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THE PHYSICAL AND THERMODYNAMICAL NATURE OF RETROGRADE CONDENSATION OF GAS-CONDENSATE SYSTEMS AT RESERVOIR CONDITION

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Abstract: In this paper, the results of laboratory experimental investigations into retrograde phase transformations of gas-condensate systems were analyzed and it has been determined that, gas-condensate system becomes two-phased at the pressure above retrograde condensation or dew point pressure where aerosol form of liquid phase appears. Learning the process in the porous medium model and in parallel in the porous free PVT bomb at different temperature condition provided comparable data and strong justifications to describe the nature of retrograde condensation phenomena. Also, according to the results of the experimental data, a new approach has been developed to highlight some aspects of the natural occurrences in the reservoir condition. Taking all obtained observations into account the physical meaning of retrograde condensation at porous medium was discussed and these considerations were used to explain the dynamics of phase transformation in the reservoir during development of gas-condensate reservoirs.

Keywords: Gas condensate, retrograde condensation, PVT cell, porous medium, condensation pressure

Introduction: The effect of porous medium on gas condensate phase changes was started to investigate since 1949. The experiments on porous medium clarified that, gas condensate at porous medium is sedimented faster [6]. As a result of many researches on gas condensate approved that, thermobaric condition of the environment should be considered while investigation gas condensate [1-4] [7-10].

According to the researches on the recent years, the effect of porous medium on gas condensate systems was discussed and the necessity of preparing more suitable and precise equipments to investigate gas condensate system was mentioned[4,9,10].

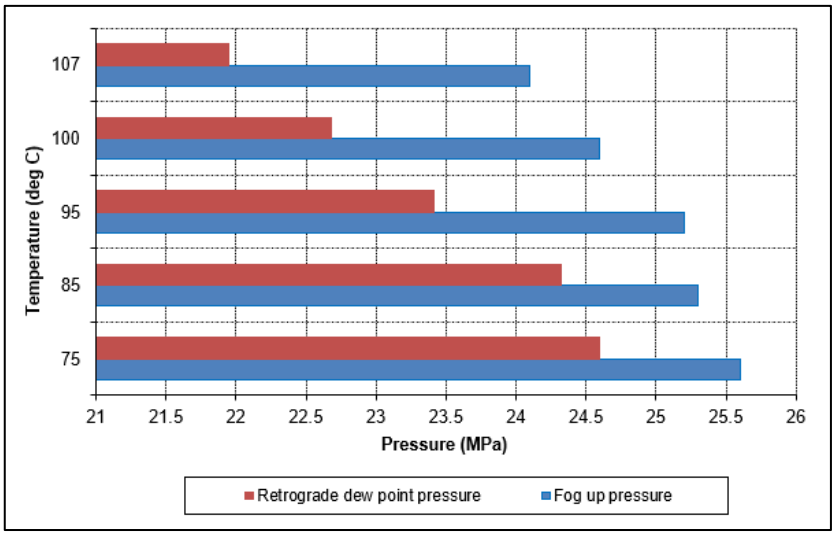
Generally, the physical-thermodynamical essence of retrograde condensation process of gas condensatet were discussed at last researches [11]. But, the porous medium was not considered at this research. First approach to the investigation of retrograde condensation at porous medium was at the research [6]. That research explained that, the retrograde condensation starts at the point of higher pressure than expected. The reason for that is the adsorbtion of condensate particles to the rock surface. But, the process were not explained quantitatively at this research.

After taking these researches into consideration, in this paper, experiments on PVT cell and at reservoir model were carried out. As a result of these experiments, the physical-thermodynamical essence of the retrograde condensation process at reservoir condition was explained again and scientific thoughts on this topic were improved. According to the experiments, it can be said that, retrograde condensation at the reservoir condition happens while liquid phase are on micro-embryo form.

Retrograde condensation pressure is considered the end of fog phase where first droplet of liquid can be observed. As it was mentioned, at the value of the pressure higher than retrograde condensation pressure, where system is one phased, even the heaviest component in the system is in a molecular seperated form. During decrement of the pressure, these particles start to unite and get grouped. At this situation, liquid particles behave as a dispersed phase and gas particles behave as a dispersed medium or change to aerosol form. And aerosol can be observed as a fog . During the researches, the aerosol form of gas condensate system can preserve its structure between 2-3MPa during isothermal decreasing of pressure (it is observed around 4MPa at reserach [1]).

Experimental investiogation of aerosol state of gas-condensate system

For learning the aerosol form of the system, the gas with the parameters of: natural, dry, density-0.7322 kg/m³, (C_1- 91.50, C_2- 4.80, C_3- 1.40, C_4- 1,69, C_5- 0.59 C_6- 0.02) and gas condensate factor 250g/m³ which is combined with the condensate which has density- 745.5 kg/m³.

