HYDRO ELECTRIC POWER DAM CONTROL SYSTEM USING FUZZY LOGIC

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ABSTRACT

This research presents the construction design of Hydro-Electric Power Dam Control System using Fuzzy Logic. In this design two input parameters: water level and flow rate and three output parameters: release valve control, drain valve control and penstock switching are used. This proposed system uses a simplified algorithmic design approach with wide range of input and output membership functions. The hardware of control system for fuzzifiers and defuzzifiers is designed according to the need of system. The proposed simplified algorithmic design is verified using MATLAB simulation and results are found in agreement to the calculated values according to the Mamdani Model of the Fuzzy Logic Control System.

***Keywords* - Fuzzy Linear Programming, Fuzzy Set Theory, Irrigation Planning, Linear, Programming, Optimization**

I. INTRODUCTION

The modern-day technologies in the areas of information storage and retrieval, web search, image processing, control, pattern recognition, bio information and computational biology, e-markets, autonomous navigation, and guidance are benefited using fuzzy sets. An integrated framework sustaining a variety of facets of human-centric computing is developed by means of fuzzy sets. The current trends of information technology have proved that the increasing level of intelligence, autonomy and required flexibility comes true with the increased human centricity of resulting results. The holistic view covers concepts, design methodologies, and algorithms with interpretation, analysis, and engineering knowledge. The computing systems are based on predefined models of two-valued logic and human information processing, concerned with two distinct words. In order to communicate between these two words we need to develop an interface. This is the key motivation behind the emergence of human-centric systems and human centric computing [1].The construction of a dam is necessary for the electric power generation, flood control, irrigation system, metropolitan and industrial water supply. Different kind of methods have been introduced and implemented to control the hydroelectric power dam due to non-deterministic behavior of water parameters such as flow rate and release etc. [2].Fuzzy Set Theory along with its membership functions was implemented to the Fairbairn reservoir in Emerald, Central Queensland, and Australia where fuzzy rules were generated with explicit recognition of storage volume non-specificity in the discrete Stochastic Dynamic Programming (SPD) [3].Fuzzy dynamic programming model was used for Hirakud dam in the State of Orissa in India in which irrigation; hydropower generation and flood control were considered as fuzzy variables [4].The neural network and fuzzy systems were also adopted for dam control in which a comparison was made between reservoir operations using the fuzzy and neural network systems and actual one by operator, using examples of floods during flood and non-flood seasons [5].Reports show that hydroelectric dams produce 20 percent of the world's total production of electrical energy. The development of a hydro-electric power dam control system based on fuzzy logic with two inputs and two outputs. Using water level and flow rate measuring devices for feedback control, and two control elements for draining and valve controlling (release), and formulated fuzzy rules for water level and flow rate has been achieved.To control the water release, the controller reads the water level and flow rate after every sampling period. This proposed design work of Hydro-Electric Power Dam System is the application of fuzzy logic control system consisting of two input variables: water level and flow rate, and two output variables: Drain valve and (Releasing) Valve control used in a reservoir plant of Hydro-Electric Power Dam to monitor the system of Dam.

II. BASIC STRUCTURE OF THE PROPOSED HYDRO-ELECTRIC POWER DAM

The main parts of the proposed hydro-electric power plant are shown in Fig.1. Upper lake where water is stored presents the water level. The greater the vertical distance b/w the upper and lower lakes, the more is the generation of electricity. In order to release or block water, a control valve is used according to the need. Water on releasing from the dam gets to the blades of the turbine all the way through the penstock. Its slope and thickness determines the efficiency of the dam. Turbine produces electrical energy and water released from the turbine is released to lower lake where the drainage system is brought into action according to the requirements [6].

The schematic diagram of the proposed hydro-electric power plant is shown in Fig.2. Water level and flow rate devices are used to monitor the status of water in the plant which is connected with the two fuzzifiers of the fuzzy logic control system after suitable amplification and voltage adjustment unit. Two outputs of defuzzifiers are the releasing control valve and drainage valve.

