Investigation and study of hydraulic fracturing and the efficiency of this in oil reservoirs naturally fractured and caven

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Abstract. Hydraulic fracture operation is one of the key technologies for the development of caven reservoirs. Modeling of hydraulic fracture processes to factors such as Situation of tensions, Shear strength and Orientation of natural fractures in the reaction(In particular, the potential for opening cracks in areas that are growing along the path of a hydraulic fracture) And also the length and height of the hydraulic fracture. Due to the presence of natural fractures with diffuse penetration and different orientations, the operation is complicated in caven reservoirs. For this purpose, two numerical methods are proposed for simulating the hydraulic fracture in caven reservoirs. In this paper, the hydraulic fracture model is considered in terms of the state of tensions, On the reaction between the hydraulic fracture and the natural fracture (45°) And also the effect of length and height of hydraulic fracture, Developed and how to distribute induced stress around the well, In order to determine the direction in which the hydraulic fracture is formed in that direction The finite difference method and the individual element for numerical solution are used and simulated. An inverse suction is an important parameter And in the operation of the hydraulic fracture will reduce production, This simulation is being studied. In every length of the hydraulic fracture, The rate of production is measured and the causes of changes in the input rate to the wells are discussed based on the natural fractures cut by the hydraulic fracture and the induction of the fracture. Finally, it can be seen that the optimum hydraulic fracture time will be The hydraulic fracture is able to connect natural fractures with large and large streams And finally, it is connected to the well, and there is a fundamental difference between the tensile and shear opening. The analyzes indicate that the growing hydraulic fracture, the tensile and shear stresses applied to the natural fracture.

Key words: hydraulic, fracturing, efficiency, reservoirs, caven.
1-1-Introduction

Given the growing demand for oil resources and increasing demand for hydrocarbon energy over time due to reduced reservoir pressure and damage and permeability of the formation. Achieving more production requires re-activation of the reservoir to increase permeability and raising the production of wells because different phases of harvesting have a dramatic effect. As a result of the need to produce more oil and gas from unusual tanks, reducing the flow of hydrocarbon fluid into the well as a result of the well construction of the wall and low permeability of the reservoir rock in some structures, especially in carbonate formations, it is necessary to use the methods of stimulation in the well.

At present, hydraulic failure is used to improve the efficiency of oil and gas wells. Hydraulic fracture layer operation, which involves injection of different fluids with high enough pressure into the formation. Applied to high-performance applications that are widely used in hydrocarbon reservoirs.

Stimulation techniques such as hydraulic fracture can help increase production from reservoirs. Hydraulic gap is one of the methods of well-induced motivation to increase the production capacity of a well and includes the creation of a high permeability path for reservoir fluid flow to wells and it is usually used in wells with low to medium permeability layers. Establishing hydraulic fractures in wells for various purposes, including creating a high-fluidity pathway to increase the well capacity capability, bypassing the damaged area around the well, connection of different reservoir layers in horizontal wells, and in condensate wells, the gas wells are used to eliminate condensate accumulation.

The term "hydraulic fracture" refers to the process of starting and spreading fractures in rocks, caused by the hydraulic pressure applied by the fluid. The energy of conventional hydrocarbon reservoirs will end sooner or later, and while only about 30 percent of the oil is landed at the initial stage. Increasing the recovery and improve recovery factor of reservoirs by using a hydraulic fracture is one of the most effective ways to produce optimum. The selection of the well and the candidate layer plays a significant role in the effectiveness of hydraulic fracturing operations. In general, the purpose of selecting a candidate, selecting one or groups of wells or zones for operations that are most likely to succeed. Research has shown that if the choice of the well and the candidate layer is well done, increasing production, particularly in wells with high crustal and permeable coefficients can be significant. Most carbonate reservoirs have a low permeability, therefore, they can only produce economically, if they are hydraulically fractured.

In this study, with the help of isolated and differential element methods, the modeling of the hydraulic fracture phenomenon and the study of the efficiency of this operation in one of the
reservoirs in the south of Iran has been investigated.

