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Sedimentation Process Modeling using Transfer Function ARIMA for Water Quality Diagnosis and Prediction

Sang-Hyuk Park[1,1], Jayong Koo[2,2]

[1] Korea Institute of Civil Engineering and Building Technology, 283, Goyandae-Ro Ilsanseo-Gu, Goyang-Si, Gyeonggi-Do, 411-712, Korea
[2] University of Seoul, Seoulsiripdae-ro 163, Dongdaemun-gu, Seoul, 130-743, Korea

Abstract. This study develops a sedimentation process model that simulate the effects of inflow water quality, treatment flow rate and outflow water quality. The model uses transfer function ARIMA (Auto-Regressive Moving Average) for reflecting the dynamic characteristics of the system The sedimentation model for outflow water turbidity are separated into low and high turbidity by input variables, turbidity, pH, alkalinity and flow rate of raw water, and coagulant is used. Determination coefficients of the optimal model selected 0.92 and 0.97 in case of using optimal model for the transfer function model. In conclusion, predictive results were estimated 0.99 and 0.65, respectively.

Keywords: Transfer Function ARIMA, Sedimentation Process, Diagnosis, Prediction, Water Quality

1 Introduction

From the productivity improvement aspects of ensuring water quality and cost optimization and driven by the high level of demand for running water service, water treatment plants have continuously pursued upgrading their facilities. However, in reality, the improvement has mainly been focused on the hardware; whereas, software wise, it is not up to par with that of the developed nations. The automated process control and integrated operating systems for water production efficiency have been established and currently under operation (Gunatilaka and Dreher 2003). However, many water treatment plants are not being used, due to the absence of real-time performance evaluation and real-time process control. It is likely that only simple operations via simple control after a certain time period are being practiced.

In order to evaluate and control the performances of various processes in real-time, water quality variation and flow rate data and an informatization process should be monitored. This monitoring referred to as modeling become necessary. In these days,

1 Researcher, Korea Institute of Civil Engineering and Building Technology (karasin811@kict.re.kr, Corresponding author)
2 Prof., Dept. Environmental Engineering, University of Seoul (jykoo@uos.ac.kr)

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a number of studies are on modeling for real-time control and diagnosis of water treatment process(White and Verdone, 2000; Song et al., 2011).

This study developed a model that simulate the effects that the inflow water quality and the results of control operation – driven by the control characteristics – have on the outflow water quality and treatment flow rate, for the performance evaluation and control of the sedimentation process of water treatment plants; and by using the developed model, the predictability of the performance of processes and water quality and water capacity in accordance with the control factor of sedimentation process was analyzed.

In order to modeling the monitoring data of water treatment plants currently in operation were used. And the statistical models and not the existing physiochemical models. The transfer function ARIMA (Auto-Regressive Moving Average) model(Box, 1976; Sudhakar et al. 1983) that can reflect the dynamic characteristics of the system was used.

2 Transfer function ARIMA model for sedimentation process simulation

In order to build "Transfer Function ARIMA model", model-identification process is used by reviewing the object systems in regards to input variables, output variables, manipulating variables and exterior impact factors. The flow chart you see is a schematic of "Transfer Function ARIMA model" in filtration process. Fig. 1 shows correlations of affecting factors in each process.

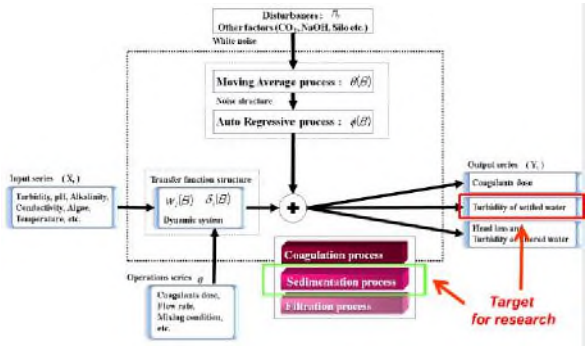


Fig. 1. Schematic diagram of TF-ARIMA model for sedimentation process

The target model consists of mixing process, sedimentation process, and filtration process. In this study, these are represented for sedimentation process.

The modeling process is being done by "Transfer Function", through varying manipulating variables such as quantity of chemicals injected and operational conditions. Regarding the factors other than those mentioned above the modeling is conducted by ARIMA, and two models are integrated into one final model.

3 Analysis of the Result

The sedimentation site outflow water turbidity models were separated into low and high turbidity, and as the input variables, the turbidity, pH, alkalinity and flow rate of raw water, and coagulant dose were used(see Fig. 2).

