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Development of minimum tie line length method for determination of minimum miscible pressure in gas injection process

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A B S T R A C T

Gas injection process is a very important technology in enhanced oil recovery. Minimum miscible pressure is one of the key parameters in gas injection processes. Various experimental methods such as slim tube are used to measure MMP. These methods are costly and time consuming. Recently computational methods are used in order to achieve a cost-effective and reliable technique to evaluate MMP. In this work, a new methodology has been proposed for determination of MMP using the minimum tie line length method. A real mixing cell model was developed to estimate the MMP, MME and key tie lines. This method is simple, robust, and faster than conventional one-dimensional simulation of slim tube. The new mixing cells method can accurately determine the whole key tie lines to a shift, regardless of the number of injection gas and reservoir fluid components. Unlike other methods of mixing cells, this method automatically corrects dispersion by additional contacts to achieve the low variation domain of tie line slope. Also, the determination and implementation of the minimum miscibility enrichment are investigated.

1. Introduction

Gas has been injected into the oil reservoir in order to enhance the recovery since the past times (Kantzas et al., 1988) Gas injection improves oil recovery by maintaining reservoir pressure, the movement of oil and evaporation of heavy and medium oil components (Ghedan, 2009; Flanders et al., 1993; Al Adasani, and B. Bai., 2011). Since the injected gas and the reservoir oil are not in equilibrium conditions at first, the phase contacts lead to mass transfer and thus change the properties of both phases (Ahmadi, 2015; Green, and Willhite, 1998). Displacement of oil by gas injection is very effective if the properties of oil and the injected gas are the same. In other words, the two phases of oil and gas are miscible and the interfacial surface between them disappears(Tiab, and Donaldson, 2015). To increase the efficiency of oil recovery through the similarity of oil and injected gas, the gas containing high percentage of rich components is used. However, middle components injection is not economically efficient to increase the recovery, so some other effective components such as injection conditions should be considered (Sheng, 2016). The injection pressure and miscibility are two of these factors (Oren et al., 1992; Johns et al., 1999). Miscibility occurs at first contact or multi contacts. The first contact miscibility occurs at a pressure that keeps oil and injected gas as one phase at any ratio of injected gas while in the case of multi contact miscibility, the oil and gas establish two phases at first contacts and after multi contacts they become miscible gradually (Bryant, and Monger, 1988; Hanssen 1988).

One of the most important parameters in the process of gas injection into reservoirs is the minimum miscibility pressure (MMP). MMP is the minimum pressure at which gas and oil are miscible at a constant temperature. When oil and gas are miscible, displacement efficiency at pore scale is 100% in the absence of dispersion process (Thomas, 2008; Alomair, O. et al., 2011). Therefore it is necessary to determine MMP in gas injection processes. There are some experimental and computational methods for determination of MMP. One of the experimental method is the slim tube test(Adekunle, and Hoffman, 2014; Gu et al., 2013). The natural reservoir fluid is used in this test and the slim tube is designed in such a way that the interaction between fluid flow and its phase behavior with the porous medium is considered. Therefore, favorable results are expected to be obtained from this test (Jessen et al., 1998). However this method is expensive and time consuming this means that long time must be spent for any laboratory test.

