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ANALYSIS AND FUZZY SIMULATION OF A PUMP WITH ECCENTRIC FOR NATURAL GASES ODORIZED

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***Abstract**: The natural gases are considered hydrocarbons by specialty literature, almost odorless or slightly odorless, by odorize of natural gases it is possible to notice the lack of tightness of the tubular material, through which the distribution to the consumer is made or any corrosion, cracking or damage. Practically, this added amount of odorant in well-established quantities of gas transported through pipelines reduces the risk of explosion, thus eliminating the danger of loss of life, as well as the destruction of buildings, buildings, and environmental damage [1]. Any event of this kind creates beyond the above mentioned, a discontinuity, interruption in the supply of hydrocarbons to consumers, and hence major financial losses or even bankruptcy of gas distribution companies. Therefore, to avoid these drawbacks, a wide range of odorants are used throughout the world to detect olfactory, and in the case of odorants and visual emissions and controlled emissions. These odorants are added to natural gas through different technologies using equipment adopted to meet the requirements of the quality of delivered natural gas.*
***Key words:** natural odorize, odorless, leakiness, explosions, potentially explosive environment, pump with eccentric mechanism, direct current electric motor, fuzzy controller.*

1. CONCEPTS REGARDING ODORIZING AGENTS

The odorizing substances which achieve the conditions presented above, as odorize agents are organic sulfuric compounds, designated thiols (mercaptans) and thioethers. Must to precise that the thiols have the most odorizing capacity but have two most significant disadvantages an acid character the odorizing effect is reducing substantial on the pipeline itinerary. Another observation is that the normal thiols due their acyclic structure, present a minimum chemical stability, fact which lead to, in the case of steel pipelines at a reaction of odorizing with iron oxide – as catalyzer from which result the oxidation of mercaptan and the effect of odorizer is reduced [2]. In the case of secondary thiols respectively tertiary (isopropyl-mercaptan and terbutyl-mercaptan) those are more resistant at oxidation then normal thiols.

Thioeters have a chemical stability greater then thiols and a stronger smell, this is classified as the best to odorize of natural gases. From practice is remark that the tetrahydrothiophene (THT) correspond mostly to the requirements for odorizing of natural gases. Experimental in the configuration of natural gases distribution network, it was found that the ethylmercaptan (EM) due its acid character was generated an “weak smell” at the end of distribution network and for each volume of odorized gases with tetrahydrothiophene (THT) and at the same initial concentration was perceived a smell “clear perceptible”.

In accordance with those presented an odorize agent shall accomplish the following conditions [2]:

- to have a strong unpleasant smell and distinctive to avoid to be confusion with others common smells;
- to have a lower limit of olfactory perceptiveness, and to be perceptible at a lower concentration in the gases;
- to have a good chemical and thermal stability during storage and at the odorizing to not react with the

compounds from gases and to not depose on the transporting pipeline;
- to not have variation of boiling into a narrow range of temperature and the evaporation to be complete;
- to not be corrosive;
- to burn complete with the gas without emissions of toxically substances;
- to be as little absorbed by pipelines, installations or soil;
- to avoid embossing of sealing materials of pipelines and fittings from distribution networking;
- to be available at the industrial scale and to not be expensive.

2. DETERMINATION OF CONCENTRATION OF ODORIZING AGENT IN GASES

The required amount of odorizing, must be dozed into a gas volume and must have effect to reaching of level 2 of smell perception, this being the necessary condition to avoid the explosion risk before the mixing of the gas with the air, into a specific volume, to reach the lower limit of explosion [5]. Starting from these conditions, the calculation of minimum concentration of odorizing agent have at the base the constant "K" which represent the value of concentration of odorizing agent in the air to reach the perceptiveness level. The values of this constant are different depending by the type of odorizing used.