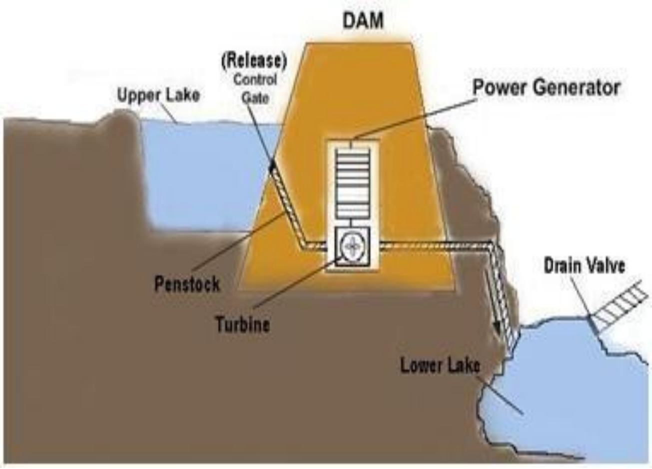

Fig.1 Arrangement of proposed hydro–electric power system

III. DESIGN ALGORITHM

The algorithm designed for this system consists of three fuzzy input variables. Five triangular membership functions are equally determined over a scale range of 0 m to 20 m for the water level and $0(m^3s^{-1})$ to$100000(m^3s^{-1})$ for flow rate inputs. The five fuzzy membership functions for water level input are termed as: very low 0-5 m, low 0-10 m, below danger5-15 m, danger10-20 m and above danger15-20 m. The five fuzzy membership functions for flow rate input are: very slow $0m^3s^{-1}$ -$25000m^3s^{-1}$, slow $0m^3s^{-1}$-$50000m^3s^{-1}$, normal $25000m^3s^{-1}$-$75000m^3s^{-1}$, fast $50000m^3s^{-1}$-$100000m^3s^{-1}$, and very fast $75000m^3s^{-1}100000m^3s^{-1}$. Three outputs of this proposed system are: (release) control valve and drainage valve. The control valves for release and drainage output variables consist of five membership functions: fully closed 0-5, 25% Opened 0-50, 50% Opened 40-60, 75% Opened 50-90 and fully Opened 70-100. Two triangular membership functions are equally determined over a range of 0 to 1 for third output variable Penstock.

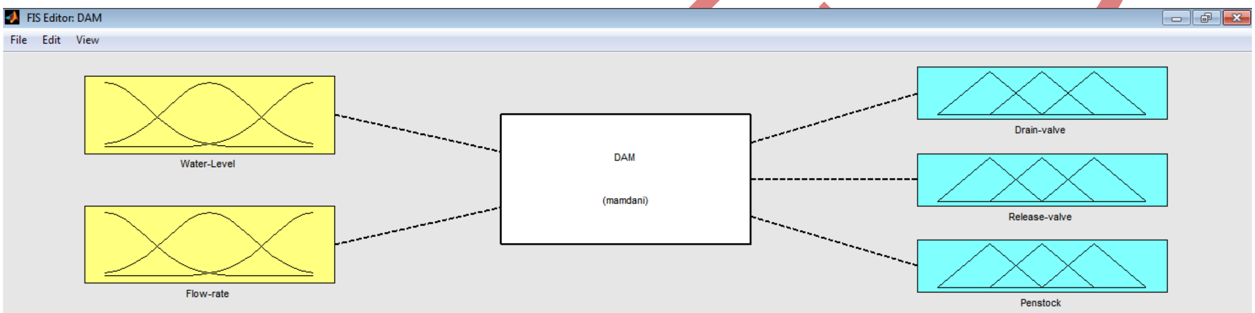

Fig. 2 Block Diagram of Hydro-Electric Power Dam fuzzy control system in FIS Editor.

Membership Function (MF)	Ranges	Region Occupied
Very Low	0-5	1
Low	0-10	1-2
Below Danger	5-15	2-3
Danger	10-20	3-4
Above Danger	15-20	4

Table 1 Membership Functions And Ranges Of Input Variable Water Level (M)

Membership Function (MF)	Ranges	Region Occupied
Very Slow	0 -25000	1
Slow	0-50000	1-2
Normal	25000-75000	2-3
Fast	50000-100000	3-4
Very Fast	75000-100000	4

Table 2 Membership Functions And Ranges Of Input Variable Flow Rate (M^3/S)

