COMPARATIVE STEAM TURBINE IN THERMAL POWER PLANT BETWEEN HYBRID MODEL (ADAPTIVE NEURO - FUZZY) ANDPI CONTROLLER

Khalid Faisal Sultan, Hosham Salim Anead and Malak Moneer Younis
Electro Mechanical and Engineering Department University of Technology, Baghdad, Iraq
E-Mail: ksultan61@yahoo.com

ABSTRACT

The research displays a new approach to control dynamic parameters of the steam turbine for thermal power plant AL - Dura (K- 160 -138.7 - 0. 068) using Hybrid(Adaptive neuro fuzzy inference system) and PI to make comparative to get optimization controller between them, by using Matlab - Simulink (2014a). parameters of turbine are input variable of temperature should be 550°C to keep blades, input of speed that's work in steady state is max3000 r. p. m , humidity that's allowed in steady state is 0.12,and pressure that's worked in all sections of turbine begin 140 bar. The performance of ANFIS controller was performed in MATLAB / SIMULINK platform and analyzed in terms of tracking the parameters(Humidity, Speed, Pressure, and Temperature).The simulation results, it was showed that the proposed ANFIS controller was the better solution from PI controller for parameters in steam turbine regulation.

Keyword: hybrid model, ANFIS, neuro - fuzzy, turbine.

1. INTRODUCTION

The type of fuel used to heat to heat water in order to get vapor defines the thermal power plant in Iraq, such as coal, oil. Furthermore, creating the steam requisite to run a thermal plant can be achieved by using solar and Nuclear power. Rotary engine (turbine) power station fundamental operations of an easy to evaporate rotary engine turbine are illustrated as follows, Figure-1 Note that the saturated water enters the feeding pump and press it to enter the steam generator (boiler) to be heated again and get to the degree of vapor at elevated temperature and pressure and then enter the turbine. External work rotates the turbine where the mechanical energy is converted to electrical energy. The wet steam leaves the turbine and passes through the condenser where the pressure is lower than atmospheric pressure to help steam condense as it becomes saturated water through the cold water of the river. This station operates on a partially closed loop and is known as the Rankine Cycle [2].

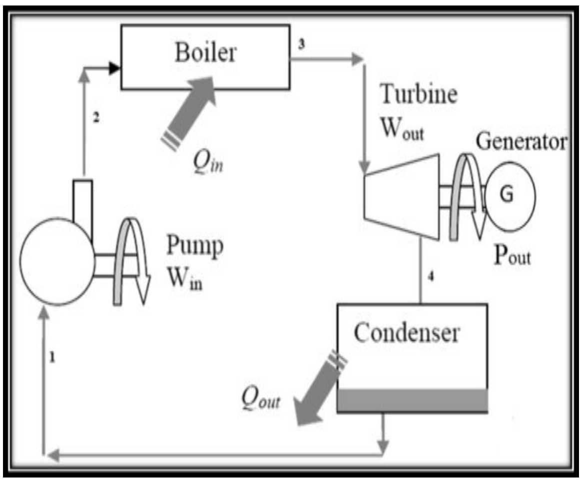

Figure-1. Rankine cycle [1].

The rankin cycle can be enhanced by putting a reheated or extraction to increase the temperature, thus increasing the thermal efficiency of the cycle. The steam, which has lost part of the energy in the high stage of the turbine, enters the reheated to raise the temperature and then enters the intermediate stage of the turbine.; however it will increase the wetness content of the steam to undesirable level other refinement of thermal efficiency to a large range of steam plants is accomplished by bleeding of feed water heaters (FWHS).Regeneration not only develops cycle efficiency, it also assists control the large size flow rate of the steam at the last stages of the turbine (due to the large specific volume at low pressure) [3]. The idea of this paper is used to control the Turbine parts through the basic parameters (humidity - Temperature - pressure - speed), by using the control Neuro-fuzzy, Where it was built by the model of mathematical in the Matlab, which was obtained more accurately and fast to stability compared to the PI.