**Methodology:**

The operation of the hydraulic fracture in the split reservoirs has some complications due to the presence of natural fractures. In this regard, numerous numerical and laboratory studies have been done to justify the complex behavior of hydraulic fracture in caven reservoirs.

Simulation of hydraulic fracture operation in caven reservoirs studied numerically and analytically. Due to the existence of natural fractures with different characteristics, it has particular complexity. The reactions that occur during hydraulic fracturing operations in the presence of natural fractures are very important in determining the efficiency of operations.

The method used in this study is field and then simulation and analysis using finite difference fractions and separate FALC software. Also, data for this work is done using the data obtained from the target field. For this purpose, in this study, two numerical methods are presented for simulating hydraulic fracture operation in caven reservoirs.

To evaluate the analysis in this study, the finite difference method, the distribution of induced stresses around the well is simulated to determine the direction in which the hydraulic fracture is formed in that direction. After determining for the formation of a hydraulic fracture, using a separate element method, hydraulic fracture operations are simulated in a caven reservoir with different lengths and in each length, the rate of production is examined. Inverse simulation, which is an important parameter and will reduce production in hydraulic fracturing operations, will be studied in this simulation. In each length of the hydraulic fracture, the rate of production is measured and the causes of changes in the input rate to the wells are discussed based on the natural fractures cut off by the hydraulic fracture and the alacrity of the fracture. Finally, it can be seen that the optimal hydraulic fracture condition will be when the hydraulic fracture can connect natural fractures with major currents and connect them to the well.

In this study, with the help of isolated and discrete element methods, hydraulic fracture operations were modeled in one of the caven reservoirs in southern Iran. To do this, first, using the finite difference method, the direction in which the fracture is created in that direction is determined. Then, by simulating the fractures around the well in the reservoir using a separate element method, a hydraulic fracture with different lengths in the reservoir and in the direction determined will be extended and at any rate the rate of production is provided. Additionally, at each stage, the number of fractures that will be cut off during the hydraulic fracture operation by the fracture will be evaluated and discussed. The intersection of fracture and reverse suction phenomena that occurs in the reaction between the hydraulic fracture and the natural fractures in caven reservoirs are also considered and their effects on the production rate have been studied.
Reaction between hydraulic fracture and natural fracture

During the development of a hydraulic fracture in split reservoirs, there are three possible situations. The shape of various scenarios that may occur after collision between the natural fracture and the hydraulic fracture can be found in Fig1.

**figure 1:** Various scenarios after collision between natural fracture and hydraulic fracture

In the first place, natural fractures do not play any role, and the hydraulic fracture, in parallel with the direction of horizontal stress, will have maximum growth. This condition may be the result of high cement resistance in natural fractures (in comparison with matrix resistance), the inadequate orientation of natural fractures or inadequate deflection pressures to overcome the normal stress of the vertical natural fracture. In the second scenario, the hydraulic fracture breaks the natural fracture, trapped by a natural fracture, and the fluid is completely diverted into the hydraulic fracture. If the growth energy of the hydraulic fracture is sufficiently bigger than the normal opening fracture of the cements, or if the shear stresses of the hydraulic fracture are so high that they overcome the stiffness between the levels of the natural fracture, natural fractures will be opened. In the last scenario, natural fractures in a situation where specific complexity is interrupted or interrupted by a hydraulic fracture, debonding the natural fracture in front of the hydraulic fracture (before being cut off by it) is also one of the important phenomena in the reaction between the inductive and natural fracture. In other cases, the natural fracture begins to open, cut, or grow before the hydraulic fracture collides with it. The reason for this phenomenon can be the concentration of tensions near the tip of the fracture [7]. If such a phenomenon occurs, even if the hydraulic fracture is diverted into the natural fracture, the natural fracture can be shaped like a double. In this scenario, if the natural fracture has a high degree of heterogeneity from the tensile point of view, it may prevent the growth of the hydraulic fracture.
3-3-Methods used

1- finite difference numerical method
The finite difference of mathematical expressions is \( f(x + b) - f(x + a) \). If a finite difference is split into b-a, then we will have a different division. The approximation of derivatives in the finite difference plays an important role in the finite difference methods for the numerical solution of differential equations, especially boundary-value problems. Certain recurrence relationships can be written as differential equations by replacing repeating symbols with finite difference. Today, the term "finite difference" is used as the synonym for the derivation of finite difference, especially in the field of numerical methods. The finite difference approximation, in fact, is the same outside of the differential divisions in the terminology used above. [1,2,3].