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Therefore the numbers of tests are usually low and a reliable estimation of MMP may not be obtained (Nobakht et al., 2008). Other methods such as Single-Cell and Multi-Contact can be used to determine MMP in which either the injected gas is mixed with equilibrium oil or reservoir oil is mixed with equilibrium gas (Li et al., 2012). This method is only useful when the miscibility process is due to either gas condensing drive or vaporizing gas drive which usually occur less frequently. Other experimental methods include vanishing interfacial tension among oil and gas and rising bubble test (Zolghadr et al.,2013). These methods do not obtain a good approximation of the MMP because they cannot reproduce the interaction between fluid flow and its phase behavior. The computational methods to determine MMP are less expensive and also faster than empirical methods (Teklu, 2012) There are three computational methods to determine the MMP. The first method is numerical simulation of slim tube(Yuan et al., 2004). Evaluation of MMP by this method is quite similar to the laboratory method. In this method the block size leads to the numerical dispersion that increase the error in the MMP evaluation. The error is reduced for the smaller size of the blocks. Analytical methods for estimation of MMP apply method of characteristics (MOC). This method is based on the equation of state and aims to find the key tie lines that control the oil displacement by gas and calculate them at various pressures. The pressure at which the tie line length is zero is equal to MMP. Mixing cells is another method which is based on several contacts between oil and gas. Several studies have been done to MMP investigation. Nedjad has studied the analytical solution of oil/gas displacement and recovery in an immiscible displacement with three components and two phases (Nedjad, M. et al., 2007). In fact, this model is an extension of Buckley-Levertte method which is an immiscible displacement. Dindoruk was the first one who noted to the similarity of this behavior to gas chromatography. This model assumed a completely self-sharpening displacement to simplify the equations (Dindoruk et al., 1997). In gas injection, the principle of cohesion means that the combination of gas and oil does not pass as a simple wave in porous media; instead, it is divided into several coherent waves moving with various speed. The concept of coherence and consistency requirement play a key role in the establishment of an algorithm to estimate the MMP. Khorsandi et al. investigated the analytic theory for quadric systems and showed that there was also a third tie line at the displacement path called the cross tie line (Khorsandi, and Johns., 2015). Orr confirmed the existence of this cross tie line in condensing/vaporizing derives and offered a simple geometric structure to find the main tie lines. In their geometric structure it is assumed that main tie lines are connected to the shocks in the path of a connection line. They showed that MMP occurred at the point where one of the three main tie lines passed the critical point. Then Johns revealed that the cross tie line controlled the growth of miscibility in condensing/vaporizing drive and the MMP is less than the estimated MMP. Johns and Orr created a method for calculating the MMP of a system that has more than four components, and developed its geometric structure for the first multi-components oil displacement with Co_2. They also declared that the miscibility would developed if the length of one of the key tie lines was zero (Orr and Silva, 1987). Therefore MMP calculation was reduced to find a series of tie lines from oil to injected gas. Wang and Orr showed a multi-component method by calculating the MMP for injection of multi-component gas. They found the intersection points of tie lines expansion using the Newton - Raphson theory. They assumed that shock shift occurred only from a main tie line to the next one that Johns and Orr found a close approximation of it. Lessen developed the method of Wang and Orr by application of the fugacity equations (Orr, and Jessen, 2007). Yaun and Johns have recently simplified the Newton - Raphson problem shown the possibility of approaching to the wrong set of tie lines that is the problem of the MOC analytical methods, as long as a proper solution is made. Rathmel et al. studied the pressure effect on the reservoir fluid displacement by CO_2 gas in the Boise sandstone. They concluded that light components (C_1-N_2) in the oil reservoir increased the MMP, while intermediate components (C_2-C_6) reduced it. They also showed that CO_2 had a lower MMP in comparison to methane (Rathmell et al., 1971). Another method for determination of CO2−crude oil minimum miscibility pressure iks based on genetic programming combined with constrained multivariable search methods (Fathinasab and Ayatollahi, 2016). A rigorous approach was studied to predict nitrogen-crude oil minimum miscibility pressure of pure and nitrogen mixtures (Fathinasab, 2015). Also, a rigorous approach has been propoded for determining interfacial tension and minimum miscibility pressure in paraffin-CO2 systems in: gas injection processes (Ayatollahi et al., 2016). Another method based on robust modeling approach was proposed (Hemmati et al., 2016). The adaptive neuro fuzzy interface system optimized with evolutionary algorithms for modeling CO2-crude oil minimum miscibility pressure has been investigated (Karkevandi-Talkhooncheh et al., 2017). In another research, modeling minimum miscibility pressure during pure and impure CO2 flooding using hybrid of radial basis function neural network and evolutionary techniques has been studied (Karkevandi-Talkhooncheh et al.,2018).

The whole listed computational methods suffer from some computational problems such as asphaltene precipitation during gas injection. In this study a new cell method was developed to estimate MMP. The problems of the MOC methods are determined and identified. And also, a simple and new method of estimating the MMP for contaminated gas combinations was investigated.

2. Algorithms and methods

2.1. Flash calculations

In this method, first the basic constant assumptions are obtained out of the stability test at specific temperature and pressure, then the calculations start. First, an initial value (eg ½) is assumed for the vapor fraction, and the mole percent of each phase are calculate based on flash calculation. Second the parameters of the equation of state for each phase, Z_l and Z_v are calculated. After that, two-phase fugacity coefficients can be obtained and the new equilibrium constants can be calculated through the ratio between these two values. In the next step vapor fraction is calculated by trial and error based on the first assumption of the vapor fraction, the calculated equilibrium constants, and the Rachford-Rice equation. Finally, the equilibrium condition is investigated that is the fugacity equality of each component in the whole phases. If this situation does not exist with the calculated values of equilibrium constants as a basic assumption, the calculations start from beginning.

In this study the program is written in MATLAB software. To evaluate MMP, the data are read and then the MMP is calculated by the described algorithm

$$TL^n = aP + b \tag{1}$$

This process continues as long as the difference between the two calculated MMP becomes less than a predetermined error. This amount of error is requested by the user at the beginning of the program. In this study it is set equal to 5 psi. The δ value is also asked from the user. Then the user will be asked for the value of α which is recommended to be equal to 0.5. Finally the user is asked to determine the equation of state.

As the program starts, tie line graph is plotted based on cell number for each pressure and the minimum length is recorded at a given pressure. Then the graph of the minimum tie line length versus pressure is plotted and MMP is achieved. The calculation of MME is also the same as MMP. The program has been implemented for a sample and the results are discussed in the following.

