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DESIGN AND BUILD OF LIQUID WASTE AERATOR CONTROL BASEDON ADAPTIVE NEURO FUZZY INFERENCE SYSTEM (ANFIS)

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ABSTRACT

Liquid waste from the production process can pollute the environment if disposed of directly, so it must be managed professionally. Liquid waste treatment is generally carried out biologically BOD (Biological Oxygen Demand) using decomposing bacteria or chemically or COD (Chemical Oxygen Demand). Wastewater treatment, both BOD and COD, requires oxygen to ensure that the quality of liquid waste is safe. In most wastewater treatment plant, the aerator machine is an air pump used to produce high-pressure air in liquid waste containing oxygen (O2). Based on preliminary research on the problem, in general, the aerator work operation is carried out manually on average 11-17 hours a day. Operating the aerator machine manually, especially at a large capacity, will cause the use of electrical energy to be wasteful. Based on the problemsabove, further research will be carried out on how to determine the optimal working time of the aerator andnot cause excessive energy consumption but the liquid waste produced is still within safe limits. The research was conducted to design an intelligent microcontroller-based tool with a long output aerator operating time on the input characteristics of liquid waste. This control system uses the adaptive neural fuzzy inference system (ANFIS) method, because ANFIS can solve all kinds of complex and nonlinear problems effectively. The input variables used are COD reduction and waste volume while the output is thelong operating time of the aerator. The results obtained, the system design can be implemented properly and according to the setting point with an average operating time of 7.6 hours aerator working hours and can reduce the use of electrical energy by 31%.

***INDEXTERMS*:** Liquid waste, Aerator, adaptive neuro fuzzy inference system (ANFIS).

I. INTRODUCTION

The production process in industry and domestic (household) always produces waste, one of which can be in the form of liquid waste. So that liquid waste does not have an impact on the environment, a waste treatment process is needed. The Wastewater Treatment Plant (WWTP) in the Suwung area uses a system of aeration ponds and sedimentation ponds. The aeration system is used with the intention of reducing the need for land area and increasing the processing process to be faster while eliminating odors due to the incomplete oxidation process.

The aeration process as a producer of oxygen in the form of air foam mixed with water is an aerobic reduction process of BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand). Based on preliminary research data, the Suwung WWTP aerator is still operated manually for 11 hours per day. Inappropriate aerator operation causes the use of electric power to be wasteful.[1,2] To meet the oxygen demand in accordance with the input characteristics of the treated waste, it is necessary to have an intelligent arrangement of the aerator's working time, so that electrical energy losses can be reduced.

The development of modern control technology using an aeration control system strategy with different treatments shows that the electrical energy consumption for treatment with a controlled aeration system is reduced by about 30%.[3,4] Methods with fuzzy logic techniques can be applied by utilizing advantages in the linguistic reasoning process without the need for complicated mathematical models. This technology as a development for classical control strategies that have constraints in dealing with nonlinear processes with the help of simulation models has proven to be a useful tool for researchers to evaluate algorithms in complex integrated environments.[5,6]

An expert system research based on fuzzy logic rules that was designed showed that although there are various types of different controls such as on/off systems and controls with proportional integrative derivatives (PID), it turns out that the easiest and most effective method to accept is the fuzzy logic control method.[7,8,9] Controlling aeration on and off at intervals of 3 hours can help reduce BOD, increase pH, maintain nitrite levels and can maintain bacterial growth in wastewater treatment.[10,11] Research on PI control on aerators shows that the aerator engine rotation speed regulation of oxygen levels to decompose pollutants in sewage can be adjusted.[12,13] Based on the description of the background above, this research will design an automatic intelligent way with the output of aerator working time (hours) and input of liquid waste characteristics COD based on the ANFIS.

II. RESEARCH METHOD

The design for the controller based on the ANFIS method will produce a design in the form of an FIS that is regulated and adjusted using a neural network. This control uses one input and one output with the Sugeno method. The input used is the COD reduction value, while the output used is the time of aerator operations. The input consists of three quantization with the type of triangular member function, the output uses a constant function and consists of 4 rules.

A. ANFIS System

COD input variable using 4 quantization, as follows. small, medium, rather large, and large, while the output in the form of a crisp value as a result of the defuzzification is a constant function. The number of epochs is selected from 75 to 100 to obtain ANFIS output from the system with a data set of 92 patterns, the number of inputs is 1 parameter and produces one output. The structure of the complete ANFIS model can be described as shown in Figure 1.