Membership Function (MF)	Ranges	Region Occupied
ON	0-1	1
OFF	1-0	2

Table 3 Membership Functions And Ranges Of Input Variable Penstock

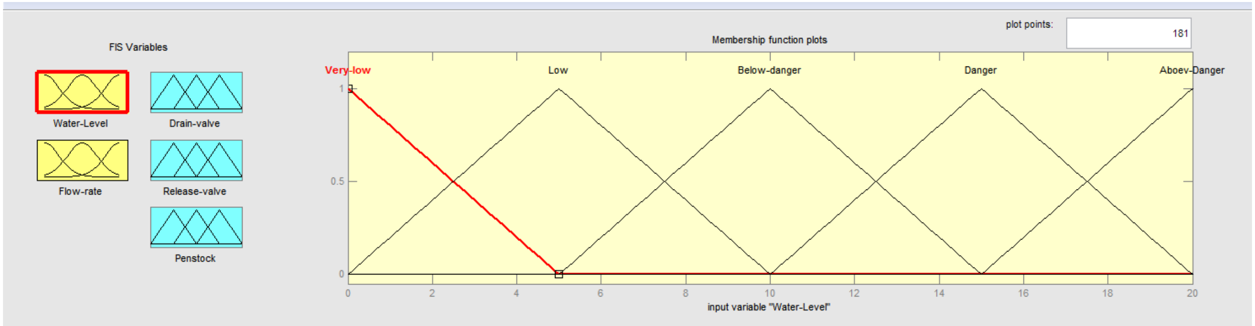

Fig.3 Plot of membership functions for input variable, "WATER LEVEL"

The five membership functions, "very low", "low", "below danger", "danger" and "above danger" are used to show the various ranges of input fuzzy variable "WATER LEVEL" in a plot consisting of four regions as shown in Fig. 3.The five membership functions, "very slow", "slow", "normal", "fast" and "very fast" are used to show the various ranges of input fuzzy variable "FLOW RATE" in a plot also consisting of four regions as shown in Fig. 4

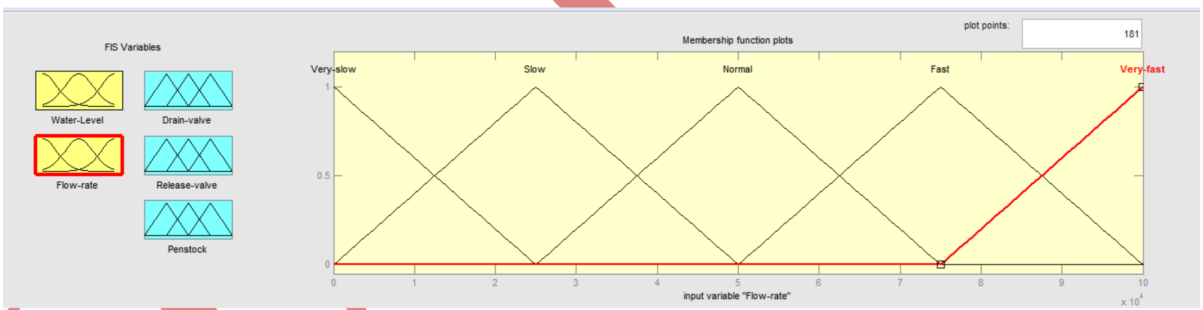

Fig. 4 Plot of membership functions for input variable, "FLOW RATE"

MFs	Range	Release(Valve)	Drain Valve	Penstock
MF1	0-5	Fully Closed	Fully Closed	ON
MF2	0-50	25% Opened	25% Opened	ON
MF3	40-60	50% Opened	50% Opened	OFF
MF4	50-90	75% Opened	75% Opened	OFF
MF5	70-100	Fully Opened	Fully Opened	OFF

Table 4 Output Variables Membership Functions

In this system, two defuzzifiers control the actuators; Release (Valve Control and Drainage Valve. The membership functions of the three output variables.

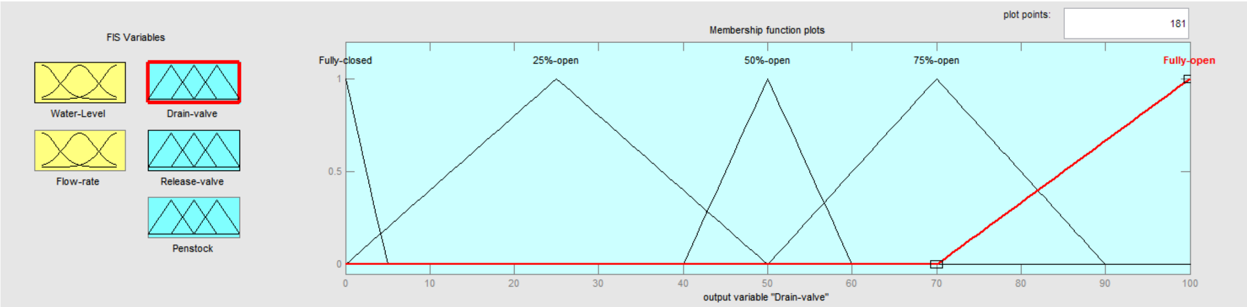

Fig. 5 Plot of Membership Functions for Output Variable, "Drain Valve"

