Signification progress is in its application as an on-line process technique to concentrate or separate product with no need for additives or chemicals, on the other hand the addition of chemicals may cause serious environmental problems[5].

The development of low pressure reverses osmosis (RO) membranes such as aromatic polyamide and sulfonated polysulfone have resulted in membrane processes which give high water flux at low pressure (<2 MPa).

The low pressure membrane can provide simultaneous separation of hazardous organics and inorganics. Selective separation of ionizable compounds is also possible with membrane containing charged groups [6, 7]. Using the updated low- pressure reverse osmosis membrane such as TFC is a suitable method to recycle more than 95% of treated water to return back to the houses ideal for dyeing [5].

The separation by membrane technique represents an extension of simple filtration which retains particles with a diameter of more than a few microns, as in the case of in depth filtration through sand. The basic types of filtration are:

- Microfiltration, which retains particles with diameter over10 microns, e.g., filtration through membranes of millipore, sartorius and similar types.

- Ultrafiltration, which retains molecules with a molar of more than 10000 to 4000000 g/mol depending on the membrane type.
- Reverse osmosis, also Known as hyperfiltretion which retains ions and molecules with a molar mass more than 50 to 10000.

EXPERIMENTAL WORK

Characteristic of Feed

Water with the same characteristics of waste from the wool dye houses was used as feed to the reverse osmosis unit, which contains about 10 p.p.m of dye. The concentration of dye in water was evaluated using UV- spectrophotometer.

Experimental procedure

Feed preparation. Concentrated solution contains 30g of solid powder dye was prepared by dissolving the dye in one liter water in a conical flask, then the solution was heated to 40 °C so as to accomplish the solubility of dye in water. The tank was filled with water and the solution was added gradually and mixed with water so as to get a homogeneous feed with concentration equivalent to 10 p.p.m.

Procedure for Reverse Osmosis Unit . The pH of the feed was measured using pH hand- held meter which was adjusted by adding a quantity of 9.96 N NaOH or 9.46 N HCl depending on the value of pH decided. The feed was heated and the temperature controlled at a certain value, then the feed solution was pumped through the module at a certain pressure. The product of the module is two streams, product stream and rejected stream. The later was kept constant at 1200 lit/ hr by adjusting the valve opening. While measuring the flow rate of product stream, samples were taken from the rejected stream for measuring the concentration of the dye. Before sampling the equipment was letting to operate at least 15 min to ensure that the hole pipes and membrane filled with a new feed.

The above procedure was repeated for different values of pressures, pH, and temperatures.

RESULTS AND DISCUSSION

Effect of Working Pressure

Effect of Working Pressure on Percentage Productivity. Figures (1) and (2) show the effect of working pressure on percentage productivity at different pH values of feed solution and temperatures respectively.

These figures indicate that as the working pressure increased. The percentage productivity increased. This effect is understandable on the basis of membrane for fluid flow varies with pressure such that it is small at low pressure and increases along with pressure [8].

Effect of Working Pressure on Pure Water Permeability Constant. The pure water permeability constant (Aw), which was calculated by equation (Aw =Pw/Lm) (9) is a fundamental quantity. It is a measure of the overall porosity of the film, it corresponds to condition of zero concentration polarization, and it is independent of any solute under consideration. (8)

Figure (3) shows the effect of working pressure on the pure water permeability constant. As the working pressure increases, the permeability constant decreases. This is enhanced the conclusion that the resistance of membrane varies with increasing pressure.

Effect of working pressure on percentage increase in productivity. Figure (4) shows the effect of working pressure on percentage increase in productivity at constant PH and different temperatures.

The figure indicates that the percentage increase in productivity is decreased with increasing pressure and become nearly constant at high pressures.

Figure (5) shows the effect of working pressure on percentage increase in productivity at constant temperature and different pH values.

The figure indicates that the percentage increase in productivity is decreased with increasing pressure until pressure value of 5 bar after which the percentage is increased with pressure. That means there is an interaction between the effect of pressure and pH on the percentage increase in productivity.

