# *The ACO-ANFIS Hybrid Method used for LFC Optimization in Wind–Diesel Hybrid Power System*


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***Abstract* — Diesel-wind turbine power plants have an economical advantage and easy to make. In areas that are difficult and far out of reach of electricity, diesel wind turbines are perfect for use. Distribution instability due to load changes causes frequency fluctuations in the system. So that could cause electrical equipment to be damaged. Utilization of diesel power plants has also been widely used, one of which is being developed is a hybrid power plant such as wind and solar power. The hybrid system is a network controlled from several renewable energy plants such as wind turbines, solar cells, micro hydro and so on. Therefore, in this research how to optimize frequency controller by setting of Proportional Integral Derivative (PID) control to manage Load Frequency Control (LFC). This study compares several control methods such as PID with conventional methods, PID with Auto Tuning Matlab, PID with Ant Colony Optimization (ACO), PID-ANFIS and PID-ACO-ANFIS. This plant is modeled in simulation using Matlab-Simulink program. This is indicated by a faster settling time value which is the fastest settling time value and also the overshoot value of 2.4197e-05 and 9.847e-06 pu which is the smallest overshoot value of the other controller model.The results of this study were developed with other methods, so the best optimization is obtained.**



***Keywords* — ACO,ANFIS, LFC, PID, Wind-Diesel**


## I. INTRODUCTION

Utilization of new renewable energy sources as a source of electrical energy is widely used.Wind power has been widely used as a source of generator for generating electrical energy.However, the use of wind energy is very dependent on wind conditions in an area, so to optimize the performance of this power plant is needed other plants to be more optimal.By using Hybrid Wind-Diesel will be able to serve consumers optimally, because its performance is more optimal than the Wind Stand Alone.Hybrid system is a controlled network of several renewable energy sources.Such as wind turbine, photovoltaic, microhydro, and so on.However, the practice of frequency fluctuation will affect the quality of power supply in the hybrid system [1,2,3].

In a previous study, hybrid studies of hybrid operation discussed frequency regulation techniques.The combined technique of fuel cell and hybrid electrolysis systems is used to improve the ability of microgrid systems.Handles power quality improvement of frequency fluctuation problems.The proposed arrangement and monitoring system is to maintain the quality of power, as well as to maintain volatility of frequency fluctuations.These frequency fluctuations can lead to the generation of random power.Also the arrangement on the load side to maintain the stability of fluctuation of power flow at the power flow level caused by frequency fluctuation of hybrid system interconnection [3,4].

The application of intelligent methods on the power system for tuning control PID has been done [4,5].One smart method discusses the application of the Ant Colony Optimization (ACO) method for tuning PID parameters.Previous research has discussed hybrid system control using PID [6,7,8].From the results of these studies there are still some shortcomings including the still large frequency fluctuations.

From several frequency regulation problems causing the fluctuation of power flow in various types of hybrid generation of connected systems, the researchers took the theme of Frequency Settings on Hybrid Power System with ACO and ANFIS Intelligent Method. The Ant Colony method is a method inspired by ant behavior in search of food sources.ANFIS is the incorporation of fuzzy inference system mechanism described in the neural network architecture.

## II. LITERATURE REVIEW

### *2.1. Hybrid System*

The Wind-Diesel hybrid power system may be economically viable in some cases of providing electrical energy in remote areas.Wind-Diesel is commonly used in mountainous areas or islands where wind speed is quite significant.Wind speed is used to drive the generator.But Wind-Diesel for energy supply on connected network systems is not economical.It is hoped that the results of electric power generation from the Wind-Diesel hybrid system can provide a good service for service load to consumers.All depends also on the type and characteristics of the generation control.This means that the variation of the frequency system must be kept stable for the equipment to operate properly and efficiently.Different strategies can be implemented by reducing the generation and load differences as well as adjusting the frequency deviation of the system.Strategies that can be done by setting the artificial load control, switching load control priorities, the use of flywheel, magnetic superconductors and battery energy storage systems.The optimal selection of control gain is recommended using ISE techniques for continuous control cases and discrete controls.The model in this case study consists of sub-systems; Wind turbine dynamic model, diesel dynamic model, wind turbine blade speed control and dynamic generator model.Block diagram of Wind-Diesel transfer function as follows [9,10,11].

