AUTOMATION OF STEAM FLOW CONTROL OF DEARATOR DEVICE

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Abstract. *This paper presents the principle of operation of the analysis of the steam flow control of the deaerator device in an industrial steam power plant based on artificial intelligence (AI). Our proposed method aims to improve the performance of the existing proportional integral (PI) control method. The results of many experiments have shown that, ELM is fast and at the same time superior in terms of runtime and fault tolerance. The ELM-based prototype also performs correctly with an error tolerance of 0.15%.*

Key words; *Deaerator, Extreme Learning Machine (ELM), FS-400a, Arduino.*

Introduction. Steam power plant industry is rapidly developing in Uzbekistan. The reason for this is that electricity is one of the important energies required for human needs and comforts Almost all man-machines use electricity.

One of the most important systems in a steam power plant is the clean water system. And, clean water is stored in the deaerator storage tank, therefore, the deaerator plays an important role in the feed water system of the boiler. Since the deaerator is a fresh water storage tank, the level of the deaerator storage tank must also be monitored. A control valve is used to adjust the amount of water entering the deaerator's storage tank, so the level has to be constant. From another point of view The implementation of control methods in the field of engineering is growing rapidly, and there are not only methods based on numerical analysis, but also methods based on artificial intelligence. [1]

In this article ELM is used as a valve control method to maintain a constant deaerator steam flow rate. The ELM method has an extreme ability in learning speed while being more accurate. A comparison method to verify the performance of the ELM control system is the application of the BPNT control system. Introducing ELM as a way to control the level of the deaerator storage tank is a new method. For example, several methods used to control the deaerator storage tank, such as the PID method, face some difficulties in obtaining a good control system due to the strong relationship between the deaerator pressure and water level. Fuzzy PID Control method, this method is flexible and easily adapted, so the results work well, static and dynamic performance is excellent, strong resistance and adaptability. And the disadvantages of this method are to achieve good accuracy. Therefore, the blur rules must be very precise, and the value of KP, KI, KD in the PID must also be precise. In addition to the advantages of each method discussed, the disadvantages of all these methods may be solved by ELM.

We may consider the following sections of the article. We describe the research methods and understand the data processing in section II of this article. Section III describes how the ELM method is implemented in hardware. Finally, in section IV, we draw a conclusion.

Metadology. The purpose of this study is to create prototype design of deaerator steam flow control level control system in industrial steam power plant comparing Neural Network (NT) and Extreme Learning Machine (ELM) methods. [3]

Stage 1. How to test most of the information in the software in step 1 and sensor, actuator calibration using Arduino IDE then, test, and test the ELM or NT method using MATLAB, Using Visual Studio 2013, there is an ELM or NT method to trace and compute. Both methods are calculated using Visual Studio 2013 and not directly from the arduino mega 2560 . Because arduino has the disadvantage of having a limit on the length of variable data.

Stage 2. Step 2 describes how to build and design the hardware.

We can see the design of the equipment in the picture below.

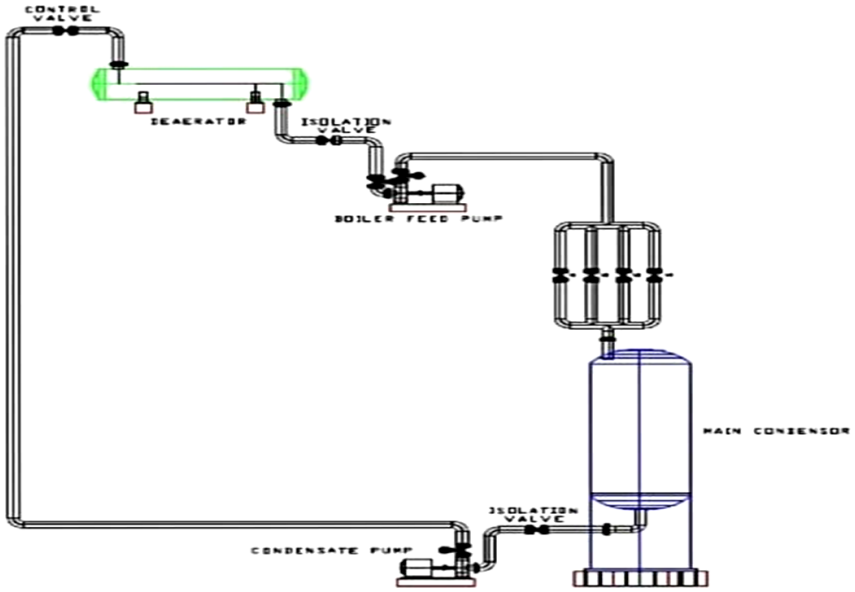

Figure 1. Equipment design.

