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A STUDY ON SIMULATION AND CONTROL OF PAC DOSING PROCESS IN WATER PURIFICATION SYSTEM

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Abstracts In this paper, it is concerned to develop control method using jar-test results in order to predict the optimum dosage of coagulant, PAC(PoliAluminum Chloride). Considering the relations with the reaction of coagulation and flocculation, the five independent variables(e,g, turbidity of raw water, water turbidity in flocculators, temperature, pH, and alkalynity) are selected out of parameters and they are put into calculation to develop a neural network model for PAC dosing process in water purification system. This model is utilized to predict optimum dosage of PAC. That is, the optimum dosage of PAC is searched in neural network model for PAC dosing process to minimize the water turbidity in flocculators.

This searching is implemented by means of expert heuristics.

The efficacy of the proposed control scheme and feasibility of acquired neural network model for PAC dosing control in water purification system is evaluated by means of computer simulation.

Keywords PAC(PoliAluminum Chloride), Neural network, Coagulation, Flocculation

1. INTRODUCTION

Relatively rapid and frequent changes in the raw water quality of eutrophic lakes and rivers require an appropriate readjustment of exiting flocculation conditions. However prompt action cannot be taken, if the required flocculant dosage is to be determined in lengthy laboratory jar test. Moreover there is often no laboratory staff available to carry out such test. In such situations, efficient flocculation processes are necessary which also provide for the control of the flocculant dosage. The present paper is aimed to predict optimum dosage of coaglant without lengthy laboratory jar test.

In plant operations, where decision-making is mainly done by experienced plant operators, introduction of the knowledge base system is considered to be effective, because it puts operators' heuristics to practical use on computer. On the other hand, an artficial neural network system is also effective, because it can support plant operation according to actual results using historical data of plants.

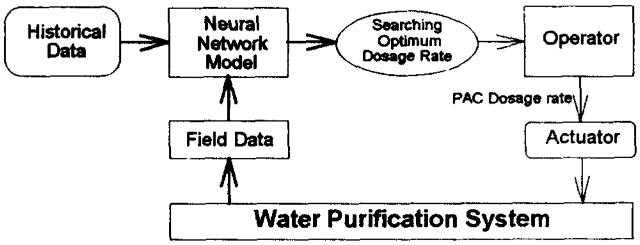

Fig 1. The scheme of propoed control informations extraction method

In this paper, we propose control informations extraction method from the neural network which is used to make the model of PAC dosing process in water purification systems and provides function for learning the relations between operational and influential factors from plant historical data trends and then reflecting them onto plant operations, like human operators do.

The learned neural network includes knowledge regarding how to operate plants. Therefore the knowledge is represented in qualatative form. And the knowledge are simulated and are put into operators to control of PAC dosing process in water purification systems. The figure 1 show the scheme of propoed control informations extraction method.

2. THE PAC DOSING PROCESS IN WATER PURIFICATION SYSTEM

The PAC dosing process in water purification plant is to make raw water be purified by eliminating and filtering the muddy meterial of raw water. To do this, we dose the PAC which coagulates and flocculates the muddy meterial. This process is shown in figure 2. As you can see in figure 2, Alcali and Cl are dosed in addition to PAC. But they are dosed to control the pH of raw water and to sterilize.

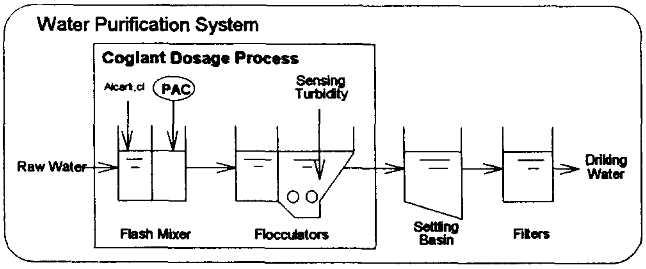

Fig 2. The PAC dosing Process in Water Purification System

The characteristics of water purification process control are as follows.

1. The ingredients of raw water vary with seasons and with water resources.
2. The PAC reaction process is related to water temperature and alcalinity in addition to turbidity, and of which the relations are not known well.
3. This process has long retention time and has no no feedback signal.
4. The failure of control is not allowable, because the output of this system is drinking water.

Conventially, PAC dosing rates are calculated by multi-regression method or jsr-test method. Multi-regression model is not effective to describe process in sudden water quality changes. And the jar-test method has a long time to determine optimum PAC dosing rates. So we need to new method to control PAC dosing rates. The proposed new method use neural network which has effective to describes nonlinear system.

3. NEURAL NETWORK FOR MODELING OF PAC DOSING PROCESS

The neural network is applied to learning the operation history of a water purification plant. Two neural networks for normal and abnormal conditions are provided because the operator's actions under normal conditions are different from those during abnormalities, like when the rain fall occures. Each neural network has five input neurons, twelve hidden neurons and one output. The five independent variables(e,g, turbidity of raw water, temperature, pH, alkalynity, and PAC dosing rate) are selected out as input neurons. The turbidity of water in flocculators is used as output neuron. And they are put into calculation to develope a neural network model for PAC dosing process in water purification system. The figure 3. shows neural network model for PAC dosing process in water purification system.

The index of selection normal and abnormal conditions is the turbidity of raw water. If the turbidity of raw water is more over 50, then this condition is abnormal. Otherwise it is normal.