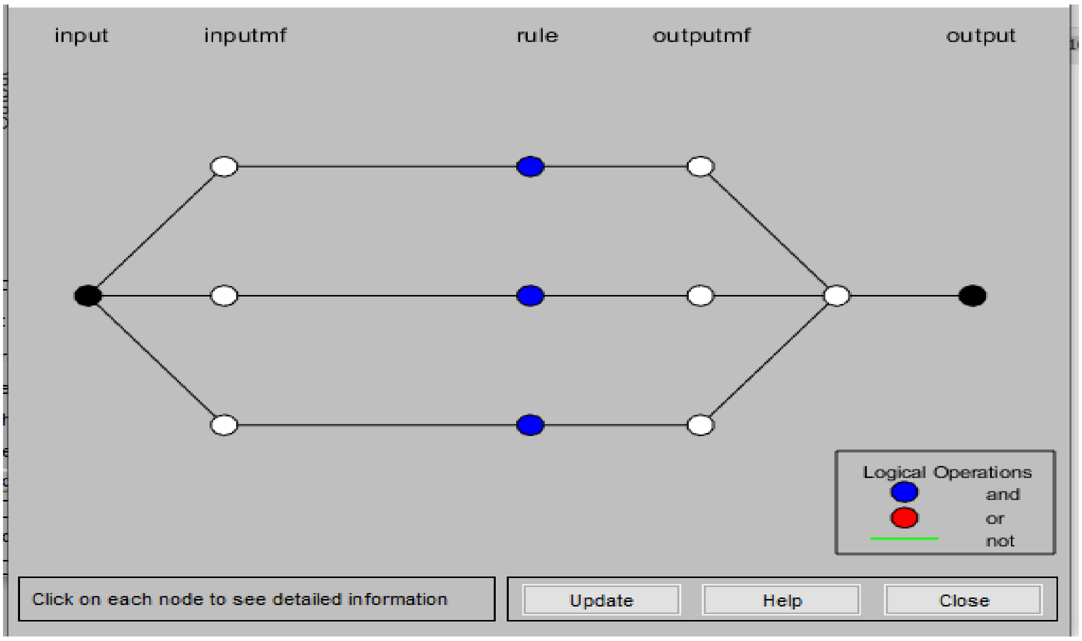

Fig. 1: Anfis Structure.

ANFIS trains the FIS by modifying the membership function parameters until a minimum error is obtained between the FIS output and the output training data. The training data used are 92 data sets and the test data are 31 test data.

B. Training and Testing Data

After the data is ready, in the load data, select the training type, then from file, then select data.dat. Next, on the Generate FIS menu, Grid partition is selected as the default mode, then select Generate FIS, a new window appears to determine the type and number of membership function inputs for the training process. In the Train FIS menu, there is an optim. Methods that have been set are hybrid. The error tolerance value was chosen as 0. In this study, the number of epochs used was 100. After determining the Error Tolerance value of 0 and the Epochs value of 100, Finally, train now selected. ANFIS will start the training process until it reaches the number of epochs. If the training process for each epoch has been completed, it can be seen theerrors obtained in the main graph as shown in Figure 2.

