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Caracterization of the Condensate from Gârbovi-Urziceni Gas Well

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Abstract

The chemical-physical properties of an untypical condensate were studied in order to find an optimal way to process it. A gas well had been drilled in the oil and gas fields in Gârbovi - Slobozia (Romania) and representative samples were collected. The experimental work revealed that the condensate extracted from this gas field is a liquid with a high content of components with boiling limits between 153- 354 °C. This composition is probably due to the specific pressure, temperature and geochemical conditions in the reservoir. The results of the overall analyses of this condensate are reported in this paper, together with potential ways of future processing (or use) the condensate from Gârbovi gas well.

Keywords: *condensate, gas well, analyses, physical properties, mixing component, and processing ways.*

Introduction

In common technical language condensate is a mixture of the heaviest components of natural gas.

Natural gas condensate is a low-density mixture of hydrocarbon liquids that are present as gaseous components in the raw natural gas produced from many natural gas fields. It condenses out of the raw gas if the temperature is reduced to below the hydrocarbon dew point temperature of the raw gas. The natural gas condensate is also referred to as simply condensate, or gas condensate, or sometimes natural gasoline because it contains hydrocarbons within the gasoline boiling range. Raw natural gas may come from any one of three types of gas wells: [2][3]

- Crude oil wells – produce crude oil with *associated gas*. These associated gases can exist dissolved in the crude oil or separate from the crude oil in the underground formation.
- Dry gas wells – typically provides only raw natural gas (without any hydrocarbon liquids). Such gas is known *non-associated* gas.
- Condensate wells – These wells produce raw natural gas along with natural gas liquid. Such gas is also *non-associated* gas and often referred to as *wet gas*.

There are hundreds of wet gas fields in the world and each has its own unique gas condensate composition. Recently, a gas well, 4500 m deep, had been drilled in the oil and gas fields in South Slovakia (Czechoslovakia).

The investigation revealed that natural gas extracted from this area contained a condensate with a high content of components boiling up to 320ºC,

However, tipically, condensate has a specific gravity ranging from 0.5 to 0.8 and may contain: hydrocarbons (straight-chain alkanes having from 2 to 12 carbon atoms; cyclohexane and the other naphthenes; aromatics (benzene, toluene, xylenes and ethylbenzene); sulfur compounds (hydrogen sulfide - H_2S, mercaptans - RSH, where R is an alkyl group such as methyl, ethyl, etc.), carbon dioxide (CO_2) etc.

In figure 1 is presented a general flow diagram to separate the condensate from natural gas.