Table 2.1

The values of constant K for most common odorizer agents used [3]

No.	*Odorizing agent*	*Value K, mg agent/m^{3}N air*
1.	*tetrahydrothiophene (THT)*	*0,08*
2.	*terbutyl-mercaptan (TBM)*	*0,03*
3.	*ethylmercaptan (EM)*	*0,03*

Regarding the connection between the odorizing agent in the air and the smell intensity, those are presented in the diagram from figure 2.1 where are represented the intensity curves of the smell for tetrahydrothiophene (THT), terbutyl-mercaptan (TBM) and ethylmercaptan (EM). Thus, on the graphic ordonate are written five levels of smell, the lines shown on the graphic are described by the Weber and Fehner laws, which explain the smell intensity as being proportional with concentration logarithm of odorizing in the air [3].

$$l = m \cdot lg\, c + n \qquad (2.1)$$

where:

l – represent the smell intensity express as smell level;

c – concentration of odorizing agent in the air, mg odorizing/Nm^3 air;

m and n – constants of the odorizing studied in the air;

for THT, $m = 2,05$ and $n = 4,30$

for EM and TBM, $m = 1,63$ and $n = 4,5$

From the bellow diagram result that for different odorizing to achieve a smell at olfactory level 2 is made at different concentrations of the odorizing agents in the air.

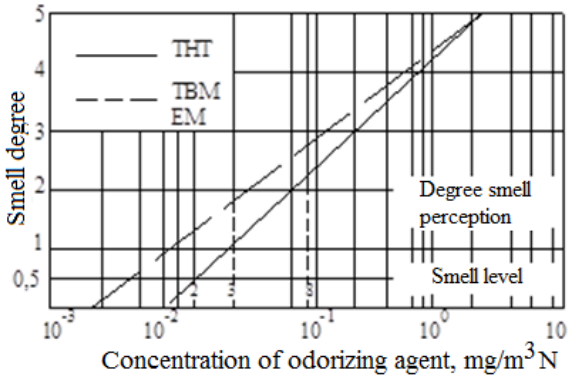

Fig. 2.1. Variation of smell intensity with the concentration of odorizing agent in the air [3]

3. DOZING PUMP ODORIZATION, WITH EXCENTRIC MECHANISM, ACTIONED BY A DC ELECTRICAL MOTOR WITHOUT BRUSHES IN CONSTRUCTION WITH ANTIEXPLOSION PROTECTION DEGREE

The experience has shown that due the fluctuations of debits of natural gases, winter-summer, in the delivery process to the consumers it is required that the odorizing process of the gases to be monitoring and properly performed on the delivering pipeline

networking (transportation and distribution). So called classic odorizing installations through evaporation, with fuse or by weeping, have adjustment on odorizing concentration much brute in such way that the diffusion between the odorizing and gas volume to be non-homogenous. This thing lead to a colmation of odorizing, on the delivery networking, because of volume conditions, temperature, pressure and speed of gases, situation that reduce the level of olfactory perception considered as value 2.

In order to achieve more homogenous diffusion between the natural gas and odorant, the odorant having the most appropriate psychic-chemical properties, it is considered important the facility of distribution networking with odorizing installations with injection pump for odorant. In this situation it is important to control, from distance, the injection points of odorizing and also the delivery parameters of natural gas to the consumer. The most common requirement from today is that to be a monitoring system from distance, which to control and to operate the delivery technological process of natural gases.

The dozing pump it is composed from: electrical motor, speed reducer, mechanism with camshaft, three pump heads (on which can adapt various piston diameters to ensure three distinct odorant debits), pushers with helicoidally arcs, plates rigid positioned in the same plane, couplings, diffusions most homogenous between the natural gas and odorant, the last one having the most properly physical and chemical properties, it is considered important to equip the networking distribution with odorizing installations with pumps injection of the odorant. In this situation it is important to control from distance, the injection points and also the delivery parameters of natural gas to the customers. The most common requirement today it is to exist a control system from distance which to monitoring and to operate the delivery technological process. Additional are used sampling methods which to not create homogeneity of the mixing but on contrary to can create a discontinuity of adding odorizing on the vehiculation natural gases debit.

