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# DETERMINATION OF OCCURRING OF SEALING DAMAGES IN TRANSPORT OF HYDROCARBONS, DETECTION OF ACCIDENTAL LEAKES OF NATURAL GASES

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***Abstract***: *Detecting and location of damages, corrosions, appeared at a certain point, in the structure of metallic material, tubular of a pipe, it is made by monitoring of transport parameters of transporting line. In the case of monitoring by SCADA it was observed the fact that is reduced the accidental leakages of natural gases and it is avoid the impact which produced it the hydrocarbons exhausting to the environment. In this paper it is presented a localization method of an accidental leakage of natural gases, through the variation analysis of pressure parameters, from a transporting process. The method it is characterized by an algorithm through which are performed simultaneous various numerical dates for the purpose of a localization, as precise of the damage in the field.*
***Key words:*** *natural gases, accidental leakages, pressure gradient, debit.*

## 1. INTRODUCTION

By development of oil and gas industry, of transporting of hydrocarbons products to the consumers, was record a requirement for the purpose increase of safety of hydrocarbons transport and to detect of accidental leakages, on the route, of those organic products.

It is very important especially for long pipelines, which pass through urban areas or near by the cultivated fields, to have a detection system of leakages and to monitories the transport by following of transporting parameters, moreover a necessary condition to perform the transporting of hydrocarbons it is to monitories permanently of variation of the transport parameters.

To monitor of transporting process of hydrocarbons we proposed a inspection method, following of transport, which we analyzed casuistic into the process, and through which by following of the pressure parameters from fluid input, into a considered pipe section, respectively of output pressure from that can be made an analysis of transport quality by pipelines.

The present paper aims to present the utility of SCADA in order to follow a transport process, receiving-deliveries, to take decisions by artificial intelligence, to modify of transport regimen respectively even to modify the transporting workflow to the consumers.

The SCADA software can provide logical variants to take decisions, through PLC, to operate in a hydrocarbons transport system, by the information which is monitories, to close the valves from the pipeline network, pipelines and/or open of a by-pass valve to the delivery network of consumers [3].

For this paper, for a section of 60 km of pipeline, with diameter Ø = 20□ through which is performed a transporting process was analyzed depending by the variation of pressure parameters a possible damage location of sealing of tubular material for transporting.

## 2. DETERMINATION OF LOSS OF GASEOUS HYDROCARBON

Once with hydrocarbons transport through pipeline section, to express the transport regimen must be noted, with general title, regimen of: pressure, density, speed and temperature of the fluid in-process transporting. From practical of pipelines construction was observed the fact that the curvature radius of pipeline is greater than the diameter of the pipeline, density of the transported fluid and the area of cross-section of the pipeline are considered constant. Thus, from the literature result the fact that the equations of continuity and motion of hydrocarbons are [1]:

$$A \cdot \frac{\partial \rho}{\partial t} + \frac{\partial Q}{\partial x} = 0 \qquad (2.1)$$

$$\frac{1}{A} \cdot \frac{\partial Q}{\partial t} + \frac{\partial P}{\partial x} + \frac{1}{2A^2} \cdot \frac{\partial Q^2}{\partial x} = -\rho g \cdot \sin\theta - \frac{2rQ^2}{D\rho A^2} \qquad (2.2)$$

Taking account the above expressions: $P$ is the pressure (pa), $Q$ is the mass debit (kg/s), $\rho$ is the density of the liquid (kg/m$^3$), x is the length of pipeline (m), $g$ is gravitational acceleration (m/s), $A$ is the cross section area (m$^2$), $D$ is pipeline diameter (m), and $r$ is friction coefficient.