2.2. Multiple mixing cell, a new method to estimate the MMP

Multiple mixing cell method is a new method to estimate MMP with any number of components. In this method calculation initially start with two cells and then the cells increase until the desired accuracy is established. The MMP is the pressure where the tie line length is zero in one cell. First, the algorithm of this new method which is significantly simple and understandable is explained. In this method pressure and temperature are calculated by an equation of state and injected gas displacement at the top of the liquid phase. The process begins with two cells and maintaining the pressure and the temperature. Oil reservoir (X^o) and injected gas (Y^G) can be mixed in any ratio. Using the mass balance represented in equation (2):

$$Z = x^o + \alpha \times \left(y^G - x^o\right) \tag{2}$$

α is considered to be 0.5. As long as the pressure is less than MMP, the overall composition z is either in the two-phase region or in the region of tie line extension. Thus two equilibrium composition for liquid (x) and vapor (y) are obtained by application of the equation of state and flash or negative flash calculations. Then, due to the gas injection, equilibrium vapor moves above the equilibrium liquid. This process is the first contact. The second series of contacts, include the vapor in equilibrium contacts with fresh oil and liquid in equilibrium with fresh injected gas. Again the equation is used to establish mixing. Then two sets of in equilibrium liquids and vapors are established, resulting in the production of six cells. These cells include oil reservoir, injected gas and two sets of in equilibrium vapor and liquid. More contacts are performed in the same way until all the cross and limiting tie line are developed. It is expected to have 2N + 2 cells after N contacts. These steps are shown schematically in the Fig. 1.

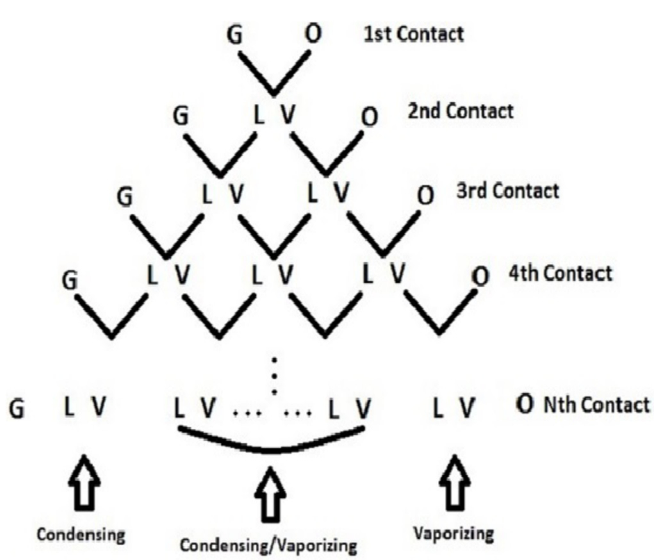

Fig. 1. Description of duplicate contacts in new Multiple Mixing Cell method, G, O, X, and Y represent Gas Injection, oil reservoir, equilibrium liquid and equilibrium vapor respectively.

The following steps represent the MMP estimation by this new method. This process is based on finding the tie line length at any pressures:

1) The temperature at the whole process is kept equal to the reservoir temperature and the pressure is less than MMP. Here the initial pressure is 500 psia.
2) The process starts with two cells, one of them contains the injected gas and the other contains oil reservoir. Oil and gas are mixed together and the new composition is flashed by the equation of state. The result is the creation of two new equilibrium compositions; x as the liquid and y as the vapor.
3) When it is assumed that the gas is moving over the oil phase, liquid and vapor in equilibrium must be mixed together again. Note that the two new compositions are created as the result of each contact which is used for the next contacts.
4) Further contacts are done when two adjacent cells are mixed, this process continuous till Nc-1 key tie lines are developed.
5) The length of the tie lines created in step 4 are calculated and the minimum length is recorded (TL_min).
6) The pressure is increased and the steps 2 to 5 are repeated. There are various methods to determine the next pressure. It is suggested to increase the pressure for 200 psia to obtain the second pressure. The third pressure is evaluated by a linear extrapolation using the first and second pressures versus TL and the amount of pressure is calculated at TL = 0 (that is the same initial guess for MMP).

Then $\Delta P = MMP_{estimated} - P_2$ is calculated and the third pressure is obtained from the following equation:

$$P_3 = P_2 + \frac{\Delta P}{\delta} \tag{3}$$

δ is usually considered to be equal to 3. To evaluate the next pressures the function can be fitted on the previous pressures and the next guess for MMP is found at TL = 0.

$$TL^n = aP + b \tag{4}$$

7) Step 6 is repeated for some other pressures till the error of the suggested MMP in the previous step and the new step reaches to the desired value (for example 20 psia) which is shown by Tol.

The proposed method has many advantages over other methods of the MMP evaluation. This method always has a unique answer and can perform simulation when there are more than two phases in the reservoir. The algorithm flowchart is shown in Fig. 2.

3. Results and discussion

The following examples have been examined to verify the proposed method.

3.1. The first case: MMP evaluation for a four-component system

In this case, the aim is to evaluate the MMP for a gas system including CO_2 and CH_4 and also oil containing CH_4, C_4 and C_{10} at a temperature of 160 °F. Required information are listed in the Table 1. An important feature of this case study is vaporizing/condensing drive mechanism that can be considered as a challenge.

