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Consideration Regarding Oil, Gasoline and Condensate Losses During Transportation through Pipelines and at the Afferent Pumping Stations

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Abstract

The paper presents the results obtained in the research carried out for the determination of losses in oil transport through the pipelines in the system served by SC Conpet SA.

Key words: pipeline, loss, oil, gasoline, condensate

Introduction

The transport of oil and of oil products through pipelines represents the main transportation mode of oil products, with numerous advantages as compared to the other terrestrial or naval transport procedures.

In Romania, S.C. Conpet S.A. is the oil (crude petroleum) and oil product transport company that serves the main beneficiaries.

The contracts concluded between the carrier and beneficiaries are concluded by the partners' acceptance of the figure that represents the losses that occur in the transport process.

Consequently, the carrier required the carrying out of a research study regarding the losses afferent to the transport of oil, gasoline, condensate and ethane with a view to concluding contracts with beneficiaries.

The results obtained for these losses are shown in the paper below. These results are obtained based on the calculation method proposed by the authors.

Gasoline, Condensate and Ethane Losses

Loses within the oil tanks storage area

The degasolination station of the oil derrick produces and delivers two distinct products to S.C.

Conpet S.A.: raw gasoline ("heavy"), with density between 660 … 680 kg/m^3, and condensed gas ("liquid gas"), with density of 515 … 525 kg/m^3, gasoline being more stable than the condensed gas. In some reception reservoirs (such as the one at Boldesti oil field), the gasoline and the liquid gas are taken over separately, in different tanks, and then mixed up in the transport pipeline, while in other reception reservoirs, the two products are taken over together, in the same tank.

The pressure in the taking over tank is has the upper limit of 18 bar, imposed upon by the carrier. The discharge of the liquid from the tank to the loading ramp of the tank cars or to the transport pipeline shall be carried out either with the help of pumps, or by the pressure exercised by the gas cushion above the liquid in the tank, introducing gases in it from the degasolination installation, at a pressure of about 25 bar.

During the discharge of gasoline from the tanks, there are losses of liquid gasoline by the generation of gas from the solution, due to the decrease of pressure in the tank during the process.

Losses in the pipeline transport

The decrease of pressure, at some portions of the pipeline, under the value of 18 bar when the reception of gasoline was made (actually, of the raw gasoline and condensed gas mixture) results in the ending of the liquid stage of more volatile hydrocarbon fractions, and the flow gets a two-phase character. There cannot be developed an accurate modelling of the two-phase flow type with a view to estimating the drop pressure along the pipeline but the two-phase flow determines energy losses that are greater than the single-phase one.

Under the real conditions of the gasoline transport system, the separated gases in the transported liquid do not re-enter the solution when the pressure increases again up to the value of 18 bar.

The pressure in the gasoline supply tank to the beneficiary (refinery) is lower than the one in the reception tank (in the degasolination station), thus the supplied liquid mass is lower than the received one, fact that proves the existence of losses along the pipeline. Consequently, at Arpechim Piteşti Refinery p = 11…13 bar, at Frasin ramp p = 15…16 bar, and at Brazi Refinery $p \cong 13$ bar. We notice the fact that the gas cushion in the reception tank belongs to the producer oilfield, while the gas cushion in the delivery tank belongs to the refinery, therefore S.C. Conpet S.A. only makes the balance sheet of the liquid quantities, a balance sheet that always shows a deficit.

The composition of the gasoline received by S.C. Conpet S.A. does not comply with the standards because, on the one hand, the liquid is not stabilized (it contains significant fractions of $C_1...C_3$) and, on the other hand, there are high fractions of inert gases (especially nitrogen). There are big composition differences between the gasoline received from the oilfields and the one supplied to the refineries, because the more volatile fractions have a greater share in the losses recorded during the transport.

In degasolination stations, the drying of the gases in order to remove water and the filtering of gasoline delivered to S.C. Conpet S.A. are no longer performed, therefore the following issues occur:

a) Water favours the development of cryohydrates in the route points that are characterised by local losses of hydraulic load; cryohydrate locks are difficult to eliminate. The prevention of cryohydrate development is made by the enriching of the transported liquid with methanol at rather high concentrations (approximately 1 l/ton in the summer and 3 l/ton in the winter), which increases the transport cost.

b) The lack of gasoline filters determines the drive of coal particles in the degasolination towers in the transport system.

Both problems lead to the blocking of the transport pipes, especially during the cold season. In order to resume transportation, the following solutions are used:

a) in order to eliminate cryohydrate locks, the pipeline shall be depressurised (upset) to the atmospheric pressure;

b) in order to resolve the solid substance plug problem (namely active carbon), the clogged section of the pipe shall be replaced after the full drainage and aeration of the pipe, in order to work with fire on it.

