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Computation Intelligence Techniques to Control the Temperature of Steam Generation in Thermal Power Plant

Hosham S. Anead*, Khalid F. Sultan and Ayat A. Monir

University of Technology, Baghdad, Iraq;
hoshams.2000@yahoo.com, ksultan61@yahoo.com, Ayat.alniamey@yahoo.com

Abstract

Objectives: The aim is to detect damage in boiler of steam plant by using intelligence technique to improve the boiler performance. Experimental information is obtained by use an industrial boiler operating at Al- Dura power plant. **Methods/ Statistical Analysis:** This manuscript presents is to compare intelligence technique for boiler of steam power plant PID, ANFIS, PSO technique. Various controllers for temperature will be developed to keep boiler operating in normal conditions as well as improving the effectiveness. Such parameters will be modified via building a model that will be implemented in MATLAB based on the requirements of steam power plants as well as the control aims. **Findings:** The results of the study indicated that the algorithm of PSO is the optimum controlled and top–quality performance regarding the power plants from PID controller. **Application/Improvements:** Application in indicated PID, ANFIS and PSO were utilized in Al-Dura power plant in Baghdad. Various industrial applications have applied these methods.

Keywords: ANFIS, Control, Optimization Method, PID, PSO

1. Introduction

Most of the electricity formed as of thermal power plant. An important component of thermal plant is a steam generation (boiler), it can be defined as closed container which is created via high-class where the steam will be produced from the water via applying thermal from the fuel's combustion like gas, coal or oil. When a fuel is burning, the boiler's surface will be experience heating, certain gases will be created in the heating surface, also exposed on one side and steam or water on the other one. Steam which has been collected over the surface of the water is obtained from boiler via super heater, after that the adequate pipes for driving turbine for electric generation or for some purpose in industrial application. The performance of steam power plant determines the performance of boiler. Many of experimental and numerical researches were discussed on the boiler characteristics in several decades. Which applied ANN for control of temperature, air/fuel ratio, flame, pressure, water level, gas available of boiler, this technique gives a good agreement and when compare between PID, ANN, the result give ANN a best performance than PID[1,2].

In[3] presented 2 approaches, the Fuzzy Logic (FL) controller and PID controller in addition to a comparison between the two techniques, FL controller showed better results. The maximum overshoot for the FL controller was approximately 9.35% in comparison to the maximum overshoot of PID which has been 47.3%. The settling time for PID has been 10.14, while it has been 7.18 for FL controller. The presented approach has been applied for controlling parameters like pressure and temperature changes due to the altered circumstances.

In[4] used FL controller for the purpose of controlling super-heated steam temperatures in thermal power plant. FL controller was created through the use of PIC 16F871 micro-controller which provides the needed signal. MATLAB with FL has been utilized for handling

*Author for correspondence

the issues caused by steam generators. A conventional PID controller doesn't have the ability of treating the non-linearities of the system. Furthermore, the study presented a comparison between conventional controllers and FL controllers. The comparisons between the two indicated that FL has more flexibility and need less time those conventional approaches.

In[5] applied Particle Swarm Optimization based PID, FLC which are modern controllers and classical PID controller are utilized to control the bed temperature regarding the circulating fluidized bed boiler and they are compared. Bed temperature can be considered as significant parameter with regard to circulating fluidized bed boiler. Since the effectiveness of the combustion will be increased as the bed temperature increasing, also the harmful emissions will be impacted via the bed temperature. Simulation results show that the settling time in PSO–PID controller will be lower than the other controllers. PSO, PID decreases overshoot like FLC but in classical PID controller overshoots are the biggest. In FLC there are no overshoot.

In[6] developed and accomplishment PI/PID controller based PSO applies to boiler element. Designing Coordinated PID controller as well as tuning parameter through the use of PSO, the results obtained that controller offers more efficient performance for the regulatory and servo responses.

The main goal of this study is to control the variable, temperature, regarding the boiler through using intelligent techniques (PID, PSO, ANFIS).

