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APPLIED NEURAL NETWORKS AND FUZZY LOGIC TO CONTROL THE SPEED TO REDUCE VIBRATION ON THE СБШ-250T

Huynh Thanh Son[*1], **Le Ngoc Dung**[*2], **Đang Van Chi**[*3]

[*1,2]Dong Nai Technology University

[*3]Hanoi University of Mining and Geology

ABSTRACT

This paper introduces the control algorithm based on neural network and fuzzy logic to adjust the firing angle α (thyristor controller) to control the rotation speed of the СБШ-250T rotary drill with different hard nesses and geological structures . The proposed solution uses an artificial neural network (neural network) tool to replace sensors to measure the vibrations to detect the amplitude and frequency of vibration on a rotating drill. The vibration amplitude, frequency of vibration and set point of the speed serve as input variables for the logic fuzzy. The logic fuzzy has the function of deducing and deciding the appropriate compensation parameter δα with the goal of reducing vibration for the drill, but the speed control range of the system needs to ensure the allowable working efficiency of machine. The evaluation results are verified through modeling with the Simulink_matlab tool to be applied to the existing control system and improve the existing control quality in order to reduce vibration for the rotary drill.

Keywords: fuzzy compensation control; drilling machine СВШ-250T; neural network; fuzzy logic.

I. INTRODUCTION

The СБШ-250T rotary drilling rig is being used very popularly today on mining sites in Quang Ninh. The drilling process breaks the rock, the drill is continuously in contact with the rock with different hardness and geological structure. To find a suitable rule or algorithm to adjust the drilling mode parameters (rotation speed and force) in complex geological conditions and a specific mining environment in Vietnam is interested by many researchers. Some previous studies at domestic and abroad also mentioned the problem of optimal control of drilling parameters based on the hardness of the rock. However, due to the limitations of technology, the direct measurement of rock hardness in the working environment of the drilling machine has many technical difficulties. So this paper proposes an indirect method applying artificial neural network to identify rock hardness through the measurement of important process parameters such as rotation speed, force ... promises to get the expected results. Based on the predicted information from the neural network, a fuzzy compensation algorithm (δα compensation) can be built to automatically adjust the firing angle α of thyristor to change the rotation speed which match the actual rock properties. The proposed solution is evaluated through modeling the control system on the simulation software. The results confirm that the control system is completely adaptable and responds well to the current operating environment, reducing machine vibration, improving the quality of the control system while ensuring good productivity and efficiency.

II. PROPOSED ROTATION SPEED CONTROL SYSTEM

2.1. Proposed diagram for a rotating speed control system.[10]

Diagram of the principle of pressure control on a drill СБШ-250T[2],[3],[5] as shown in figure 1.

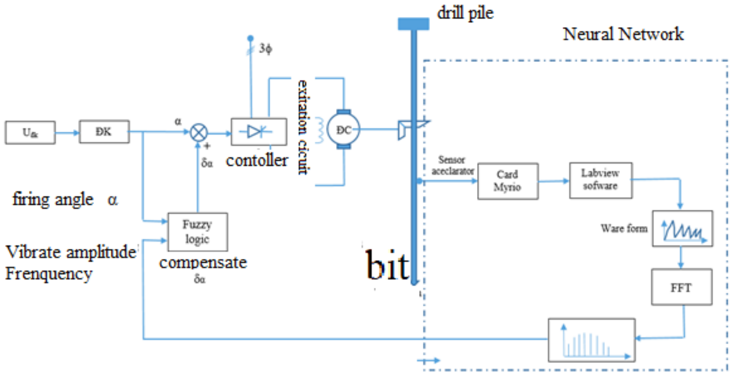

Figure 1. Principle of rotary speed control for drilling machine СБШ-250T

In the current control system, the set point Uđk signal is set directly by the operator, the controller system change the firing angle α. In the proposed system, the firing angle α will be compensated by an amount of δα through 2 devices (2 blocks) including:

- Vibration sensor block: in the proposed modeling, it is equivalent to replace the Neural Network unit (recognizing amplitude and frequency of vibration after successfully training the network)
- Fuzzy block: collecting amplitudes and frequency signals from the vibration sensor to decide the fire angle α to compensate (δα) suitable to reduce vibration.