2. STEAM TURBINE PLANT COMPONENTS

The steam rotary engine is kindled with warmth engine that drives a lot of its improvement in thermo dynamical efficiency from the use of multiple stages in the enlargement of the steam that results in a nearer method of the ideal reversible enlargement method. There are several dynamic models for every part of turbine, as simple empirical relations between system variables are often valid for the steam rotary engine to use actual system responses. Steam turbine power plant (T–160–138.7 –0. 068) the consists of HP, IP and LP turbines. System configuration is shown in Figure-2.

VOL. 13, NO. 18, SEPTEMBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

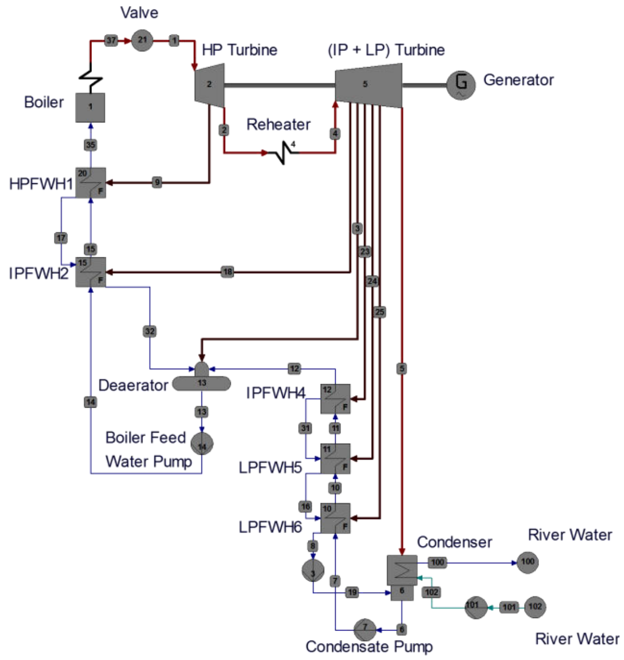

Figure-2. Thermal power station construction (cycle - Tempo) (T - 160 -138.7 -0. 068).

The system contains six feeds bleeding another supplementary system as Illustrates Figure-2. One closed feed water heaters of HP stage turbine. The second stage of turbine IP consists of three feed water heaters (IPFWH_S), one open feed heater / deaerator and two closed feed water heaters. Final stage consists of two LP closed feed water heaters (LPFWH_S). Water condensate exit from condenser pushes by pump to re - heated in feed heaters .The output power has controlled via a control valve of steam flow.

2.1 High pressure turbine

Steam turbine unit is6 of AL - Durastation could be a principal installation from the thermoelectric power plants, origin Germany. In thermal sketch of the thermoelectric power plants, show in Figure-3.

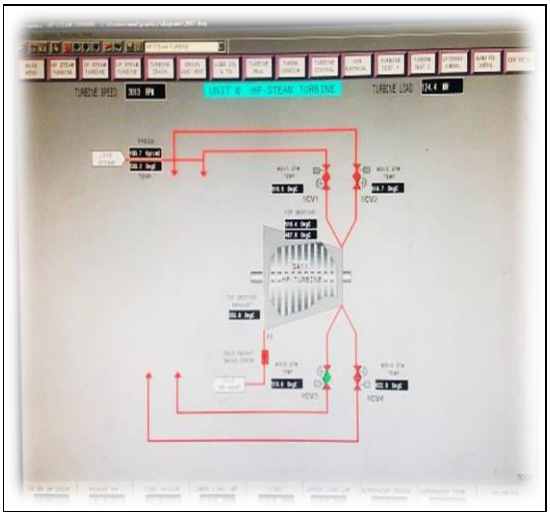

Figure-3. High turbine in unit6 Al - dura power plant.

To explain changes within operative conditions, mass flow must be constant across high pressure turbines through a complete set of stages. This implies that so as to explain demeanor of the whole rotary engine. Many interconnected sections will be necessary.

2.2 Intermediate and low pressure turbine (rotary engine)

The turbine of intermediate and low pressure sections is additional advanced in contracture than HP. Much bleeding points are used to improve plant efficiency. Through the turbine phases, the heat will be cancelled and this will lead to the effect of condensation and the quality of steam, which will affect the performance of the rotary engine. Model for the IP and LP turbine is shown Figures 4 & 5.