Must precise that to form the algorithm we considered: speed and compressibility of the gases as being neglected, in the transporting regimen, and the fact that the barrel of the pipeline is positioned horizontally, starting from these conditions the expression (2.2) become [2]:

$$\frac{\partial P}{\partial x} = -\frac{2rQ^2}{D\rho A^2} \qquad (2.3)$$

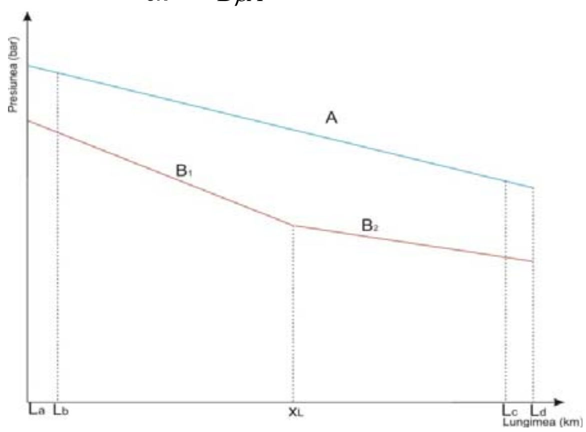


**Fig. 2.1** Variation of pressure gradient
A – normal transporting process, $B_1$, $B_2$ – sections, in the case of damage, considered by the side and the other of the defect $x_L$

Considering a crack, leak through which is in the considered point on section described graphic in figure 2.1 can we write:

$$Q_{x_L} = \lambda \sqrt{P_{x_L}}, \lambda \geq 0 \qquad (2.4)$$

where:

$\lambda$ − hydraulic resistance coefficient

In the considered situation the pipeline shall be treated as an assembly of two sections of pipeline or as two distinct sections:

$$Q^d_{x_L} = Q^a_{x_L} + Q_{x_L} \qquad (2.5)$$

where:

$Q^d_{x_L}$ and $Q^a_{x_L}$ − represent the mass debit of section: before and after drain point;

$Q_{x_L}$ − indicate the point of accidental discharge from pipe.

Supposed the situation: the pressure gradients are equally spreads on each pipeline section can write:

$$\left.\frac{\partial P}{\partial x}\right|_{x \leq x_L} = \frac{P_{x_L} - P_{L_a}}{x_L} \qquad (2.6)$$

$$\left.\frac{\partial P}{\partial x}\right|_{x_L \leq x \leq L} = \frac{P_{L_d} - P_{x_L}}{L - x_L} \qquad (2.7)$$

$$x_L = \frac{P_{L_d} - P_{L_a} - L \cdot \left.\frac{\delta P}{\delta x}\right|_{x_L \leq x \leq L}}{\left.\frac{\partial P}{\partial x}\right|_{x \leq x_L} - \left.\frac{\partial P}{\partial x}\right|_{x_L \leq x \leq L}} \qquad (2.8)$$

Assuming that the accidental leakage is an stochastic incident and the fact that the pressure and the parameter $r$ are not constant in the two sections, moreover the parameter $r$ being more difficult to be determinate, in practice it is propose to use the method of localization with pressure sensors. Thus, can be mounted four pressure sensors at the section edges of the pipeline at positions: departure $L_a$, $L_b$ and $L_c$, $L_d$ arrival, as is presented in figure 2.1.

In this case the pressure gradient (2.6), (2.7) can take the following shape:

$$\left.\frac{\partial P}{\partial x}\right|_{x \leq x_L} = \frac{P_{L_b} - P_{L_a}}{L_{ab}} \qquad (2.9)$$

$$\left.\frac{\partial P}{\partial x}\right|_{x_L \leq x \leq L} = \frac{P_{L_d} - P_{L_c}}{L_{cd}} \qquad (2.10)$$

Generally, practically was observed that the pressure values determinate are usual distorted by the noise, vibrations [2]. In this sense the calculus of the pressure gradient for the both sections using pressure values instantly measured, can occur high errors. Therefore, are calculated the pressure gradients by use a certain dates volume, delimitated by the time was detected an accidental discharge of the fluid.

**Fig. 2.2** Changing of pipeline section (photo Transgaz S.A.)

## 3. DETECTION OF ACCIDENTAL LEAKAGES OF GASEUOUS HYDROCARBONS FROM A PIPELINE SECTION

The pipeline which will considered experimental will be a section with a length of 60 km and with a diameter Ø = 20’ (508 mm) with a pressure of 23 bar at departure.

