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EVALUATION THE PERFORMANCE AND IMPLEMENTATION OF FUZZY LOGIC CONTROLLER IN STEAM TURBINE OF THE THERMAL POWER PLANT

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ABSTRACT

For the present, it has been dispensed with the traditional ways using modern methods in a lot of practical industries that require a more accurate control. In this paper, a Fuzzy logic has been applied to control the important variables of steam turbine in AL Dura station in Baghdad that generate (160MW). These controlled variables are pressure, temperature, speed and humidity. Fuzzy requires a data which obtained from actual power plant. This work explains the control on turbine stages during operation in order to make a right decision if any faults occurred during these stages at limit conditions based on fuzzy system. It was used simulation of Fuzzy system in MATLAB program (V 2014 a). The interest of the fuzzy controller that it is fundamentally based on the practical experience of engineer for putting specific values must be appropriate for the system's work within the normal operating limits for control via fuzzy logic and make a right decision when a problem occurs.

Keyword: fuzzy logic controller, turbine, pressure, speed, humidity.

1. INTRODUCTION

Most of the electric energy produced in most countries is from thermal power plants. Thermal power plants share in 65% of the electrical power produced in the world. There are other sources of electric power such as hydro power, geo power, wind power, bio-gas power, etc. At present, the efficiency of this type of stations is few in spite of efforts to improve energy, to meet demand of electrical power produced. The turbine requires an identical construct with thermal power plant [1]. At the present time there is a modern technique called Fuzzy logic controller for improving the performance boiler for increasing the efficiency and productivity of power. Fuzzy logic represents soft computing method for solving problems where classical logic cannot provide satisfying results. Fuzzy logic is multi-value logic derived from theory of fuzzy sets proposed by L. A. Zadeh (1965.). This kind of logic gained success because it makes use of the tolerance for imprecision and uncertainty to achieve tractability, robustness, and low cost solution [2].The fuzzy theory gives a mechanism linguistic constructs such as “many,” “medium,” “low,” “often,” “few.” In general, the fuzzy logic can be able to understand human reasoning. Fuzzy Logic Controller (FLC) has faster and smoother response than conventional

Systems Proportional integrated Derivative (PID) and control complexity is less [3]. In this research FIS will use in Matlab

Program with M - file for controlling of turbine give a proper conditions to operator when happen any problem during operation.

2. DESCRIPTION OF THE PROBLEM

A steam turbine plant of type (K-160-13.34-0.0068) used in this work. This type consists of three stages HP, IP and LP turbines. As well as, the system includes bleeding extractions, feed water heaters and other supplementary system. A boiler is steam generator where the transfer of heat from the combustion chamber to the water then becomes superheated steam. The combustion procedure depends on the kind of fuel used in burner and excess air. A result of high-pressure steam generated makes the size of steam almost 1, 600 times and this produces great force appropriate for moving the blades of turbine. Therefore, the boiler requires more care. Steam output of the boiler is superheated steam at a temperature of 535°C and 13.34MPa pressure enters to the HPT section. A standard boiler room graphics is shown in Figure-1 [4].

3. SYSTEM CONFIGURATION

In this study, fuzzy controller was applied by using fuzzy linguistic expressions instead of the numbers shows the status of the system in order to take the appropriate decision. Fuzzy Inference System consists of fuzzification which includes the input of variables as a membership function. Defuzzification is the other part from FIS which includes the output of variables. The third part represents the rules of the system which is processing the variables for building the control system [5]. As shown in Figure-1.

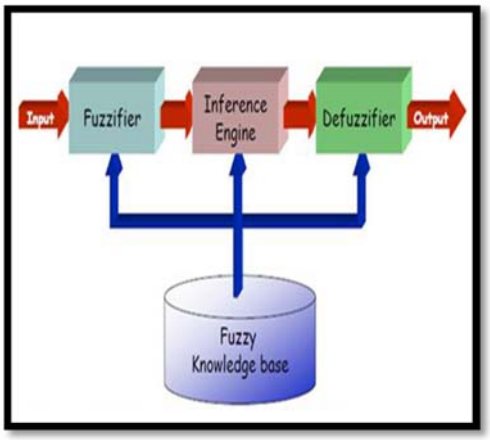

Figure-1. Block diagram of FIS [6].

