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Application Of Fuzzy Logic To Control The Process Of Natural Gas Drying

A.A. Abdukadirov
Department Automation Of Production Processes, Tashkent State Technical University, Uzbekistan

B.U. Shomirzaev
Senior Lecturer Of The Department Of Automation Of Machine-Building Process, Andijan Machine-Building Institute, Uzbekistan

ABSTRACT

The article is devoted to the development of an imitation fuzzy model of the natural gas drying process during its preparation for transportation. To solve the problem, adaptive means of automatic control have been proposed, which will almost completely compensate for the change in the parameters of the gas drying process. The paper proposes methods and models of optimal adaptive control aimed at increasing the efficiency of gas drying. The use of the proposed model allows parametric and structural optimization of production in order to improve the quality of gas drying.

KEYWORDS

Simulation model, gas dehydration, absorption, separator, technological process, fuzzy logic, fuzzy controller.

INTRODUCTION

The presence of liquid hydrocarbons in natural gas increases the pressure drop in the pipeline and negatively affects the efficiency of the gas transmission system. Therefore, it is important to choose the dew point for hydrocarbons in the transport system depending on the composition of the environment. Separating liquid hydrocarbons from gas before transportation also allows them to be used. To this end, emphasis is placed on separating liquid and heavy hydrocarbons from gas produced in the production environment. The amount of heavy hydrocarbons in a gas determines its dew point. The difference between the presence of liquid and heavy hydrocarbons. The difference between heavy hydrocarbons and the pressure dew point in gas compared to water is that in this case there is no direct relationship between heavy hydrocarbons and the dew point of the gas under pressure. As the pressure decreases over time, the amount of heavy hydrocarbons in the liquid phase increases.

Depending on the method of processing the extracted raw gas, the process of drying the gas from the moisture contained in it and separating heavy hydrocarbons can be carried out in one device or in separate devices.

The main process of gas preparation is the low-temperature separation method using the throttle effect. If the gas pressure drops below 0.6 MPa, the low-temperature separation method will not give good results. In this case, other methods are used, such as absorption or artificial cooling of gas in the main building.

MAIN BODY

At gas condensate fields, it is necessary to provide a point for preparing well products for the supplied gas in terms of humidity and hydrocarbons. The main technological process of gas condensates gas preparation is low-temperature separation. The process takes place at a low temperature and helps to purify the gas from moisture and condensate.

The gas drying shop includes several technological systems. In terms of composition, each technological gas drying system is (Fig. 1):

- Gas separator with flushing part (c-1);
- Absorber (a-1).

In the separator with the washing part c-1, the drain is drained through a control valve and cleaned of mechanical impurities, salts and partially methanol with washing (reflex) water. The flow rate of the supplied flushing water depends on the amount of drying gas.

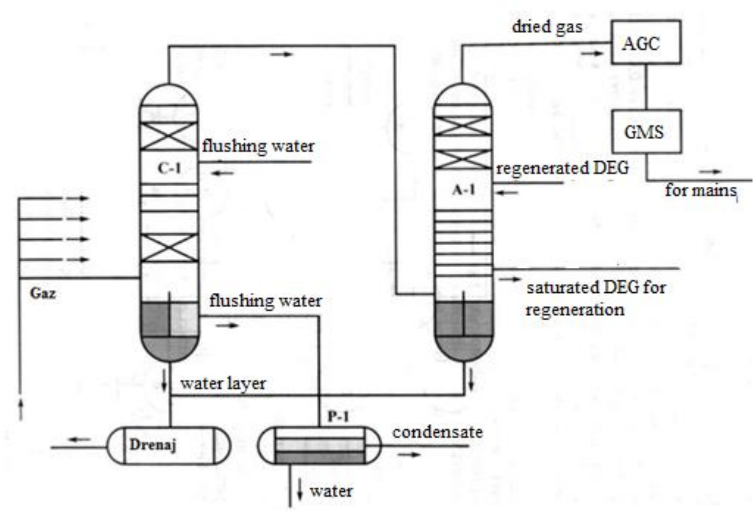

Figure 1. Gas absorption device

Gas purified from water, mechanical impurities and salt is transported through the separator and piped to the bottom of the absorber a-1.The absorber is a vertical device consisting of two sections: mass transfer and separation.

The gas enters the absorber under the turbid saucer, where the phenomenon of partial separation of droplet liquids occurs. As a result of entering the mass transfer section and mixing the upper layer with the lower layer, the gas comes into contact with a high-concentration liquid absorbent in the saucers (or top layer nozzle). The absorbent, gradually soaked in moisture, drains into a low (cubic) section of the mass transfer section and is removed from the absorber.

The dried gas flows from the mass transfer section to the filtered section at the outlet, where glycol droplets are separated. Gas is supplied from the upper part of the absorber to the drained gas collector.