2. Intelligent Control Techniques

2.1 Particle Swarm Optimization Method

PSO can be defined as a method for optimizing difficult numerical function by recruit or metaphor the social behavior of fish schools and flocks of birds. The most important PSO algorithm is founded by simplifying the social simulation model. The algorithm was planned the first time to emulate birds search for food which is simulated to be a cornfield vector. The bird would find food through united cooperation among birds. Then, expand to contain multidimensional search. In PSO algorithm, each particle in swarm appears to be as a result of the trouble and it is resolute by its velocity and position. For numbers of variable (n) in the optimization problem, particle's flock will be placed in equal number of the dimensional of search space with random selection positions and velocities in order to know their best magnitude for determining (P_{best}) the greatest speed value and location in the specified dimensional space throughout the random movement of each part and at each iteration. Or, the velocity of both particles is fitted as to its own flying test and another particles flying experiment.
particle will be specified, as:

$$x_i = (x_{i,1}, x_{i,2}, x_{i,3}, \ldots\ldots..x_{i,n}) \quad (1)$$

In n-dimensional space, most excellent previous position of the particle is:

$$P_{best_i} = (P_{best_{i,1}}, P_{best_{i,2}}, \ldots\ldots P_{best_{i,n}}) \quad (2)$$

The adapted velocity and position of both particles can be considered using the current velocity and distance from ($P_{best_{i,d}}$) to (g_{best_d}) as shown in the formula as:

$$V_{i,m}^{(It.+1)} = W * V_{i,m}^{(It.)} + c_1 * r\,and * \left(P_{best_{i,m}} - x_{i,m}^{(It.)}\right) + c_2 * r\,and * \left(g_{best_m} - x_{i,m}^{(It.)}\right) \quad (3)$$

$$x_{i,m}^{(It.+1)} = x_{i,m}^{(It.)} + v_{i,m}^{(It.)} \quad (4)$$

Where:

I	1, 2, 3,……, n.
M	1, 2, 3,……, n.
N	Number of particles.
D	Dimension.
Iter	Iterations pointer.
$V_{i,m}^{(It.)}$	Particle (no. i) velocity at iteration It.
W	Inertia weight factor.
c_1, c_2	Acceleration constant.
rand	Random number between 0–1.
$x_{i,m}^{(It.)}$	Particle i current position at iteration It.
P_{best_i}	Best previous position of particle.
g_{best_m}	Best particle among all particles in population.

The Integrated of Time Weight Square Error (ITSE) is used for evaluating the coefficients[1,2,7].

$$ITSE = \int_0^t t.e^2(t)\,dt \qquad (3–5)$$

2.2 The Adaptive Network based Fuzzy Inference System (ANFIS)

Such system has been carried out via Jang and applies the fuzzy interference system of Takagi–Sugeno–Kang (TSK). The square nodes in the construction of ANFIS indicate certain limitation set regarding the membership functions of TSK fuzzy system. The circular nodes have been non–modifiable/static and provided operations including produce or max/min calculations. Hybrid learning rule will be utilized for increasing the speed of parameter adaption. It uses the sequential least square in forward bypass for identifying the consequent parameters, and back-propagation in backward pass for setting up basis parameters.

2.3 Genetic Algorithm based PID Controller

Genetic Algorithms (GA) applied to analyze a range of engineering problems through implementing GA in PID tuning. The recognized PID control approach was indicated to be important method because it is inexpensive, maintained easily and simple in control design. Majorly, there are 3 separate variables in PID controller: Proportionality (kp), integral (ki) and derivative values (kd). Appropriate setting regarding such variables is going to enhance the system's dynamic response, reduce overshoot, remove the steady state error and improve the system's stability[8]. In the Figure 1, the most important constriction regarding PID control system will be seen. The set point was changed, error is going to be calculated between real output and set point. Error signal, E(s), will be utilized for producing integral, proportional and derivative actions, as the signals which have been resulted will be weighted and summed for creating control signal, $U_C(s)$, utilized to specific model. After that, obtaining new output signals. The new real signal is going to be emitting to the controller and the error signal will be calculated again. The new control signal, $U_C(s)$, is going to be sent to plant. Such proves is going to be run constantly until the steady – state – error come close to zero. The Figure 2 indicated PID control system.