As it previously stated, for a four-component sample, the three key tie lines are: the oil tie line, the gas tie line and the cross tie line. The graph of tie lines length versus the cell number for the last two

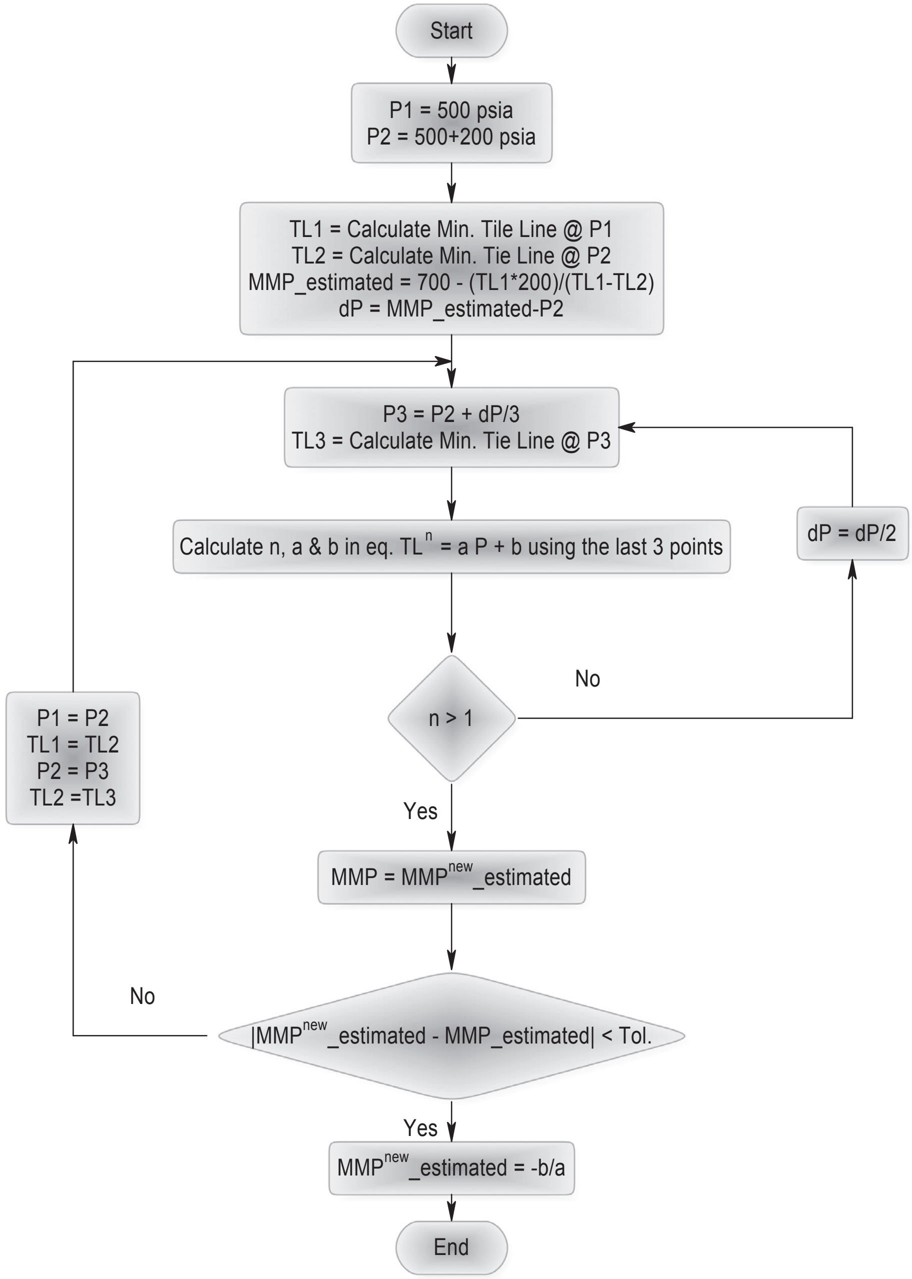

Fig. 2. MMP prediction Algorithm.

Table 1
Oil and gas components and their properties.

Component	Oil	Gas	Tc(deg F)	Pc(psia)	ω	Binary Interaction Parameters			
C1	0.2	0.2	−116.63	667.8	0.0104	0	0.027	0.042	0.1
C4	0.015	0	305.65	550.7	0.201	0.027	0	0.008	0.1257
C10	0.65	0	652.1	305.7	0.49	0.042	0.008	0	0.0942
CO2	0	0.8	87.9	1071	0.225	0.1	0.1257	0.0942	0

pressures of calculations which is shown in Figs. 3–6, confirms this matter. To make this graph visible at any pressure, the program is written in such a way that for each pressure (which the calculations are done) the graph formation can be observed based on the number of cells. As it can be seen by the increasing the number of the cells, key tie lines develop sharper. For example, when there are 20 cells, the key tie lines starts to appear and when the number of cells becomes more than 40, the tie lines are totally appeared. It can be observed that the tie line which controls the miscibility is the cross tie line.