After the drying unit, gas passes through the air cooling device (GSK) or after the gas purification system-from the gas measuring station(Gsk), the emergency crane switch network and (through the SCS - and compressed air compressor stations) enters the gas device.

The mathematical model of the absorption process shows that industrial regulators are used for optimal process control.

In the industry, the most widely used stabilizing automatic regulators of continuous operation and relays, which regulate the amount of deviation of the regulator and are used to influence the electrical energy of the actuator or the energy of compressed air. This controller usually consists of: a primary (transmitting) converter 1, a transmitting device 2, an adder 3, a measuring unit 4, a correction unit 5, an actuator 6, and a feedback correction device 7.

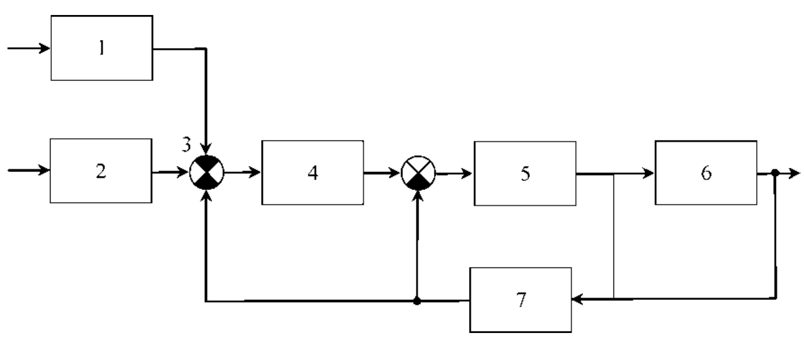

Figure 2. Block diagram of the automatic controller.

The question of the correct choice of the control signal (continuous or discrete) is solved based on the analysis of the dynamic characteristics of the object adjustment. The most favorable evaluation criterion in this case is the ratio between the delay time of the object τ and its time constant T. In this case, a relay regulator is used if τ/T<0,2, and a continuous-action regulator or pulse regulator is used if τ/T>0,2. Model laws are often used as adjustment laws.

In the presence of external and parametric disturbing effects on the object (for example, a change in gas pressure by 15%, a change in the concentration of components of the reaction mixture by 10%), the quality indicators of the transition process are significantly reduced. Changing these parameters over a wide range can cause the control system to become unstable. This is due to the fact that regulators with strictly defined parameters in automatic control systems cannot ensure the transient quality of the process under the influence of significant disturbances [41].

Also, the uncertainty of changing the parameters of the object model and the concentrations of reacting chemicals greatly affects the indicators of the management system and product quality. Therefore, it was proposed to use the theory of fuzzy logic to solve such problems.

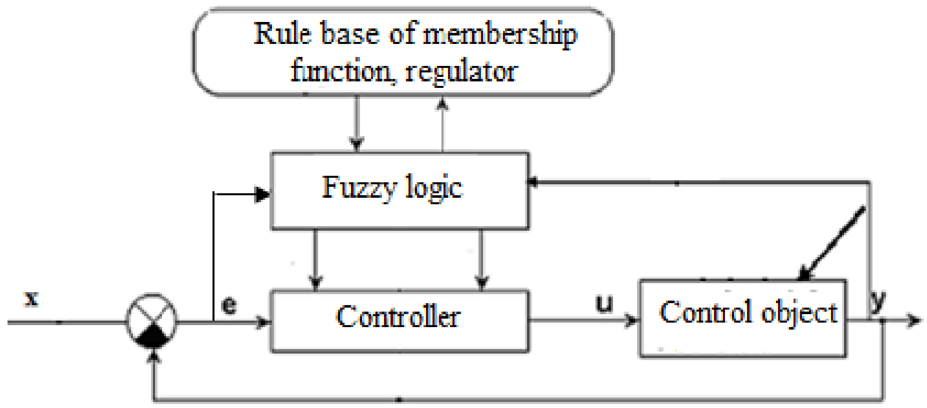

Figure 3. Automatic adjustment of the absorption drying system with a fuzzy controller.

In this case, the input vectors of a nonlinear logic controller are converted to a nonlinear representation using the fuzzification block according to the scheme. Then, based on the rule base compiled by experts, the output variable i* is obtained.

A defuzzifier is used to convert the control vector i* to a numeric value. The function of the fuzzy controller is to generate a control signal by reproducing the error signal and its derivative.

Generally, a fuzzy controller should have a knowledge base based on terms of linguistic variables.