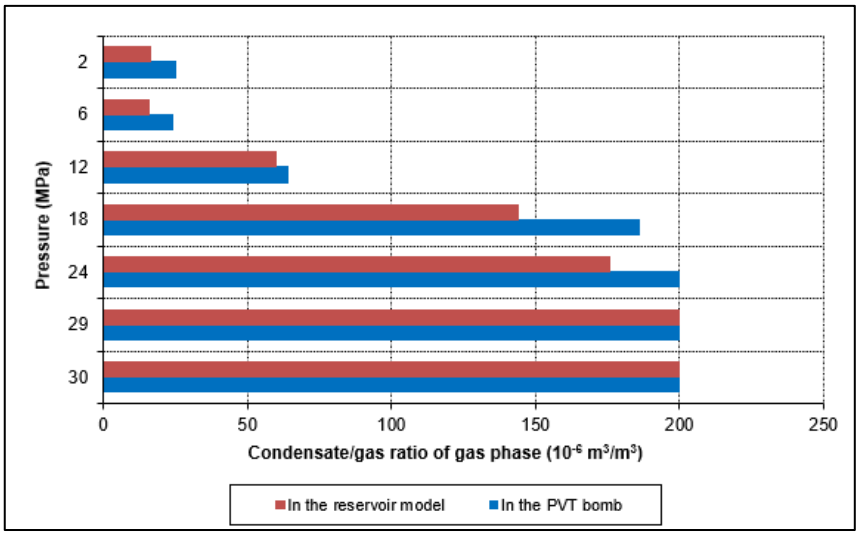


Picture 1. The dependency between the change of gas condensate system to aerosol-fog form and retrograde condensation pressure with temperature

The experiments were carried out with the help of УКГ-3 type PVT cell. Retrograde condensation and aerosol-fog pressure of the system were determined of the given system by observation. According to the results, it can be said that, the increment of the temperature increases the stabiliity of aerosol phase of the system.

It is certain, high value of the reservoir pressure and low value of rertrograde condensation pressure have a positive impact on condensate production. But, there is one more positive effect. This positive effect is about, another reason of good impact of high temperature on reservoir production is the stability of aerosol form of the gas condensate system and production period of the reservoir increase in aerosol form.

Micro-embryo form of liquid phase at retrograde condensation zone of gas condensate system and the effect of this form on production parameters of the reservoir were investigated at the research [3]. According to the data which were obtained at these experiments, one of the reason of the porous medium effect on the gas condensate system is system can be in a better contact with the rocks at aerosol form. Retrograde condensation may begin at this period. For making sure this probability, some special experiments were carried out.



Picture 2. Differential condensation in reservoir model and PVT cell

At the Picture 2., typical differential condensate isotherms can be seen. At this picture, the dependency between condensate factor of the gas phase at PVT cell and reservoir model with pressure were constructed. The compound of the gas was : C_1-93.5, C_2-4.1, C_3-1.26, C_4-0.63, C_5-0.15, C_6-0.03, CO_2-0.22, C_{5+}-6.02q/m³ and density: 0.724 kg/m³. The density of condensate 737.91 kg/m³, the condensate factor of the system: 200g/m³, the starting value of retrograde condensation pressure: 24.3MPa.

As it can be seen from the picture, retrograde condensation starts at a higher point at reservoir model. As a result of calculations and graphical methods, the starting value of pressure for retrograde condensation was 29MPa, but system changes to fog phase at 26.4MPa. Another interesting process is the rate of retograde condensation of the system at reservoir model was increasing after 24.3MPa (The value of the retrograde condensation at PVT cell). This process clarified that, in a porous medium, condensation of the system starts even at higher values of pressure than its aerosol form where condensate particles have microscopic sizes.

Consequently, after taking the results of the experiments into consideration, retrograde condensation can happen in 2 different way by their physical essence.

As a result of the effect of contact between liquid-gas-rock. With the gradual decrement of the system pressure (higher than retrograde condensation pressure, at one phased state of system), micro-embryos appears, system is changed to aerosol form. These particles are absorbed by rock surface and retrograde condensation process starts.

It is obvious that, the value of the pressure is higher than the value on PVT cell and this value is conditionally called as a “retrograde condensation by surface forces”.

According to the classical considerations, retrograde condensation can happen with the effect of gravity force. With the reduction of the pressure, micro-embryos appear and these little particles get united with each other as decreasing aerosol pressure. Not only their volume, but also their density increase. Therefore, at the value of the retrograde condensation pressure, liquid particles are sedimented to the bottom by the effect of gravity force.

Conclusion: There was not clear understanding of the effects of porous medium and micro-embryos on the value of retrograde condensation pressure of gas condensate systems. For clarifying these effects, two kinds of experiments were carried out. One in reservoir condition, one in PVT cell. As a result of these experiments, it was observed that, the value of retrograde condensation pressure may have higher values than expected in reservoir condition. There are 2 different approaches may be reason for that process. With the effect of the forces between liquid-gas-rock and with the effect of gravity force. This explanation of retrograde condensation may have an impact on new approach for planning production in gas condensate reservoirs.

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QUYULARIN BİR İSTİSMAR OBYEKTİNDƏN DİGƏRİNƏ KEÇİRİLMƏSİ ŞƏRTLƏRİ

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Müasir dövrdə neft-qaz sektorunda bir sıra problemlər mövcuddur. Bu problemlərə misal olaraq istismar olunan quyuların yetərincə istismar edilə bilməməsi başqa sözlə desək quyularda kifayət qədər çıxarıla bilməyən qalıq neft ehtiyatının olmasını, proseslər