To build a software based on the presented algorithm, in section 2, will considered necessary to mount four pressure sensors positioned as follows: for pressure p (bar) at section entrance; at a distance of 8 km shall be mounted the second sensor $P_{L_b}$ ; in position $P_{L_c}$ at a distance of 8 km from the upstream end section another sensor; at the end of section will be mounted an another sensor $P_{L_d}$ (according to figure 2.2).

To write the software was use the program QB64 (Quick BASIK), program considered compatible for monitoring and automation through SCADA. Thus, after algorithm compilation to determine the discharge point $X_L$ the software which we designate “Gradient” will look like this [4]:

```
TITLE "Gradient"
OPTION BASE 1
DIM SHARED nl1(10) AS INTEGER, dnl(10) AS INTEGER, nc1(10) AS
INTEGER, dnc(10) AS INTEGER
DIM SHARED ww(10) AS STRING * 13
DIM i AS INTEGER, x AS INTEGER, y AS INTEGER, IA AS INTEGER, KK
AS INTEGER
DIM I1 AS INTEGER, K1 AS INTEGER
dim L,Pla,Plb,Plc,Pld,Pxl,xl,Lab,Lcd,d1,d2 as single
dim st as string*13

        '=====================================
        OPEN "date" FOR BINARY ACCESS read AS #1
        on error goto a
        get #1, ,Pla
        on error goto a
        get #1, ,Plb
        on error goto a
        get #1, ,Plc
        on error goto a
        get #1, ,Pld
        on error goto a
        get #1, ,L
        on error goto a
        get #1, ,Lab
        on error goto a
        get #1, ,Lcd
        on error goto a
        _printstring (200,116),str$(Pla)+" Bar"
        _printstring (200,176),str$(Plb)+" Bar"
        _printstring (200,236),str$(Plc)+" Bar"
        _printstring (200,296),str$(Pld)+" Bar"
        _printstring (200,356),str$(L)+" km"
        _printstring (200,416),str$(Lab)+" km"
        _printstring (200,476),str$(Lcd)+" km"
a:        CLOSE #1
        '=====================================
DO WHILE KK <= IA
    CALL Cbut(IA, KK)
    IF KK = 1 THEN
        st=" Pla [Bar] = "
        call rnput(st,16,10,48,300,Pla)
        _printstring (200,116),str$(Pla)+" Bar"
        KK = 0
    END IF
    if kk=2 then
        st=" Plb [Bar] = "
        call rnput(st,16,10,48,300,Plb)
        _printstring (200,176),str$(Plb)+" Bar"
        KK = 0
    end if
    if kk=3 then
        st=" Plc [Bar] = "
        call rnput(st,16,10,48,300,Plc)
        _printstring (200,236),str$(Plc)+" Bar"
        KK = 0
        if kk=7 then
        st=" Lcd [km] = "
        call rnput(st,16,10,48,300,Lcd)
        _printstring (200,476),str$(Lcd)+" km"
        KK = 0
    end if
    IF KK = 8 THEN
'        i = 0
'        FOR K1 = 90 TO 690 STEP 40
'            FOR I1 = 20 TO 920 STEP 60
'                CALL Fretan(K1, I1, 40, 60, i)
               REM                 CALL LocBGI(K1 + 12, I1 +
22)
               REM                PRINT i
'               _PRINTSTRING (I1 + 20, K1 + 12), STR$(i)
    END IF
    IF KK = 9 THEN SYSTEM
        '=====================================
        OPEN "date" FOR BINARY ACCESS WRITE AS #1
        PUT #1, ,Pla
        PUT #1, ,Plb
        PUT #1, ,Plc
        PUT #1, ,Pld
        PUT #1, ,L
        PUT #1, ,Lab
        PUT #1, ,Lcd
        CLOSE #1
        '=====================================

LOOP
'
END
sub rnput(st as string*13,nl1 as integer,nc1 as integer,dnl as
integer,dnc as integer,x as single)
call Frame(nl1,nc1,dnl,dnc)
_printstring (nc1+10,nl1+16),st
locate (nl1+32)/16,(nc1+105)/8
input x
end sub
sub grf
dim i,j as integer
call Frame(100,300,650,850)
call Fretan(120,320,609,810,8)
call Retan(120,320,609,810,0)
for i=1 to 29
for j=1 to 19
line (320+(i-1)*870/30,120)-(320+(i-1)*870/30,729),1
next j
next i
call fretan(120,320,609,3,1)
end sub
sub grfr(Pla as single,Pxl as single,Pld as single,L as
single,xl as single)
'or.axelor: 320,689
' inalt. max.oy: 130
' lung.max.ox: 1100
' pct.a: 320,130
' pct.xl:(1100-320)*xl/L+320 , (689-130)*Pxl/Pla+130
'pct.b: 1100,(689-130)*Pld/Pla+130
_printstring (345,130),"Pla="+str$(Pla)+" Bar"
_printstring (1050,729-(729-130)*Pld/Pla-20),"Pld="+str$(Pld)+"
Bar"
_printstring (320+(1100-320)*xl/L,729-(729-
130)*Pxl/Pla),"Pxl="+str$(Pxl)+" Bar"
_printstring (320+(1080-320)*xl/L,710),str$(xl)+" km"
line (320+(1100-320)*xl/L,729-(729-130)*Pxl/Pla)-(1100,729-(729-
130)*Pld/Pla),12
'line
end sub

'
REM $INCLUDE: 'BIBL1.BAS'
```