Finite difference method Which is briefly called (FDM), Is one of the numerical methods for solving the approximate differential equations. In this method, the derivatives of functions with their equivalent differences are approximated. The basis of this method for solving equations is using the Taylor method to approximate the function. For the approximation of the function \( f \) at \( x_0 + h \),

\[
 f(x_0 + h) = f(x_0) + \frac{f'(x_0)h}{1!} + \frac{f''(x_0)h^2}{2!} + \ldots + \frac{f^{(n)}(x_0)h^n}{n!} + R_n(x) \quad \ldots (1)
\]

we use the Taylor expansion:

Then for \( x_0 = a \) and split sides on \( h \) and for the approximation of the function \( f \) at \( x_0 + h \), we use the Taylor expansion:

\[
 \frac{f(a + h)}{h} = \frac{f(a)}{h} + f'(a) + R_1(x) \quad \ldots \quad (2)
\]

As a result, we have:

\[
 f'(a) = \lim_{h \to 0} \frac{f(a + h) - f(a)}{h} \quad \ldots \quad \ldots \quad (3)
\]

In a finite difference method, a suitable approximation for this function will be:

\[
 f'(a) \approx \frac{f(a + h) - f(a)}{h} \quad \ldots \quad \ldots \quad (4)
\]
First, to determine the direction of the hydraulic fracture, we need to distribute the stresses around the well to determine the fracture for them. For this purpose, a finite difference method was used. This method is characterized by a finite difference code that simulates the behavior of structures composed of soil, rock and materials, which, when they reach a degree of flexibility, may exhibit plastic behavior. Each component employs a stress-strain relationship - a nonlinear or linear strain in response to the force input and boundary boundaries. If the tensions are large enough, it causes the flexibility and shape of the material, in which case the network will actually be transformed and moved.

This form is called the Lagrangian calculation problem, and for modeling, the changes include an intermediate model. A finite difference method is also used to simulate the continuous behavior of the individual regions of the sloping surfaces, the presence of separate faults or joints within a single or separate or sloping region.

Underground formations are often subjected to tensile stresses or tensile stresses or other tectonic factors. When excavated in a well form, due to the lack of rock space to withstand earth tensions, the well wall is maintained only by the fluid pressure inside it.

With respect to the minimum and maximum horizontal tensions in the cylindrical coordinates, according to the rules of the Kirsch, for a vertical well which is centered on the main stresses, tensions around the well are expressed as follows [6]:

\[
\sigma_r = \frac{\sigma_H - \sigma_h}{2} \left(1 - \frac{r^2}{r_w^2}\right) + \frac{\sigma_H + \sigma_h}{2} \left(1 + 3 \frac{r^4}{r_w^4} - \frac{4}{r_w^2}\right) \cos 2\theta + p_w \frac{r^2}{r_w^2} \tag{5}
\]

\[
\sigma_\theta = \frac{\sigma_H - \sigma_h}{2} \left(1 - \frac{r^2}{r_w^2}\right) - \frac{\sigma_H - \sigma_h}{2} \left(1 + 3 \frac{r^4}{r_w^4}\right) \cos 2\theta - p_w \frac{r^2}{r_w^2} \tag{6}
\]

\[
\tau_{r\theta} = -\frac{\sigma_H - \sigma_h}{2} \left(1 - 3 \frac{r^4}{r_w^4} + 2 \frac{r^2}{r_w^2}\right) \sin 2\theta \tag{7}
\]

In these equations, \(\sigma_r\) is the effective stress in the radial direction, \(\sigma_H\) is the maximum horizontal stress, \(\sigma_h\) is the minimum horizontal stress, \(r_w\) is the well radius, \(r\) is the study radius, \(p_w\) is the pressure inside the well, \(\sigma_\theta\)
tangential stress, “τrθ” is the shear stress and “θ” is the maximum angle with respect to horizontal stress.