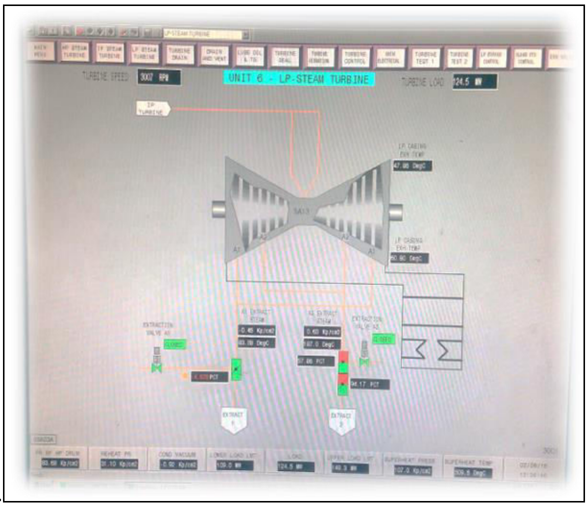

Figure-4. Low turbine in unit6 Al - dura power plant.

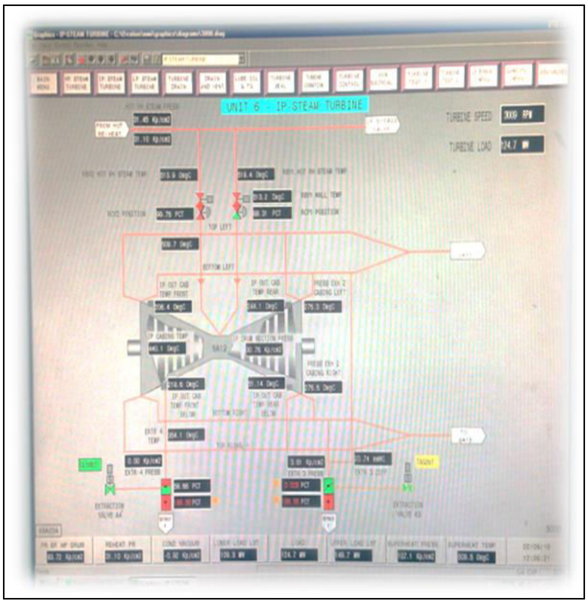

Figure-5. Intermediate turbine in unit6 Al - dura power plant.

VOL. 13, NO. 18, SEPTEMBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

3. PID CONTROLLER

The PID contains three basic things a proportional controller - integrated - derivative where feedback mechanism is considered loop control and variety for optimal response in short, the idea of this algorithm is to treat error, error as showed in the equation the difference between the change process and the control point. Error = PV - SP

These three modes are used in different groups:

- P - some times used ● PI - most commonly used
- PID - Used some times● PD - very rare and useful for motor control.

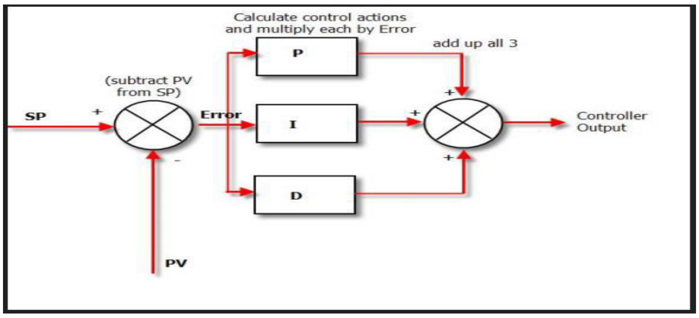

Figure-6. PID control structure.

4. THE SIMULATION OF ROTARY ENGINE

The simulation model would be organized in terms of pressure, temperature, speed, and constant humidity. The model training operation is compared through joining MATLAB (2014a), between controller by using Hybrid (neuro - fuzzy inference system) and PI controller to obtain optimization controller. Figure-7. Show Simulation ANFIS steam Turbine AL-Dura power plant. Figure-8. Show structure simulation of turbine ANFIS controller.

