OPTIMIZATION OF ZLD IN DISTILLERY INDUSTRY BY REVERSE OSMOSIS PROCESS FOR PREDICTION OF MULTI RESPONSES BY TAGUCHI ORTHOGONAL ARRAY

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Abstract: In this study, the effects of Operating Pressure, Potential Hydrogen, Oxidation Reduction Potential and Anti Scaling Agent on multi responses like Permeate, COD, Total Solids, Conductivity and Hardness in the Reverse Osmosis Process were experimentally investigated on RO 8100 PHARM ST8 PT44 400Wl machine. The settings of RO parameters were determined by using Taguchi's experimental design method. Orthogonal arrays of Taguchi, the signal-to-noise (S/N) ratio, the analysis of variance (ANOVA) are employed to find the optimal levels and to analyze the effect of the RO parameters. Results show that potential of hydrogen, operating pressure, oxidation reduction potential and anti scaling agent are the four Parameters that influence the Permit more effectively and COD, Total Solids, Conductivity and Hardness respectively. Finally, the ranges for best RO conditions are proposed for ZLD process.

Keyword :ANOVA, reverse osmosis parameters, design of experiment, multi response, orthogonal array, Taguchi method.

INTRODUCTION

One of the most important environmental problems faced by the world is the pollution that is mostly generated by industries. India is the most sugar producing country in world in recent time and integrated with distilleries and distillery waste have hazardous effects. Molasses based distilleries are classified as a 'Red' category Industry by the Central Pollution Control Board. With the amount of highly polluting, spent wash being generated at 10 to 15 times the volume of spirit produced, it is an area of major environmental concern. A recent report suggests that there are 325 molasses based distilleries in the country producing 3063 million litres/year (M.Ltr/year) of alcohol and generating 45945 M.Ltr/year of spent wash as waste annually. A Spent wash goes through different phases like pretreatment in digester then lagooning for settling of solids and then major process of reverse osmosis separating clean water from effluent and make the spent wash concentrate for agriculture Biocomposting and clean water again used in industry. In this paper the RO processes parameters are complete study and how to improve the clean water call permeate with quality in that again used in industry and study. The RO Parameters are pressure ph, ORP and anti scaling which more affect the process of RO by Taguchi Array set of representation in done so that effective utilization in resources to get the maximum quality output.

Literature review

Lingyung Hung et.al [1] this paper states that objective of this study is to remove salt from high salinity wastewater and recycle a purified stream using an RO process. It was found that high operating pressure and temperature were beneficial for wastewater treatment using the RO process. R Gunther et al [2] states that the paper some aspect of engineering plant designs and economics of high pressure reverse osmosis system will be discussed. S. Velikova ET. Al. [3] The effects of operating pressure and feed concentration on the solutetransport parameter (D,,/KS) and mass transfer coefficient (k) with respect to aqueous sodium chloride solutions for different cellulose acetate membranes have been studied. PayelSarkar ET. Al. [4] Small scale brackish water desalination units are used in remote areas and their sustenance depend on the twin factors of consistency of product water quality and availability of raw water resources. Jongs up Hong eP. Al. [5] Pressurized oxy-fuel combustion power cycles have been investigated as alternatives. In this paper, as the extended work of our previous study, we perform a pressure sensitivity analysis to determine the optimal combustor operating pressure for the pressurized oxy-fuel combustion powercycle. R.Rauntenbach ET. Al. [6] this Paper discussed a simpler and more-energy efficient process the combination of RO, operating at 16, 120 and 200 bar, with nano filtration ad crystallizer/filtration. JolantaBohdziewicz ET. Al. [7] this paper review an attempt at removal of nitrate ions from tap water by means of the compound reverse osmosis process and nono filtration. In the first stage water was filtered from Nano filtration membranes which resultant in the absence of bivalent ions in the obtained permeates. Vidyadhar V. Gedam ET. Al. [8]

this paper examines the influence of different operating parameterssuch as pressure, temperature, pH on the performance of polyamide reverse osmosis membrane. Thus, proper control of these factors is essential for successful operation and maintenance. B. A. WINFIELDet. Al. [9] states that Investigations have been made into techniques of removing sewage fouling from cellulose acetate membranes using a pilot scale reverse osmosis unit. It has been found that reductions in the pH of solutions surrounding the membrane when not pressurized are effective in loosening the fouling: Hoang ET. Al. [10] states that conversely, calcium rejection improves in the presence of even small quantities of alginate foulant at all pH values. The concentration of foulant, the feed pH and the presence of calcium are all shown to impact upon this performance.

Pham ThanhHaiet. Al.[11]This project aims to investigate the effect of pH in order to improve the efficiency of the RO desalination process. Based on the primary knowledge, decreasing the pH of the solution to a certain extent can create several improvements to both the plant and the product. Bogdan C. Donoseet. Al.[12]In this study, three types of commercially available RO membranes were statically exposed to hypochlorite solutions and analyzed by Fourier transform infrared spectroscopy (FTIR), Scanning Electron Microscopy (SEM) and Atomic Force Microscopy(AFM) in conjunction with performance tests.) Hiroaki Ozaki et. Al.[13] states that the investigation was conducted for synthetic wastewater and wastewater from the heavy metal industry. L. Y. Dudley ET. Al. [14] this paper highlights how the selection of appropriate proprietary chemicals and their use in conjunction with good pre-treatment design can ensure cost-effective and efficient operation. YuelianPeng ET. Al. [15] In this work, effects of four anti-scaling and five cleaning agents on calcium sulfate scaling in direct contact membrane.