The results of the program running, and the percentage of error are illustrated in the Table 2. As mentioned before, using PR-78

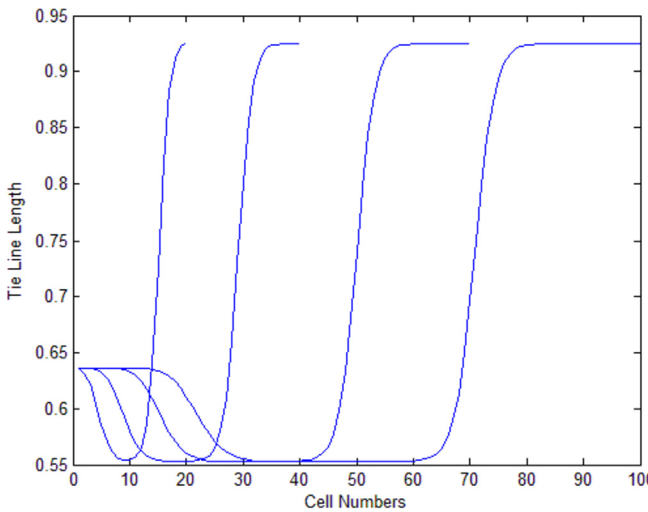

Fig. 3. The graph of tie lines length versus the number of cells for the pre-final pressure of the calculations using a binary interaction coefficient.

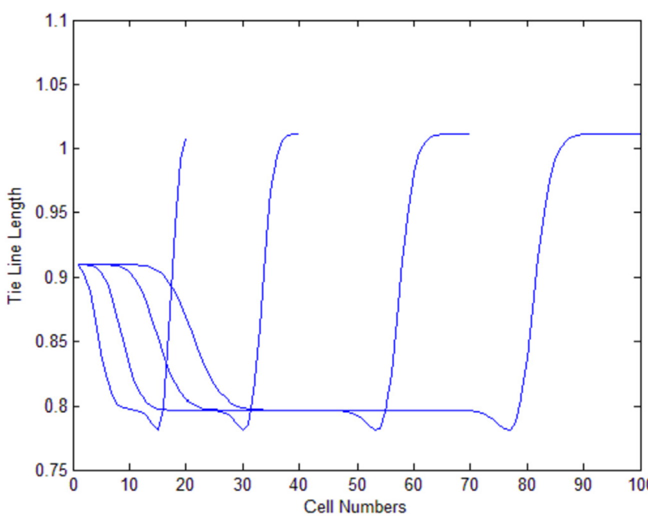

Fig. 4. The graph of tie lines length versus the number of cells for the final pressure of the calculations using a binary interaction coefficient.

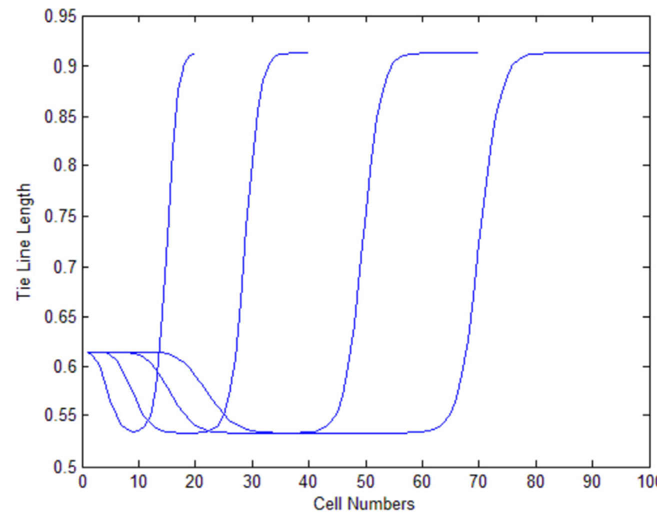

Fig. 5. The graph of tie lines length versus the number of cells for the pre-final pressure of the calculations using a binary interaction coefficient.

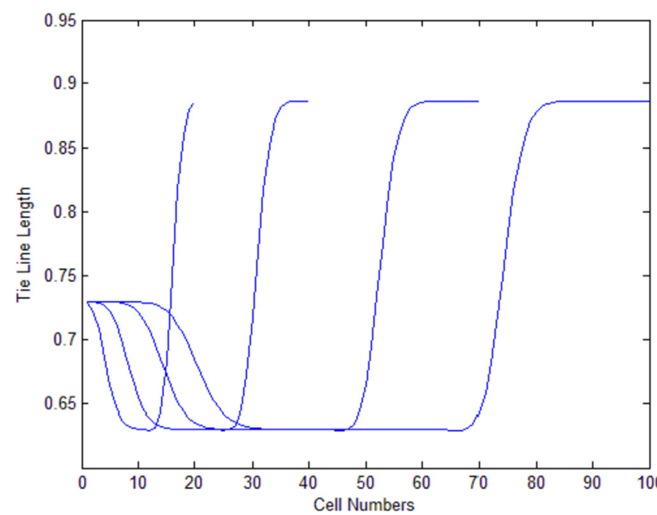

Fig. 6. The graph of tie lines length versus the number of cells for the final pressure of the calculations using a binary interaction coefficient.

equation of state for their calculations and the reported MMP is 2303 psia. This written program calculated 2301.2 psia for the MMP while it applied the same equation of state and the error is 0.08% that represents how accurate the program is. The program the amount Tol., δ, and α were 5 psi, 5 and 0.5 respectively. Figs. 7 and 8 show how to evaluate the MMP for this case by the chart extrapolation.