2.2 Build a neural network to receive frequency and amplitude vibration. [1],[6]

Neural networks are a very useful tool for identifying and controlling objects, nonlinear and immutable systems. Their ability to self-learn, self-update knowledge and information data, making the network more and more knowledgeable and becoming more intelligent. Those are the basics principals to build and develop an intelligent tool which capable of deducing and predicting the hardness and rock properties in reality and thereby assessing the vibration of the machine. The success in developing a neural network is highly dependent on the quality and number of samples during training. Variables of the drilling process such as speed, torque,drilling force are important and selected as inputs for neural networks. The output is the amplitude and frequency of the vibration.

Table 1: Network input and output data for training

STT	Rock hardness	Spectrum (FFT)		Amplitude	Drilling rotation speed	Pressing force F	Torque Mc
	f_c	(rad/s)	(Hz)	(m/s^2)	(r/m)	(1000kg)	(Nm)
1	13	1	0.16	0.3	50	30	260
2	12	3	0.48	0.65	63	27.5	218
3	11.5	5	0.8	0.35	70	25	185
4	11	10	1.6	0.15	75	24	183
5	10.5	15	2.4	0.23	78	23	172
6	10	18	2.88	0.2	84	20	165
7	9	26	4.16	0.75	90	17	156
8	8.5	31	4.96	0.25	96	15	153
9	8	35	5.6	0.2	102	13	134
10	7	40	6.4	0.15	107	12	121
11	6.5	55	8.8	0.1	110	10	102
12	6	60	9.6	0.02	123	9	91
13	5	82	13.12	0.05	132	8	83
14	4.5	100	16	0.03	138	7	82
15	4	120	19.2	0.05	145	6	75
16	3	140	22.4	0.03	150	5	67

- **Network design and training:**

Neural networks can be used either NN_Tool tool orm_file in window of Matlab. Setup the requirements inputs for structural networks, number of layers, number of neurons in a layer, transfer functions, deviation ... perform the training process. Training results and deviation graph of training process as shown in figure 2, figure 3.

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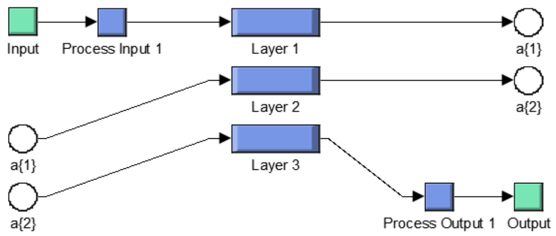

