DESIGN AND IMPLEMENTATION OF INTELLIGENT CONTROL METHODOLOGIES FOR REVERSE OSMOSIS PLANTS

by

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This dissertation was prepared under the direction of the candidate's dissertation advisor, Dr. Ali Zilouchian, Department of Electrical Engineering, and has been approved by the members of his supervisory committee. It was submitted to the faculty of the College of Engineering and was accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

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This dissertation presents the design, implementation and application of soft computing methodologies to Reverse Osmosis (RO) desalination technology. A novel intelligent control scheme based on the integration of Neural Network (NN) and Fuzzy Logic (FL) is presented to optimize plants' performance.

In the first part of the research work, two optimal NN predictive models, based on backpropagation and Radial Basis Function Networks (RBFN), were developed for three types of RO feed intakes. The predictive models utilized actual operating data for the three RO plants in order to predict system recovery, total dissolved solids and ion product concentration in brine stream. A predictive model is proposed based on redistributed receptive fields of RBFN. The proposed algorithm utilizes integration of supervised learning of centers and unsupervised learning of output layer weights. Extensive

simulations are presented to demonstrate the effectiveness of the proposed method for generalization on prediction of non-linear input-output mappings.

In the second part of the study, the design of FL control strategy for direct seawater RO system is carried out. The real-time controller design is based on integration of sensory information, predicted outputs, mathematical calculations, and expert knowledge of the process to yield a constant recovery, constant salt rejection and minimum scaling under variable operating conditions.

To implement the designed methodology, a 250/800 Gallon per Day (GPD) prototype RO plant with direct Atlantic Ocean intake is constructed at FAU Gumbo Limbo research laboratory. Two types of membrane modules were used for this study: Spiral Wound (SW) and Hollow Fine Fiber (HFF). The prototype plant indeed demonstrated the effectiveness and optimum performance of the proposed design under variable operating conditions.

The system achieved a constant recovery of 30% and salt passage of 1.026% while ion product concentration for six major salts were kept below their solubility limits at all time. The implementation of the proposed intelligent control methodology achieved a 4% increase in availability and a 50% reduction in manpower requirements, as well as reduction in overall chemical consumption of the plant. Therefore, it is expected that the cost of producing fresh water from seawater desalination will be decreased using the proposed intelligent control strategy.