It is considered that in this study the amount of predicted MMP by SRK and SRKG & D equations of state is less than the amount of MMP predicted by PR-76 or PR-78. Therefore it might be stated that the applications of SRK and SRKG & D equations of state increase the error in the estimation of MMP for this case.

3.2. The second case: to evaluate the MME for a four-component system with vaporizing/condensing drive mechanism

To check the written program for MME evaluation, first a four-component system has been examined and the amount of CO_2 Enrichment was intended. The amount of CO_2 increase was 0.01. As we know when the pressure increases the MME reduces. Hence, the MME is measured in various pressures to check the validity of the written program, and the results are shown in Table 3. Also to confirm the results of the program and the error calculation, the pressure was set on 2300 psia (the MMP designated in the second case where MME was 0.8) and the MME is estimated in this pressure. The estimated MME was 0.63 and thus the error was 21% in comparison to 0.8. This error is significant. The estimated amount is illustrated in Fig. 9 at 2000 psia pressure.

As noted in the previous sections, the equation of state has an important effect on the MMP evaluation. The results indicated that the PR-76 and PR-78 equations of state seemed more appropriate to evaluate MMP. While SRK and SRKG & D equations of state sometimes predict MMP more or less than the actual amount. The higher number of components results in the deviation increase. Fig. 10 shows the calculations of the minimum tie line length using a binary interaction coefficient obtained from WinProp software for the final pressure.

In this case 16-component oil is displaced by carbon dioxide gas at a temperature of 160 °F. Properties of components are listed in Tables 4 and 5.

Table 2
Results of the program and comparing them with the result expressed in the reference Jafari behbahani et al., 2014.

EOS	MMP from Dissertation(psia)	MMP from MATLAB(psia)	Error%
PR76	–	2301.2	–
PR78	2303	2301.2	0.078158923
SRK	–	2229.4	–
SRKG&D	–	2230.2	–

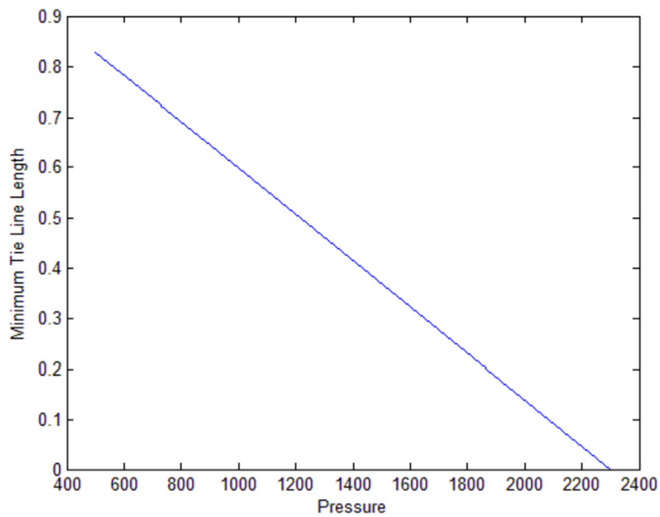

Fig. 7. The graph of the minimum tie line length versus pressure using the binary interaction coefficient.

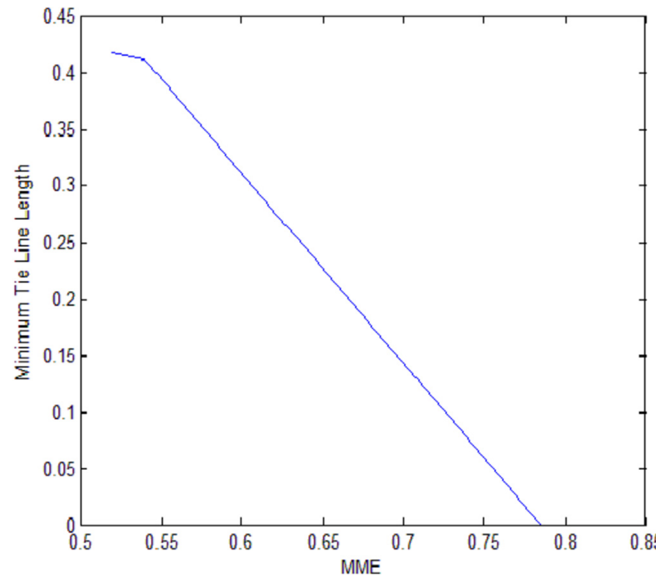

Fig. 9. The estimated MME by graph at 2000 psia pressure.

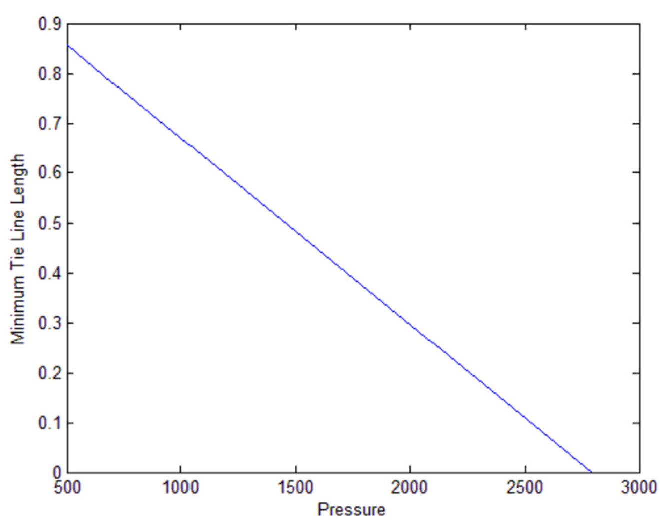

Fig. 8. The minimum tie line length versus pressure using the binary interaction coefficient.

