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DISPOSAL OF ICE PLUGS FROM PRESSURE REGULATORS FOR NATURAL GASES, BY USING OF NON-CONVENTIONAL ENERGY

Vasile RAFA, Marian BORZAN, Emil TEUTAN

***Abstract**: During the transport performed by artery pipes, the natural gases are delivered, processed, by the measuring-adjusting stations for consumers. In the cold season the pressure regulators, make conversion of pressure from a higher domain, of this parameter, to a smaller one to its distribution to consumers. Because of the humidity of natural gases and also of other hydrocarbons components from natural gases composition at temperatures below 0OC appear ice plugs which lock the proper functioning of pressure regulators and, therefore even stopping of supplying of natural gases. To control this phenomena, so common winter, the present paper propose presentation of an equipment with non-conventional energy to maintain, to these regulators, of over the congealing limit of the moisture and cryohydrates from the natural gases composition.*

***Key words:** pressure regulator, humidity, cryohydrates, non-conventional energy.*

1. INTRODUCTION

Into a transporting system for natural gases, as interface on deliveries process of natural gases to consumers, the transporting society detain measuring-adjusting stations with or without operating personnel. At this work stations, the two categories mentioned, was found casuistic that in the could period because of the mixing multiphase – water (humidity) and associated hydrocarbons, of natural gases on their flow at atmospheric temperatures under 0OC, or due the meteorological conditions and, not at least of constraint of gases occur ice plugs which block the functioning of pressure regulations from the technological system configuration.

This leads to discontinuities in supplying of consumers with natural gases and increasing of pressure in piping of measuring-adjusting installation which is a risk which can generate explosions, fires with very severe consequences.

The regulators which made the conversion of the pressure, necessary to the distribution networks, it is a equipment with membrane and servo-regulator which make possible the conversion of pressure from a high value to a small one suitable for use by consumers.

If the at the level of a MRS (natural gases measuring-adjusting station) with personnel the delivery process can be controlled by the operator, service operators, modifying the parameters of thermal installation, dependent on the ambient temperature, through which are equipped the supply technological installations [1].

In the case of a workstation which doesn't have operating personnel and in the situation of a meteorological change through which the most important parameter it is the sudden drop of the ambient temperature, the flaw of pneumatic equipment it is more higher and hence direct proportional the risk of generating of an a undesirable event.

Starting from those mentioned above in the phraseological it is evident the necessity to control this phenomena and to eliminate the ice plugs, of cryohydrates through technical methods to be compatible with classified areas as potentiality explosive environment [3].

The present paper aims to present an installation with non-conventional energy, for MRS without personnel, which to eliminate the formation of ice plugs from RPA 3 regulators.

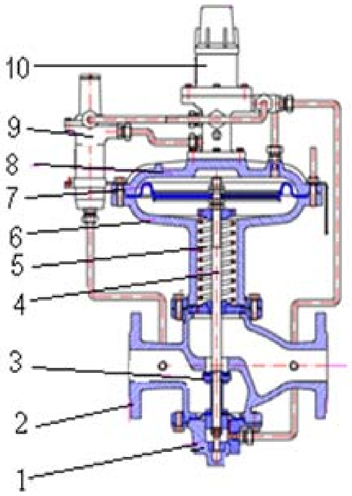

Fig. 1.1 Pressure regulator RPA 3
(Drawing and photo source: catalogue ARMAX GAZ Medias)

Fig. 1.2. Pressure regulator RPA 3(photo)
Components: 1 – End flange, 2 – Regulator body, 3 – Valve, 4 – Core bar, 5 - , 6 – Lower lid, 7 – Membrane, 8 – Upper lid, 9 – Reduction with filter, 10 – Servo-controller

2. PRESENTATION OF EXISTING PROBLEM

In the cold season in some areas of the country known through meteorological annual statistics as being areas with very low temperatures (-20 ÷ -30)^{o}C and of which we highlight: that from county Botosani, assignation that the SRM's located in this area was recorded year by year issues above mentioned and which leads, each time, to stopping of natural gases supplying to consumers.

Fig. 2.1. Measuring-adjusting station of natural gases with exterior technological installation

Fig. 2.2. Technical installation with regulators RPA3

All natural gases contain water vapours in a small or large quantity. Due the pressure conditions and temperature, it is a known thing from practice and from the speciality literature that: all the natural gases contain water in vapour form and because of that it is use the concept of biphasic flow. Must be mentioned the fact that in transporting on artery pipelines the natural gases are accompanied also with liquids hydrocarbons components associated by exploitation of deposits and in this case is use, in the speciality literature, the concept of multiphase flow.