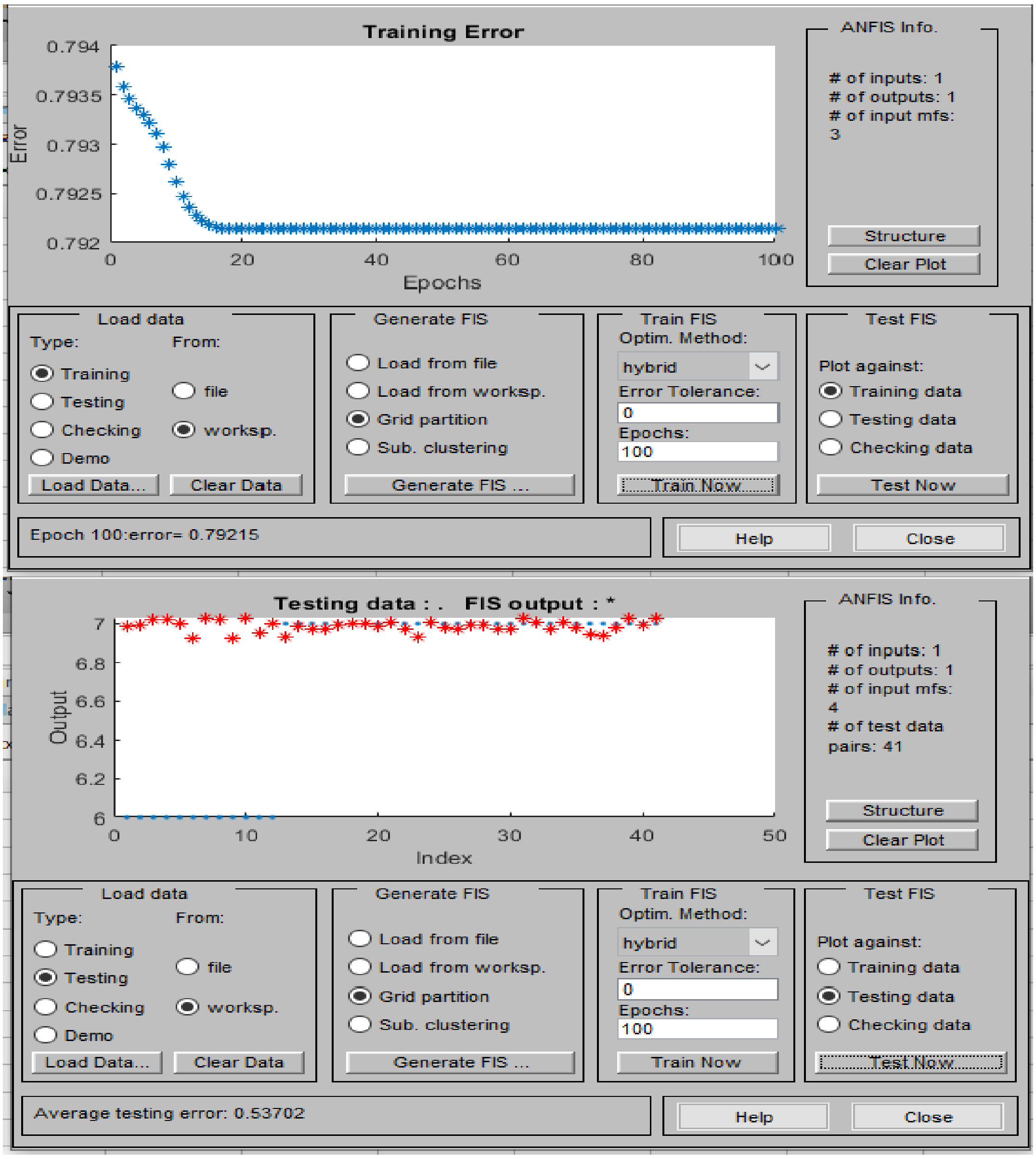

Fig. 2: Training and Testing ANFIS.

III. RESULTS AND DISCUSS

Based on the results of ANFIS, it can be determined in more detail the control to be designed by looking at the resulting FIS. The FIS designed in a block diagram consists of three components, namely one input, the Sugeno process and the f(u) output as shown in Figure 3.