### *2.2.Ant Colony Optimization (ACO)*

The ACO Algorithm was first introduced by Lumer and Faieta (1994). This algorithm is an algorithm that mimics ant behavior and sorting ant larvae. The principle of ants in collecting and sorting ant larvae is used in this algorithm. The ACO algorithm provides the relevant partition of the data without prior cluster center knowledge. There is an agent ant that performs a random displacement on the two-dimensional grid where in the grid there is a randomly scattered object, and the grid size depends on the number of objects. An ant agent selected or allowed to move in the grid, will take the object and also drop the object affected by the similarity and density of the object.

The probability of retrieving an object from the ant agent will be increased in a low-density environment and decreases if the object's similarity is high around it. Instead the probability of dropping the object will increase the high density environment. Ants and objects in the grid can be in two situations; (A) one agent ant holds the object and evaluates the possibility of dropping it at that position. (B) an ant agent without holding a moving object in the grid and evaluating the probability of taking an object. Finally, agent ants will group objects based on objects that are similar to each other[6,7,8].

### *Local Pheromone Update Rules on ACS*

During the tour to find a solution, the ants pass through the path and change the pheromone level on the path by applying the local pheromone update rules shown by the following equation.

$$\tau_{ij}(t) = (1-\rho)\tau_{ij}(t-1) + \rho\tau_0 \quad (1)$$

With;

$\rho$ = constant evaporation (evaporation)

$\tau_0$ = an initial value of the initial pheromone

Flowchart of the whole pros described ACO-section of the section above can be seen in the following figure.

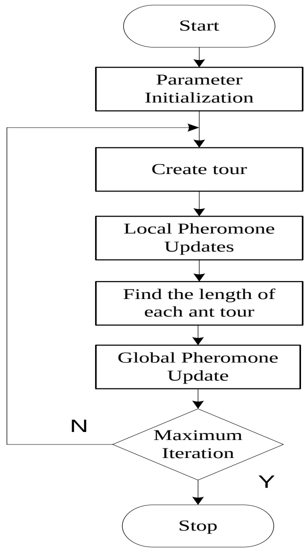


Fig. 1. ACO Flowchart

### *2.3. Adaptive Neuro Fuzzy Inference System (ANFIS).*

Adaptive Neuro-Fuzzy Inference System (ANFIS) is the incorporation of fuzzy inference system mechanism described in the neural network architecture. The fuzzy inference system used is the first-order fuzzy model of Tagaki-Sugeno-Kang (TSK) model with consideration of simplicity and ease of computing [13,14].

The first order fuzzy inference TSK mechanism with two x and y inputs (Fig 2). The rule base with two fuzzy if-then rules, like below:

Rule 1 : if x is $A_1$ and y is $B_1$ then $f_1 = p_1x + q_1y + r_1$(2)

Rule 2 : if x is $A_2$ and y is $B_2$ then $f_2 = p_2x + q_2y + r_2$(3)

Input: x and y. Consequent is f.

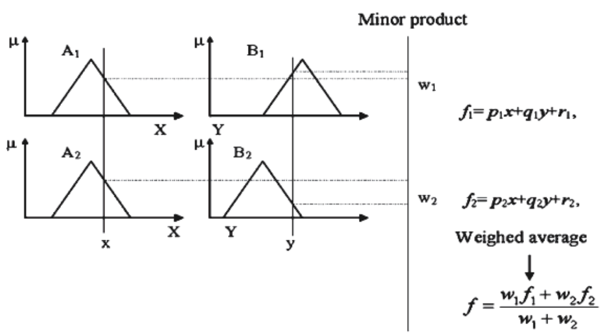


Fig 2. Fuzzy inference system

As for ANFIS Structure can be seen in (Figure 5)