As shown in Fig. 2, fluid pressure is often not consistent with tensions, which can cause tensions to collapse around the well.

![Figure 2: The path of the main stresses around the well based on the Kirsch equations (the well wall is a free surface and the well axis is in the direction of vertical stress)](image)

In order to minimize stress azimuth, tensile stress has increased greatly and in the direction of azimuth of maximum stress, the tensile stress has reached its lowest level. Therefore, by increasing the internal fluid pressure of the well, according to Equation 2, there is the possibility of creating and extending the crack for the azimuth of maximum stress.

Unlike breakout the well wall, when the permeability stress of the well is more than the resistance of the rock and is due to the pressure stress of the well wall, The breakout of hydraulic fracturing is due to tensile stress and a 90 degree angle to the direction where breakout is possible. Since the work done to defect the gap (which is caused by the tensile force applied perpendicular to the slit plane at the opening rate), perpendicular the to the stress is minimal (Fig. 3), in this direction, the least energy is consumed.
According to linear elastic theory, when the tensile stress at the tip of the slit reaches the tensile strength of the rock, the fracture begins to progress. Of course, it should be noted that the linear elastic hypothesis is used only for large-scale fractures. Afterwards, the fracture extends vertically onto the plate perpendicular to “Sh”.

The minimum pressure known to cause a fracture in the well wall and known as the (Pf) start-up pressure is given by the following equation,

\[ P_f = \frac{T + 36 \epsilon_{22} - 6 \epsilon_{11}}{2 - \alpha \left( \frac{1 - 2\theta}{1 - \theta} \right)} + P_o \]

\[ \text{.................................(8)} \]
In cases where the fluid is impenetrable, the total stress of “$S_{θθ}$” is changed as follows:

$$S_{θθ} = \sigma_{θθ} + P = 3\sigma_{22} - \sigma_{11} + P_0 - P_w$$  \hspace{1cm} (9)

In the above relations, “$P_w$” is the fluid pressure difference, “$P_0$” is the pore pressure of the fluid in the formation, “$\sigma_{θθ}$” of the effective tensile stress, “$T$” is the tensile strength of the stone, “$\nu$” Poisson ratio, “$\alpha$” is the bite factor, “$\sigma_{11}$” and “$\sigma_{22}$” are respectively the maximum and minimum stresses.

1- Discrete Element method

A discrete elemental method, or "DEM," is one of the numerical methods for calculating the interactions of a large number of small particles. Despite the very close relationship between DEM and molecular dynamics simulation, features such as the degree of rotational freedom (rotational), The particle contact and complex geometry distinguish this approach in general with other options.

With the development of computer computing power and the development of numerical algorithms for sorting by the nearest neighbor method, it was possible to simulate millions of particles by employing only one processor.

Today, the acceptance of the discrete elemental method is growing as an efficient approach to solving engineering problems in discontinuous and materialized environments such as rock mechanics, powdery material mechanics, material flow, etc.

Considering the thermodynamic principles of DEM and its combination with Computational Fluid Dynamics (CFD) and discrete Element Method (FEM), the Extended discrete Element Method, or so-called “XDEM”, has been developed in recent years.

2-1-The overall process discrete element method

Simulation of the DEM begins by creating a model, determining the location of all particles and assigning the initial speed to each of them. Calculation of the forces applied to each particle with the help of initial data, physics rules and models related to the surface of the contact. In general, a DEM simulation has three stages:
Initialization

Determine the time step Later processing

Usually to reduce the number of common contact surfaces and computational power required, a sorting process is used by the closest neighbor method in the step of determining the time. This process often takes place within certain timeframes.