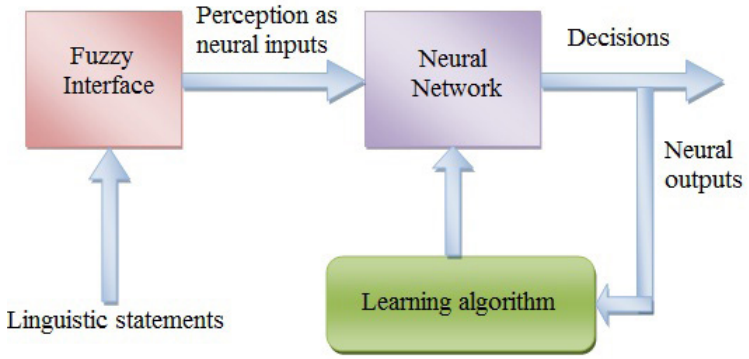

Figure 1. General structure of neural fuzzy system.

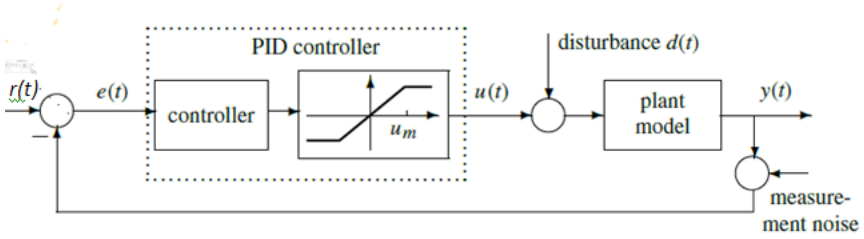

Figure 2. PID control system.

3. Simulation Models of Parameters of Boiler

3.1 Simulation Models of Temperature

Temperature generate from boiler are similar to entering the turbine. In the case of data attainment, indicate that temperature must be below 550°C for avoiding damage. The Figure 3 displays simulation models of temperature.

3.2 Simulation Models of Pressure

After obtaining the real values of the station it found that the suitable pressure for boiler is less than 140 bar so it was employ intelligent technique. The Figure 4 depicted simulation models of pressure.

4. Results of Simulink Model

Figure 5 shows the temperature increase with time of the boiler in Al-Dura power plant using (PSO, ANFIS, PID). This result give a small setting time in PSO technique than ANFIS, PID. But ANFIS is less overshoting comparter other methods.

Figure 6 shows the pressure increase with time of the boiler and reach to 140 bar or less than to 135 bar. This limit of pressure is suitable with design of boiler appears using (PSO, ANFIS, PID). These results give a small setting time in PSO technique than ANFIS, PID. But ANFIS is less overshooting comparer other methods.

