# ASPECTS ON OPTIMIZING THE TRANSPORT OF CRUDE OIL THROUGH COLLECTOR PIPES

*Iuliana Veronica GHEŢIU**

***Abstract***
*The transport activity of petroleum products is now an essential component of the economy. This paper aims at optimizing the crude oil transport for a section of the collector pipe that provides transport from three parks to a central repository. Based on the hydraulic calculation relying on the fundamental equation of real fluid flow through the current tubes, the number of pumps required in each park, the production time of each park, the exhaust flow rate for each park and the maximum pressure were calculated.*
***Keywords:*** *petroleum products, transport activity, collector pipe, reservoir park*

## 1. Introduction

The activity of collecting, transporting and storing oil, petroleum products and gas is currently an essential component of the economy. The rapid growth of primary energy supply needs and the consumption of petroleum products, increasingly complex requirements, and international cooperation in this field require a better understanding of both fundamental issues and the latest achievements. In the current market context, with an unfavorable oil price, which is expected to persist for a longer period, it is intended to step up programs focusing on efficiency, with priority projects being optimized.

This paper aims at optimizing crude oil transport for a section of the collector pipe that provides the transport of crude oil from three parks to a central warehouse.

From a technological point of view, tank park equipment consists in four main components: container-collector system (Fig. 1); container-separator system and equipment; container pump; container - system for electrical cabinets and command and control equipment.

The command and control equipment of the system will be designed to meet the requirements of a "no operator" operation and will be designed for the current station size, guaranteeing fast and ideal operations.

Collector pipes are branch pipes that collect the oil from the separator parks and transport it to the central repository. The main collector is actually a pipe system mounted in series, on each section, allowing the determining of not only the lengths and inner diameters, but also of the flows.