There can be noticed that both solutions involve the loss of the entire quantity of gasoline that make up the “stock” of the pipe section between the cutting valves. The same loss is recorded when the general overhaul of the pipeline is carried out or when accidents happen whose outcomes involve the performance of some welding works on the pipe.

The visual detection of gasoline or ethane leakages from the transport pipelines is not possible unless these leakages affect the vegetation nearby the respective pipes. Under these circumstances, the loss of a highly significant quantity of products is possible.

Maintaining pressure during the transport at above 18 bar is not possible (the imperfection of the sealing at junctions, choke valves etc.). Taking into consideration the peak points of the transport pipeline route, the pumping pressure required to maintain the 18 bar value along the entire route would be, in some cases, too high as compared to the pressure values the transport system can support.

Similar problems as those related to the gasoline pipeline transport are also recorded with the ethane transport system, which is carried out between the Turburea oilfield and the Arpechim Pitesti Refinery.

Oil Losses

Oil and condensate losses in the transport pipelines

The losses occur in: leaks of joints between the sections of the pipeline, in corrosion orifices, cracking or breaks of the pipeline. The leak of the oil from the pipe through corrosion orifices, cracking or even breaks cannot be detected immediately, therefore the lost quantities are, in some situations, very significant.

Thus, the pipes are inspected visually by the route operators at pre-established time periods. If the leak starts shortly after the inspection, the loss lasts for a long period of time.

The visual detection of liquid leakages can be easily made only on the over ground sections of the pipeline route. In the underground areas of the route, which are preponderant, the leakages can be observed visually only after the liquid reached the surface of the ground, which can happen after a long period of time, according to: the soil permeability above the pipeline, the presence and the composition of the vegetal layer, the flow due to a defect and the nature of the transported liquid. Thus, some light oils, gasoline and condensate do not leave visible marks on the ground, because they evaporate quickly; only the potential degradation of vegetation may indicate the product leakage from the pipe. On the other hand, liquids have the tendency of infiltrating in the soil, so as the time the product reaches the surface increases.

As a rule, significant losses of liquid (due to some serious defects or due to the accidental breaking of the pipe) can be detected indirectly by the sudden drop of the pumping pressure. This indication allows the minimization of the liquid quantity that is lost, by the immediate shutdown of the pumps, followed by the shutting off of the cutting valves on the route. There must be taken into account the possibility of the pipe failure at the final section of its route, in which case the pumping pressure does not have any significant change. Thus, if the final pressure was, under normal working conditions of the pipe, several meters liquid column (in the reception tank), its decrease to the atmospheric pressure value in a section situated several kilometres (or less) before the final point affects the pumping pressure by a percent that is too low to be noticed and correctly interpreted.

Paraffin oils are transported through pipes only after their having been heated up. Along the pipeline, the oil cools down and starts depositing paraffin crystals on the walls. The cleaning of the paraffin layer must be performed frequently, in order to eliminate the blocking risk of the pipe. Pipe go-devilling implies some losses, namely: oil losses during the manoeuvres executed in the go-devil stations at the initial and final end of the pipeline; the loss of the entire quantity of paraffin separated from the oil mass and brought by the go-devil to the reception station, because S.C. Conpet S.A. does not exploit the paraffin that enters the mass balance sheet of the taken-over oil.

The evaluation of oil losses due to pipeline defects

In order to establish the quantity of the leaked oil through a defect of the transport pipeline, there shall be used the calculation algorithm proposed by the authors in the paper handed in to SC Conpet SA.

Firstly, there shall be treated the situation of a free defect, developed on a pipe through which oil is transported. The following data is known: oil density ρ = 880 kg/m^3, relative pipe pressure in front of the defect p = 2, 5, 10, 15, 20 and 30 bar, equivalent diameter of the defect d = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 mm and flow coefficient c_d = 0,59.

By using the relation put forward by the authors in the research study, the results below are obtained.