Discrete element method is a two dimensional numerical analysis method that is considered for the analysis of rocky mechanics of discontinuous environments. By this method, it is possible to simulate the reaction of a discontinuous medium (such as tectonized and highly bonded) to static and dynamic loads. This method defines a rock environment as a set of discrete blocks in which discontinuities (such as joints) act as boundary conditions between blocks and shear displacements can be done along these discontinuities as well as rotation of the blocks. In this method, it is possible to define the blocks in rigid and ductile form. Modifiable blocks are divided into a network of elements with a finite difference, and each element acts with predetermined linear or nonlinear strain-strain behavior.

Reservoir studied

Southwest of Iran is known as one of the most important hydrocarbon reservoirs in the world. Although the geological position of this area is well known. But it is still not well known how the hydrocarbons from the different fields are.

Zagros Mountains in Iran with its central north-west-south-east trend starting from Lorestan area and ending with minab fault in Bandar Abbas.

The north-east of this huge mountain range is the Zagros line of life, which is also known as the Sanandaj-Sirjan line. The Zagros basin is generally divided into three zones of drift; Distinct zone of the folded zone is divided. Maroon oil field is located near the border of the corrosive zone (Southwest of Iran) and the non-corrosive zone in the zone of the plain zone.

But the most important and comprehensive research on the dispersion of the origin and maturation stones of the oil produced in the orogenetic basin of Zagros using carbon-isotope, sulfur and biomarkers is based on Bordenave and Burwood studies.
Geological location
In this study, the reservoir of Bangestan has been evaluated. Using lithologic columns drawn from wells in the field, the longitudinal section was drawn to stratigraphic adaptation. The zoning carried out on the above section shows that the Bangestan reservoir consists of 7 zones consisting of Ilam, Lafan and Sarvak formations. Major areas of interest include zones 3, 4 and 5. Among these zones, zone 4 with a facade that is clean and dolomitic has the highest reservoir quality and the largest share of production from the reservoir. Also, the results of petrophysical assessments show that the upper parts of Sarvak Formation compared to its main section have better conditions for reservoir quality. The central area of the field, which has the highest thickness, with proper fractures due to the elongation of the upper part of the Sarvak Formation, it has a high potential for field production.

According to the results of this study, the north of the well No. 9 for the withdrawal of the reservoir with the latticework zone 4 is the best region for future drilling.
Results:
In this study, using Discrete Element and finite difference methods, hydraulic fracturing operations were modeled in one of the caven reservoirs in southern Iran. To do this, first, using the finite difference method, the direction in which the fracture is created in that direction is determined. Then, by simulating the clefts around the well in the reservoir using a discrete element method, a hydraulic fracture with different lengths in the reservoir and in a predetermined direction will extend along the length of the production rate. Additionally, at each stage, the number of fractures that will be cut off during the hydraulic fracture operation by the fracture will be evaluated and discussed. The intersection of gap and reverse suction phenomena that occurs in the reaction between hydraulic fracture and natural fracture in caven reservoirs are also considered and their effects on production rates are investigated.

Numerical results
In this section, we will look at the methods used (discrete element and finite difference), which we will continue to discuss.

1-Finite Difference Method
In this section, in order to investigate the reaction between the hydraulic fracture and natural fractures, only fractures that are about 45 ° to the hydraulic fracture are desirable; Because, as can be seen from the previous method, most of the natural fractures that are cut off by the hydraulic fracture are about 45 degrees angular hydraulic fracture. The hydraulic fracture, when approaching the natural fracture with a 45 degree angle, causes it to dry before the natural fracture is debonding. In the natural fracture, there are two types of tensile and shear debonding that vary in different areas of the natural fracture. In this section, the failure caused by the progress of the hydraulic fracture occurs according to Fig. 5 in three regions a, b and c.