Effect of pH

Effect of pH on Percentage Productivity. Figures (6) and (7) show the percentage productivity change with pH at different working pressures and feed temperatures respectively. These figures indicate that the percentage productivity increase as the pH values goes from the acidic side towards the alkaline side and vice versa. This behavior is due to that the membrane seemed to shrink more at lower pH values (i.e. the pores being small in size which lead to reduce the productivity) [8].

Effect of pH on Percentage Flux Drop. The percentage flux drop at particular pressure and temperature can be defined as [10]:

$$\%\text{Flux Drop} = \frac{\text{Distilled water flux} - \text{flux with wastewater}}{\text{distilled water flux}} \times 100$$

Figure (8) shows the effect of pH on percentage flux drop. According to this figure, the % flux drop decreases as the pH value increase, that is because, at high values of pH the flux drop decreases as the pH value increase, that is because, at high values of pH the flux with wastewater is increased.

Effect of pH on Concentration of Dye in Rejected Stream. Figure (9) shows the effect of pH on concentration of dye in rejected stream. The figure indicates that as the pH value increases, the concentration of dye in the rejected stream increases. This is due to high performance of module at high values of pH (8).

Effect of Temperature on Percentage Productivity

Figures (10) and (11) show the effect of feed temperature on percentage productivity at different pressures and pH values of feed solution respectively.

According to these figures, the percentage productivity increased with increasing operating temperature. A change in operating temperature changes (i) the densities and viscosities of the feed solution and preferentially sorbed pure water, (ii) the preferential sorption characteristics of the membrane. An increase of temperature increases the osmotic pressure of feed solution, resulting in a decrease in the effective pressure of feed solution, resulting in a decrease in the effective pressure (i.e. operating pressure minus the osmotic pressure) and therefore a decrease in percentage productivity. But changes of (i) and (iii) have greater effected in increasing percentage productivity (8).

Effect of Percentage Recovery on the Concentration of Dye in Rejected Stream

Figure (12) shows the effect of percentage recovery on the concentration of dye in rejected steam at 20 °C, 3 bar and pH =6.

It was found that the concentration of dye decrease with increasing the recovery. That is mean, when increasing the flow rate through the pores of module, the dye is accumulated on the surface of the membrane which cause after long time of operation a fouling inside the pores of membrane. The result is in agreement with the finding of previous work (10).

Effect of Time on Productivity

The productivity of reverse osmosis unit is plotted vs. time as shown in Figure (13). It can be easily observed that the flow rate from reverse osmosis unit decrease with increase in operating time.

The productivity of reverse osmosis unit decrease as fouling occurs, because the foulants on the membrane surface retard the back diffusion of the solute (dye) into the bulk solution which cause concentration polarization at membrane surface. The increase in concentration polarization causes a decrease in productivity with increase operating time.

CONCLUSIONS

The following conclusions could be drawn from the current investigation:

1. The three variables of operating conditions; working pressure, feed pH and feed temperature effect the percentage productivity in the order: Working pressure > pH > feed temperature
2. The percentage productivity is increased by increasing working pressure, while the concentration of the dye in the rejected stream is increased as the value of feed pH increased.
3. The percentage productivity increases when the pH values goes from acidic side towards the alkaline side.
4. The reverse osmosis reducing the concentration of the dye in the water, in the same time it reduces the salt concentration in the product.