This prototype uses two tanks and two pumps and then some PVC pipes to create the mechanics. Arduino Mega 2560 is used to make the controller. Sensor, for the actuators, a level sensor is installed as a water level detector in the deaerator storage tank, two FS400a flow sensors are installed outside it as a flow detector, and a stepper motor in the regulator. A valve clutch is also installed as a control valve that controls the amount of water in the deaerator storage tank.

Stage 3. In 3rd step, we consider the integrated software and hardware. The working principle of this research is as follows:

1. In the initial state, all pumps are activated.

2. There are a few requirements that must be met before starting, kondansativ tank must be filled with water.

3. After the condenser tank is filled, the start button turns on.

4. When the pump is started, deaerator storage tank filling process has occurred.

5. If the deaerator storage tank level is still not correct so there are some conditions that need to be controlled.

6. The situation is managed using ELM, it is used to set the percentage of opening valve. The information can be seen in Table 1.[4]

Table 1. ELM jarayoni jadval.

Start	Situation	Exit
Error rate	10 <= X >= -10	100 % to open or 0 % to close

Filled situation	0% ; 25% ; 50% ; 75% ; 100%	High level (6), Safe (5), low (4)

Input and output information. An example of multiple inputs and outputs to a lab process in an ELM network. The data represent 80% of the 105 valid data

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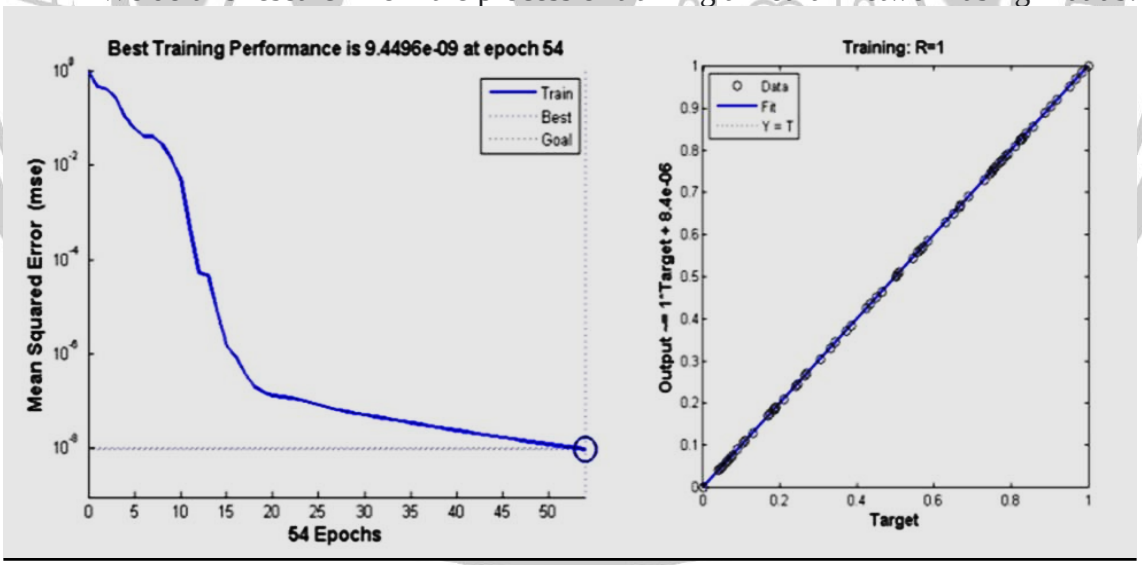
Table 2. Example of training information.

№	Error rate	Filled situation (%)	Control screw (%)	Pointer
1	-10	0	84	4
2	-9	0	75.5	4
3	-7	0	58.5	4
4	-6	0	50	4
5	-4	0	33	4
6	-3	0	24.5	4
7	-1	0	7.5	4
8	0	0	0	5
-	-	-	-	-
84	10	100	0	6

We do this research from the process of training a Neural Network using Matlab.



2-rasm. Best training results and regression.

