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Active fault detection in DO sensors - automated tuning

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Abstract Topic: Digitalization

Summary

The dissolved oxygen (DO) sensor is a key component to achieve resource efficient and effective water resource recovery, which presume accurate sensor readings. Biofilm fouling is a common cause for biased sensor readings, which is today manually monitored during routine cleaning. Active fault detection was studied as a solution to instead automatically monitor the foul-up on two types of DO sensors. More specific, four fault detection (FD) methods with different degrees of complexity were adapted to active fault detection data and evaluated with the goal to detect a 0.5 mg/L bias due to biofilm fouling. The results showed that simple FD-methods could be adapted and successfully used for active fault detection. The main challenge was to automatically tune the FD-method's decision threshold values to suppress false alarms, which needs to be further studied.

Abstract

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Abstract

In this article we study how existing FD-methods can be adapted to active fault detection (AFD) data to detect biofilm fouling on two types of dissolved oxygen (DO) sensors in WRRFs. Active fault detection is one promising fault detection (FD) method, which uses prior knowledge about the diagnostic problem formulation differently than traditional (passive) fault detection (PFD). The AFD approach has potential to solve three general difficulties for FD-methods regarding non-specificity. More specific, AFD has the potential to: 1) distinguish between process and sensor disturbances, 2) isolate one faulty sensor among data from multiple (potentially correlated) sensor signals, and 3) diagnose the root cause of a sensor fault. In this study we use full-scale WRRF AFD data targeting the critical DO sensor. More specific we:

- Assess the performances of four FD-methods (Rise time estimation (RT, RTi), Principal component analysis (PCA), Gaussian process regression (GPR), Pragmatic engineering approach (PEA)) with different complexity degrees, and how they can be modified to better make use of AFD data with the goal to monitor DO sensors.
- Conduct a thorough assessment by using benchmark AFD data containing data from both artificial- and real organic biofilm fouling on DO sensors located in full-scale WRRFs.
- Study the interplay between FD-methods and data by combining the data transformation model in (Venkatasubramanian et al. 2003) with the well-established fault detection performance measure Receiver operating characteristics.

A bias larger than 0.5 mg/L was detected in the optical DO sensor in with a low number of false alarms with the three simplest FD-methods: PEA, RT, and RTi. Surprisingly, it was only GPR that gave good results among the remaining more advanced machine learning FD-methods A general challenge with FD-method is to reduce false alarms, and understand their source. The results indicate that sufficient spread in initial DO concentration in training data was necessary to reduce false alarms for both GPR and RTi. Further, sudden changes in the DO concentration during an AFD event (in comparison to the DO concentration during training) can produce false alarms, although it was not the main reason. The FD-methods in this study were only trained with normal data, in contrast to the standard machine learning classification task were training data from both normal and faulty modes are provided. The lack of faulty samples can be part of the tuning problem since the FD-methods have difficulties to decide "how far" from normal data the fault is. A fully automatic tuning procedure is highly desirable in order to assure a cost effectve process monitoring, especially since the DO sensors with the suggested AFD approach needs to be trained and tuned individually. This was challenging in

this stuyd and needs further research We conclude that Active fault detection can provide timely information about the common biofilm fouling on the critical DO sensor and can be a new tool for process operators to improve sensor maintenance

References

Venkatasubramanian, V., Rengaswamy, R., Yin, K. and Kavuri, S.N. (2003) A review of process fault detection and diagnosis. Computers & Chemical Engineering 27(3), 293-311

Comments

The results have been submitted for publication in a peer-reviewed journal.

Target Group

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