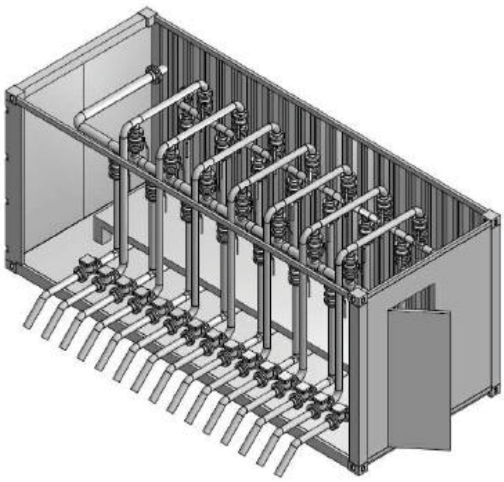

*Fig.1* **Collector measurement system**

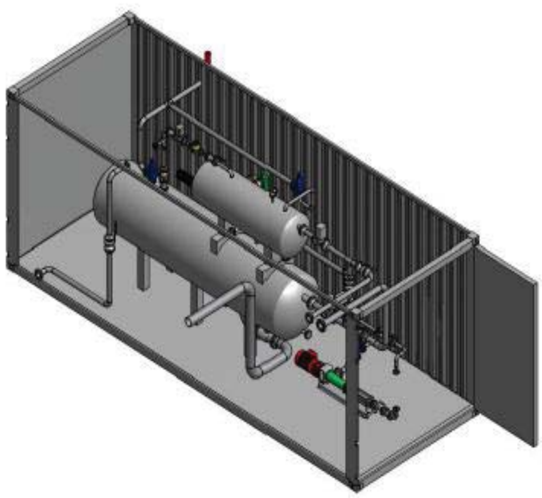

*Fig.2* **Metering system for the separator**

** Asist.Ph.D.eng. U.P.G. Ploiești*

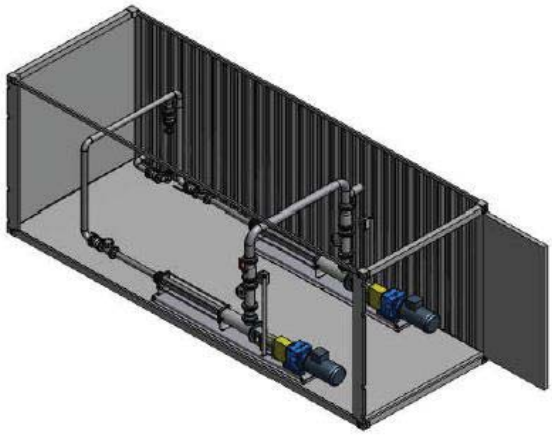

*Fig.3* **Measuring system for the pump**

The hydraulic calculation of the pipes is aimed at simultaneously determining the pumping pressure and the inner diameter of the pipe. Knowing the initial pressure is required for pumping station dimensioning, pipeline resistance calculation and investment assessment.

Hydraulic calculation is based on the fundamental equation of real fluid flow through electric tubes.

## 2. Theoretical and experimental aspects

The objective of the work is to optimize the transport by replacing the existing large parks, compared to the actual production level, with modern systems and the replacement of the collecting pipe, which has a long life span.

Based on the site data for the parks considered, the design of the collector pipe replacement works is carried out. In order to achieve this objective, the hydraulic and mechanical calculation of the collecting pipeline between the three oil storage tanks and the central warehouse was carried out.

The properties of the transported crude are shown in Table 1 and Table 2.

*Table 1* **Oil properties in site measurement units**

| Temperature $^0$C | Density g/cm$^3$ | Kinematic viscosity, cSt | Dynamic viscosity, cP | Freezing oil point, $^0$C | Freezing point, $^0$C | Paraffin content, % gr |
|---|---|---|---|---|---|---|
| 20 | 0,8870 | 38,93 | 34,530 | +10 | +30 | 15,00 |
| 30 | 0,8804 | 16,19 | 14,250 | | | |
| 40 | 0,8738 | 11,54 | 10,080 | | | |
| 50 | 0,8672 | 9,13 | 7,920 | | | |
| 60 | 0,8606 | 6,97 | 6,000 | | | |

*Table 2* **Oil properties in SI units**

| Temperature, $^0$C | Density, kg/m$^3$ | Kinematic viscosity, m$^3$/s | Dynamic viscosity , Pa·s | Freezing oil point, $^0$C | Freezing point, $^0$C | Paraffin content, % gr |
|---|---|---|---|---|---|---|
| 20 | 887,0 | $38{,}93 \cdot 10^{-6}$ | 0,034530 | +10 | +30 | 15,00 |
| 30 | 880,4 | $16{,}19 \cdot 10^{-6}$ | 0,014250 | | | |
| 40 | 873,8 | $11{,}54 \cdot 10^{-6}$ | 0,010080 | | | |
| 50 | 867,2 | $9{,}13 \cdot 10^{-6}$ | 0,007920 | | | |
| 60 | 860,6 | $6{,}97 \cdot 10^{-6}$ | 0,006000 | | | |

The characteristics of the collector pipe from the parks to the storage are shown in Table 3, and the park layout is shown in Figure 4.

*Table 3* **Collector pipe characteristics and operating pressures**

| Pipeline section | Length, m | Diameter, in | Operating pressure, atm |
|---|---|---|---|
| Park 1-CollectorA | 1.200,18 | 4 | 5 |
| Collector A-Collector B | 1.171,05 | 8 | 8 |
| Collector B-deposit | 6.546,06 | 8 | 8 |
| Park2-Collector A | 8,48 m | 3 | 8 |
| Park 3-Collector B | 61,10 | 3 | 5 |