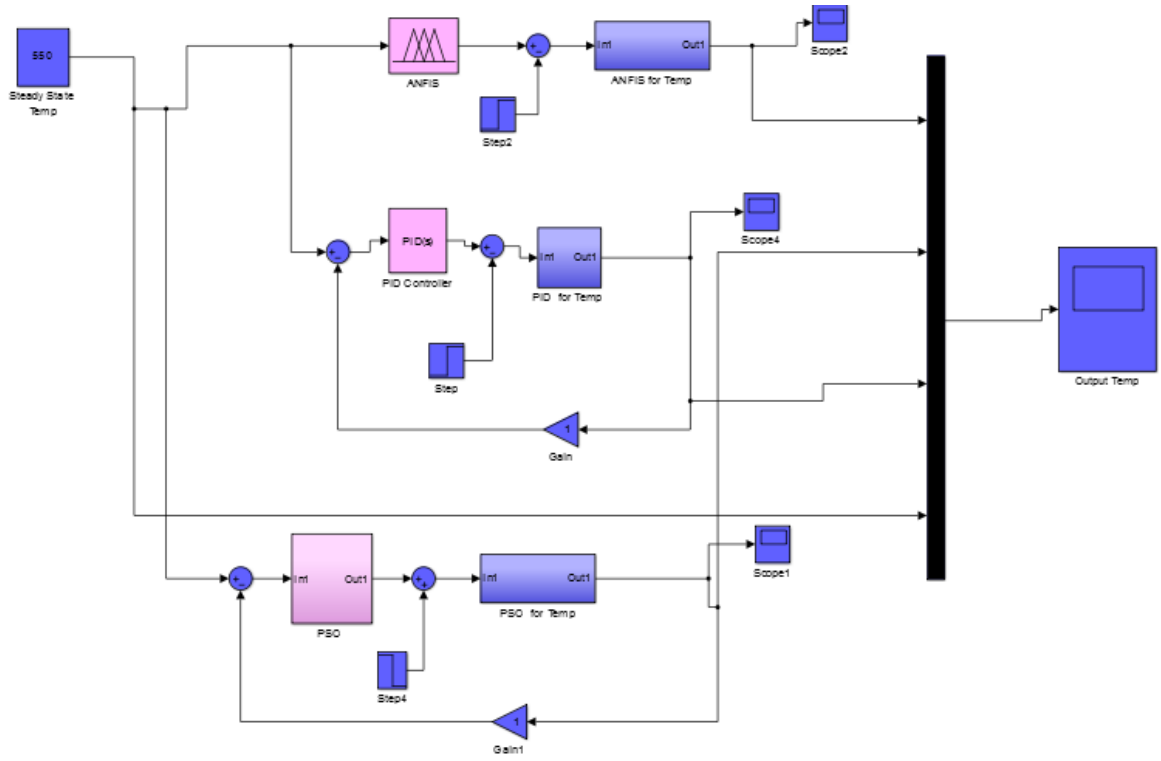

Figure 3. Simulation models of temperature.

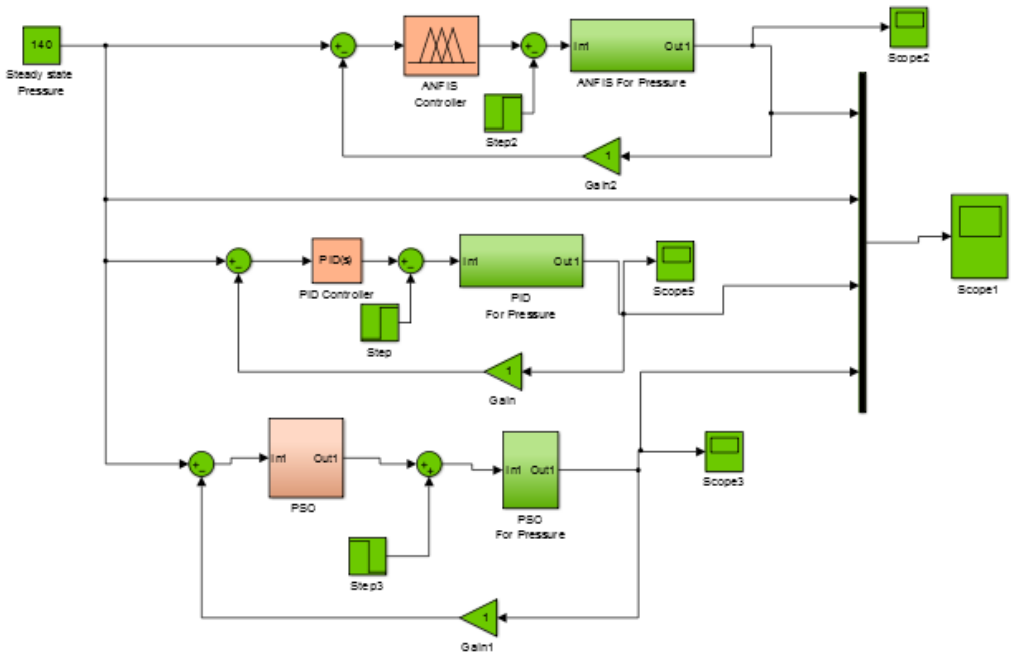

Figure 4. Simulation models of pressure.