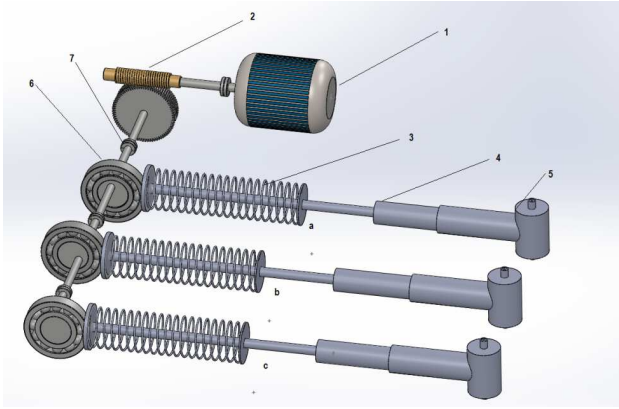

Fig. 3.1. Odorizing pump with eccentric mechanism

The odorizing pump is composed from: 1 – DC electrical motor without brushes, 2 – worm gear reducer, 3 – helicoidally arc and plates rigidly mounted in the same plane, 4 – pump piston, 5 – odorizing pump (shaft with eccentric mechanism train three odorizing pumps on which can be adapted different pistons diameters in order to ensure three distinctive odorizing debits), 6 – mechanism with eccentric (using ball bearings), 7 – couplings.

The odor flow rate is calculated with [10]:

$$Q = \frac{\frac{\pi d^2}{4} \cdot h \cdot n}{60} \quad m^3 / s \qquad (3.1)$$

where:

h – the length of piston stroke, mm

n – speed of pump with piston, rot/min

and from relation (3.1) was build expression (3.2) as a adaptation to the parameters, the characteristics of dosing pump which are presented in the content of this paper

$$A = \frac{\pi d^2}{4} mm^2 \qquad (3.2)$$

A – piston area, mm^2

$$Q = S \cdot L \cdot n \cdot \eta \quad m^3 / s \qquad (3.3)$$

where:

Q – odorizing agent, m^3 / s

S – piston area, mm^2

L – length of double stroke a, mm

n – number of double strokes per minut, rot / min

η – volumetric efficiency (0,92 ÷ 0,98)

From practice it is considered that a dosing pump is considered to operate slowly with piston speed below 0.2 m/s, [3] thus:

$$V \le 0,2\ m/s \qquad (3.4)$$

where:
V – piston speed, m/s

$$V \le \frac{\pi \cdot L \cdot n}{1000 \cdot 60} \le 0,2 \qquad (3.5)$$

In order to limit the wear of pre-setup of piston it is chosen a speed n = 145 rot/min; there is no necessary a higher speed because that must be proportional with the flow speed of the gases in the delivery pipelines.

$$V = \frac{\pi \cdot L \cdot n}{1000 \cdot 60} = \frac{\pi \cdot 10 \cdot 145}{1000 \cdot 60} = 0,08\ m/s \qquad (3.6)$$

4. FUZZY ANALYSIS AND CONTROL THROUGH MATHWORKS, OF DIRECT CURENT ELETRICAL MOTOR TO ANTRENATE OF PUMP

Using fuzzy logic we can analyze the functioning of dispensing pump in certain conditions requested by the delivery process for natural gases through the modification of speed of direct continuous electrical motor creating a variable range of debit of odorizing depending by the debit of gas delivered to the consumers; using a set of three rules, two connected by the variation of supply tension of electrical motor and one by the variation of electromagnetically field of stator of the motor.

Practically the fuzzy logic is used to change the speed of electrical motor and to have an intelligent control on amplification or reducing of number of strokes of motor's stator [4].

The advantage in the monitoring of functioning of odorizing pump, through fuzzy controller of the electrical motor, it is the fact that the mathematical variables take usually numerical values, and by fuzzy logical applications are used rules non-numerical values which can generate an intelligent functioning adapted to the requirements [4].

The analysis of the motor drive model, through simulation into Matlab software have as scope also the designing, implementation of a controller by logic fuzzy in functioning of electrical motor in order to ensure an efficient functioning of odorizing pump, controlling thus the risk of occurring of certain accidental emanations of natural gases and appearing of explosions, fires.