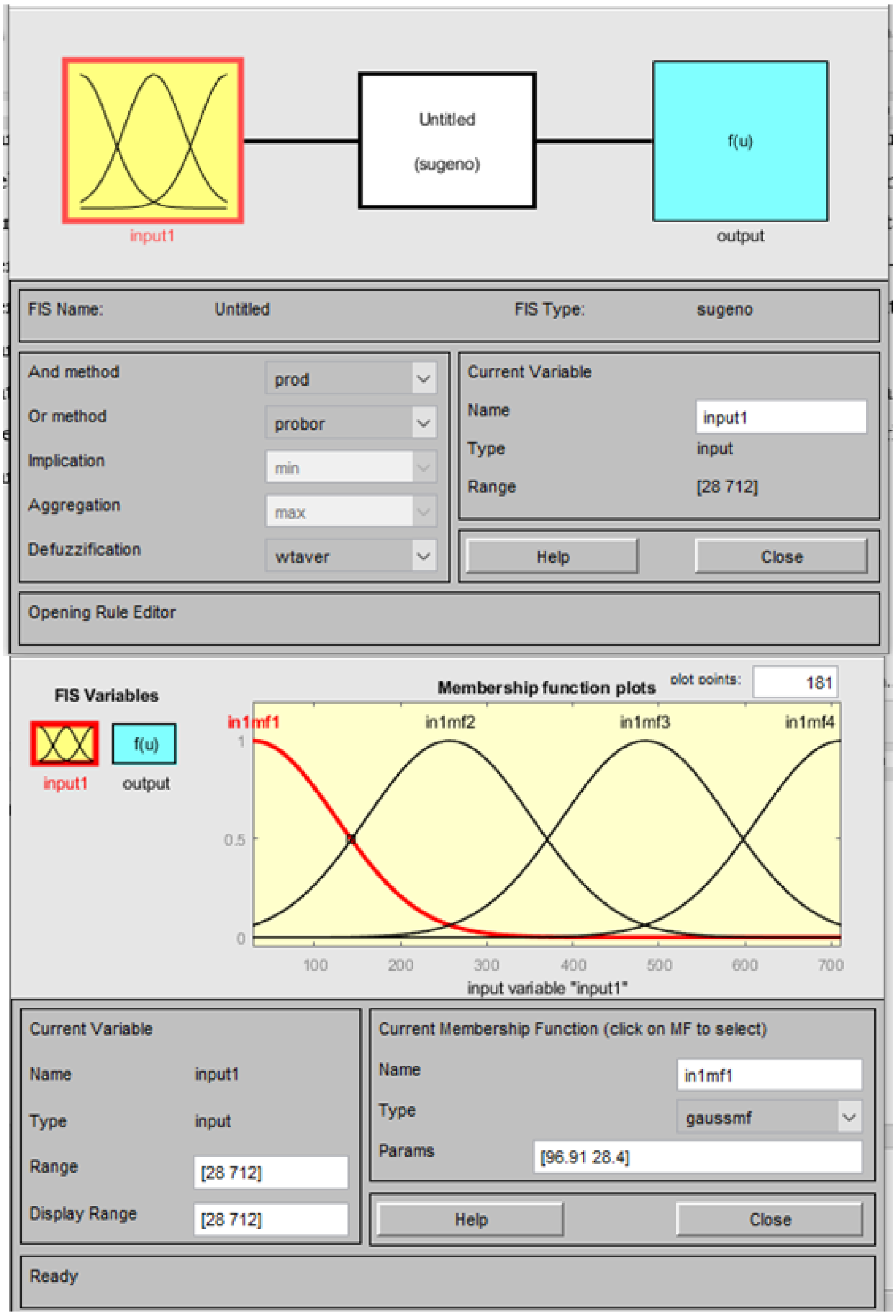

Fig. 3: Input ANFIS.

The output produced by ANFIS consists of 4 membership functions of constant type, namely out1mf1, out2mf2, out3mf3, and out4mf4, and the rule base generated by ANFIS consists of4 basic rules as shown in Figure 4.