4. FUZZY SIMULATION

In this study, the control of parameters which effect on turbine is simulated using MATLAB and M - file program according to structure control language that has been obtained within the operating limitations. Based on data obtained from actual station, fuzzy system was built to control important variables for the turbine in the thermal power plant. This system consists of (4 input) of variables, (1 output) for turbine operating status and rules of control, these construct was explained by using MATLAB program as shown in Figure-2.

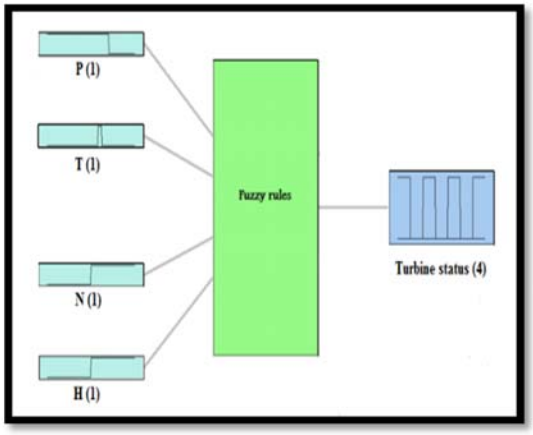

Figure-2. Fuzzy controller 4 input, 1 output, 4 rules.

5. INPUT VARIABLES OF FUZZY CONSTRUCT

There are many variables that affect the operation of the station; are 4 inputs which discussed as follows:

a. Pressure input variable

After obtaining the actual values of the station it found that the proper pressure for steam turbine is less than 140 so it was employing fuzzy logic on that basis, as shown in Figure-3.

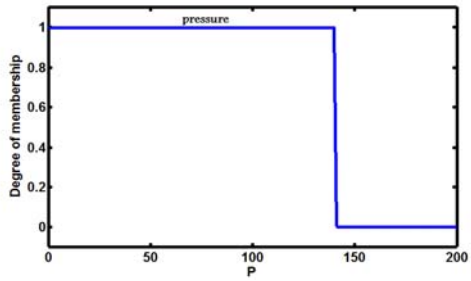

Figure-3. Input membership function of pressure (p).

b. Temperature input variable

Temperature generated from the boiler is show that the temperature should be less than 550℃ to avoid damage. Therefore fuzzy applied in this limit as explained in Figure-4. A safety operation of the steam temperature before reaching the maximum peak to avoid the fault before it occurs.

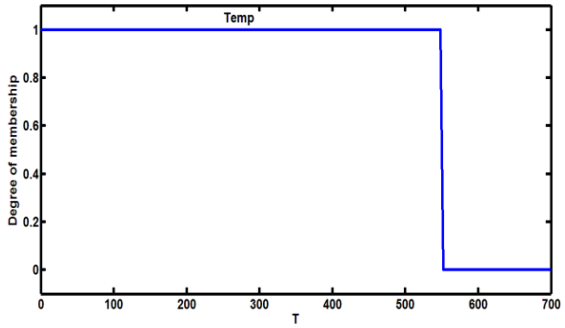

Figure-4. Input membership function of temperature (T).

c. Speed input variable

Of the most important factors directly linked to the generator to produce electrical power in generator [6]. The speed depends on amount of steam that enter turbine across mechanical valve which controlled by fuzzy decision when the speed exceed 3020 r.p.m as shown in Figure-5.

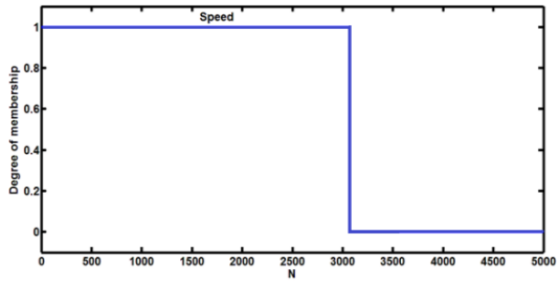

Figure-5. Input membership function of speed (N).

d. Humidity input variable

Steam inside the turbine must be superheated appropriate degree of rotary blades and the wall, while avoiding humidity on the inside because it causes

corrosion and crash parts of the turbine so it must be 0.12, fuzzy has been applied for this value as in Figure-6.