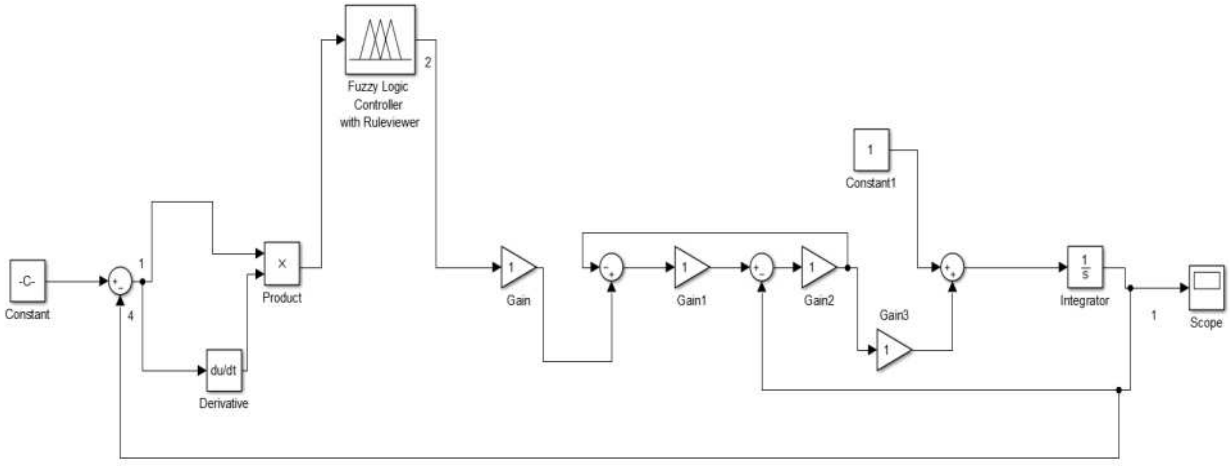

Fig. 4.1. Simulation model of DC electrical motor without brushes with fuzzy logic controller

As an approach in this intelligent control of functioning of odorizing pump, through modeling of functioning parameters of DC electrical motor by a fuzzy controller, it is to take over the information about odorizing concentration on the natural gases delivered; the information can be primate even through SCADA tele-transmission or directly through the transducers mounted on pipelines, and by the rationament builded on three rules set can

assure functioning of the pump corresponding to the required odorant debit. Thus, by using heuristic knowledge and even uncertain we can create by fuzzy logic an elastic range of functioning of the pump through adaptive algorithms [7].

The analysis of motor drive model, by simulation in Matlab software has main purpose also for design, implementation of a controller by fuzzy logic into functioning of electrical motor [9]. In order to ensure an efficient functioning of odorizing pump, controlling thus, the risk of apparition of accidental emanation of natural gases and occurring of explosions, fires.

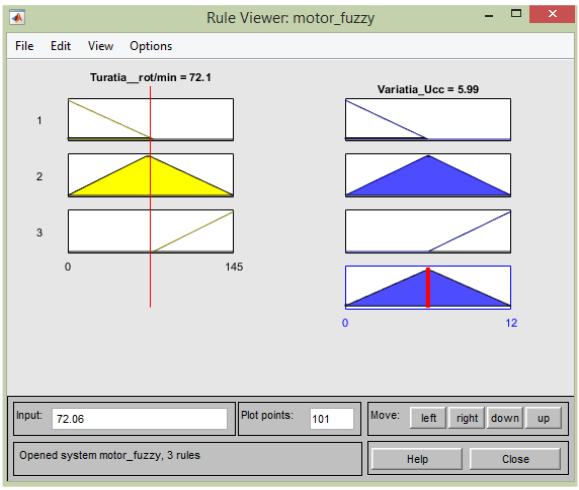

Fig. 4.2. Construction of fuzzy rules for modeling the speed of DC electrical motor

By the Matlab simulation model (fig 4.1) through using of fuzzy controller to manage all three rules considered, DC tension with small value, DC effective tension, the variation of electro-magnetically field by stator of the electrical motor on a small tension range, nominal or higher are presented in figure 4.2.

