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Determining Optimum Oil Separator Size and Optimum Operating Pressure

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Abstract

The optimum separators operating pressure is determined by using flash calculations and equilibrium ratios. In this study, the optimum separator size for Jambur field is calculated by using equations introduced by Arnold and Stewart and API12J Specification [1]. Because Jambur field has a high production rate two conditions are taken in the study to determine separator size, first based on production rate 80,000 bbl/day and second based on split the production between two banks A and B (40,000 bbl/day for each bank). The calculation resulted in optimum separator pressure for the first stage of 700 psi, and the second stage of 300 psi, and the third stage of 120 psi. The results show that as the number of stages increased above three-stage for Jambur field less incremental liquid recovery achieved and this will not cover the cost of adding an extra stage.

Keywords: flash evaporation, insulators, chemical composition

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1- Introduction

When oil flows from a well with high pressure and temperature, it is subjected to a decrease in temperature and pressure. The gases are released from the fluids and the character of the well stream changes. The gas velocity carries liquid drops, and the liquid carries gas bubbles. Separating materials to these stages is one of the essential processes in the treatment of oil and gas, processing and production. Various studies have been managed to determine the volume of surface separators and to determine the optimal separation pressure [2].

Oil separators are categorized as two-phase if they separate gas from the total liquid and three phase if they also separate the liquid stream into its water components and crude oil.

Jambur field is one of the producing fields in the North Oil Company. Jambur field is located 20 km southeast of Kirkuk governorate, with an area of (35 * 4.5 km). The field represents one of the structures intertwined with the fields of the Kirkuk region, as it is located southeast of Bay Hassan and Khabaz fields and along with them [3]. It is considered one of the important fields in the North Oil Company, but in the past few years, the field productivity has been reduced by half due to the worn-out and absence of periodic maintenance of separators which led to a significant loss in profit. In this study, the optimum separator size for the field will be calculated to take advantage of the maximum productivity of the field [4].

In the oil separator, oil and accompanied gas, because of the mixing of the accompanied water, therefore the level of oil must not be override a rang as not to be less than a proper level [5].

Ken Arnolds and Maurice Stewart [6] made a significant contribution to oil separation. They presented a set of equations obtained for application to separator size and select two phase and three phase separators types. Their two researches were then appeared with other subjects in a book coverage all aspects of treatment and oil separation [6].

2- The Calculation of the Flash

Flash computations can be considered an essential part of reservoirs computation and the process engineering. They are needed whenever it's significant to know the quantity of a liquid hydrocarbons and gas co-existing found in any reservoir or vessels at a certain pressure and temperature. It's important to mention that such calculations are carried out to determine the structure of the current hydrocarbon phases [7]. When the general chemical composition of any hydrocarbon system at a certain pressure and temperature is given, the calculations of the flash will be used to measure:

- Number of moles of the vapor phase (nv).
- Number of moles of the liquid phase (nL).
- Mole fraction of the liquid phase (xi).
- Mole fraction of the gas phase (yi).

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3- Selecting Optimum Separator Pressure

One of the most critical in separation designing is determining the most favorable separator pressure. Whenever the pressure of the separator is high, considerable quantities of light components will be found as a liquid and will be lost over with other important components to the gas phase at the stock tank. However, big quantities of sprightly components are separated from the liquid. Therefore, they will attract considerable amounts of intermediate and heavier hydrocarbon components, if the pressure is too low [8].

The pressure, which is named the optimum separator pressure, must be selected to maximize the volume of oil buildup in the stock tank. Such optimum separator pressure could also result in the followings [9]:

- A maximum API gravity of the stock-tank oil.
- A less oil shrinkage or minimum oil formation volume factor.
- A minimum gas solubility.

4- Separator Type Selection

Since Jambur field has a high GOR ratio (1000-2000 SCF/bbl) and high wellhead pressure (1000 psi) and the area are available, so two-phase horizontal separator is the best choice to deal with because it is less expensive and easy to shipping, install, and maintenance [10].

5- Number of Stages

Table **1** gives the result of flash calculations to determine the optimum number of stages for Jambur field.

Table 1. Effect of Number of Stages on Liquid Recovery

Number of Stages*	Liquid Recovery bbl/day	Total Cost of Equipment $	Net Income of Selling Incremental Oil (after 10 years) $
1	78700	12,456,000	-
2	79500	21,034,600	146,000,000
3	79932	45,700,550	78,850,000
4	80005	63,520,200	12,775,000

*Excluding stock-tank

Table **1** shows that four stages give the highest stock-tank liquid recovery but it will not cover the cost of adding an extra stage. So three-stage separation process is selected for Jambur field.

6- Separator Operating Pressure

By performing a flash calculation for the Jambur field fluid composition that feds the first separator Table **2** obtained.