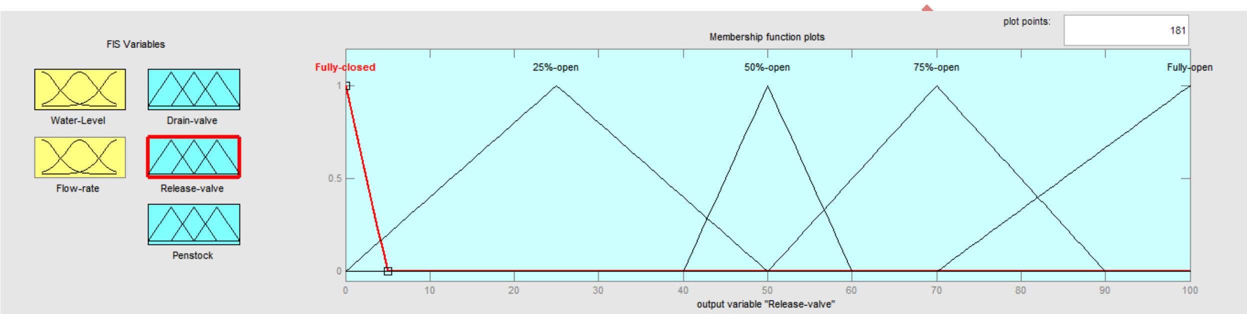

Fig. 6 Plot of Membership Functions for Output Variable, "Release (Valve Control)"

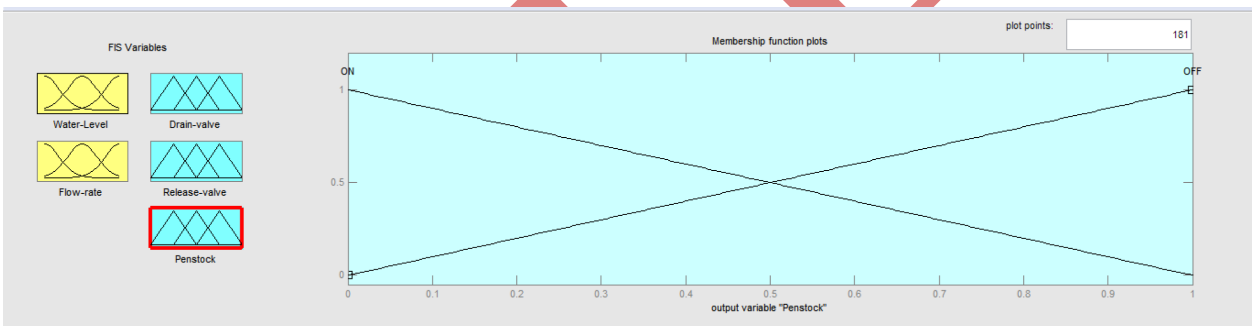

Fig.7 Plot of Membership Functions for Output Variable, "Penstock"

Results are compared in Table 8 and found correct according to the design model. MATLAB simulation was adapted according to the arrangement of membership functions for four rules as given in Table 7.

Rule No.	INPUTS		OUTPUTS		
	Water Level	Flow Rate	Release Valve	Drain Valve	Penstock
1	Below Danger	Fast	50% opened	50 % opened	ON
2	Below Danger	Very Fast	50% opened	75% opened	ON
3	Danger	Fast	75% opened	Fully Opened	OFF
4	Danger	Very Fast	75% opened	Fully Opened	OFF

Table 5 Arrangement Of Membership Functions For Simulation

Various values of input and output variables match the dependency scheme of the system design. The simulated values were checked using MATLAB-Rule viewer as shown in Fig. 4.1.

The correctness of results shows the validity of the simplified design work for processing system using control system.