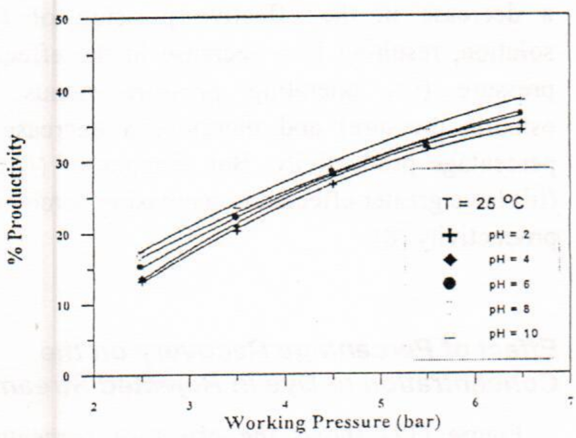

Fig. (1) Percentage productivity vs. working pressure at different pH

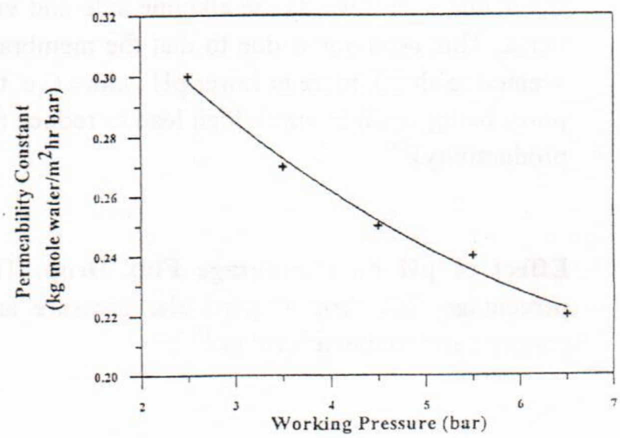

Fig. (3) Permeability constant vs. working pressure at T=25°C

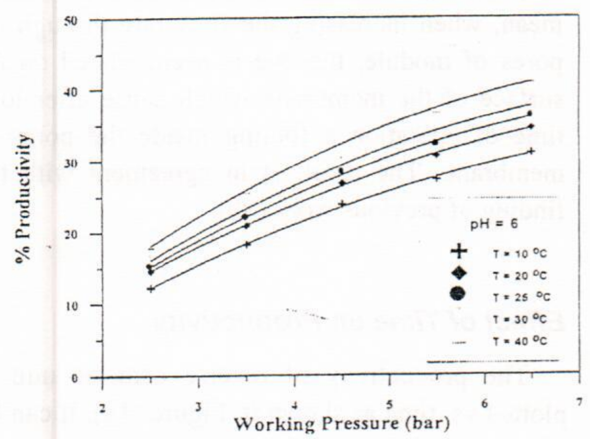

Fig. (2) Percentage productivity vs. working pressure at different temperature

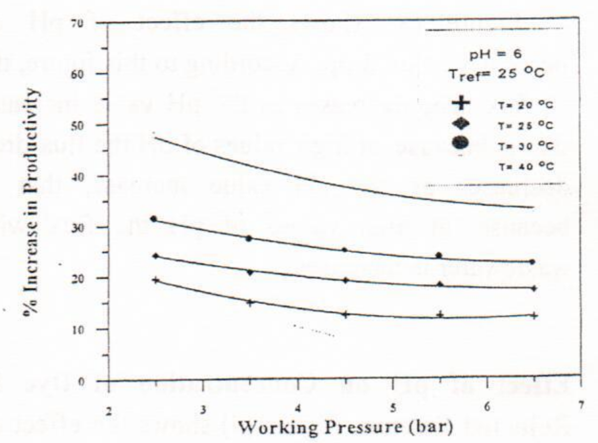

Fig. (4) Percent increase in productivity vs. working pressure at different temperature