To do this, we enter the following linguistic variables:

e_1 =("control error", Te_1, E_2);

e_2 =("Derivative of the error", Te_2, E_2);

u= ("Control", *Tu*,*U*).

$$T_e = \{T'_e, T'_e, ... T^k{}_{e_i}\}, i = \overline{1,k}, T_u = \{T^1{}_u, T^2{}_u, ... T^k{}_u\}$$

Now we divide each linguistic variable into 7 terms with the membership function in the form of a triangle:

$$T_x = \{'NB', 'NM', 'NS', 'ZE', 'PS', 'PM', 'PB'\};$$

$$\mu_{Tx}(x,a,b,c) = \begin{cases} 0 \; if \; x \le a, \\ (\text{x-a})/(b-a) \text{ if a} \le \text{x} \le \text{b}, \\ (\text{c-x})/(c-b) \text{ if b} \le \text{x} \le \text{c}. \end{cases}$$

Then the phasification results are written as follows:

$$e_1 = \text{error}=\begin{bmatrix} \mu_{NB_e}(e)/NB_e, \mu_{NM_e}(e)/NM_e, \mu_{NS_e}(e)/NS_e, \mu_{ZE_e}(e)/ZE_e, \mu_{PS_e}(e)/PS_e, \\ \mu_{PM_e}(e)/PM_e, \mu_{PB_e}(e)/PB_e \end{bmatrix};$$

$$e_2 = \text{"the rate of change of the error"}=$$

$$= \begin{bmatrix} \mu_{NB_e}(\dot{e})/NB_{\dot{e}}, \mu_{NM_e}(\dot{e})/NM_{\dot{e}}, \mu_{NS_e}(\dot{e})/NS_{\dot{e}}, \mu_{ZE_e}(\dot{e})/ZE_e, \mu_{PS_e}(\dot{e})/PS_{\dot{e}}, \\ \mu_{PM_e}(\dot{e})/PM_e, \mu_{PB_e}(\dot{e})/PB_e \end{bmatrix};$$

$$u^* = \text{control} = \begin{bmatrix} \mu_{NB_u}(u)/NB_u, \mu_{NM_u}(u)/NM_u, \mu_{NS_u}(u)/NS_u, \mu_{ZEu}(u)/ZE_u, \mu_{PS_u}(u)/PS_u, \\ \mu_{PM_u}(u)/PM_u, \mu_{PB_u}(u)/PB_u \end{bmatrix}.$$

Let's formulate the fuzzy logic controller inference rule base as follows:

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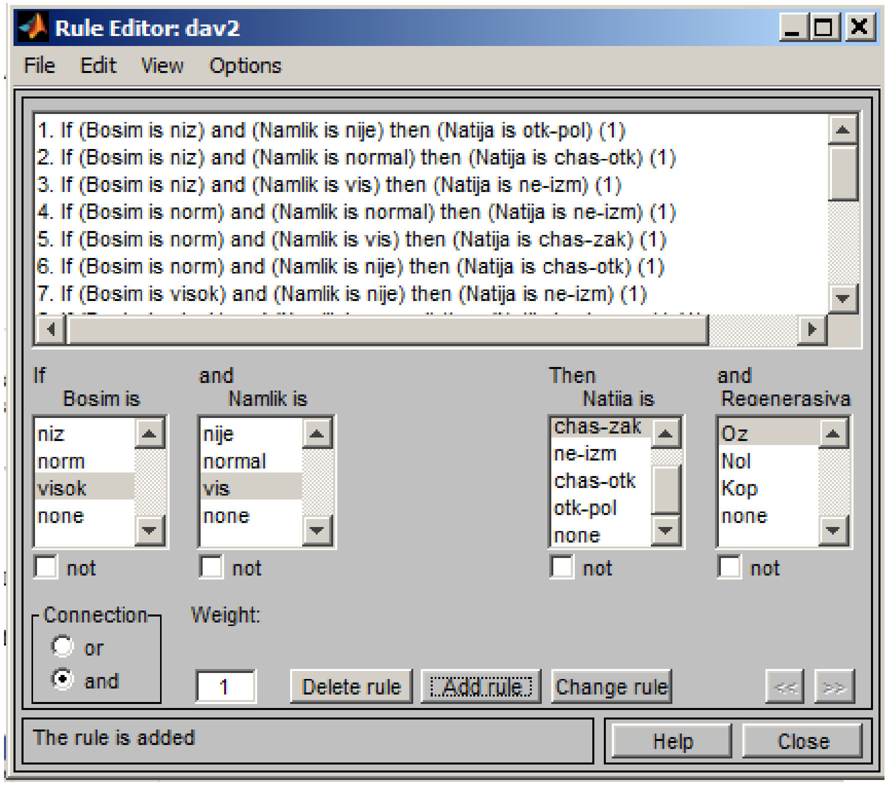

Figure 4. The rule database, consisting of 18 structured rules, is the Rule Viewer control window.