The presence of water into natural gases is known under designation of humidity/moisture and it is expressed in g/Nm3, the humidity can be controlled by the drying process of gases performed generally by the manufacturer of those societies which explore the hydrocarbons deposits.

We note that the humidity of the gases create the matrix forming of cryohydrates, reducing thus the transporting capacity of pipelines, due the colmation of tubular material, this thing encouraging the corrosion of pipeline, of regulating equipments of natural gases, in the case of SRM's, creating critical issues also in the operation of compression stations for natural gases [4].

In this sense results a risk which can leads to unscheduled corrective maintenance and at great financial losses in the transporting of natural gases society.

2.1 Cryohydrates

The cryohydrates are formed by interaction, under certain conditions, between gaseous hydrocarbons and water vapours contained in the structure of the natural gas and with the ratting of water deposit at temperatures relative lowness, high detent speed of the gases and of random pressure.

From speciality literature description the cryohydrates are solid substances having ice aspect or of snow with physical properties more light as water and with crystallization at temperatures near of 0 ºC.

It should be mentioned the fact that the most favorable forming conditions of cryohydrates are created, especially in the areas where the gases through artery pipelines are exposed either in a medium extremely cold due the speed of natural gases, to the detriment of pressure, which leads to a sudden cooling of the gases and hence at the congealing phenomena.

2.2 The regulators from SRMS's

Are those pneumatically equipments for adjusting of natural gases to ensure supplying conditions for existent consumers on a parametric range adapted to required pressures.

During the adjusting process of natural gases interven the following situations and conditioning:

- upstream pressure regulator which, in the analyzed situation, it is on range of (3,5-25 bar);
- gases debits supposed to regulation, various in large limits, horary debits at the consuming top being in certain cases by 2 – 3 time higher than that minimum;
- downstream pressure regulator which must be constant unconcerned by the variation of the debit respectively the upstream pressure regulator;
- adjusting process of gases should be carried out continuously and full safety to not put in danger technological processes and the installations for usage of gases.

From the presented figures (1.1, 1.2) we can understand the vulnerable points where the ice, cryohydrates, can obstruction the normal functioning of these pneumatic equipments. In this situation "in situ" it was casuistic found the frequency of certain damages as: check blockage, of membrane and even ice plugs on the tubular material which make connection between the servo-controller and end flange etc.

3. HEATING INSTALLATION BY USING OF SOLAR ENERGY

A method of using of non-conventional energy, through which we analyzed in the present project, it is to create a heating installation by using of solar energy, this thing it is useful in the areas oriented to south and where the sunshine days are quite numerous as in the cold season.

Thus, the present project aims as a quality indicator: gases supply to consumers in continuity conditions without to record discontinuities in delivering of natural gases and claims from consumer's side.

It is constitute in terms of applicability by the phenomena of preservation of regulator temperature for gases at a value over the body regulator temperature above 0°C, by using of installation through on the base of using of solar energy it is worming an thermal agent, for example, antifreeze solution and create an favorable microclimate, by concentric spiral, exterior laid-down to the regulator, in the purpose of maintaining in normal conditioning of pneumatically equipment.

The variant which we propose for SRM's without personnel it is an installation compose by an concave mirror which is have positioned in the mirror fire point an recipient, which will size the volume from case by case, through which shall be heating the thermal agent, which transmitted by an tubular material, isolate, for pneumatically equipments, create a microclimate suitable to course of natural gases delivery process.

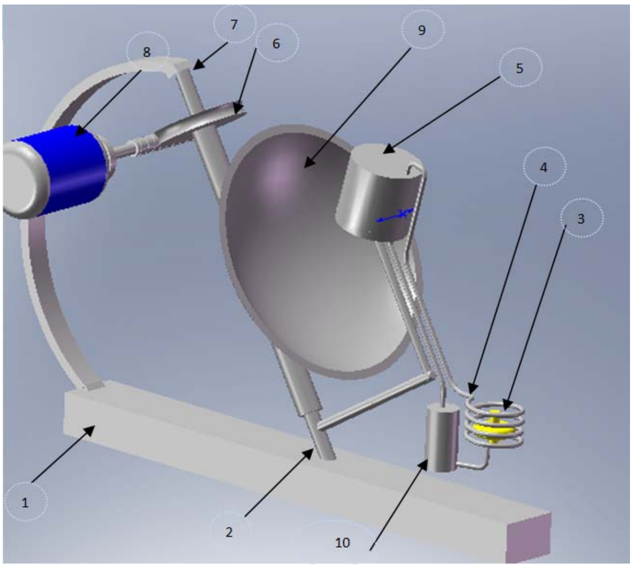

Fig. 3.1 Installation with solar energy to heat the pressure regulators for natural gases
1 – Bed frame, 2, 7 – Ferromagnetic fluid bearings, 3 – Regulator positioned on the thermal heating current, 4 – isotherm tubular material, 5 – Recipient with thermal agent, 6 – Reduction snail worm gear, 8 – electric engine continuous current 12 V (brushless), 9 – Concave mirror, 10 – Tampon recipient of thermal agent