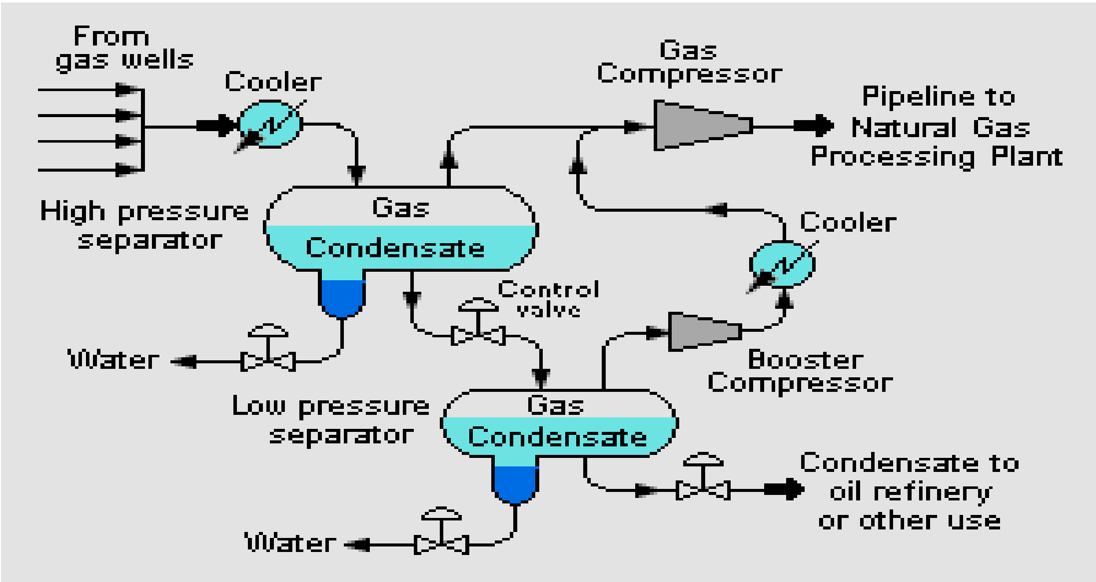

Fig 1. Schematic flow diagram of condensate separation from raw natural gas

This scheme shows that the water removed from both the high and low pressure separators could be processed to remove hydrogen sulfide before the water can be disposed or reused in some fashion.

Experimental

A complete study was carried out to determine physical and chemical characteristics of the condensate samples from Gârbovi gas well.

Condensate samples, in liquid phase, were collected in plastic bottles.

Visual examination shows, for collected samples, the presence of water at the bottom of the collection vessel, and water content was determined later by a specific analysis.

Test methods

The test is carried out according to specific international standards (i.e. EN, ISO, IP or ASTM). The analyses were carried out in "The laboratory testing of petroleum products" in Petroleum &Gas University of Ploiesti, and "Petroleum Products Laboratory Vega"- - Rompetrol Quality Control SRL.

Two major types of analyses are performed:

a. analyses that help to include this type of product in the general distillate products category;

b. technical data that will indicate the future processing ways.

In addition, it there performed supplementary analyses necessary to manipulate, keeping and storing of the condensate in safety conditions.

It has already been mentioned that the product named, in this work, *Condensate* has atypically characteristics, presented and discussed in the conclusions part.

Table 1 shows the complete projected data from general analyses of the condensate from Gârbovi gas well, to evaluate suitability of the condensate as a gas oil component.

Table 1. Physical-chemical properties of the condensate

Crt. No.	Characteristic	Measure unit	Test method	Value
1.	Density at 15 °C	Kg/m^3	SR EN ISO 3675	862.5
2.	Water and sediment (Centrifuge method)	%	SR ISO 9030	0.65
3.	Freezing point	ºC	ASTM D 2386	Under - 28ºC
4.	Viscosity at 20 ºC	cSt	SR EN ISO 3104-02	2.71
5.	Sulfur content	% (m/m)	SR EN ISO	1.175
6.	Ash content	% (m/m)	SR EN ISO 6245-03	0.005
7.	Lower Heating Value (LHV)	Kcal/kg	ASTM D 4868	10 084
8.	Chemical composition -saturated hydrocarbons - aromatic hydrocarbons - resins	percent	IP 469-01	 70.51 18.65 10.84
9.	Flash point (Penski Martens method)	ºC	SR EN ISO 2719-03	41.0
10.	Molecular weight	Kg/kmol	Calculated	227.0

In Table 2 are shown the main results of the analyses of this condensate, carried out by capillary gas chromatography (capillary GC) and by mass spectrometry (MS).

Table 2. Results of the GC-MS analyses

Components	Percent mass
n-C4	0,1
Iso and *n*-C5	0,38
Iso and *n*-C6	0,38
Cyclohexane + *n*-C7	1,55
C8 - Cycloalcans	2,54
C9 - Cycloalcans	6,01
C10 - Cycloalcans	6,88
C11 - Cycloalcans	5,36
C12 – Cycloalcans + aromate	3,35+2,63= 5,98
C13 – Cycloalcans + aromate	8,08+0,64= 8,72
C14 - Cycloalcans+ aromate	10,48+1,44=11,92
C15 - Cycloalcans+ aromatics	11,59+1,27=12,86
C16 - Cycloalcans	12,29
C17 - Cycloalcans	7,74
C18 - Cycloalcans+ aromatics	5,98+1,35=7,33
C19 - C23 (Unidentified)	9,99

Table 3 presents the distillation data obtained by applying of the test method SR EN ISO 3405-03, equivalent to ASTM D 86.