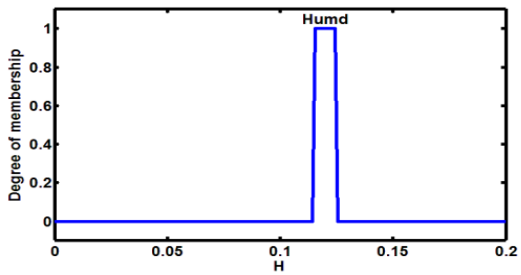

Figure-6. Input membership function of humidity (H).

6. OUTPUT OF FUZZY CONSTRUCT

The output of Fuzzy inference system has been contained turbine conditions to save operation in right direction. As shown in Figure-7, this explains the checking process to avoid any problem that may occur. These figures have been obtained from M-file program in matlab after simulation.

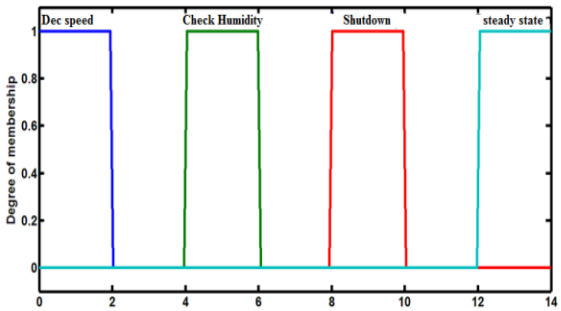

Figure-7. The output of FIS for turbine status.

7. RESULT AND DISCUSSIONS

The fuzzy system for boiler variables is simulated using MATLAB and too verified by using M - file Program. Membership functions are subject to a 4 rules during the procedure, which included the If - then method which based on the limit conditions for the work of the turbine for the purpose of control [7], as shown in Figure-8. This method can be expressed by using general formula as follows [7]:

If x_1 is A_1 and x_n is A_n , then $y = f(x_1, x_2, \ldots\ldots\ldots, x_n)$…(2)

Where: x and y are linguistic variables. The section "x is A" is called premise part, while section "y is B" is called conclusion part. A and B represents the linguistic values.

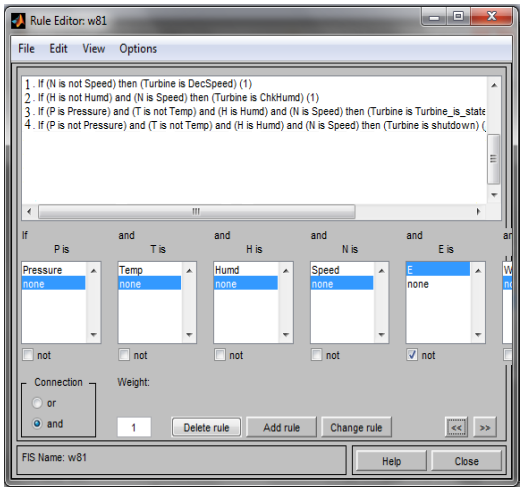

Figure-8. The graph of Fuzzy rules in the proposed FIS.

The value for which the zone under the graph line of the membership functions is divided with equally. This procedure is called a center of gravity defuzzification process as shown in Figure-9. The efficiency of FIS depends on the process of defuzzification and type of input mfs .However, the variables of mfs and area can be adjusted to enhance efficiency of the whole system. The surface for turbine speed of membership function can be shown in Figure-10.

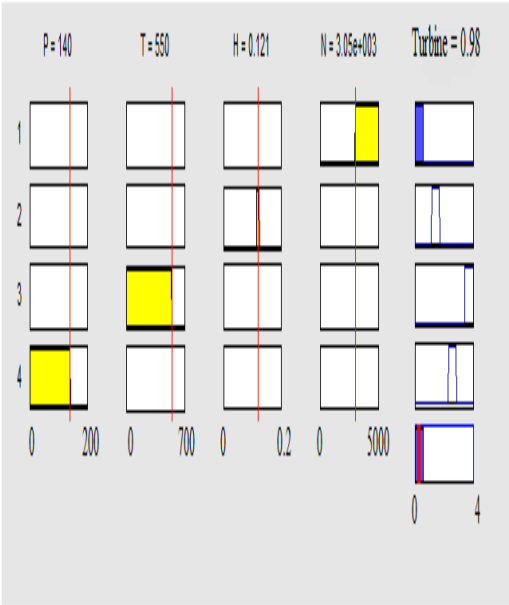

Figure-9. Center of gravity defuzzification method.