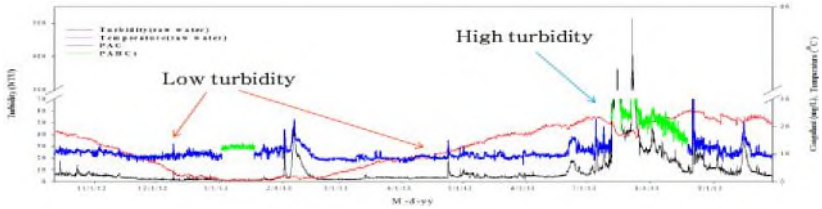
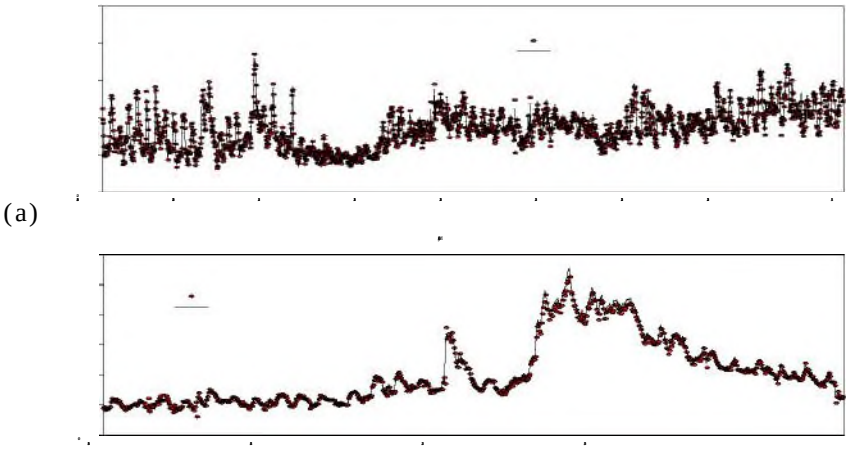
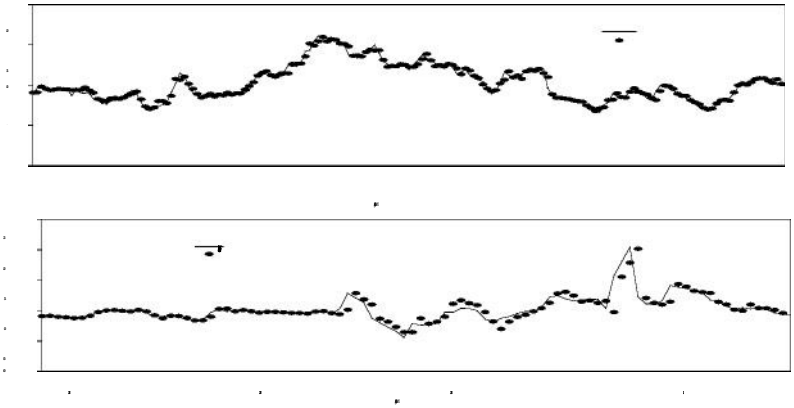


Fig. 2. Variation of turbidity, temperature and coagulants dose in raw water



(a)

Fig. 3. Variation between real and estimated turbidity of settled water in



(a)

(b)

estimation and prediction during low turbidity : (a) estimation, (b) prediction

Fig. 4. Variation between real and estimated turbidity of settled water in estimation and prediction during high turbidity : (a) estimation, (b) prediction

Fig. 3 shows the predicted results of the model during low turbidity. After the comparison of the real data and predicted results, the real value was 0.92, which was thought to be well estimated.

Fig. 4 shows the real value as 0.97 after comparing the real data and estimated results, which is also thought to be well estimated. The real value of the estimated result shows itself as low as 0.65.

Conclusion

This study has developed a model that simulate the effects of inflow water quality, treatment flow rate and the results of control operation have on the outflow water quality. In order to achieve a modelization, the monitoring data of water treatment plants currently in operation were used and, of the statistical models and not the existing physiochemical models, the transfer function ARIMA(Auto-Regressive Moving Average) model that can reflect the dynamic characteristics of the system was used; and the results from which are as follows.

1. The coefficients of determination of the optimal model selected as the transfer function ARIMA model for the turbidity of sedimentation water were 0.92 and 0.97, respectively; and the predictive results were 0.99 and 0.65, respectively.
2. As a result of schematizing the predicted values and actual values at high turbidity, it was confirmable that errors between the predicted value and actual value were seen to be large when a temporary increase in turbidity occurs; however, because – after the temporary increase in turbidity – starting in the next time point the errors due to the ARIMA term of the transfer function ARIMA model becomes calibrated and thereby the errors recover, it was deemed that the model was carried out well.

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