The purpose for running ASTM distillation is to correlate the composition of the material under study and, for reason the boiling range of condensate is of primary importance.

Table 3. Distillation data of the entire condensate

Crt. Nr.	Characteristic	Measure Unit	Test Method	Determinated value
	Distillation:			
	- initial boiling point			153
	- 10% (v/v)			182
	- 20% (v/v)			200
	- 30% (v/v)			220
1.	- 40% (v/v)		SR EN ISO 3405-03	234
	- 50% (v/v)	°C		248
	- 60% (v/v)			262
	- 70% (v/v)			279
	- 80% (v/v)			299
	- 90% (v/v)			340
	- final boiling point			354
	-distillation residue + losses	%Vol.		4

Figure 2 shows the ASTM distillation curve for the studied condensate. It should be noted that distillation residue and losses are to high for a fraction as condensate.

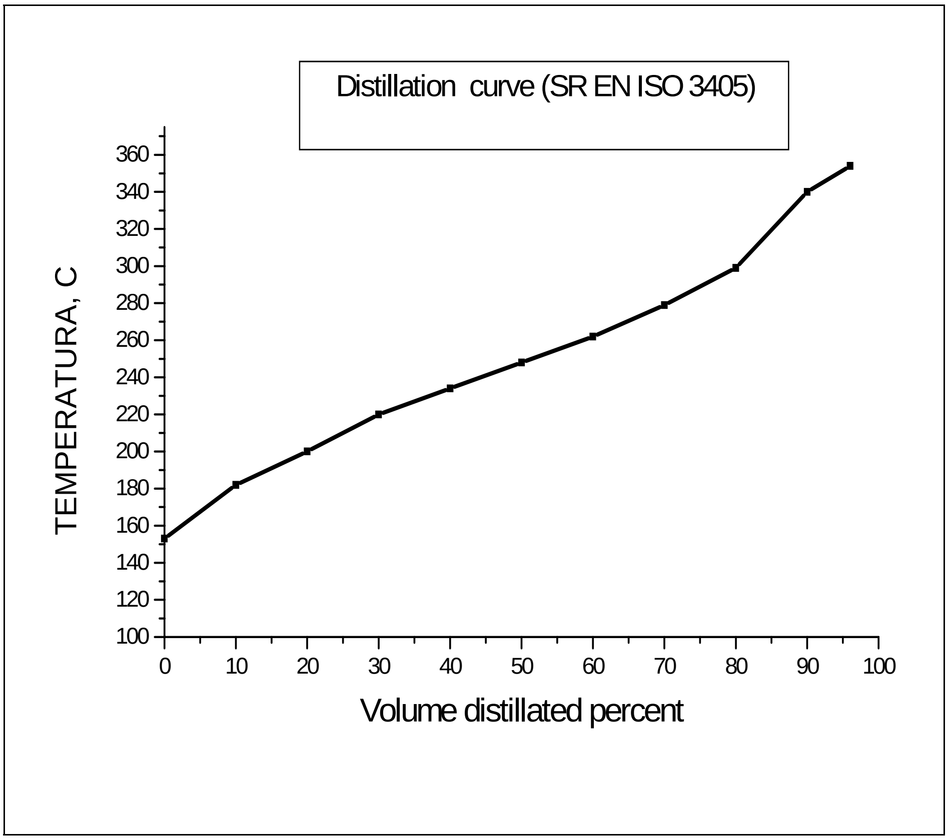

Fig 2. Distillation curve of the condensate

Results and Discussion

The investigation revealed that condensate from Gârbovi gas well has high content of components boiling up to 354ºC, which are probably due to the specific reservoir conditions (pressure, temperature and geochemical conditions).