Table **4** shows optimum separator pressure for each stage and the total gas-oil ratio, API gravity and oil formation volume factor of stock-tank oil.

Table 2. Optimum Separator pressure

Stage	Pressure , psi	API	GOR scf/STB	Bo bbl/STB
First	700			
Second	300	39.73997	986.0572	1.487687
Third	120			

Optimum separator pressure is selected based on a maximum API gravity of stock-tank oil, minimum formation volume factor of the oil (less oil shrinkage), and minimum producing gas solubility (producing gas oil ratio).

7- Separator Sizing

Based on liquid capacity constraints and by using equations introduced by Arnold and Stewart separator size for each stage is obtained [11].

Because Jambur field has a high production rate (80,000 bbl/day), it may be better to split the production between two banks A and B. So two conditions will be taken to calculate separators size for Jambur field.

One minute retention time for oils has (API > 35) with no foaming tendencies proved to be sufficient (API for Jambur field = 40).

1- Based on Production Rate 80,000 bbl/day:

Table **3** gives the result of optimum Separator Size calculations for each stage based on the slenderness ratio must be between 3-5 to prevent liquid re-entrainment into the vapor phase.

Table 3. Optimum Separators Size for Each Stage

Stage	internal diameter (inch)	effective length for liquid (ft)	seam-to-seam length (ft)	slenderness ratio
First	68	19.92708848	26.56945131	4.688726702
Second	66	20.34140102	27.12186803	4.931248733
Third	66	19.84946871	26.46595828	4.811992415

2- Based on Production Rate 40,000 bbl/day:

Table **4** shows the result of Separator Size calculations for each stage based on slenderness ratio as mentioned previously.

Table 4. Separators Size for Each Stage

Stage	internal diameter (inch)	effective length for liquid (ft)	seam-to-seam length (ft)	slenderness ratio
First	60	12.79761905	17.06349206	3.412698413
Second	54	15.19326867	20.25769155	4.501709234
Third	54	14.82583774	19.76778366	4.392840813

It is always better to determine the standard vessel size according to API12J specification, so:

a. For the First stage separator size, API12J accepted 60-in diameter x 20-ft seam to seam length.
b. For the second stage separator size, API12J accepted 54-in diameter x 20-ft seam to seam length.
c. For the third stage separator size, API12J accepted 54-in diameter x 20-ft seam to seam length.

8- Conclusions

1- For determining the separators' optimum pressure and identifying the number of stages for Jambur field, different cases of pressures and the number of stages are taken. The calculations results showed that the four stage separation unit can produce 1,300 bbl/day more stabilized oil compared to the one stage separation unit. Furthermore, the number of separation stages effects on the oil recovery was investigated. Four cases with one, two, three, and four separators in the production unit were considered to reach the maximum oil recovery. Then, economic evaluations are applied to these cases to indicate the most economic case. The results revealed that a three stage separation unit with separators operating pressure of 700 psi, 300 psi, 120 psi respectively would be more economical.

2- For determining optimum separator size two cases are taken. The first case assumed that the 80,000 bbl/day fed a single bank and the second case based on that the production disturbed between two banks (40,000 bbl/day for each bank). The calculations results showed that the first case gives a separators diameter of 68in for the first stage and 66in for the second and third stage while the second case gives a smaller separators diameter (60in for the first stage and 54in for the second and third stage). Engineering evaluations are applied to the two cases taking into account API 12J specification to indicate the better case. The evaluation showed that the second case more flexible and easy to operate and maintain.

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تحديد الحجم وضغط التشغيل الأمثل لعازلات النفط

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الخلاصة

يتم تحديد ضغط التشغيل الأمثل للعازلات باستخدام حسابات التبخير الومضي ونسب التوازن. في هذه الدراسة ، يتم حساب حجم العازلة الأمثل لحقل جمبور باستخدام المعادلات التي قدمها الباحثين ارنولد وستيوارت. نظرًا لأن حقل جمبور يحتوي على معدل إنتاج مرتفع ، فقد تم أخذ شرطين في الدراسة لتحديد حجم الفاصل ، أولاً بناءً على معدل الإنتاج 80،000 برميل / يوم والثاني بناءً على تقسيم الإنتاج بين حالتين A و B (40،000 برميل / يوم لكل حالة). نتج عن الحساب ضغط فاصل مثالي للمرحلة الأولى 700 رطل / بوصة مربعة ، والمرحلة الثانية 300 رطل / بوصة مربعة ، والمرحلة الثالثة 120 رطل / بوصة مربعة. تظهر النتائج أنه مع زيادة عدد المراحل إلى ما يزيد عن ثلاث مراحل لحقل جمبور، يتم تقليل استرداد السائل الإضافي الذي تم تحقيقه وهذا لن يغطي تكلفة إضافة مرحلة إضافية.

الكلمات الدالة: التبخير الومضي, العازلات, التركيب الكيمياوي