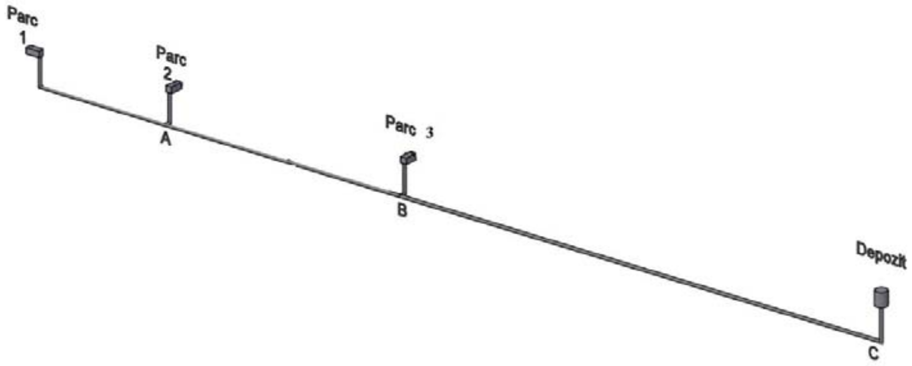


*Fig. 4* **Scheme of the location of parks and central warehouse**

In order to establish an optimum pumping program, it was chosen to pump each park in a row and calculate the number of pumps required in each park, the production time of each park, the exhaust flow rate for each park and the maximum pressure.

Calculating the number of pumps required in each park, $N_{pc}$

$$N_{pc} = \frac{Q_i}{q_p \cdot t_z} \quad (1)$$

where $Q_i$ – daily production of parks, $m^3$;

$q_p$ – actual pump flow rate $m^3/h$;

$t_z$ – daily pumping time, $t_z$ = 3 h.

Calculation of production time out of each park, $t_{ev}$

$$t_{ev} = \frac{Q_i}{q_p \cdot N_{pc}} \quad (2)$$

Calculation of exhaust flow,

$$q_{ev} = \frac{Q_i}{t_{ev}} \quad (3)$$

The obtained results are presented in Table 4

*Table 4* **The obtained results for parks**

| Park | Daily production of the park, $m^3$ | Actual number of pumps | Escape time, hours | Discharge rate, $m^3$ / h | Maximum pressure, bar |
|---|---|---|---|---|---|
| 1 | 59,386 | 2 | 4 | 14,847 | 15,023 |
| 2 | 94,318 | 2 | 6 | 15,720 | 15,027 |
| 3 | 37,739 | 1 | 5 | 7,548 | 0,152 |

The sizing of the connecting pipes was made according to the speed of the fluid, the economic speed being around 1m/s.

The results obtained are shown in Table 5.

Following the analysis of the obtained data, the pumping progression shown in Figure 5 was chosen.

*Table 5* **Results obtained for pipeline sections**

| Pipeline section | Internal diameter, mm | Outer diameter, in | Maximum oil speed, m/s |
|---|---|---|---|
| A –B | 74,7 | 3 1/2 | 0,996 |
| B – Deposit | 74,7 | 3 1/2 | 0,996 |
| Park 1 - A | 74,7 | 3 1/2 | 0,941 |
| Park 2 - A | 74,7 | 3 1/2 | 0,941 |
| Park 3-Deposit | 53,1 | 2 3/8 | 0,947 |

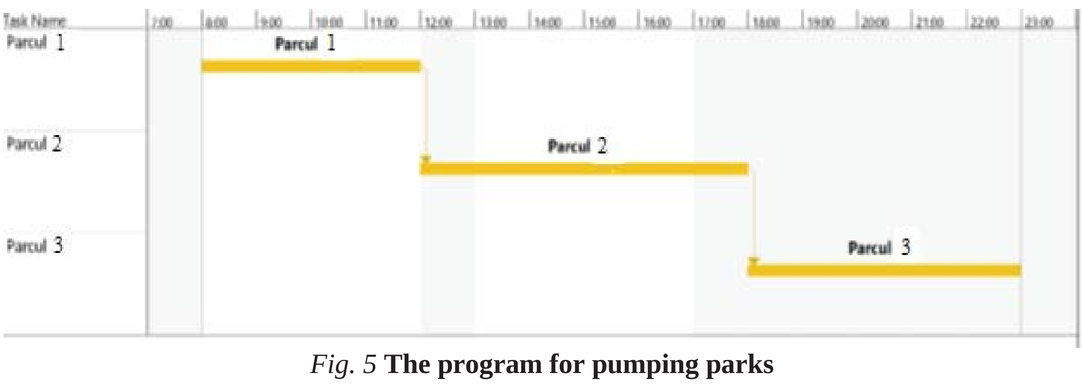


*Fig. 5* **The program for pumping parks**

The calculation relationships used to determine pumping pressure to the central repository in the situation where each park will pump according to the graph in Figure 5 are shown in Table 6.