- **Density** at 20°C, with a value of 862.5 Kg/m^3, is specific for a product more heavy as typically condensate that is associated to natural gas, density of the condensate is close of a crude oil or of a gas oil density;
- **Test Method for Water and Sediment in Crude Oil by Centrifuge Method** shows the presence of certain amount of water that during the analyses it can be then quickly separated;
- **Freezing point** under -28ºC is specific to easy petroleum compounds and non-waxy crude oils;
- **Kinematic viscosity** at 20 ºC is low (2,71 cSt) and is close of a petroleum product as classified as kerosene;
- **Distillation curve**. Versus a classical (typical) condensate the distillation limits are higher, analyzed product having limits that comprise two important petroleum fractions: kerosene and gas oil. The study of the distillation curve shows that the condensate is split in approximately 80% kerosene (initial boiling point 150ºC and final boiling point 299 ºC) and about 15 % represented of the gas oil, with a final boiling point of 354 ºC.

- **Sulfur content** test indicates a higher concentration of the sulfur (about 1 %), presence confirmed also by an odor investigation;
- ***Ash content.*** This analyses is evidenced also the presence of a heavy components (as resins) in condensate;
- **Lower heating value (LHV).** This analysis followed the evaluation of the potential using of the condensate as a fuel. Inferior caloric power of *10084 Kcal/kg versus 9500* kcal/kg at atmospheric residue underlines the important caloric potential of this condensate;
- The value **of the average molecular weight** confirms the our classification of analysed products between medium distillates (kerosene-gas oils);
- **Flash point (FP) temperature** represents an important parameter concerning the safety in handling and storage of the condensate. Flash point (FP) temperature is defined as the lowest temperature where a fuel will give off sufficient vapors for ignition under ambient conditions. It is an estimate of the lower flammability limit and determined value (41 ºC) is specific to a kerosene product;
- **Chemical composition** provided really information concerning the content of the saturated, aromatic hydrocarbons and resins. Analyzed condensate presents an untypical composition, because although has a distillation curve that classify its in the medium distillates class, the resins content is higher (10.84%). The saturate proportion is significant (*70,51%)* while the aromatic content is under 19%.
- The chemical **composition** of the various **hydrocarbon classes.** Our results confirm the presence, in a high proportion of the cycloalcanes, with 6 and 18 carbon atoms (approximately 80%), normal and isoalcanes (about 1%), branched aromatics, with two benzene cycle (around 7.5%). Difference of 10% is attributed to the unidentified compounds (in corresponding with the heavy parts in composition analysis performed according to IP 469-01 method*).*

Conclusions

On the basis of the results of analyses it can underline the next final conclusions:

1. The condensate (fluid) extracted from the gas fields in Gârbovi - Slobozia (Romania) has an atypical composition, uncharacterized until now (no evidenced in related literature).
2. Regarding to the number of carbon atoms that were identified we can say that the studied condensate includes partial the three important fractions in crude oil (as how are described in literature):
    - Naphta (from C_5 to $C_{10} – C_{11}$);
    - Kerosene fraction (from $C_9 – C_{10}$ to $C_{13} – C_{14}$);
    - Gas oil fraction *($C_{13}– C_{14}$ to $C_{20} – C_{25}$*

The results of our laboratory work identified components from n-butane (C_4) up to C_{23} (see the chromatographic analysis).

3. Condensate samples contain water and this water was relatively easy to be separated in mixture hydrocarbons- water. We suggest, before of the choosing of the any processing direction, that this water to be removed by simple decantation or, if it necessary, by a distillation process.
4. Composition analysis established:

- major saturated nature of the analyzed fluid, property that will contributes to a high stability in time (unsaturated compounds that might lead to the formation of gums).
- the major proportion is represented by the cycloalkanes and approximately of 80% in studied fraction correspond to a distillated petroleum.

5. Previous observations indicate at least 2 main directions of the upgrade of condensate:

A) as a solvent for wax deposits in pipes used in the extraction process;

B) as a light fuel, due to their superior burning properties.