Figure 5: A schematic of the position of the natural gap relative to the hydraulic gap in the three regions a, b and c

The graph of tensile and normal opening is shown in Fig. 6.
Figure 6: Tensile and shear displacements in specified areas

When the hydraulic gap reaches the a region, the tensile fracture is almost normal; In this way, the midpoint of the natural fracture (the intersection point or the area of the natural fracture that passes through the progressive hydraulic fracture) takes the greatest amount of opening. As the hydraulic fracture reaches the area b, the situation will be slightly different; Because, despite the highest opening at the intersection of the two fractures, this time the upper part of the natural fracture is denser. This becomes noticeable by reaching the hydraulic fracture to the natural fracture (point c). The upper part of the natural fracture is dense and the lower part is open. In the case of shear failure, with the achievement of the hydraulic fracture to a, there is no longer symmetric opening, but there is a displacement peak in two regions. In area b, this situation is more perceptible. Carefully, it can be deduced from the diagram that with the closeness of the hydraulic fracture, the maximum shear opening from the upper regions of the natural fracture to the lower parts is changing. By reaching the hydraulic fracture to the natural fracture (area c), this inference appears to be somewhat correct; Because the cut-off peak occurs at the bottom of the natural fracture. In fact, in order to move the two plates, the natural fracture is in the upper and lower directions.
In both tensile and shear joints, the least amount of opening is related to the nodes of the natural fracture or close to it; because the tensions are concentrated in a fracture at its tip. In the case of the tensile and shear opening phenomena induced by the hydraulic fracture in the natural fracture, discussed above, the state of stress was assumed to be isotropic. Fig. 7 shows the distribution of induced stresses around the well using a finite difference method.

If the well is in equilibrium, that is, the pore pressure “P0” and the “PW” well pressure are equal to each other. Considering that based on the available data from wells, “SH” is 44 MPa, “Sh” is 40 MPa and “Sv” is 87 MPa. Therefore, the minimum and maximum inductive stresses will be 76 and 92 MPa, respectively. As shown in Fig. 7, these points, which are simulated by the finite difference method, also represent approximately the same numbers. Determining the position of the minimum and maximum induced stresses will determine the direction in which the hydraulic fracture is determined in that direction. The fracture will be formed in the direction of minimum and maximum induced stress in maximum induced stress. The alignment of the hydraulic fracture is shown in Fig. 8.

Figure 7: Status and position of minimum and maximum induction stresses on well walls
Figure 8: To form a hydraulic fracture based on the distribution of tensions around the well

2- Discrete Element Method

After determining the direction of the hydraulic fracture, the situation of the fracture between the wells is simulated using the discrete element method. As shown in Fig. 9, in this simulation only the natural fractures around the well that are connected to each other and form a natural fracture are shown.

The discrete element method is a two dimensional numerical analysis method that is developed for the analysis of the rocky mechanics of discontinuous environments.

In Figure 10, the natural fracture situation around the well is simulated using this method.
Figure 9: Location of fractures and currents around them.

Figure 10: Status and location of natural fractures around the well
As can be seen, in this simulation only the natural fractures around the well that are connected to each other and form a natural fracture are shown. In other words, in areas where there is no natural fracture, there is a possibility that the fracture is separate and there is no connection to another natural fracture. The proposed model is a two-dimensional model that consists of a 20 x 20 meter block in two X and Y, and the well is located in the middle of the block.

It is assumed that the hydraulic fracture is applied only to the optimum layer and all parameters are constant and the only parameter that can be changed is the length of the hydraulic fracture, its direction and its opening. Four nodes are defined in the well, with two nodes on the ceiling and two nodes in the wall to measure the flow rate of the fluid into the well. The data used in this model are obtained by plotting wells and corrugations. The most basic of these data is given in Table (1).

The flow state of the fluid in the fractures is shown in Fig. 10. This figure only shows the major flows in the more permeable fracture. Fluid flow is present in all of the slots, but here large flows have been shown here. In Fig. 11, it can also be seen that the flow of fluids in the fractures is large.
|                           | Public data         | Intact rock Properties | Properties of natural fractures |
|---------------------------|---------------------|-------------------------|--------------------------------|
| size of the selected block | $8 \times 8$ m     |                         |                                |
| Well diameter             | 8/5 in              |                         |                                |
| reservoir fluid density   | 11 kg/m$^3$        |                         |                                |
| Bulk reservoir fluid model| $1 \times 10^6$     |                         |                                |
| Density                   | 1800 kg/m$^3$      |                         |                                |
| Shear modulus             | $20 \times 10^9$   |                         |                                |
| Average hardness          | Displacement / (400 $\times 10^9$) tension |                        |                                |
| Average deflection angle  | $30^\circ$         |                         |                                |
| Average permeability      | 100 mD             |                         |                                |
| Structural model          | Columbus            |                         |                                |
Figure 11: Small currents in low permeability fractures