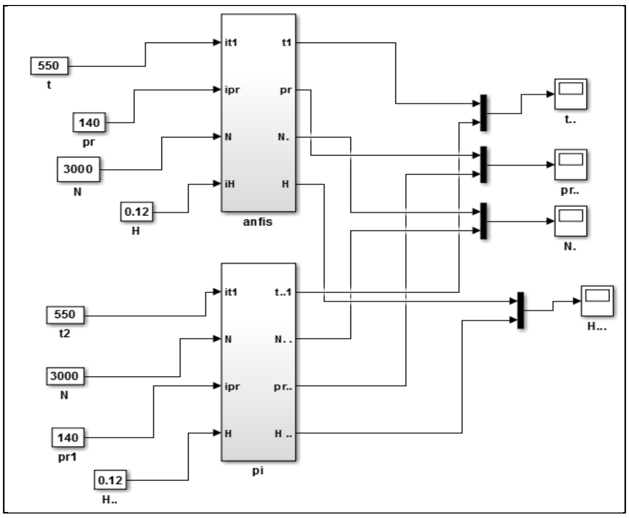

Figure-7. Simulation ANFIS steam turbine Al - dura power plant.

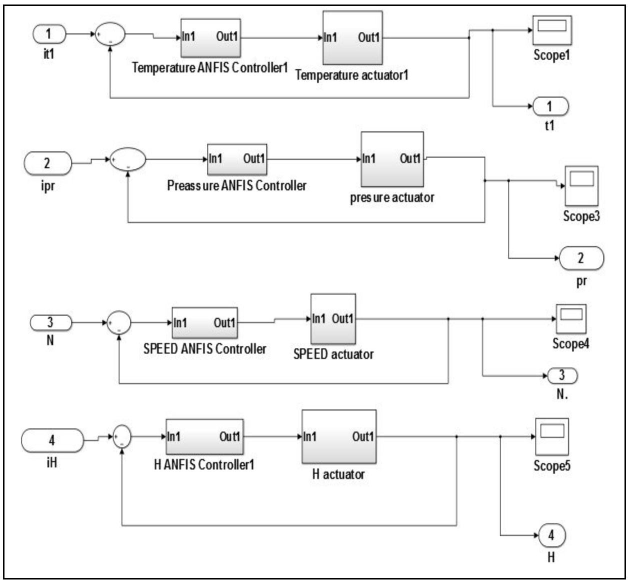

Figure-8. Structure simulation of turbine ANFIS.

5. ANFIS MODEL

Mysterious neural modeling is involved with determine the samples of the numeric data that are running system behavior. This type of modeling has two Purposes: Firstly, to prepare a model allows for control and possibly predicts a way unknown system. Secondly, to supply a model for superior understanding of the system. The model is based on rules, the use of the formal form of (FL), i.e. Consisted of groups of mysterious "if - then " rules. The ability to benefit from feeding forward networks support bleeding if model The architecture of the network, once properly, may To rules without losing information. Many have studied this idea accurately the authors began with the beginning of the 1990s, [4 - 8], remains important Research area. Anfis is available in MATLAB [9].

VOL. 13, NO. 18, SEPTEMBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

6. TURBINE ANFIS MODEL

In thermal scheme of the thermoelectric power plants when training data Humidity, Temperature, Speed, and Pressure exist types of membership function (triangular, trapezoidal, bell shaped, Gaussian). A lower error rate would be the best type. As showed in the table error training shown below:

Table-1. Training error.

Parameter of turbine	Best linear function	Average error	Type of Mf	N. layer	N. Epoch
Humidity	Bell	0.0005	constant	6	10
Temperature	Gaussian	0.0098	linear	6	50
Speed	Triangular	0.0972	constant	6	100
pressure	Triangular	0.0002	linear	6	50

7. RESULTS AND DISCUSSIONS (SIMULATION ANALYSIS)

This paper uses Humidity, Temperature, Speed, and Pressure model of a turbine in a power plant AL - Dura of Iraq as the controlled object. Simulate the adaptive neural fuzzy network controller (ANFIS) by Matlab/Simulink (2014Ra). In the Humidity, Temperature, Speed, and Pressure cascade control system. The simulation results are shown in Figures 9, 10, 11, 12, 13, 14, 15, 16 and Table-2.