6. A method more sophisticated to upgrade the condensate is presented in the Fig. 3.

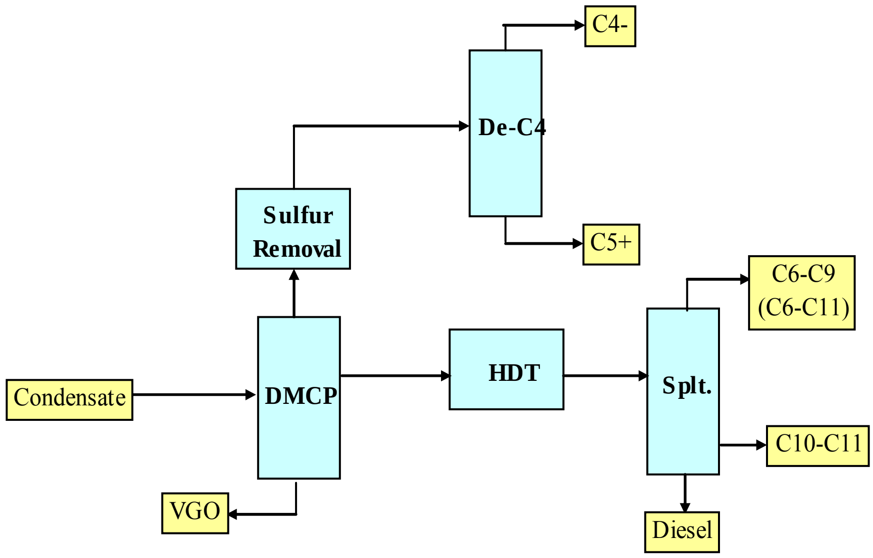

Fig. 2 – Condensate processing scheme

This scheme contains and separation part of the light component (DMCP, C_{4-} and C_{5+}) and a unit of hydrotreating for sulfur removal.

- Pre-distillation of the condensate feed in DMCP column and separation of the following three fractions:

- DMCP fraction at the top of the column – sent to the Sweetening unit

- Heavy oil cut at the bottom of the column –sent to the battery limits

- C_{6+} side cut as side product of the column –sent to the Condensate HDT unit

The main steps of processing comprised in this complex scheme are:

- Sweetening the overhead product of the DMCP column for sulfur removal. Merichem's THIOLEX/REGEN process is used for sulfur removal

- Debutanizing the treated overhead product of the DMCP column in debutanizer column and getting the C_{4-} and C_{5+} products, ready for blending in condensate or gasoline products

- Hydrotreating the C_{6+} side cut for sulfur removal, and obtaining the stabilized hydrotreated condensate

- Fractionating the stabilized hydrotreated condensate in the Condensate Splitter and getting the following fractions:

  - C6-C11 fraction at overhead of the column – sent to Aromatics Extraction area for further processing, or
  - Diesel product at the bottom of the column – sent to battery limits

  Alternative option to C6-C11 distillation:

  - C6-C9 fraction at the overhead of the column – send to Aromatics Extraction area for further processing
  - C10-C11 fraction obtained as side cut – available for direct blending into gasoline product

7. Other investigation and research experimental directions, however, remain open to find the using optimal processing solutions.

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Caracterizarea condensatului extras de la sonda Gârbovi-Urziceni

Rezumat

În lucrare, s-au studiat proprietăţile fizico-chimice ale unui condensat atipic pentru găsirea direcţiilor viitoare de prelucrare. A fost săpată o sondă în schela petrolieră Gârbovi - Slobozia (Romania), din care au fost colectate probele de condensat. Analizele experimentale efectuate au relevat că acest condens extras din sondă este un lichid cu componenţi cu limite de distilare cuprinse între 153 şi 353 ºC. Această compoziţie se datorează presiuniispecifice, temperaturii şi condiţiilor geotermice din rezervor. Rezultatele raportate în această lucrare prefigurează prin analizele globale potenţialele direcţii de prelucrare ale condensatului din schela petrolieră Gârbovi - Slobozia.