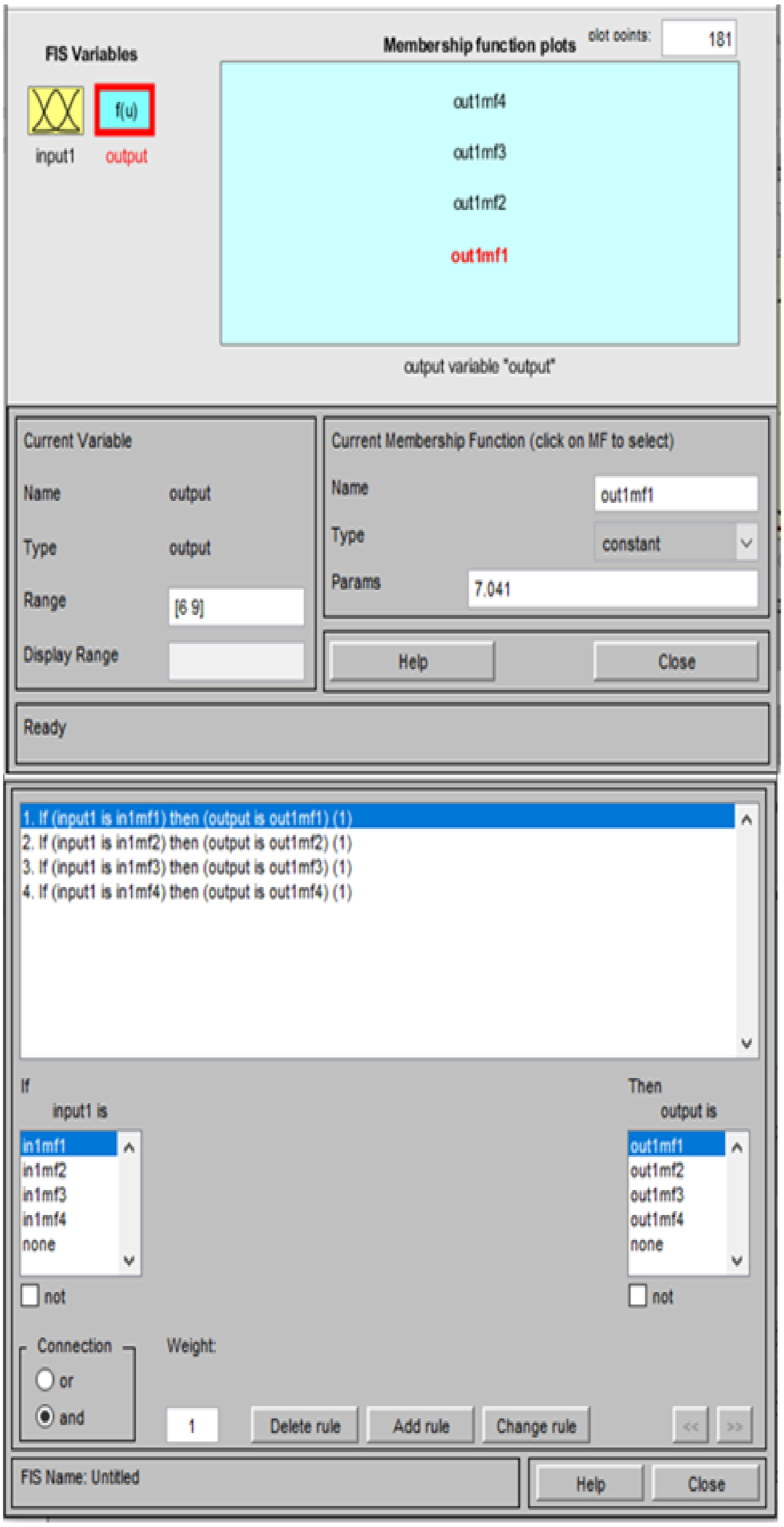

Fig. 4: Output and rule base ANFIS.

Based on the resulting ANFIS design, the rule view can be displayed and to see the working area of this control can be seen by displaying the surface view facility. A detailed description of the controller work area can be seen in Figure 5.