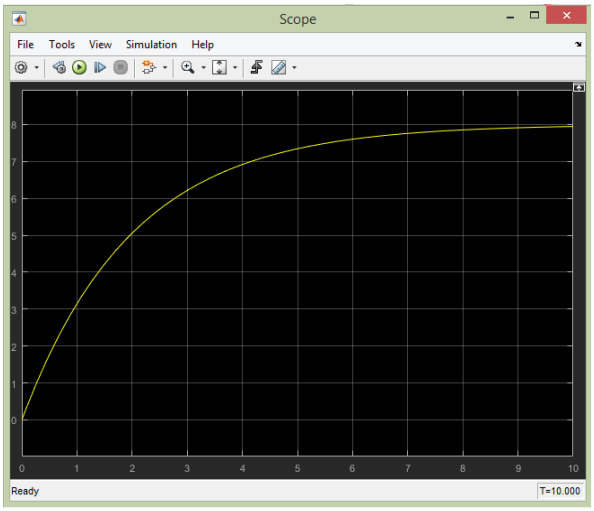

Fig. 4.3. Variation of electric motor speed through the Fuzzy controller

It is remark that the control of tension variation in exponential mode (fig. 4.3) during the interference of those fuzzy rules, resulting a functioning without discontinuities, shocks, to transmit of the moment to the odorizing pump.

The functioning by this fuzzy control can even lead at removing of certain electrical energies, when is no necessary a high concentration of the odorant in pipelines and as

such, is required a small speed of electrical motor.

5. CONCLUSIONS

The DC electrical motor without brushes it is a ferrite magnet on the rotor, with convolute stator, through the change of supply tension and of electro-magnetically field using a fuzzy controller which manage a set of establish rules, it is achieved an intelligent control of odorizing pump.

The modular construction of odorizing pump with eccentric mechanism is a mechanical viable solution and enough chipper to be attract for delivery operators for natural gases which have two or three delivery degree for natural gases.

The fuzzy logic and also the fuzzy intelligent control of odorizing pump are considered as an advantage in order to automate this odorizing process of natural gases, and also to control it through SCADA (Supervisory Control and Data Acquisition).

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Analiza si simularea fuzzy a unei pompe cu mecanism cu excentric pentru odorizat gaze naturale

Gazele naturale sunt hidrocarburi considerate, de literatura de specialitate, aproape inodore sau slab mirositoare, prin odorizarea gazelor naturale se poate sesiza lipsa de etanşeitate a materialului tubular, prin care se face distribuţia spre consumatori sau orice coroziune, fisură sau avarie. Practic, aceasta adaos de odorant, în cantităţi bine stabilite, în volumele de gaze transportate, distribuite prin conducte, reduc riscul de explozie eliminând astfel, pericolul de pierderi de vieţi omeneşti, dar şi distrugerea de clădiri, imobile, precum şi afectarea mediului înconjurător. Orice eveniment de acest gen creează dincolo de cele menţionate mai sus şi o discontinuitate, întrerupere în furnizarea de hidrocarburi spre consumatori şi de aici pierderi financiare mari sau chiar faliment a unor societăţi de distribuţie pentru gaze natural. De aceea pentru a preîntâmpina materializarea aceste neajunsuri sunt utilizaţi în lume o scară largă de odoranţi prin intermediul cărora să se poată sesiza atât din punct de vedere olfactiv, iar în cazul unor odoranţi şi vizual emisiile accidentale si cele controlate. Aceşti odoranţi sunt adăugaţi gazelor naturale prin diferite tehnologii utilizând echipamente adoptate cerinţelor generate de calitatea gazelor naturale livrate. Lucrarea de faţă prezintă o pompă, cu un mecanism simplu şi uşor de întreţinut, care poate să funcţioneze în condiţii din teren cu mediu potenţial exploziv, cu o durata mare în exploatare şi fără a necesita o mentenanţă complexă, având un control al funcţionării motorului de curent continuu prin intermediul unui controller fuzzy.

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