Figure 2.1. The 3-layer structure of the network

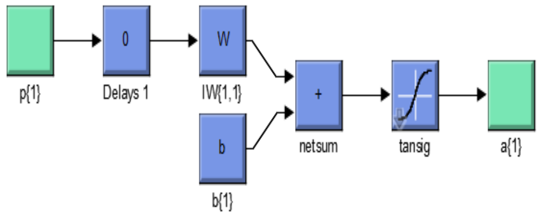

Figure 2.2. The structure of input layer

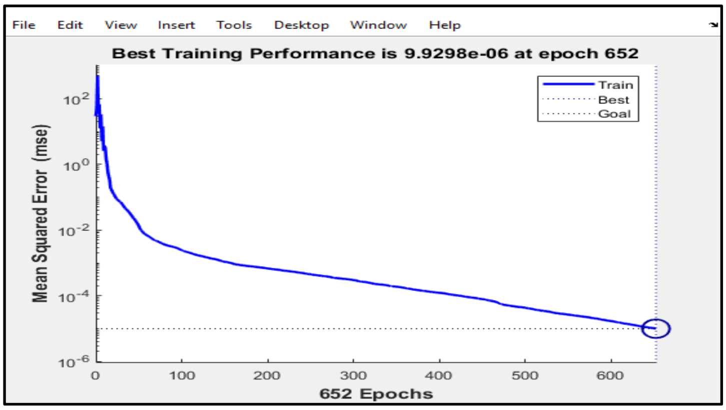

Figure 3. Erors in network training

The test results on the input and output data sets of the 3-layer network model [16 x 36 x 2] showed that the identification data set followed the sample data set. To conclude that the neural network has learned the pattern signal. Deviations between net value and target value achieved after 652 Epochs of training.

2.3. Design fuzzy logic controller to get the compensate firing angle (δα); [1],[9]

➢ **Fuzzilization input_output variable** :

Input :

1. Frequency of vibrating signal, 5 fuzzy members (0.08 – 22.4) Hz .
2. Vibration amplitude, 5 fuzzy members(0.003 – 1.14) m/s^2 .
3. Firing angle α, 5 fuzzy members (53.2^o – 88.2^o) .

Output: compensate angleδα ,5 fuzzy members (-35^o – $+35^o$).

The structure of the Deduction in fuzzy logic using matlab is shown in figure 4

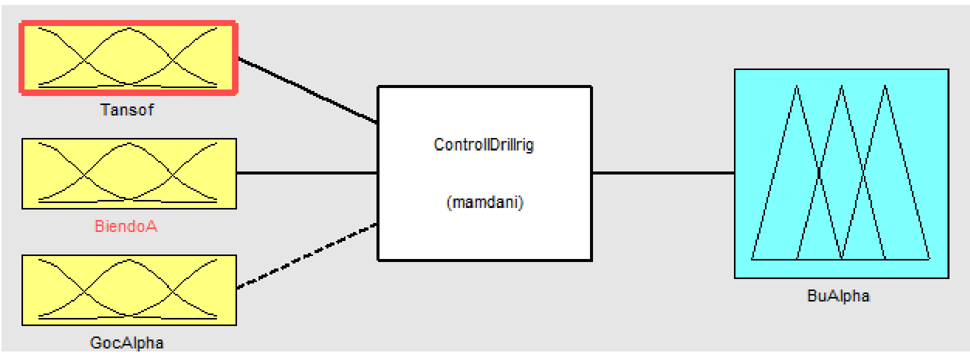

Figure 4. The structure of the fuzzy logic

➢ building fuzzy controller and defuzzification:

With 3 input variables and 1 output variable according to the data table has a total of 125 rules:

If Tansof=Tansofi and BiendoA=BiendoAi and Alpha=Alphai then Bualpha=Bualphaj

Set up to fuzzy inference block is Madani,. Defuzzification is using weighted fuzzy average.

➢ Results of the simulation in matlab are shown in figure 5.