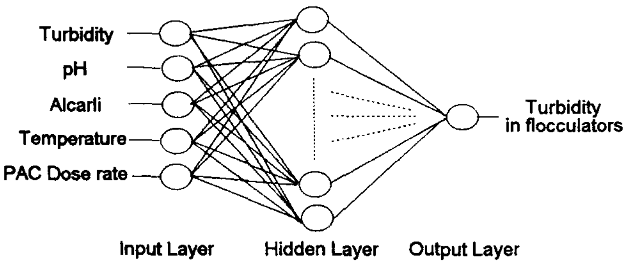

Fig 3. Neural network model for PAC dosing process in water purification system

4. LEARNING AND SEARCHING

OPTIMUM PAC DOSING RATES

Relatively frequent changes in the raw water quality of rivers require an appropriate readjustment of exiting flocculation conditions. But conventionally multi-regression method and jar-test method cannot readjust present flocculation conditions according to water quality's changes. The neural network model can learn exiting flocculation conditions, so that copes with system states variances. The back propagation algorithm which proposed Rumelhart et al. are used. The learning algorithm is as following.

[Output layer]

$$\Delta w_{3k,2j} = \frac{\partial E_{e,3k}}{\partial W_{3k,2j}} \quad (1)$$

$$E_{e,3k} = \frac{1}{2} = (Y_{3k} - Y_{t,3k})^2 \quad (2)$$

where, $\Delta W_{3k,2j}$: the change of $\Delta W_{3k,2j}$;

$W_{3k,2j}$: weights between the k-th hidden and j-th output neurons;

Y_{3k} : value of the k-th output neuron;

$Y_{t,3k}$: training signal of the Y_{3k};

[Hidden layer]

Weights between the input and hidden layer, $W_{2j,1i}$ are changed by

$$\Delta W_{2j,1i} = \frac{\partial \sum_k E_{e,3k}}{\partial W_{2j,1i}} \quad (3)$$

The optimum PAC dosing rates are searched from learned neural network by means of output trend in the ranges of feasible dosing rates. In the extraction of PAC dosing rates from learned neural network, the floating point value of dosing rates is trival. So the values of PAC dosing rates for output trend is integer.

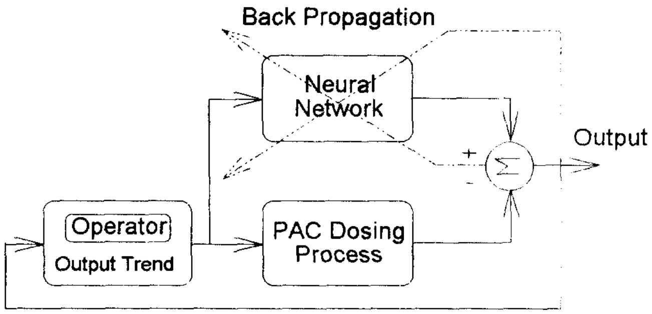

Fig 4. Overall scheme of the process learning and searching optimum dosing rates

By trending outputs, we can find optimum PAC dosing rates from neural network which can minimize the turbidity of water in flocculators. This rates are put into operators to readjust exiting flocculation conditions. This is guidence role for operatings.

Figure 4. shows overall scheme of the process learning and searching optimum dosing rates.

5. SIMULATION AND RESULTS

5.1 Traning Data

The training data of coaglant dosage in a water purification plant during one year were used. Table 1. shows data item and the range of values.

Table 1. Data item and the range of values

Data	Range
Turbididty	4.0 - 230
Alcarli	15 - 230
pH	6.0 - 8.0
Temperature	0 - 25
PAC dosing rate	10 - 50

Respective typical one-day data during one year were selected for two networks(normal and abnormal). The data of different operation histories for each day were learned by the proposed algorithm in the two networks. The neural networks, in which the learning was finished, were used for associations to predict the coaglant dosage for unknown conditions during one year.

5.2 SIMULATION RESULTS

The average values of the errors between actual and associated dosages are shown in table 2 in which values obtained with multi-regression analysis are also shown for the comparison. In table 2, errors obtained theses methods are almost the same values. Therefore learned neural networks are sufficient for association, while multi-regression analysis cannot cope with abnormal conditions.

Table 2 Comparision of errors represented in root-mean-square

METHOD		ERRORS
Neural Network	Normal	0.21
	Abnormal	0.83
Multi-regression model		5.91

The figure 5 shows the seaching of optmum coaglant dosage rates to minimize turbidity of water in flocculators.

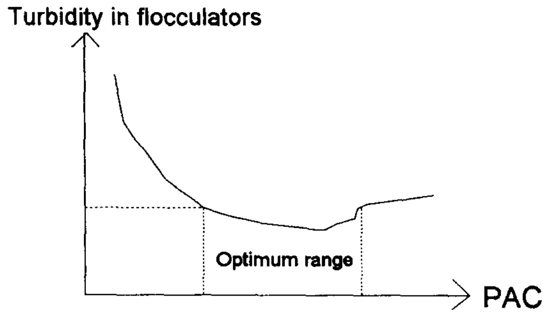

Fig. 5 Seaching of optmum coaglant dosage rates to minimize turbidity of water in flocculators

Results obtained here were limited to one year. However, a self growing ability can be expected to be realized by renewing operation guidance by iterating learning day-by-day, or yaer-by-year.

6. DISCUSSION

we propose control informations extraction method from the neural network which is used to make the model of PAC dosing process in water purification systems and provides function for learning the relations between operational and influential factors from plant historical data trends and then reflecting them onto plant operations, like human operators do.

The validity of the developed algorithm was investigated using historical data of coaglant injection operation in a water purification plant. The improvements of the association ability for unknown conditions was realized.

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