The results obtained are shown in Table 7.

*Table 6* **Calculation relationships necessary to determine the pumping pressure**

| The size | The calculation relationship |
|---|---|
| The speed of the oil on the collector pipe sections | $v_{tronson} = \frac{4 \cdot (q_{ev})}{\pi \cdot (d_{conductei})^2}$ |
| Reynold number on the connecting pipes | $Re = \frac{v_{tronson} \cdot d_{conductei}}{v_{am}}$ |
| The coefficient of hydraulic resistance on the connecting pipes | $\lambda = \frac{0,3164}{(Re)^{0,25}}$ |
| Pressure gradient corresponding to friction losses | $iL_i = \frac{8 \cdot q_{evi}^2 \cdot \lambda_i \cdot L_i}{\pi^2 \cdot g \cdot d_i^5}$ |
| Pressure at the park | $p_{i,interval\ orar} = p_i + \rho \cdot g \cdot [\ iL_i + L_i + (Z_D - Z_i)]$ |

*Table 7* **Calculated values for optimization of the pumping program**

| Park | Hourly pumping interval | The speed of the oil on the collector pipe sections | Reynold number on the connecting pipes | The coefficient of hydraulic resistance on the connecting pipes | Pressure gradient corresponding to friction losses, liquid flow/m pipe | Pressure at the park bar |
|---|---|---|---|---|---|---|
| 1 | 8 - 12 | 0,941 | 2882,053 | 0,043 | 58,545 | 12,985 |
| | | | | | 170,354 | |
| 2 | 12 - 18 | 0,996 | 3051,542 | 0,043 | 64,70 | 15,027 |
| | | | | | 188,751 | |
| 3 | 18 - 21 | 0,478 | 1465,181 | 0,051 | 52,274 | 0,152 |

## 3. Conclusions

The design of the transport and storage system is a complex calculation which aims to achieve a technical transportation and storage scheme so that the expenses incurred for it are as low as possible, but with a maximum yield. The calculation of the pumping variants requires special attention because it is necessary to achieve an economically efficient option as well as the time of pumping and evacuation of petroleum products.

The required pumping power (Table 8) calculated for the chosen variant, i.e. a 6-hour pumping interval for each park, confirms the technological and economic optimization of the transport through the collector.

*Table 8.* **The required pumping power**

| Park | Time Interval 08:00-12:00 | Time Interval 12:00-18:00 | Time Interval 18:00-23:00 | Total |
|---|---|---|---|---|
| 614 | 29,155 | | | **29,155** |
| 901 | | 43,476 | | **43,476** |
| P9 | | | 0,187 | **0,187** |
| **Total** | **29,155** | **43,476** | **0,187** | **73,088** |

## References

**1. Bulău, L.**
*Colectarea, transportul și depozitarea țițeiului* - multiplicat Institutul de Petrol și Gaze, Ploiești, 1978

**2. Crețu, I., Stan, Al.**
*Transportul fluidelor prin conducte. Aplicații și probleme* - Editura Tehnică, București, 1984

**3. Crețu, I., Soare, Al., și alții**
*Probleme de hidraulică* - Editura Tehnică, București, 1972

**4. Crețu, I.**
*Hidraulică generală și subterană* - Editura didactică și pedagogică, București, 1983

**5. Soare, Al., Rădulescu, R.**
*Transportul și depozitarea hidrocarburilor* – Editura U.P.G., Ploiești, 2004

**6. Trifan, C., Albulescu, M., Neacșu, S.**
*Elemente de mecanica fluidelor și termodinamică tehnică*, Editura U.P.G., Ploiești, 2005;

**7.** *Normativ departamental NR. 3915-94 Proiectarea și construirea conductelor colectoare și de transport gaze naturale*

**8. *****
*Confind, Fișe tehnice*;

**9. *****
*OMV Petrom, Memorii tehnice*, documentații din șantier.