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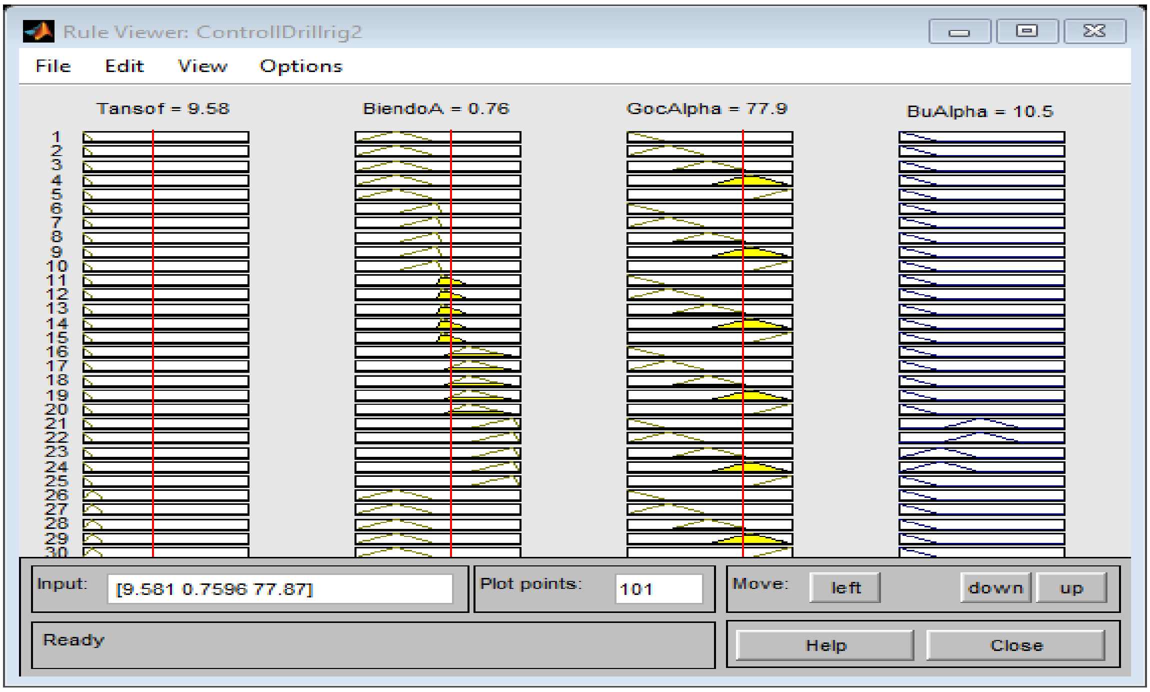

Figure 5.results of the output compensatory $\delta\alpha$

1. **APPLYING NEURAL NETWORK AND FUZZY LOGIC TO MODEL THE SPEED CONTROL SYSTEM ON THE СБШ-250T ROTARY DRILLING RIG. [1], [7], [8], [9], [10]**

After successfully developing Neural network and Fuzzy logic tools, they will be saved in the library of simulinkmatlab to serve for the research and modeling process. From the proposed diagram (Figure 1), which is modeled Chapter 3 of the PhD thesis, performing the linking of block together and run the simulation (Figure 6)