To protect against of a overheating of thermal agent shall be forecast on the ascendant route of that also a boost pressure valve. Positioning of the installation will be on south with instrumentation, for east-west movement of the mirror and also of the recipient on synchronous regime, with a current continuous electrical engine without brushless step by step dedicated to the mediums potential explosives and which shall be gifted with an orientation sensor for sun.

Engine power shall be done from a tampon accumulator at a photovoltaic cellule of 12V. The support frame is sized to use in the field as connection between mobile shaft, with ferromagnetic bearings, and the electric engine it is provide with a reduction snail worm gear for silenced transmission of the movement. At the construction of this installation are used materials composites, being considered anisotropy materials, which are wearing to corrosion and fatigue [2].

3.1. Determination of radiant heat

The equipments which are using solar energy in the purpose of taking of this energy and converting of that into a quantity of heat are strictly related to the necessity to storage of thermal agent into a storage tank. Determination of required volume, building of a tank adapted to the requirements in which to conserve heating is an issue that every designer must calculate or empirically deduct based on solar radiation and of the time when the sun is present during the day.

In this sense result that the role of heat accumulation, energy it is to compatibilities the energy source with consumer. In other vein, must show the fact that the most important part of this installation when the source supply, the sun more radiate the consumer needs energy continuously.

In the simplest description: an solar energy caption installation and transforming of that in thermal energy, it is compound from a solar collector that transmit to a heating tank of the thermal agent and through a circuit, thermal insulated and as soon as possible, to the tank from which an thermal pump shall be pumped into the consumer's installation.

From the thermodynamic point of view the main parameters of a certain heating circuit are the flow of thermal agent Qag (m^3/h) and the temperature of the thermal agent Tag (K).

The rate of change of thermal energy in an amount of volume V, related to time it is equal with to the net flow of energy on the surface S of the volume V.

Based on the two main parameters which characterize the thermodynamic process which result the energy transferred through convection by spiral, coaxially positioned to the natural gases regulator.

$$\frac{\Delta E}{\Delta t} = k_1(t)Q_{ag}(t) + k_2(t)T_{ag}(t) \quad (3.1)$$

where:
E – energy (J);
$Q_{ag}\left(m^3/h\right)$ – debit of thermal agent;
$T_{ag}(t)$ – agent temperature;
k_1, k_2 – constants;
$t(s)$ – time

Explaining of discrete energy notion of a finite element from thermal agent we have the expressions:

$$\frac{dE_f}{dt} = k_1(t)Q_{ag}(t) + k_2(t)T_{ag}(t) \quad (3.2)$$

$$dE_f = k_1(t)Q_{ag}(t)dt + k_2(t)T_{ag}(t)dt \quad (3.3)$$

By integrations result:

$$E_f(t) = E_i + \int_0^t k_1(t)Q_{ag}(t)dt + \int_0^t k_2(t)T_{ag}(t)dt \quad (3.4)$$

where:

E_i – initiation energy (J).
In the case that is considered system build, the solar collector and the tank of thermal agent, the last one is characterised by temperature $\theta(\tau)$.

In the case of solar collectors:

$$t_e = t_r + (t_i + t_r)\cdot E \quad (3.5)$$

where
t_e – the temperature of output agent from the container of heating mirror;
t_r – the temperature of thermal agent into the container of heating mirror;
t_i – the input temperature of thermal agent;

$$q\rho_c = (t_e - t_i)d\tau = V\frac{dt_i}{d\tau}\rho c\cdot d\tau \quad (3.6)$$

or

$$\frac{dt_i}{d\tau} = -\frac{q}{V}(t_i - t_e) \quad (3.7)$$

where
q – the debit (m^3/h)
V – the volume m^3

It is specify that:

- the temperature of thermal agent at output from solar collector is equal with the temperature which enter on storage container.