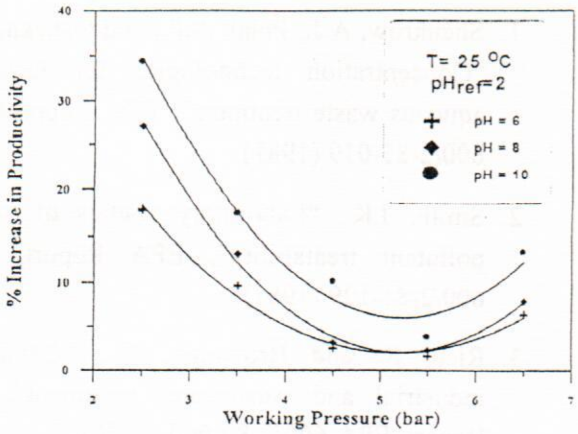

Fig. (5) Percent increase in productivity vs. working pressure at different pH

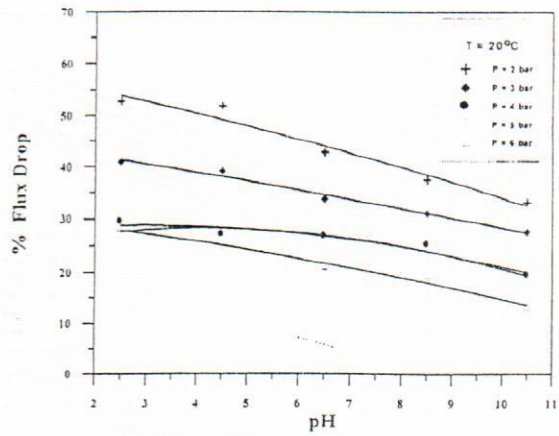

Fig. (8) Percentage flux drop vs. pH at different pressure

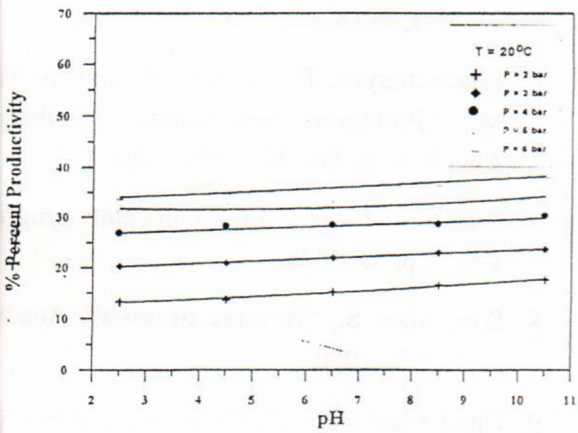

Fig. (6) Percentage productivity vs. pH at different pressure

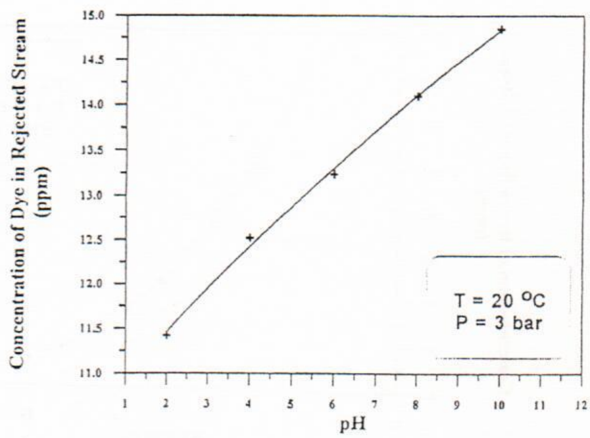

Fig. (9) Concentration of dye in rejected stream vs. pH at T=20°C

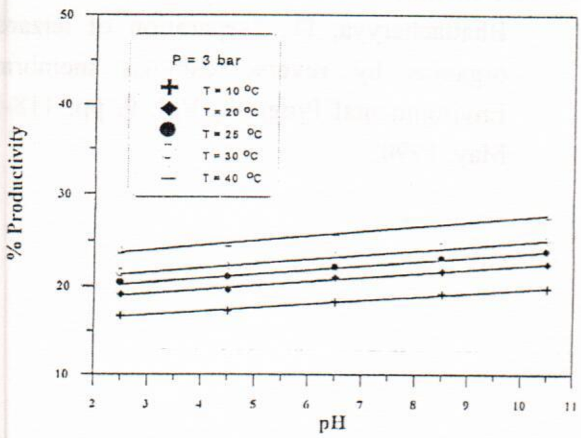