To view the operating of this software, called Gradient, it is form a command window through which is sets: the pressures from all four points considered $P_{L_a}, P_{L_b}, P_{L_c}, P_{L_d}$; the section length (Fig. 2.3); and then by starting of the software it is obtained graphic (fig. 2.4) depending on the pressure values which we considered – location where occur the accidental leakage, on the pipeline workflow.

**Fig. 2.3** Command window of QB64 software

## 5. CONCLUSIONS

Using the method of localization discharges the accidental leakages from the main pipelines to transport the hydrocarbons, the method which we called method of analysis of pressure gradient, and results analysis, through QB64 software depending by the pressure variation on pipeline workflow increase the quality of transport process on system.

It is an analytical version, with improvement possibilities, monitoring compatible to the SCADA system through which can protect the environment and can be removed to create an explosive medium (gases, vapors, mists).

The method can be suitable to an automation system by PLC, through which can be ordered sectioning valves (stopping the fluids delivery) pictured upstream by the damage and/or organization of deliveries through by-pass to consumers.

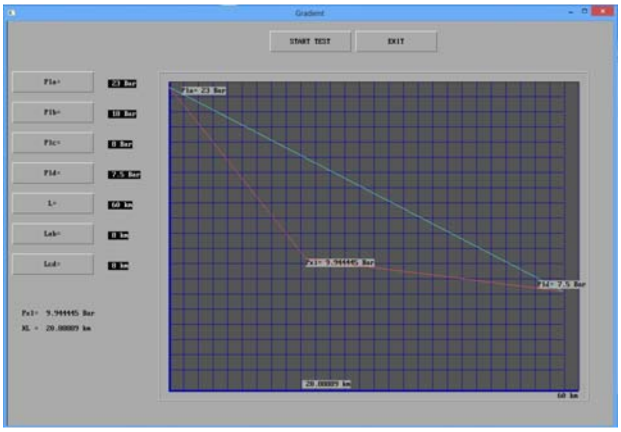

**Fig. 2.4** Answer window of QB64 software, determination of location of accidental discharge of hydrocarbon and discharge's pressure

## 6. REFERENCES


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**Determinarea apariției defectelor de etanşare în transportul de hidrocarburi, detectarea scurgerilor accidentale de gaze naturale**

Detectarea şi localizarea avariilor, coroziunilor, apărute la un moment dat, în structura materialului metallic, tubular a unei conductei, se face prin monitorizarea parametrilor de transport a rețelei de transport. În cazul unei monitorizări prinSCADA s-a constatat că se reduc pierderile accidentale de gaze şi se evită impactul pe care îl produce evacuarea hidrocarburilor asupra mediului. In această lucrare este prezentată o metoda de localizare a unei scurgeri accidentale de gaze naturale, prin analiza variației parametrilor de presiune, dintr-un proces de transport. Metoda este caracterizată de un algoritm prin care se operează simultan diferite date numerice, în scopul unei localizări, cât mai precise a avariei în teren.



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