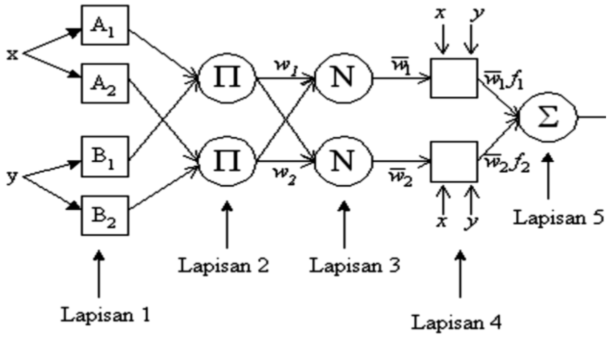


Fig 5. ANFIS Structure

### *2.3. PID Tunning Using ACO*

Figure 2 shows a flow diagram ACO algorithm method used in this research to tune PID parameters. The objective function is used to Integral Time Absolute Error (ITAE).

$$ITAE = \int_0^t t\left|\Delta\omega(t)\right|dt \qquad (4)$$

PID parameters are tuned by the ACO is Kp, Ki and Kd.Modeling for Wind-Diesel on Simulink Matlab 2013.

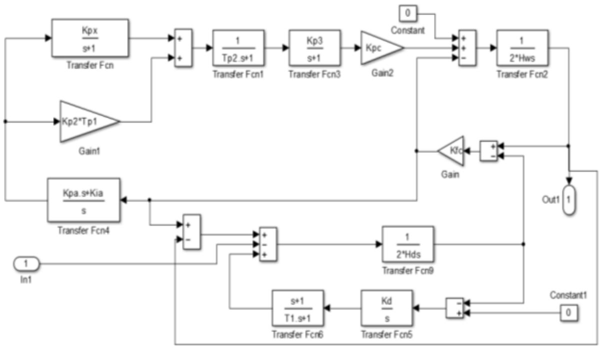

Fig. 4. Wind-diesel model

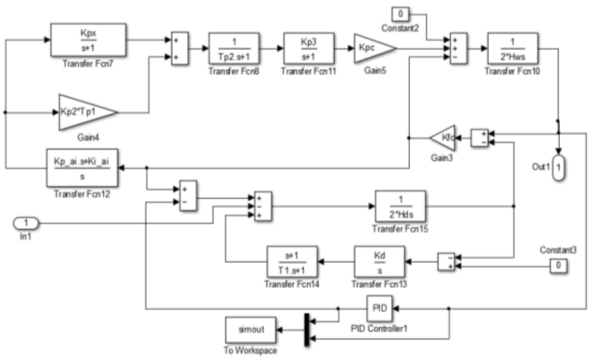

Fig.5. PID Controller model

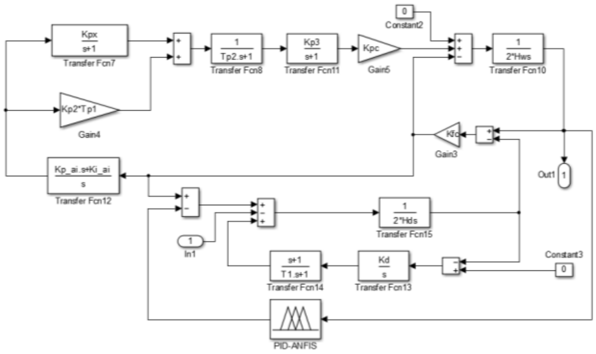

Fig.6. PID-ANFIS Controller model

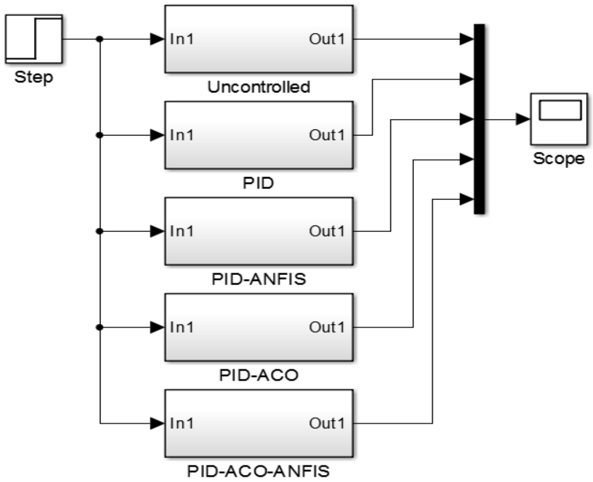


Fig.5. Blocks of various controls on Wind-Diesel

## III. METHOD

The research flowchart is shown in the following figure8.