Taguchi based Design of experiments:

Among the available methods, Taguchi design is one of the most powerful DOE methods for analyzing of experiments. It is widely recognized in many fields particularly in the development of new products and processes in quality control. The salient features of the method are as follows: a. a simple, efficient and systematic method to optimize product/process to improve the performance or reduce the cost. b. Help arrive at the best parameters for the optimal conditions with the least number of analytical investigations. c. It is a scientifically disciplined mechanism for evaluating and implementing improvements in products, processes, materials, equipment's and facilities. d. Can include the noise factor and make the design robust. e. Therefore, the Taguchi method has great potential in the area of low cost experimentation. Thus it becomes an attractive and widely accepted tool to engineers and scientists. [20] Sharda R. Nayse ET. Al. The machining processes generate a wide variety of surface textures. Surface texture consists of the repetitive and random deviations from the ideal smooth surface. These deviations areRoughness: small, finely spaced surface irregularities (micro irregularities) Waviness: surface irregularities of greater spacing (macro irregularities) lay: predominant direction of surface texture [21]AnilIdriset. Al. states that cellulose acetate hollow fiber membranes for reverse osmosis (RO) were spun using a forced convection technique. Inthis study, a systematic experimental design based on Taguchi's method (which is a fractional factorial method) has beenemployed for discussing the relationship between the rejection rate coefficient, permeation rate and the dry–wet spinningconditions for making cellulose acetate hollow fibers for RO. The factors considered in the experimental design includedthe polymer contents (PCs), the ratio of the solvent (acetone) to swelling agents (form amide) in the dope solution, the dopeextrusion rate (DER), the type of bore fluid (BF), the residence time (RT) and the nitrogen gas flushing rate (GR). The resultsindicate that the BF and the DER are the two most important factors in determining the performance of the RO membranes. [22] SoumayaYacout ET. Al. Quality control, quality assurance and total quality management are all concerned with managing and controlling variations. The less variation a system has the better quality it provides. Using the Taylor Expansion Series, Dr. Taguchi (1986) developed a mathematical model in which loss is a quadratic function of the deviation of the quality of interest from its target value.

Experimentation

The experiment was performed on **RO 8100 PHARM ST8 PT44400W** machine. The experimental set figure 6.2 consist of list of attachment and steps of different quality sensors, sense the parameter like temperature, ph, ORP, Conductivity of the feed. Some of them can be control through the different attachment given to the system such as HCL feed pump with HCL tank provide the level of ph control. Sodium Meta Bisulfate (SMBS) tank with pump that it can control ORP level of the feed antiscalant tank and pump control the scaling and fouling as per the need of the feed given. The temperature is noise factor can't be control its total depend on the environmental factor but for experimentation a small lagoon is made so that the define degree can be achieved. The four parameter and noise factor have different setting and adjustment such as Ph-HCL adding, ORP- SMBS adding, Anti Scalant- ROHIB adding and Operating Pressure- By HP pump adjustment by control this four factor over year and with whether support the experimentation are conducted. The sensors are well calibrated with six month duration. After the different setting given by taguchi array experimentation are conducted and water sample as permeate is taken to ORIPAL Lab pvt.Ltd. For COD, Conductivity, Total Solids and Hardness by a procedure manual with calibrated equipment and the result are taken out. The results are feed to MINITAB software to get the interaction and result.

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Figure:RO Process

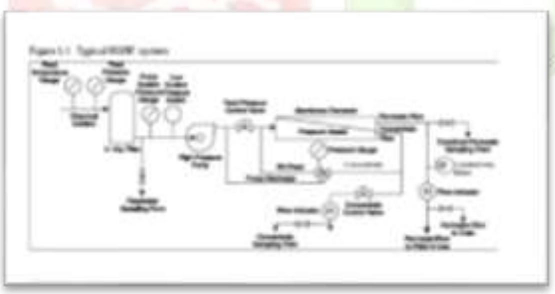

Fig :Control Panel

Experimental Data Analysis

Minitab 14 software was used as it provides an effortless method to create, edit and update graphs. Also it provides a dynamic link between a graph and its worksheet that helps in updating the graph automatically whenever the data is changed. Its appearance and easy to use enhancements further add to its advantages. Data analysis has been carried out by the procedural hierarchy as shown below.

1. Computation of (Signal-to-Noise Ratio) S/N ratio of experimental data. For calculating S/N ratio of Permeate, Total Solids, Conductivity and hardness, formula of S/N ratio has been selected from equation 1,2&3 according to the objective of optimization.