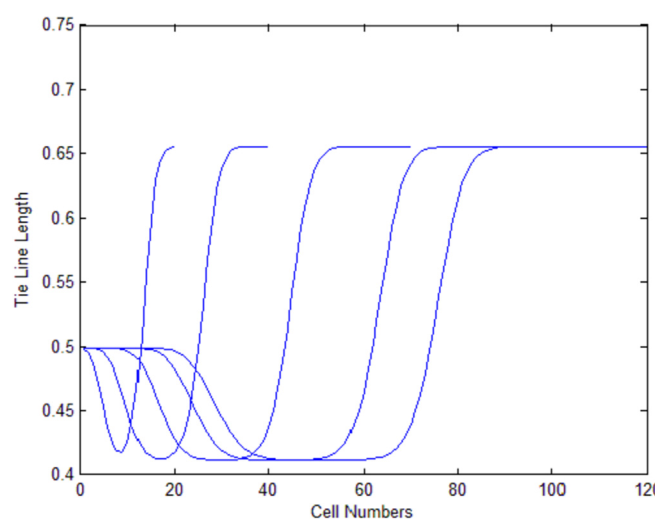

Fig. 10. Tie line length versus the number of cells for the final pressure calculations using a binary interaction coefficient. The third case: MMP evaluation to displacement a16-component system by CO2.

Table 3
The MME for CO_2 at various pressures.

Pressure	MME
1500	0.9371
2000	0.7857
2100	0.7625
2200	0.7404

The graph of tie line length versus the number of cells for the last two pressures of calculations is illustrated in Figs. 11 and 12. The binary interaction coefficient obtained from WinProp software was used for calculations. As the cell numbers increase the key tie lines developed sharply.

The results of the program are represented in the Table 6. It should be noted that for the program the amount Tol., δ, and α were 5 psi, 5 and 0.5 respectively. Fig. 13 shows how to evaluate MMP for this case by the graph extrapolation.

Table 4
Oil and gas components and their properties.

Component	Oil	Gas	Tc(deg F)	Pc(Psia)	ω
N2	0.003	0	- 232.51	492.115	0.04
CO2	0.0183	1	87.89	1069.432	0.225
C1	0.227	0	- 116.59	666.926	0.008
C2	0.0824	0	90.05	708.058	0.098
C3	0.0614	0	205.97	615.511	0.152
i-C4	0.0119	0	274.91	528.84	0.176
n-C4	0.0361	0	305.69	550.875	0.193
i-C5	0.0138	0	369.05	490.646	0.227
n-C5	0.0159	0	385.61	489.177	0.251
C6	0.0695	0	453.83	476.8374	0.27504
C7	0.041	0	518.09	454.9493	0.308301
C8	0.0388	0	567.23	427.7728	0.351327
C9	0.0249	0	617.63	395.7486	0.390781
C10	0.0403	0	660.11	367.3969	0.443774
C11	0.0285	0	698.81	340.3673	0.477482
C12+	0.2872	0	1340.7404	150.04366	1.154211

4. Conclusions

In this study different methods of evaluating MMP including experimental and computational methods were introduced and discussed. Multiple mixing cell method which is one of the latest methods was investigated extensively. MMP and MME were predicted in several cases by a written program based on the multiple mixing cell method. Also the MMP of asphaltene oil samples was calculated. Results obtained by multiple mixing cell method confirmed with the results of previous methods and even this new method is more applicable for some displacements than previous methods. Conclusions are as the following:

(1) A real mixing cell model was developed to estimate the MMP (or MME) and key tie lines on the combination track. This method is simpler, more reliable, and faster than conventional one-dimensional simulation of slim tube.
(2) The new method of mixing cell can accurately find the whole tie lines for a displacement, regardless to the number of components of the injected gas and reservoir fluid. Unlike other methods of mixing cells, this method automatically

Table 5
Binary interaction parameters.

component	N2	CO2	CO2	C1	C2	C3	i-C4	n-C4	i-C5	n-C5	C6	C7	C8	C9	C10	C11	C12+
N2	0.00	−0.02	0.03	0.04	0.09	0.10	0.10	0.10	0.10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.00
CO2	−0.02	0.00	0.10	0.13	0.14	0.13	0.13	0.13	0.13	0.15	0.15	0.15	0.15	0.15	0.15	0.15	−0.02
C1	0.03	0.10	0.00	0.00	0.01	0.02	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.11	0.03
C2	0.04	0.13	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.08	0.04
C3	0.09	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.06	0.09
i-C4	0.10	0.13	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.05	0.10
n-C4	0.10	0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.05	0.10
i-C5	0.10	0.13	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.10
n-C5	0.10	0.13	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.10
C6	0.12	0.15	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.12
C7	0.12	0.15	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.12
C8	0.12	0.15	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.12
C9	0.12	0.15	0.04	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12
C10	0.12	0.15	0.04	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12
C11	0.12	0.15	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12
C12+	0.12	0.15	0.11	0.08	0.06	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.00	0.12