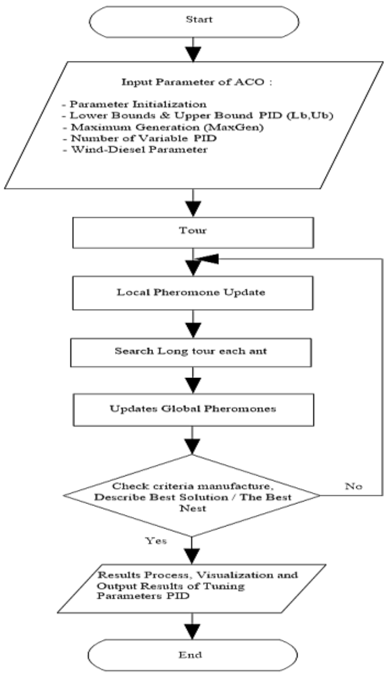


Fig. 8. Flow chart research

The data of ACO parameters can be seen in table 1.

TABLE I ACO PARAMETERS

| Parameters | Value |
|---|---|
| Node | 50 |
| Max_It | 50 |
| Alpha | 1 |
| Beta | 2 |
| Rho | 0.1 |
| C | 50 |
| L_Best | Inf |
| T_Best | 0 |

Optimization results can be seen in table 2.

TABLE II
THE CONSTANTS OF Kp, Ki AND Kd

| | Uncon-trolled | PID | PID-ANFIS | PID-ACO | PID-ACO-ANFIS |
|---|---|---|---|---|---|
| Kp_ai | - | 1 | - | 1.1977 | - |
| Ki_ai | - | 1 | - | 0.0174 | - |
| Kdf_ai | | 0 | | 4.0606 | - |
| Kp_aco | - | 1 | - | 13.602 | - |
| Ki_aco | - | 1 | - | 28.879 | - |
| Kd_aco | - | 0 | - | 6.0851 | - |
| ANFIS training | - | - | 4.073e-05 | - | 5.066e-05 |

## IV. SIMULATION RESULTS AND ANALYSIS

The results can be illustrated in Figure 9

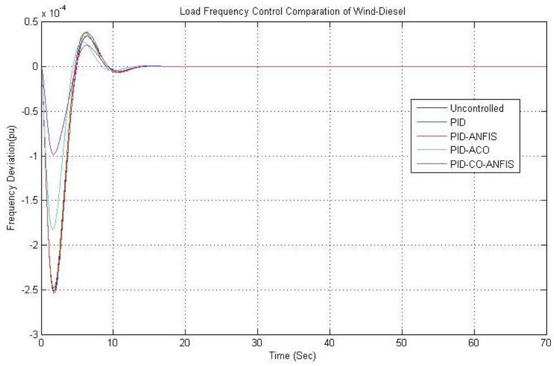


Figure 11. Graph frequency Wind-Diesel without controller

The picture above is a comparison of the response graph of each control model.Of the five types of control models of wind-diesel systems it can be concluded that wind-diesel power plants absolutely require a controller. The controller is used as a frequency oscillation damper due to load changes.

## V. CONCLUSION

From the comparison result of the control model obtained; For overshoot control system of 4.008e-05 and undershoot of -2.5523e-05, conventional PID overshoot controller of 3.83433-05 and undershoot of -2.4802e-05, PID-ANFIS overshoot controller of 3.897e-05 and undershoot of - 2.5352e-05, PID-ACO overshoot controller of 2.8168e-05 and undershoot of -1.824433-05, and PID-ACO-ANFIS overshoot controller of 2.4197e-05 and overshoot of 0.9847e-05.

Control Models Using PID-ACO-ANFIS in the designed Load Frequency Control (LFC) control system; it can improve the frequency response of a Wind-Diesel system. This is indicated by a faster settling time value which is the fastest settling time value and also the overshoot value of 2.4197e-05 and 9.847e-06 pu which is the smallest overshoot value of the other controller model.

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