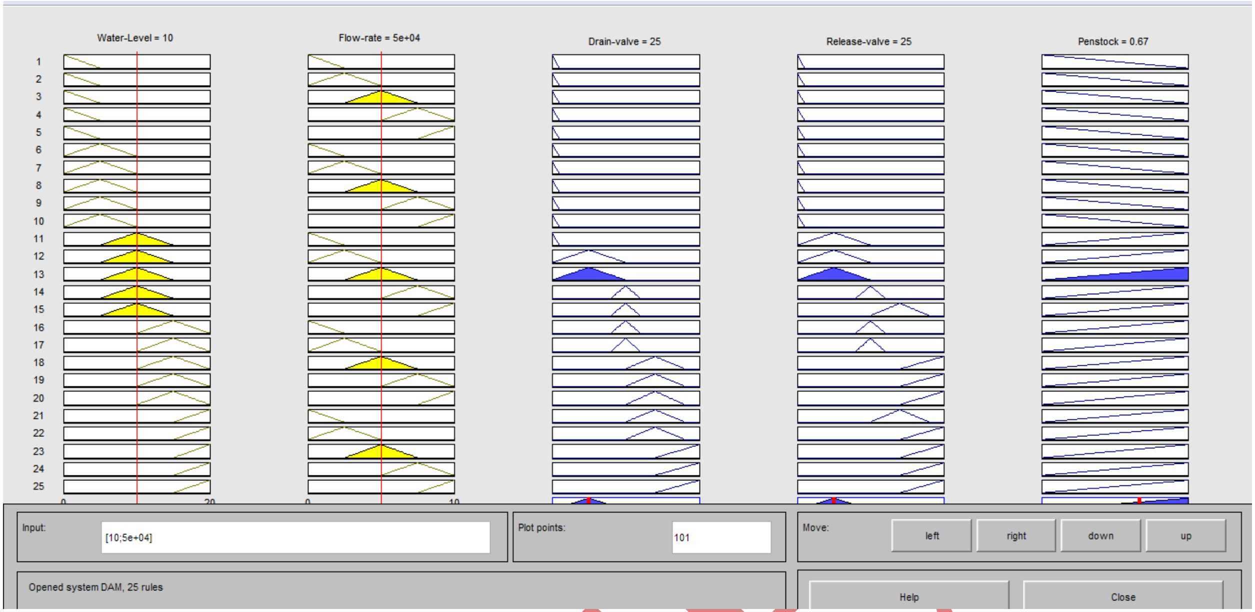

Fig. 8 MATLAB-Rule Viewer

Result	Release Valve	Drain Valve
Design Values	64.2	85.7
MATLAB Simulation	65.2	83.8
% error	1.55	2.21

Table 6 Comparison Of Simulated And Calculated Result

IV.SIMULATION GRAPHS DISCUSSION

This system was simulated for the given range of input variables. The given value of: Water Level = 13 lies in region 3 of the range 10-15 and Flow Rate = 95000 lies in region 4 of the range 75000-100000. The four rules were applied for MATLAB simulation according to this range scheme. In this design model, the release and drain control valves depends upon the selected values of water level and flow rate. The simulated and calculated results are according to the dependence scheme.

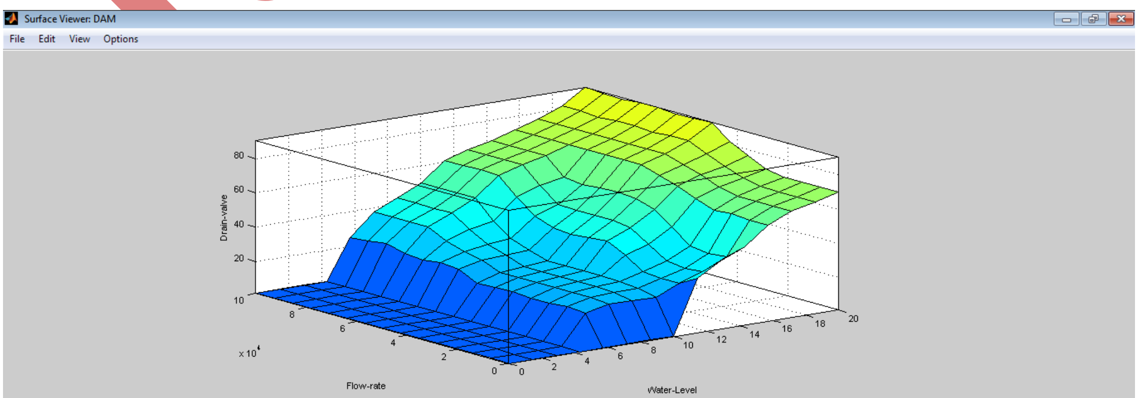

Fig. 9 Plot between Water Level - Flow Rate Drain/Release Valve Opened/Closed and Penstock

Fig. 4.2 shows that the control valve is directly proportional to water level and it does not depend upon the flow rate. Fig. 4.2 also shows that the drain valve system is directly proportional to flow rate.

V. CONCLUSION

Both the design model and simulation results are same. The designed system can be extended for any number of inputs and outputs. The drain valve control output can be utilized further for land irrigation according to the need and water release control valve for electric generation to fulfill the dire need of this system in automation. The design work is being carried out to design state of the art fuzzy logic Hydro-Electric control system in future using FPGAs.

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