Source	DF	SS Adj	SS Adj	MS	F	% contribution
OP	2	79.72387	79.7238743	39.861937	195.2102	24%
PH	2	199.4341	199.43419	99.717094	488.3305	62%
ORP	2	17.45676	17.4567687	8.7283843	42.74429	054%
ASA	2	11.81435	11.814356	5.9071779	28.92839	036%
OP+PH	4	9.386	9.386	2.3464	11.49	22%
OP+ORP	4	0.735	0.735	0.1837	0.90	25%
OP+ASA	4	0.627	0.627	0.1568	0.77	15%
Residual Error	6	1.225	1.225	0.2042		
Total	26	319.68				

2. ANOVA is carried out to find out the contribution of each parameter on the reverse osmosis process.

3. The predicted optimal setting has been evaluated from Mean Response.

4. Finally optimal setting has been verified by confirmatory test.

Taguchi Analysis (Signal to Noise ratio): The Mean S/N Ratio is used to find out Optimal Level for Each Parameter and Rank of the parameter. The Rank of the parameter shows that which parameter is most effective. The mean S/N ratio for each factor at levels 1, 2, 3and 4 can be calculated by averaging the S/N ratios for the experiments. Fig. 6.1, Fig. 6.3, fig. 6.5 shows the S/N response graph for Permeate, COD, Total Solids, Conductivity and Hardness and respectively.

Level	OP	PH	ORP	ASA
1	40.69	40.23	43.99	41.98
2	43.10	46.62	46.62	43.18
3	44.88	41.82	42.11	43.51
Delta	4.19	6.39	1.88	1.53
Rank	2	1	3	4

Table: Response Table for Signal to Noise Ratios (Permeate) Higher is better

Analysis of variance (ANOVA)

The main aim of ANOVA is to investigate the design parameters and to indicate which parameters are significantly affecting the output performance characteristics. In the analysis, the sum of squares and variance are calculated. F-test value at 95 % confidence level is used to decide the significant factors affecting the process and percentage contribution is calculated.

Table: Analysis Of Variance For (Permeate) Higher is better

Results and Discussion

For Permeatethe objective is to maximize it, therefore for calculating the S/N ratio larger the better S/N ratio is used and S/N ratio is calculated for each experiment and mean of S/N ratio is also calculated for each parameter. The mean of S/N ratio is calculated to find the rank of parameter and rank of parameter shows that which parameter is most effective to the reverse osmosis process. From the mean S/N ratio at each level, maximum S/N ratio is selected which indicates the optimal level for that parameter. For potential of hydrogen (PH) the maximum S/N ratio is 62% at B2 .This indicates the optimal level for PH. Similarly for OP, ORP and anti agent the minimum S/N ratio is at A3, C1, and D3. Therefore, optimal parameter for maximum permeate is at level (A3B2C1D3) shown in fig. 7.1 i.e. Operating Pressure = 24%, potential of hydrogen = 62%, Oxidation reduction potential; = 054%, Anti Agent = 036%.

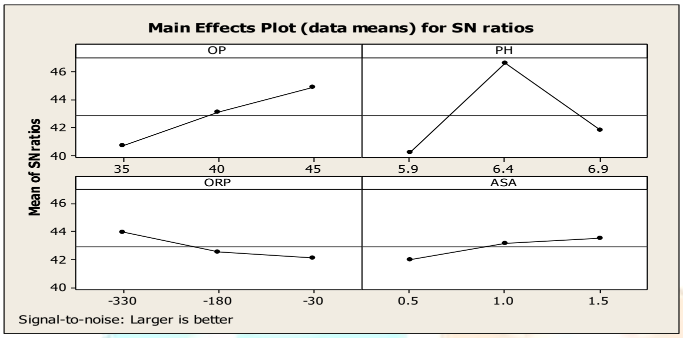

Figure: Main effect plot for Permeate

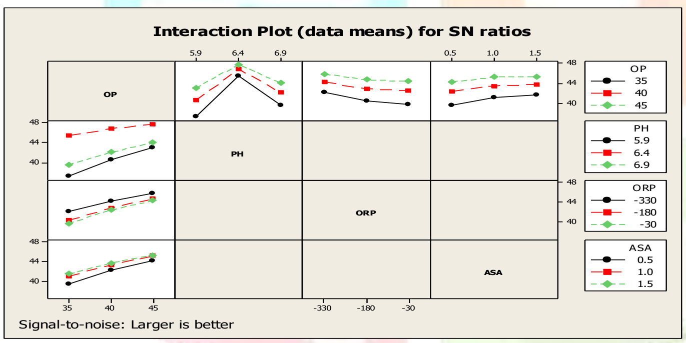

Figure: Main effect plot for Permeate

Conclusion

The following are conclusions drawn based on the tests conducted on reverse osmosis process.

I] For Permeate:-

1) From the ANOVA, Table 7.4 and the P value, the nose radius is the most significant factor which contributes to the permeate i.e. 52% contributed by the PH on Permeate

2) The second factor which contributes to permeate is the Operating pressure (OP) having 24%.

3) The third factor which contributes to Permeate is the ORP having 054%. 4) The Fourth factor which contributes to Permeate is the Anti Agent (ASA) having 036%

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