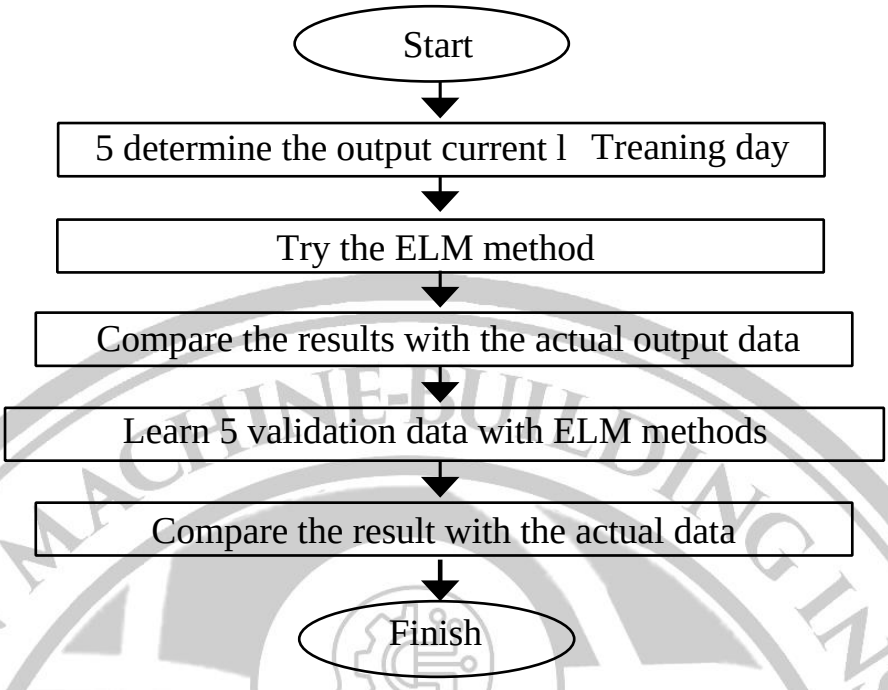


Figure 3. Test process and procedure.

Table 3 shows the performance comparison results of Neural Network and Extreme Learning Machine method.

Table 3. NT VS ELM comparison result.

Experience information							
input			output			error	
Error level	Filled situasion (%)	CV (%)	Ind	NN		NN	
-9	0	75.5	4	75.50685	4.00712	4.69E-05	5.07E-05
-4	25	45	4	44.99727	4.007084	7.47E-06	5.018E-05
0	50	42.5	5	42.50281	5.011765	7.88E-06	0.0001384
2	75	50	6	49.99305	6.010399	4.83E-05	0.0001081
8	100	37.2	6	37.21039	6.001619	0.000108	2.621E-06
All errors						0.000219	0.0003501
Middle squared error (MSE)						0.006612	0.0083674
Confirmation information							
Input			Output			Error	
Error level	Filled condition (%)	CV (%)	Ind	NN		NN	
-5	0	41.5	4	39.5565	3.817594	3.777204	0.0332718
-3	25	39	4	50.73921	3.769358	137.8089	0.0531957
5	50	22.5	6	18.53428	6.059001	15.72693	0.0034812
8	75	11	6	13.03489	5.940531	4.140783	0.0035366
6	100	74.4	6	74.91622	5.806361	0.266483	0.0374959
Total error						161.7203	0.1309812
Root Mean Square Error (RMSE)						5.687185	0.1618525

Training information							
Input		Output				Error	
Error level	Filled condition (%)	CV (%)	Ind	ELM		ELM	
-9	0	75.5	4	75.5	4	1.55E-17	1.051E-22
-4	25	45	4	45	4	3.85E-19	1.456E-17
0	50	42.5	5	42.50004	4.999997	1.95E-09	1.121E-11
2	75	50	6	50	6	1.41E-15	3.323E-17
8	100	37.2	6	37.2	6	1.34E-17	7.898E-20
Total error						1.95E-09	1.121E-11
Root Mean Square Error (RMSE)						1.98E-05	1.497E-06
Training information							
Input		Output				Error	
Error level	Filled condition (%)	CV (%)	Ind	ELM		ELM	
-5	0	41.5	4	41.50001	4	6.55E-11	2.025E-15
-3	25	39	4	39	4.254436	1.02E-11	0.0647376

5	50	22.5	6	22.50001	6	2.04E-10	1.115E-16
8	75	11	6	10.99969	6	9.42E-08	1.483E-15
6	100	74.4	6	74.40001	6	1.71E-10	2.09E-15
Total error						9.47E-08	0.0647376
Root Mean Square Error (RMSE)						0.000138	0.1137871

From table 3 above shows Root Mean Squared Error (RMSE) value on the NN method in training data is smaller than validation data. And for RMSE in ELM method in training data is also smaller than validation data. However, if the RMSE is overall compared between the NN and ELM methods, the RMSE value of the ELM method is smaller than the NN method. Training time for the NN method is longer than the average training time of 21 parts of the ELM training method. For more details, the performance comparisons of NN and ELM are shown in table 4 below. [5]

Conclusion. I realized while doing this experiment that what we did in ELM was better compared to the experiments from both ELM and NN in automating the Dearator steam flow control. In this experience, ELM is faster than NN. So, to recognize new experiment values and changes, ELM can provide results that are nearly identical to the target experiment. Since the control of the steam flow control level of the deaerator unit requires high accuracy and high time efficiency adjustment, the ELM method can be made as the main choice over the NN method and other methods. And so, the risk of failure of the deaerator's steam flow control level control can be avoided

Foydalanilgan adabiyotlar.

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