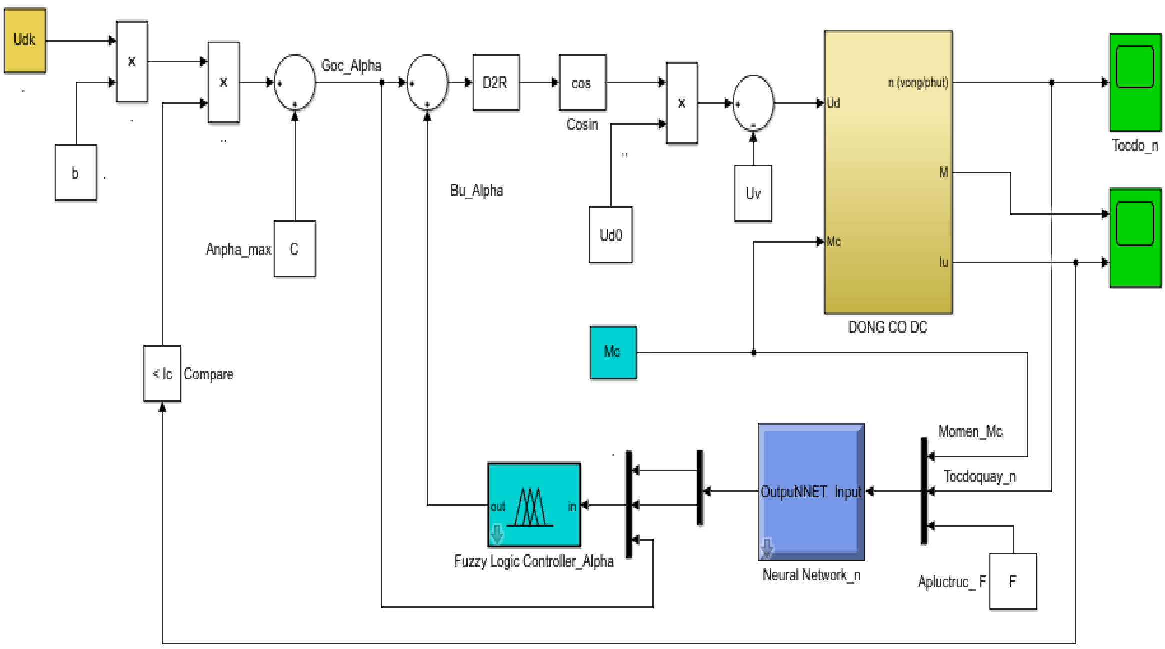

Figure 6. Simulation of the СБШ-250T drill

The results under operating conditions with rocky soil of different hardness, the system without the compensator(red) and the system with the compensator(blue). As figure 7, it shows that the peak amplitude decreased by 50%.

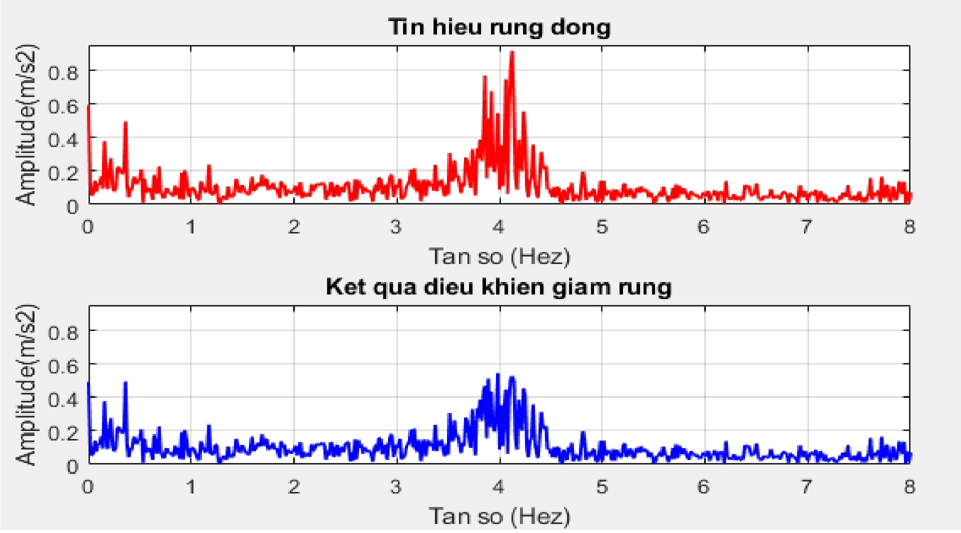

Figure 7.Test results on the model at a depth of 6.5m

III. CONCLUSION

This paper mentions the research and development of combining neural network and fuzzy logic with the aim of building a controller to control the speed of rotation and reduce vibration for the machine, included:

- Successfully trained a neural network to determine amplitude and frequency of vibration
- Developed fuzzy logic to determine the firing angle to adjust the speed of rotation
- Modelization the rotation speed control system using Neural-Fuzzy controller, compare and evalue with the controller currently in use.
- The research results are tested on the simulation model, evaluated the quality criteria of the control system and the vibration reduction criteria on the machine which allow the applicability of the controller to the actual operation.
- The research results confirm that using the combined neural network and fuzzy logic to improve control quality and reduce vibration for drilling machines is a suitable solution in controlling nonlinear electric drive systems in different geological conditions.
- Proposing to continue evaluate the stability and sustainability of the control system through the simultaneous control of pressure and rotation. The desired solution to be applied in the practical operation. Calibration of the drilling machine will contribute to improving the quality and the working efficiency in the traditional controller.

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