In this sense:

$$t_e = t_r + (t_i - t_r)E \quad (3.8)$$

where:
E – energy in (j)

Result: $t_i - t_e = (1-E)(t_i - t_r) \quad (3.9)$

Starting from equation (3) it is obtain an differential equation of order 1:

$$\frac{dt_i}{d\tau} = -\frac{q}{V}(1-E)(t_i - t_r) \quad (4)$$

Considering that t_r = constant, we achieve:

$$\theta = t_i - t_r \quad (4.1)$$

Result:

$$\frac{d\theta}{d\tau} = -\frac{q}{V}(1-E)\theta \quad (4.2)$$

with solution : $\theta = \theta_0 - E_1^{\tau} \quad (4.3)$

and $E_1 = exp\left[-\frac{q}{V}(1-E)\cdot 1\right] \quad (4.4)$

Result: $t_i = t_r + (t_{i0} - t_r)E_1^{\tau} \quad (4.3)$

$(0,\tau)$ – represent the time range for t_r = constant.

We consider that on the time period $\Delta\tau$ the temperature is constant $t_{rj,j+1}$ and result the recurrent equation:

$$t_{ij+1} = E_1^{\Delta\tau}t_{ij} + \left(1+E_1^{\Delta\tau}\right)t_{rj,j+1} \quad (4.4)$$

The heat quantity integrated, collected:

$$Q = \int_0^{\tau} q \cdot \rho c \left(t_e - t_i\right) \cdot d\varsigma \quad (4.5)$$
$$\rightarrow Q = V \cdot \rho c \cdot \left(\theta - \theta_0\right)$$

4. MONITORING OF QUALITATIVE FUNCTIONING OF INSTALLATION

On the cold season it is necessary to monitories the installation like this:

- through daily field trips to check the installation operating;
- following the deliveries of natural gases quality to consumers;
- isothermal recipient with thermal agent shall be positioned in the soil at a depth under freeze level;
- this heating installation with non-conventional energy can be associated with a wind turbine to which represent an backup energy source.

5. CONCLUSIONS

After getting the results through to consider it adequately and with real efficiency regarding the initial costs ratio respectively value energy, will propose implementation in a large scale of this project.

The installation which we presented it is perfectible thus to achieve a maximum performance concerning the initial costs report, respectively energy value, we propose implementation on large scale of this project.

The installation it is useful to the isolated areas where doesn't exist the electrical networks and where the positioning of certain thermal boilers with thermal agent represent an real danger giving the fact that the potential explosive environment generated by the possible natural gases accidental leakages at those working stations.

6. REFERENCES

[1] Simescu, N. (2001), *Design, Construction and Exploation of natural gases pipe lines,* Lucian Blaga, Sibiu, Romania;

[2] Soare, A., Stratula, C. (2002) *Transporting and storage of fluids*, Publisihing House Of University from Ploiesti, Romania;

[3] Iancau, H., Nemes, O., (2003), *Composites materials and manufacturing,* Cluj-Napoca, Romania;

[4] ****Maintenance of pipelines designated to natural gases transporting,* (2011), Technical Publishing House, Bucharest, Romania;

[5] www.solidworks.com/2013.

Eliminarea dopurilor de gheață, din regulatoarele de presiune pentru gaze naturale, prin utilizare de energie neconvențională

Rezumat: În procesul de transport efectuat prin conductele magistrale, gazele naturale sunt livrate, procesate, prin stațiile de reglare-măsurare spre consumatori. În perioada sezonului rece regulatoarele de presiune, fac transformarea presiunii de la o plajă mai mare, a acestui parametru, spre una mai mică în vederea distribuiri acestuia spre consumatori. Datorită umidității din gazele naturale cât şi a altor componente de hidrocarburi din compoziția gazelor naturale la temperaturi sub 0 ºC apar dopuri de gheață care împiedică funcționarea corespunzătoare a regulatoarelor de presiune şi, din această cauză, oprind chiar furnizarea de gaze naturale. Pentru a controla acest fenomen, atât de des întâlnit iarna, lucrarea de față își propune prezentarea unui echipament cu energie neconvențională în vederea menţinerii, pentru acestor regulatoare, a unui climat peste limita de congelare a umidității și crio-hidraților din compoziția gazelor naturale.

Vasile RAFA, Drd. Eng., Technical University of Cluj-Napoca, Manufacturing Engineering Department, raffavasile@yahoo.com, Pr. Prof. Stefan Manciulea nr.12, Medias, jud. Sibiu.0269⁄ 832749

Marian BORZAN, Prof. Dr. Eng., Department of Manufacturing Engineering Department, marian.borzan@tcm.utcluj.ro, Office Phone 0264/401200

Emil TEUTAN, Lect. Dr. Eng., Department of Mechanisms, Precision Mechanics and Mechatronics, Emil.Teutan@mdm.utcluj.ro, Office Phone 0264/401606.