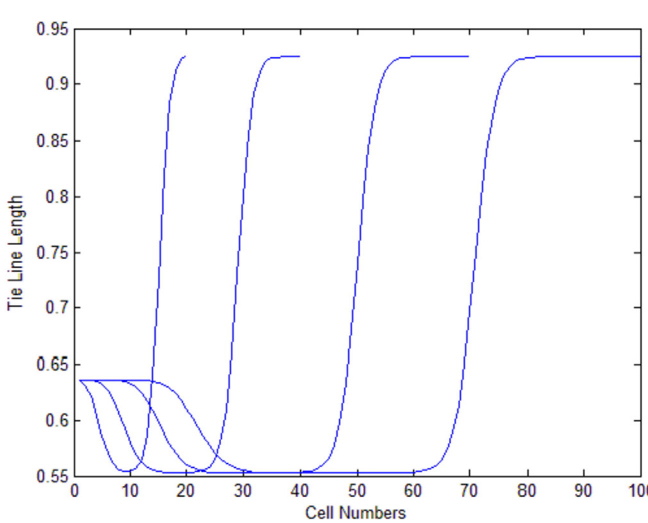

Fig. 11. The graph of tie lines length versus the number of cells for the pre-final pressure of the calculations using a binary interaction coefficient.

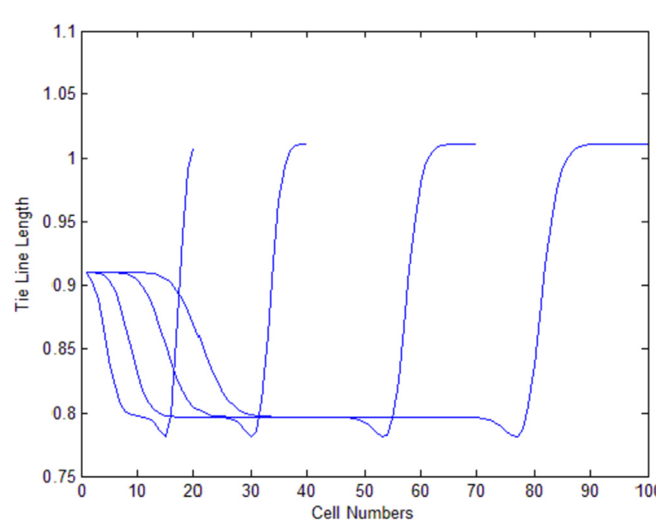

Fig. 12. The graph of tie lines length versus the number of cells for the final pressure of the calculations using a binary interaction coefficient.

Table 6
The results of the program for the fluid of Ref (Jafari Behbahani et al., 2014).

EOS	MMP From Matlab (psia)
PR76	3616.5
PR78	3616.5
SRK	3535.4
SRK G&D	3531.6

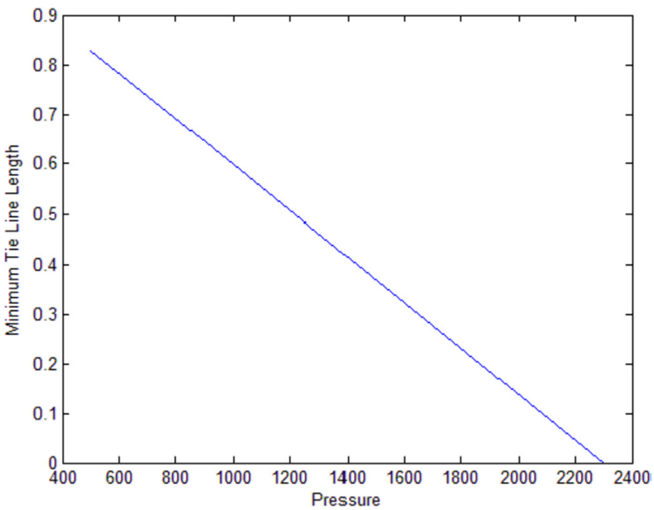

Fig. 13. The minimum tie line length versus pressure using a binary interaction coefficient obtained from WinProp software.

corrects dispersion to achieve to the low-range slope of tie line by performing additional contacts.

(3) The MMP calculated by mixing cell method confirmed with the MMP derived from the CMG software and the slim tube experiments. Mixing cell method is slightly more accurate than the results of CMG software.
(4) Multiple mixing cell method is accurate for all types of displacement, such as condensing/vaporizing drive.
(5) Speed of multiple mixing cell method to estimate the MMP can increase by an extrapolation method for positive and negative tie lines.

Nomenclature

MMC	Multiple Mixing Cell
MMP	Minimum Miscibility Pressure
MW_{C5+}	Molecular Weight of C_{5+} in Oil Reservoir (g/mol)
PR	Peng-Robinson
SRK	Soave Redlich Kwong
VIT	Vanishing Interfacial Tension

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