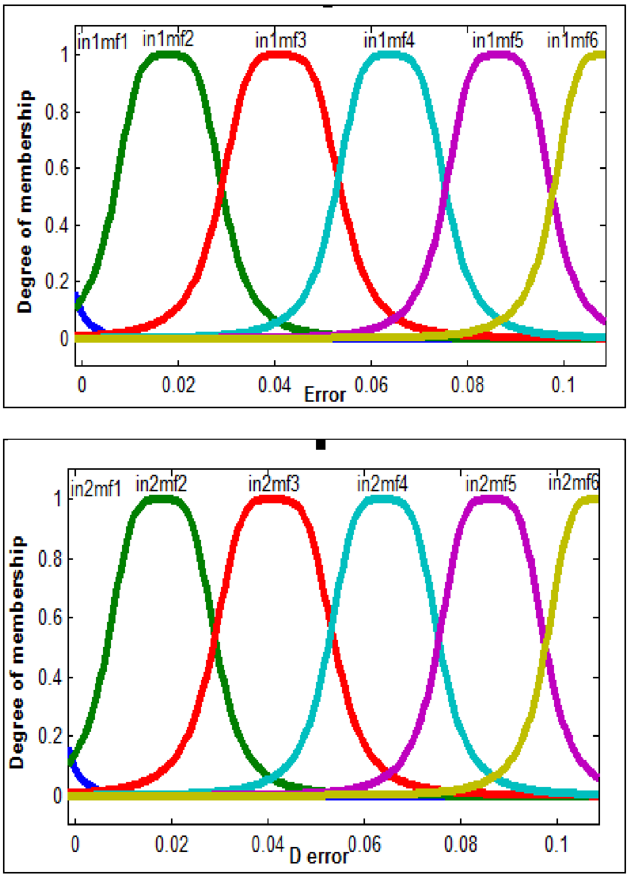

Figure-9. Humidity of membership function plot.

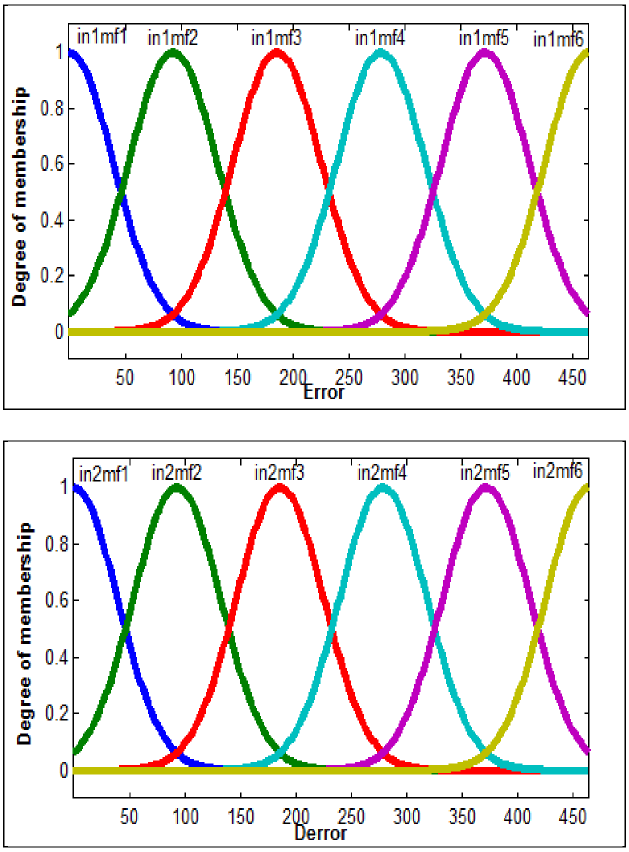

Figure-10. Temperature of membership function plot.