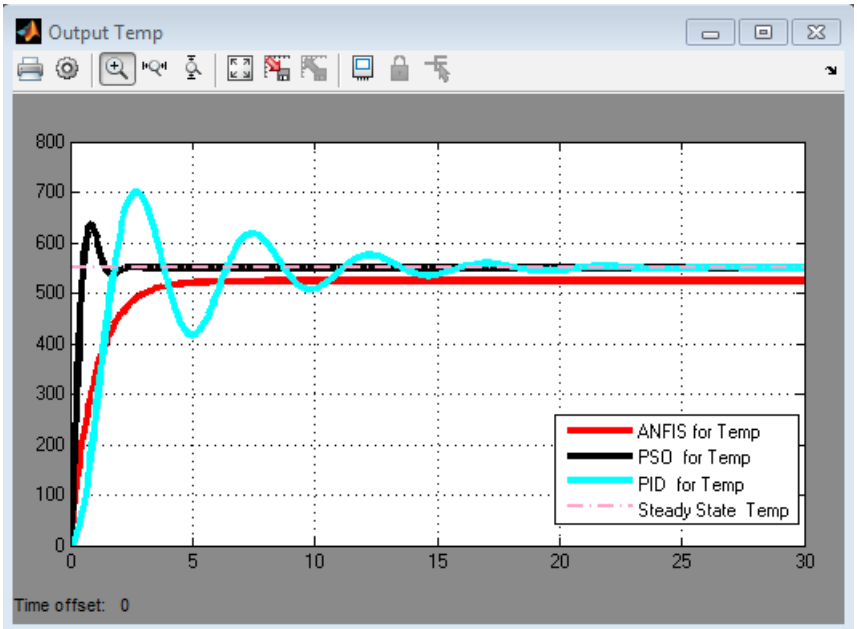

Figure 5. The temperature of the boiler.

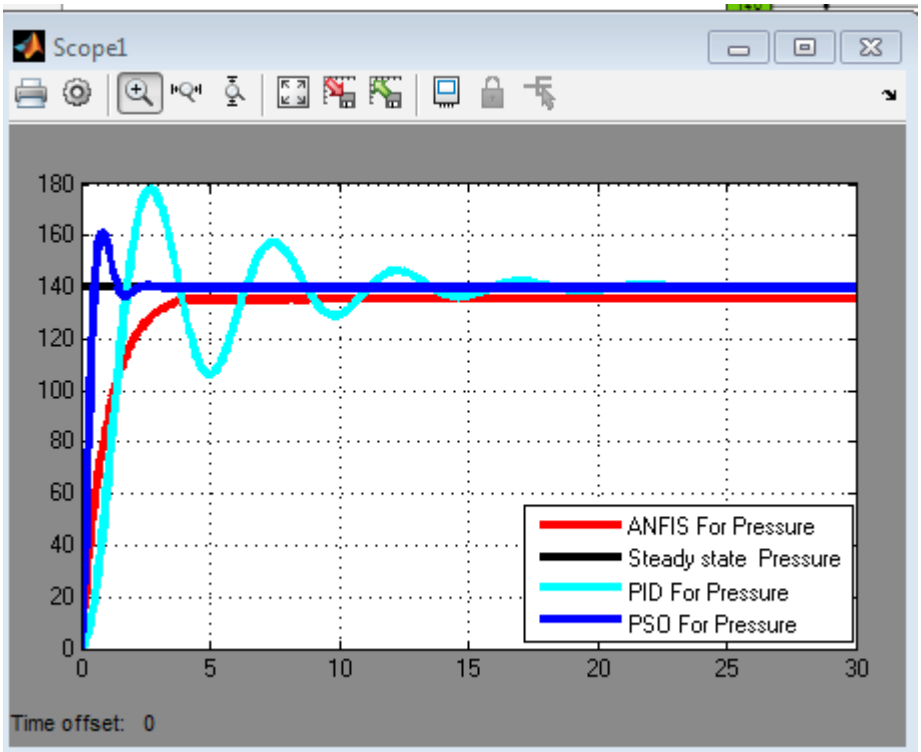

Figure 6. Pressure of boiler.

5. Conclusion

This study applied to Computation intelligence technique to control of temperature and pressure of steam generation. In the presented study, process control case study regarding the boiler was carried out through the use of ANFIS, PID and PSO. Initially, mathematical model regarding the system will be created and traditional PID controller, ANFIS, PSO will be applied in it. When comparing with PSO, PID, ANFIS controller, it is indicated that such approach have enhanced the dynamic performance regarding the system. PSO can be considered as the most efficient one as it provided optimum robustness and suitable performance. Traditional PSO utilizes only primary math operators and receive efficient results in the static, noisy and nonstop varying environments. All the presented benefits make PSO utilized in more fields of study. Lately, PSO approaches were efficiently utilized in various real-world and engineering problems.

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