The PKN model is used to propagate the hydraulic fracture. In this model, the length of the hydraulic fracture is assumed to be much greater than the height or opening of the natural fracture. The created fracture has a constant height independent of the length of the fracture. As noted, the characteristics of the reservoir including natural fractures, wells, and stone particles are listed in Table (1). Accordingly, the hydraulic fracture is created in the specified direction. The fracture length increases at each step; that is, at first a fracture of 2 meters is created, in the next step, the fracture is 4 meters long, and this process continues until we reach a fracture of 20 meters, which is actually equal to the dimensions of the block. These steps can be seen in Fig. 12.
Figure 12: Hydraulic fracture applied with different lengths
The hydraulic fracture is shown in Figs when it is connected to the fracture. For example, in Fig. 10, when the length of the hydraulic fracture is 2 meters, there is no fracture in the shape; because a fracture with this length does not cut another fracture or is not connected to the fracture. When the length of the hydraulic fracture is 16 meters, its length increases below; because it connects to other fractures, but because it does not bond to the fracture, it does not extend on the other part, i.e., the upper part of the fracture. Therefore, the extension of the fracture does not increase in shape.

It is assumed that the hydraulic fracture is applied only to the layer, all the factors are constant and the only variable that can be changed is the length of the hydraulic fracture, its direction and its opening. Based on the distribution of stresses around the well, the hydraulic fracture is in a 90 degree direction.

Carefully, in the form (Fig. 13), we find that half of the hydraulic fracture extends from an area that is characterized by a large accumulation of natural fractures.

Figure 13: Hydraulic fracture Operations 90 degrees in two different sizes

But half the other, the hydraulic fracture passes through a section where there are few natural fractures. The production chart also shows that by increasing the length and height of the hydraulic fracture, the production will have an acceptable change. In Figure 14, a section of the hydraulic fracture that is in contact with more natural fractures is shown.
Figure 14: A section of the hydraulic gap in an area where cutting of natural gaps is a major factor in increasing production

It can be deduced from the form that a large flow of natural fractures enters the hydraulic fracture, which may be due to the cutting of these fractures by a hydraulic fracture. But in the other half the hydraulic fracture is not the situation; That is, the cutting of natural fractures is not a factor in increasing production, but the fractures coalescence has a more significant role. As shown in Fig. 15, in this region, coalescence caused the connection of natural fractures with hydraulic fracture and led to increased production.
Figure 15: Part of the hydraulic fracture in the area where the coalescence of the main factor of production

Based on the production rates, if the height of the hydraulic fracture increases, it will be economically justified to have more natural fractures in the hydraulic fracture.

Fig. 16 shows the production rate in the case of a hydraulic fracture with different lengths.

The production rate is based on the two nodes on the ceiling and the other two nodes in the well wall, and the total flow of these nodes is equal to the total production rate. Figure 17 shows the phenomenon of coalescence fracture for a 6 meter long hydraulic fracture.
Figure 16: Production rate in normal conditions and hydraulic fracture with different lengths

Figure 17: The phenomenon of coalescence fractures in a 6 meter long hydraulic fracture
Here are two small fractures connected to a hydraulic fracture that is applied at a length of 6 meters. Typically, by increasing the fracture length, the number of fractures that are cut off by the hydraulic fracture is increased, and on the other hand, the probability of coalescence the fractures is also increased. The production rate in different lengths indicates hydraulic fracture. When the length of the fracture is 10 and 12 meters, not only does production not increase as the fracture length is equal to 8 meters, but also with the decrease of production. As shown in Fig. 18, in reverse b and c sections.