VOL. 13, NO. 18, SEPTEMBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

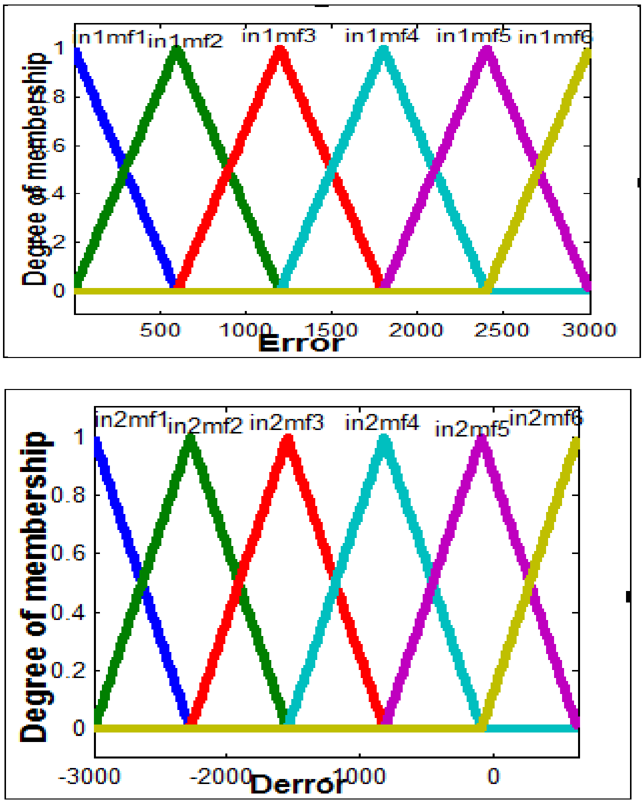

Figure-11. Speed of membership function plot.

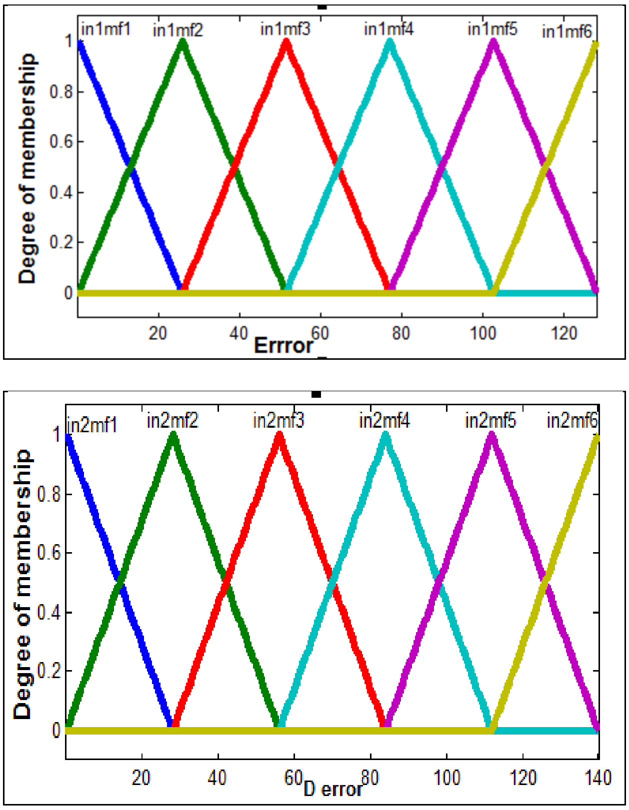

Figure-12. Pressure membership function plot.

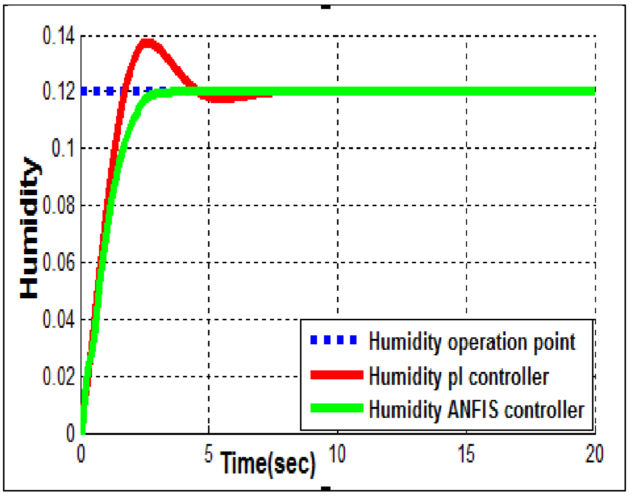

Figure-13. State response curves humidity.