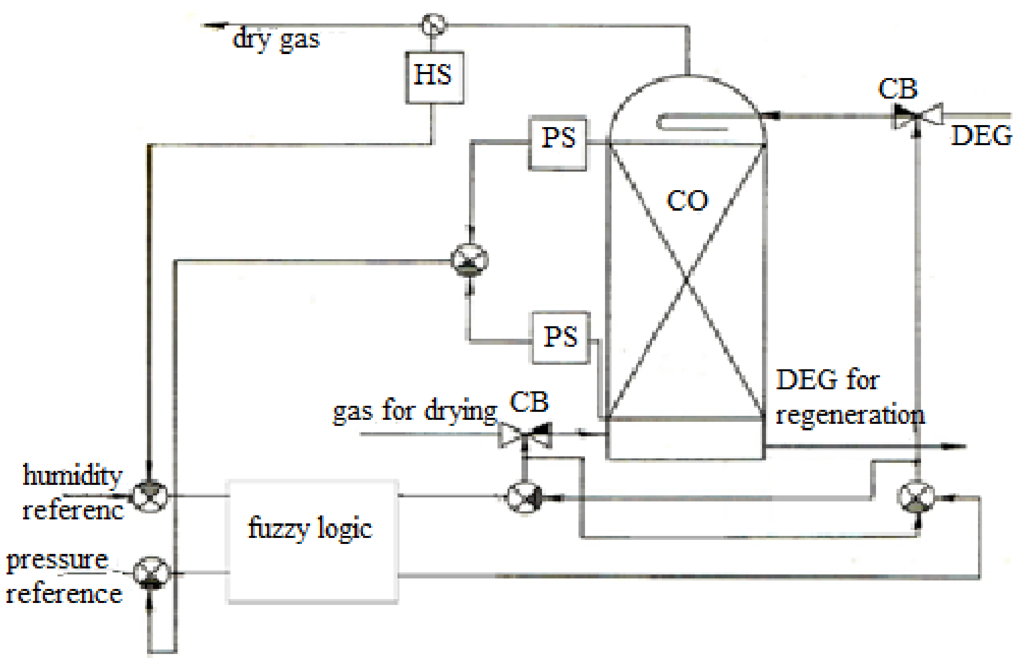

Figure 5. Functional diagram of automatic adjustment of the absorption drying system with a fuzzy controller.

Below is a simulation model of the automatic adjustment system for absorption drying with a fuzzy controller, implemented in the MatLAB program.

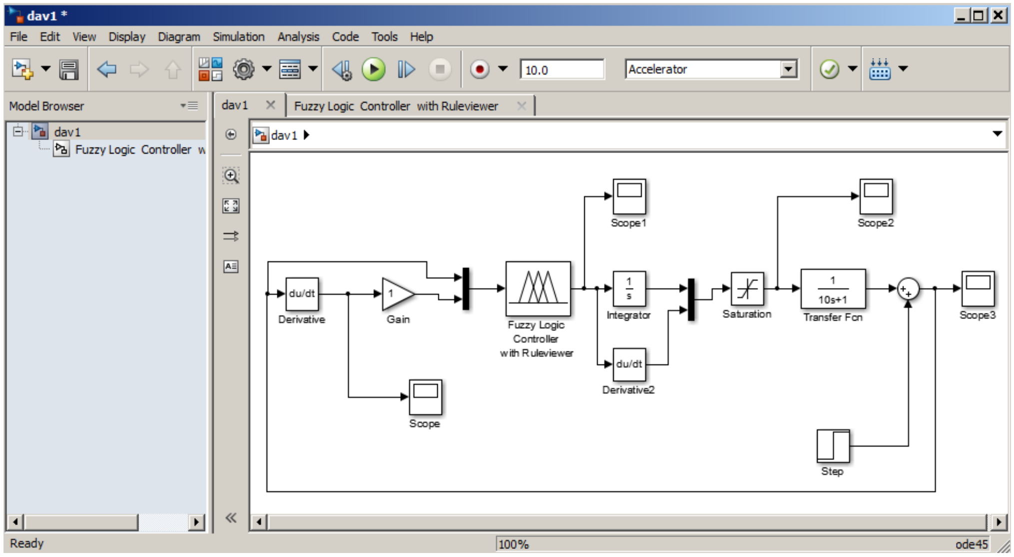

Figure 6. Control system of the absorption drying system based on a fuzzy controller.

CONCLUSION

The simulation model was tested for monotonicity in a real technological object-an absorption column. The results of the study show that the simulation model has a satisfactory agreement with the results of the laboratory.

The introduction of the results of simulation modeling of the process of absorption purification of natural gas into the product quality management system made it possible to increase the level of gas purification by 6-7%.

The quality characteristics of the transition process of a fuzzy controller are significantly higher than those of a classical controller.

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