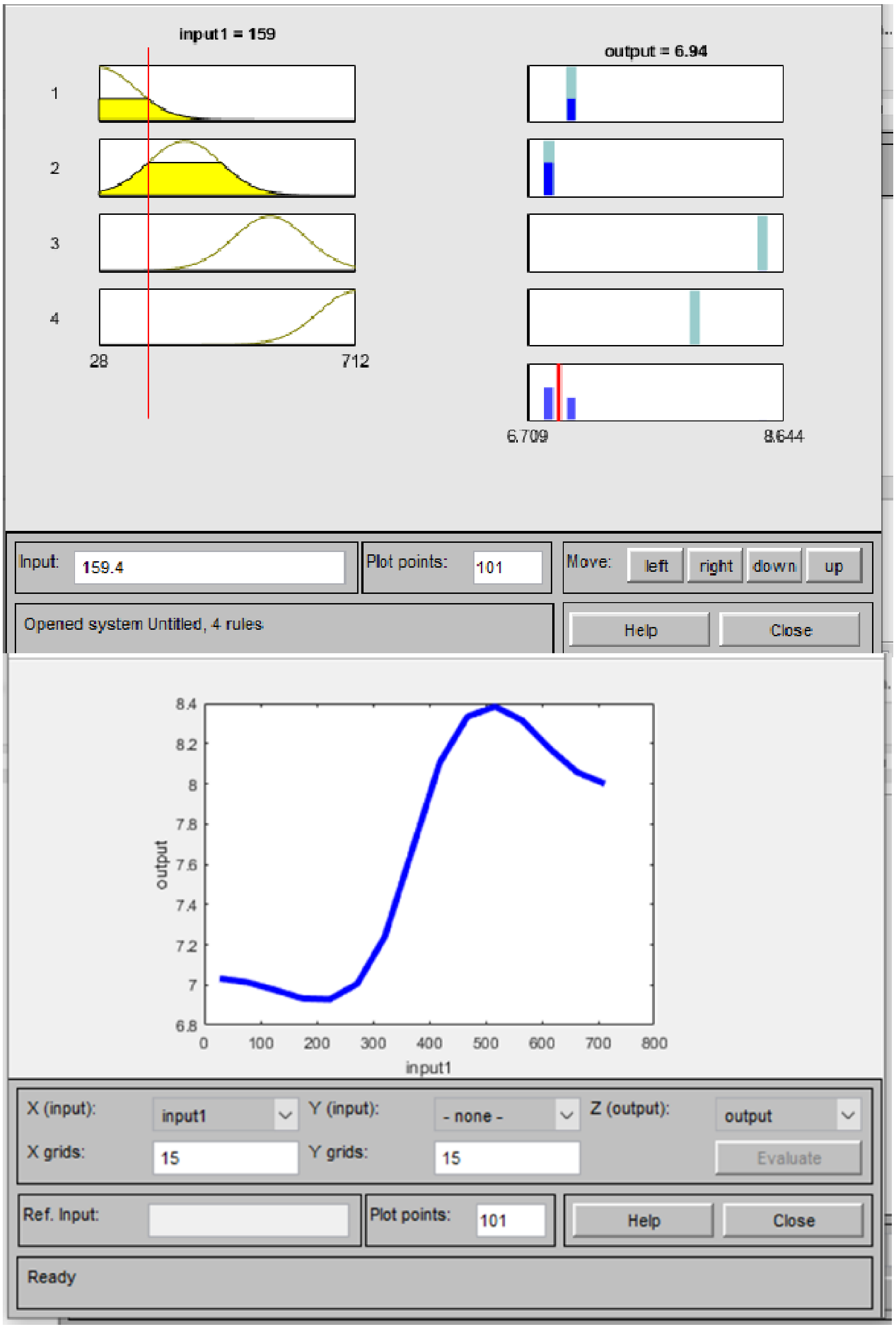

Fig. 5: Rule and surface view ANFIS

Based on the proposed type-2 fuzzy logic interval design, testing using real data for 30 (thirty) days. The simulation results can be seen in table 1.

Table I: Output Results of Aerator Operation and Electricity Consumption.

Parameter	Unit						Result				
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
COD-1	mg/l	22.5	28.5	31	32.5	33	34.5	36	38	41	45
COD-2	mg/l	48	52	53.5	56.5	59.5	63.5	64.5	68.5	74.5	78
COD-3	mg/l	81	82	85	89	90	92	94.5	96.5	98	100
Optime1	h	6.17	6.19	6.37	6.5	6.6	6.67	6.8	6.9	7	7
Optime2	h	7	7.16	7.23	7.36	7.47	7.6	7.64	7.84	8	8
Optime3	h	8.05	8.1	8.26	8.63	8.81	8.81	8.82	8.83	8.87	8.97
Energy-1	KWh	1018.05	1021.35	1051.05	1072.5	1089	1100.55	1122	1138.5	1155	1155
Energy-2	KWh	1155	1181.4	1192.95	1214.4	1232.55	1254	1260.6	1293.6	1320	1320
Energy-3	KWh	1328.25	1336.5	1362.9	1423.95	1453.65	1453.65	1455.3	1456.95	1463.55	1480.05
Average COD= 62,3 mg/l Average Optime= 7.6 Jam Average Energy= 1252.075 KWh Total Energy: 37562,25 KWh											

Based on table 1, it can be calculated that the average COD reduction is 62.3 mg/l, with the smallest value of 22.5 mg/l, and the largest of 100 mg/l, while the average operating time (optime) of the aerator is 7.6 hours, with the smallest value of 6, 17 hours and the largest is 8.97 hours. The average energy consumption per day is 1252,075 KWh, with the smallest energy consumption value of 1018.05 KWh and the largest 1480.05 KWh. Total energy consumption per month is 37562.25 KWh, while based on real data, electricity consumption is 54,450 KWh. This means that there is a decrease in electricity consumption per month by 31%. This is also supported by research conducted by Amand L, et al and Filali A et al.[1,2]

The ANFIS control design uses COD input with the output of aerator operating time and 4 basic rules to produce a Surface view graph as shown in Figure 4. The average aerator operating time is almost the same for small to medium COD, while the aerator operating time shows an increase for COD. large to very large reduction.

IV. CONCLUSION

The ANFIS aerator control design has been well used for setting the working time of the aerator in wastewater treatment and the calculation process to obtain a relative output does not require much high-level mathematics. In this study, the proposed control design is able to reduce the use of electrical energy by 31% with an average aerator operating time of 7.6 hours, this means that it automatically reduces the cost of monthly electricity payments. For further research, it can be developed and the performance of the system can be compared with conventional control methods and other intelligent controls.

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