Table 1

d, mm	*A*, mm^2	*p*, bar					
		2	5	10	15	20	30
		Q, dm^3/min					
0	1	2	3	4	5	6	7
1	0,7854	0,5928	0,9372	1,3255	1,6234	1,8745	2,2958
2	3,1416	2,3711	3,7490	5,3018	6,4934	7,4979	9,1831
3	7,0686	5,3349	8,4352	11,9291	14,6102	16,8704	20,6619
4	12,5664	9,4842	14,9959	21,2074	25,9736	29,9917	36,7322
5	19,6350	14,8191	23,4311	33,1365	40,5838	46,8621	57,3941
6	28,2743	21,3395	33,7407	47,7166	58,4406	67,4814	82,6475
7	38,4845	29,0454	45,9249	64,9476	79,5442	91,8497	112,4925
8	50,2655	37,9369	59,9835	84,8295	103,8945	119,9670	146,9290
9	63,6173	48,0139	75,9166	107,3623	131,4914	151,8332	185,9570
10	78,5398	59,2764	93,7242	132,5461	162,3351	187,4484	229,5765

In the table, *d* represents the diameter of the defect; *A* represents the area of the defect and *Q* represents the volumetric flow of oil that leaked through the defect.

From the analysis of the results obtained, there can be noticed the fact that the oil losses in the transport pipes due to free defects are quite significant, even if the dimensions of the defect are low, under the conditions of regular pressures during transportation.

In the case of a buried pipe, the defect is covered by a porous environment and the flow of the leaked liquid can be calculated based on a different methodology for the following numerical data: the radius of the pipe R = 0,0508 m, the burial depth H = 0,9 m, the soil permeability k = 1,000 D = 10^{-9} m^2, the dynamic viscosity of the oil μ = 150 cP = 0,15 Pa·s, the equivalent diameter of the defect d = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 mm, and the pressure at the exterior part of the defect p_e = 2, 5, 10, 15, 20 and 30 bar. The volume flows Q and the mass ones M of filtered oil to the ground surface, corresponding to the chosen calculation parameters, are shown in *table 2*.

Table 2

	p, bar					
	2	5	10	15	20	30
d, mm	*Q*, dm^3/min					
0	1	2	3	4	5	6
1	0,01207	0,04875	0,10988	0,17102	0,23215	0,35443
2	0,04825	0,19494	0,43944	0,68393	0,92842	1,41740
3	0,10852	0,43847	0,98837	1,53827	2,08818	3,18799
4	0,19283	0,77910	1,75621	2,73332	3,71043	5,66465
5	0,30110	1,21655	2,74229	4,26803	5,79377	8,84524
6	0,43325	1,75043	3,94575	6,14106	8,33638	12,72700
7	0,58914	2,38029	5,36555	8,35081	11,33606	17,30657
8	0,76866	3,10559	7,00047	10,89535	14,79024	22,58000
9	0,97164	3,92569	8,84910	13,77252	18,69594	28,54277
10	1,19791	4,83989	10,90987	16,97984	23,04981	35,18976

There results the fact that the oil losses through a covered defect (in the case of the buried transport pipelines) depend not only on the dimensions of the defect and on the pipe pressure, but also on the burial depth of the pipe, on the soil permeability and on theh viscosity of the transported oil.

Liquid losses in pumping stations

The pumps used are, almost exclusively, with pistons.

The losses in the pumping stations are produced by: leaks of the pump equipments, of the joints through flanges or of the manoeuvre valves, by the corrosion of the manifolds or by the damaging of the discharge pipes nearby the pumps, due to the maximum pressures and to the inherent pulsations at the piston pumps.

As regards some of the oil reception stations at the oilfields reservoirs, the line from the tank to the pumping station belongs to the oilfield. Under these circumstances, the operators of the oilfield can use the respective pipe also for internal manoeuvres of the deposit, moving back the oil quantity that represents the “stock” of the pipeline into the tanks of the oilfield, which was previously supplied to Conpet.

Before pumping to the refinery the oil taken over by S.C. Conpet S.A. from the oilfields, the clean oil tank is emptied of free water. This operation involves the loss of a quantity of oil due to the incorrect evaluation of the moment when the discharge valve was shut off and, on the other hand, by the discharge of the cut oil from the tank.

The losses in these stations were evaluated based on the S.C. Conpet S.A. data.

Conclusions

The analysis of the losses of oil products transported through pipelines by the SC Conpet SA allowed the establishment of the quantum of these losses, based on the relations put forward by the authors. These results were agreed upon by the partners involved in the transport process, by the executer and beneficiary, namely SC Conpet SA and SC Petrom SA, which represented the setting-up of bilateral contracts. The results obtained are in accordance with the data that exist in the specialty literature, based on experiments carried out during long analysis periods of the transport process.

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Consideraţii privind pierderile de ţiţei, gazolină şi condensat la transportul prin conducte şi în staţiile de pompare aferente

Rezumat

În lucrare sunt prezentate rezultatele obţinute în studiul efectuat pentru determinarea pierderilor în transportul ţiţeiului prin conductele din sistemul deservit de SC Conpet SA.