Fig. (7) Percentage productivity vs. pH at different temperatures

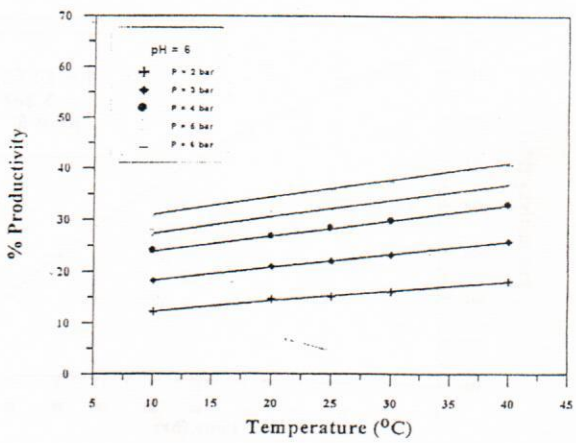

Fig. (10) Percentage productivity vs. temperature at different pressure

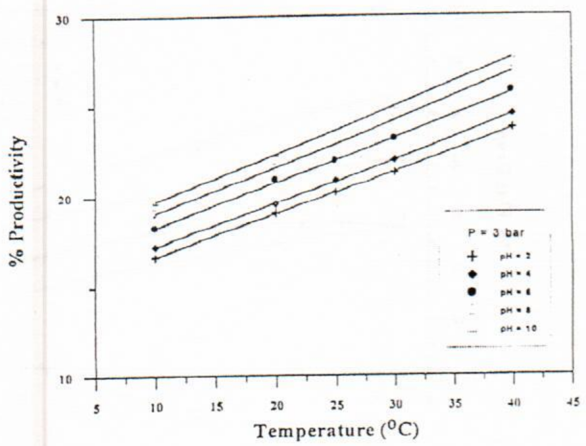

Fig. (11) Percentage productivity vs. temperature at different pH

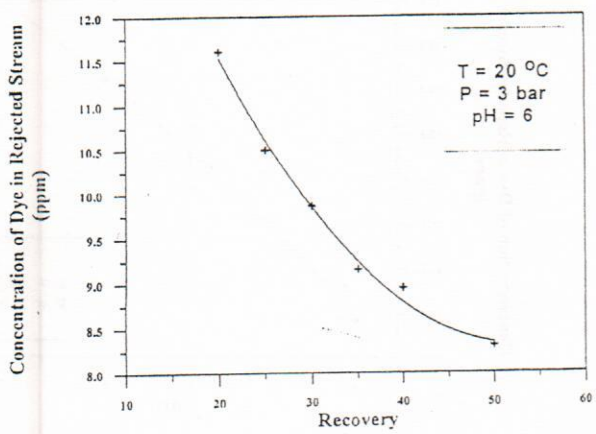

Fig. (12) Concentration of dye in rejected stream vs. recovery at T=20°C

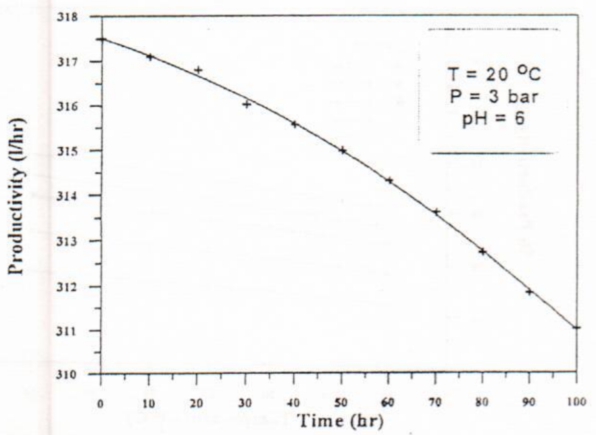

Fig. (13) Productivity vs. time at T=25°C

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