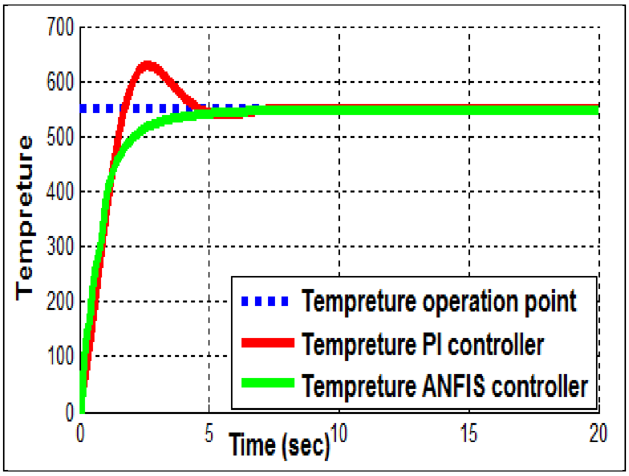

Figure-14. State response curves temperature.

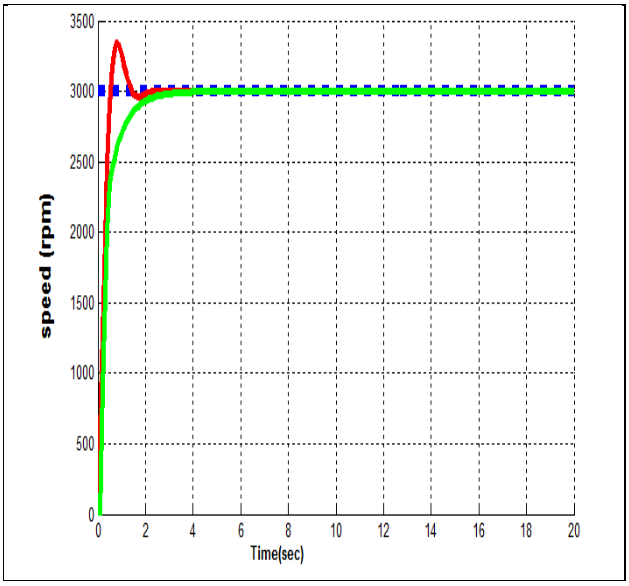

Figure-15. State response curves speed

VOL. 13, NO. 18, SEPTEMBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

The performance graphs are shown in Figures 13, 14, 15 and 16. The ANFIS controller tracked parameters accurately and within the short period of time. This shows the accurate performance of the proposed controller in tracking this parameters thus good regulation, compared with PI controller and it shows in that, the performance of the PI controller is having large overshoot and more time than ANFIS controller for first peak, as show in Table-2.

Table-2. Comparison parameters between ANFIS and PI.

Parameter	**Rise time** (sec)	**Settling time** (sec)	**Overshoot**	**Peak**	**Peak time** (sec)
Speed(N)					
ANFIS	0.980	2.7405	0	3000	20
PI	0.398	1.3002	11.59	3347	0.8
Humidity					
ANFIS	1.764	2.5948	0	0.12005	18.8
PI	1.28	4.3419	13.915	0.1367	2.7
Temperature					
ANFIS	1.8137	4.2284	0	548.4	20
PI	1.267	6.091	15.68	636.24	2.7
Pressure					
ANFIS	2.8087	5.1472	0	138.19	20
PI	1.292	4.3477	13.22	158.52	2.7

In the proposed system's SIMULINK model, the parameters of the turbine are given as step functions. Now, execution of the suggested controller is analyzed to different set main parameter of steam turbine in the power plant AL - Dura of Iraq.