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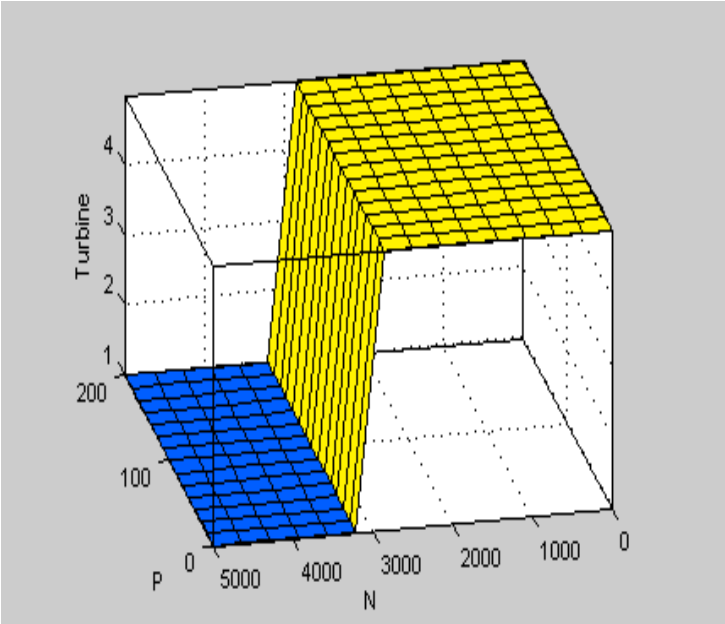

Figure-10. The surface of turbine speed.

Table-1. Decision table for turbine system.

Variables decision	Weights				
	L^+	L	M	H	H^+
Pressure P (bar)	**(1.1, 1.2) Stop Tur.**	**(1.2, 1.3) Inc. p**	**(1.3, 1.4) Steady state**	**(1.49, 1.5) Dec. P**	**(1.5, 1.6) Stop Tur.**
Temperature T(°C)	(5, 5.2) Stop Tur.	(5.2, 5.3) Inc.T	(5.3, 5.5) Good values	(5.5, 5.7) Dec.T	(5.7, 6) Stop Tur.
N (r.p.m)	(2.21, 2.24) Shutdown	(2.24, 2.27) Inc.N	(2.27, 3.03) Good values	(3.03, 30.6) Dec.N	(3.06, 3.09) Shutdown
H	(0.9, 0.1) Check H	(0.1, 0.11) Check H	(0.12, 0.13) Good values	(0.13, 0.14) Check H	(0.14, 0.2) Check H

8. CONCLUSIONS

The application of the fuzzy logic for the procedure control is one of the best methods for the automation engineer to construct the controller by himself based on his knowledge and experience in the plant .In the present, the nonlinear and unstable procedure make Fuzzy logic controller at the beginning of modern technological because of the difficulty of controlling via the method traditional. The interest of the fuzzy controller that it is fundamentally based on the practical experience of engineer for putting specific values must be appropriate for the system's work within the normal operating limits for control via fuzzy logic and make a right decision when a problem occurs.

Figure-10 represents the surface of turbine speed. Most of the previous studies included simulation of fuzzy logic using computer programs with the traditional PID method and compared the results between them, in this article use the technique of fuzzy logic with MATLAB program Simulink to control 4 variables for turbine. Table-1 explains the range of values for each variable that obtained from experts in the plant. This table called decision table which give different case for system variables in order to show operator what is optimum case for operation. Scale has been taken for variables.

Nomenclature		
FIs	Fuzzy inference system	–
mfs	Membership functions	–
FLC	Fuzzy logic controller	–
H	Humidity	–
T	Temperature	^{0}C
P	Pressure	bar
N	Speed	rpm
L^+	Very low	–
L	Low	–
M	Medium	–
H	High	–
H^+	Very high	–

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