Figure 18: Fluid flow conditions in sections of hydraulic fractures of 10 and 12 meters in length

This means that by connecting the hydraulic fracture to the fracture that is shown in the figure, it is natural to flow from the hydraulic fracture to the fracture. The reason for this reduction in production is that, by connecting the hydraulic fracture to this fracture, the fluid flow into the slot instead of entering the well through the hydraulic fracture. The same situation will be established for a 12 meter long hydraulic fracture; Because in the section where the flow enters the fracture, with a
fracture lengthening of 10 to 12 meters, the hydraulic fracture is not bonded to the fracture.

To ensure this analysis, a hydraulic fracture of 14 meters in length is also being examined. As shown in Fig. 19, the flow into the hydraulic fracture is in fact one of the main and big flows.

Figure 19: Current status in a section of the hydraulic fracture of 14 meters in length

Therefore, the reason for the increase in production can be indicated by the fact that when a hydraulic fracture with a length of 14 m is applied, this fracture is connected to fractures that have high permeability and have a main and big flow that causes the flow to be neutralized from the hydraulic fracture to the fracture in the studied section and leads to increased production.
**Conclusion**

In this paper, the operation of hydraulic fracture was investigated in one of the South Pars gas field discharged reservoirs. For this purpose, two numerical methods of separate element and developed finite difference were used. In a separate element method, the development and development of hydraulic fracture was simulated in a fracturing environment. The results obtained in this paper can be summarized as follows:

Based on variation of length and height of hydraulic fracture in this method, in cases where the density of natural fractures is low, an increase in length is acceptable and in cases where the density of natural fractures in the natural fracture is high, the increase in logic seems to be logical; Because when the hydraulic fracture is slightly associated with natural fractures, increasing the length of the hydraulic fracture compared to the height increase has a more visible effect on the production and conversely, when the hydraulic fracture is located in areas with high natural fractures, increasing the height of the hydraulic fracture will affect production more. The criterion in this case is the amount of production.

In the numerical finite difference method developed, the reaction of hydraulic fracture with natural fracture was simulated (450 °). The growing hydraulic fracture has exerted a high pressure on natural fractures and causing them to be cut off before they reach the hydraulic fracture to the natural fractures, it has the effect of creating an open area in natural fractures. In this way, the deviation that the hydraulic fracture becomes when it reaches that open area within the fracture will be doubled. Tensile and shear joints before and after the hydraulic fracture to the natural fracture were evaluated. It was observed that between the fracture coalescence and the natural fracture would be different and the degree of opening would be different. In this study, hydraulic fracture operation with different lengths in a caven reservoir was investigated. In caven reservoirs, the production rate is usually increased by increasing the length of the hydraulic fracture. But this depends on the number of broken fractures and the induction of fractures. If the hydraulic fracture does not connect to the natural fractures in which the main flows are flowing, it can not increase production as expected; So that if this length of the hydraulic fracture is designed to end with natural fractures that contribute little or insignificantly to the fluid flow in the reservoir (that is, natural fractures with low permeability), this will even change the direction of flow and reduce production. Therefore, determining the
length of the fracture that can end the natural fractures with the main currents is very important in designing hydraulic fracturing operations.

When the hydraulic fracture is applied to such a fracture with natural fractures, Complex reactions occur between the hydraulic fracture and natural fractures. Increasing the

length of the hydraulic fracture was observed in caven reservoirs; But due to the fact that in the reaction between the hydraulic fracture with the natural fracture was the reverse suction phenomenon, this increase was discontinuous. Depending on the natural fracture, this phenomenon affected the production and reduced its production. Considering that using the distribution of principal stresses or induced stresses around the well, one can determine the direction in which the hydraulic fracture occurs ,(In this study, this work was carried out using finite difference method) Therefore, depending on which fracture occurs and are there any natural fractures with the main flows in the fracture?,The economic performance of the hydraulic fracture and the production rate are predictable. Of course, in the hydraulic fracture operation, the process of fractures coalescence should also be taken into account; Because it can increase or decrease production. The optimum hydraulic fracture action can be considered when the main fractures with large currents are in the same direction as the hydraulic fracture, so that the hydraulic fracture can connect these natural fractures to the well.

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