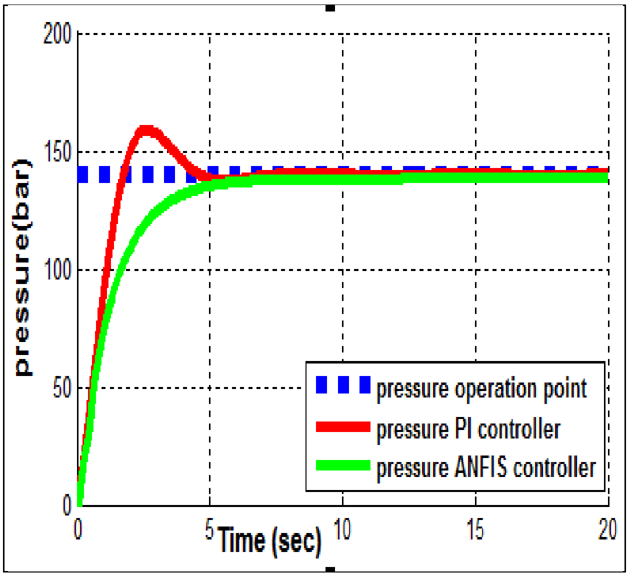

Figure-16. State response curves pressure.

For this purpose, the humidity, speed, pressure, temperature regulations by ANFIS controller is checked for points of step input for size of 0.12, 3000, 140, 550 respectively.

8. CONCLUSION ON ANFIS CONTROL

a) In the paper, regulation of parameters (Humidity, Speed, Pressure, and Temperature) in steam turbine in power plant AL - Dura of Iraq was achieved by ANFIS controller.

b) The error and change of error between the set value and actual of each parameter were given as input and the actuator control valve was taken as output.

c) From the determination of valve point by ANFIS controller, parameters of turbine were regulated.

d) The performance of ANFIS controller was performed in MATLAB / SIMULINK platform and analyzed in terms of tracking the parameters (Humidity, Speed, Pressure, and Temperature).

e) The performance of the proposed ANFIS controller was compared with PI controllers to show its superiority.

f) The simulation results, it was showed that the proposed ANFIS controller was the better solution from PI controller for parameters in steam turbine regulation.

Nomenclature

Symbol	**Description**
HP	High pressure
IP	Intermediate
LP	Low pressure
FL	Fuzzy logic
KP	proportional
KI	Integral
KD	derivative
SP	Set point
pv	Process variable

ARPN Journal of Engineering and Applied Sciences

REFERENCES

[1] M. Bahrami ENSC 461 (S 11) Vapor Power Cycles. 2016.

[2] British Electricity International. 1991. Modern Power Station Practice: incorporating modern power system practice. 3rd Edition, 12 volume set, New York. Pergamon.

[3] P.R. Sahm, E. Fiender. 1985. Advanced steam turbine power plant technologies and the materials implications. Foundry - Institute, Aachen Institute of Technology, EUR 10040 EN.

[4] S.I. Horikawa, T. Furuhashi, and Y. Uchikawa. 1992. A New Type of Fuzzy Neural Network for Linguistic Fuzzy Modelling. Proc. 2nd. Int. Conference on Fuzzy Logic and Neural Networks, Iizuka, Japan. pp. 1053-1056.

[5] J.S.R. Jang. 1992. Neuro - Fuzzy Modelling: Architecture, Analyses and Applications, PhD. Thesis, University of California, Berkeley, USA.

[6] J.S.R. Jang. 1993. ANFIS: Adaptive Network based Fuzzy Inference System. IEEE Trans. on Systems, Man and Cybernetics. 23(3): 665-685.

[7] J.S.R. Jang and C.T. Sun. 1995. Neuro - Fuzzy Modelling and Control. Proceedings IEEE. 83(3): 378-406.

[8] J.S.R. Jang, C.T. Sun and E. Mizutani. 1997. Neuro - Fuzzy and Soft Computing. A Computational Approach to Learning and Machine Intelligence, Prentice Hall, New Jersey.

[9] 2014. MATLAB®, Fuzzy Logic Toolbox User's Guide, The Math Works.