
CALCULATION OF FLUID FLOW VELOCITY IN A SLOPING RESEVOIR WITH VARIABLE DATUM LEVELS

Listiana Satiawati^{1*}, Yusraida Khairani Dalimunthe², Harin Widiyatni³, Prayang Sunny Yulia⁴, Ridho Abdillah⁵

¹Petroleum Engineering Department, Faculty of Earth and Energy Technology, Universitas Trisakti, Jakarta, Indonesia.

^{*})corresponding author e-mail: listianasatiawati@trisakti.ac.id

ABSTRAK

Pengetahuan dan perhitungan tentang sifat aliran fluida pada reservoir miring sangat penting dalam kegiatan eksplorasi migas, karena dalam perjalanannya dari batuan sumber (source rock) hingga bermigrasi ke reservoir, fluida akan melewati batuan yang seringkali bersifat non-struktural berupa lereng-lereng di dalam reservoir. Oleh karena itu, perhitungan aliran minyak dan gas untuk reservoir miring sangat penting. Teori patahan lereng merupakan suatu gagasan baru dalam pencarian reservoir non-struktural, karena semakin sulitnya menemukan reservoir struktural yang berskala besar. Oleh karena itu, reservoir struktural-litologi di daerah lereng lambat laun menjadi fokus eksplorasi, dan pada lereng merupakan tempat yang menguntungkan bagi akumulasi minyak dan gas. Untuk menghitung aliran fluida pada reservoir miring dengan menggunakan derivasi persamaan Darcy, datum level merupakan variabel yang dapat dipilih dari titik terbawah sampai titik teratas tinggi reservoir. Permasalahannya adalah apakah hasil perhitungan kecepatan aliran sama untuk setiap titik. Hal ini untuk memudahkan pengukuran di lapangan migas. Penelitian ini akan membuktikan bahwa pemilihan datum level secara acak tidak mengubah nilai kecepatan aliran fluida yang mengalir. Pertama-tama pada artikel ini akan dihitung kecepatan aliran fluida dengan menggunakan ketiga titik datum level yang digunakan. Perhitungan menggunakan cara biasa/manual dengan kalkulator dan terbukti hasil perhitungannya sama. Kemudian akan dihitung semua titik dari dasar sampai dengan puncak tinggi reservoir. Cara yang akan digunakan ini menggunakan data yang banyak untuk membuktikan hasilnya sama. Karena jumlah perhitungannya cukup banyak maka perhitungannya akan dihitung secara numerik dengan cara coding menggunakan program Fortran. Ternyata dari hasil pemrograman tersebut laju aliran fluida pada reservoir yang miring memiliki nilai yang sama dengan menggunakan data datum level yang dihitung dari dasar sampai dengan tinggi reservoir dengan kenaikan setiap 1 ft. Jadi dapat disimpulkan bahwa perhitungan dengan menggunakan datum level dapat dilakukan dimana saja pada rentang tinggi reservoir minyak dan gas..

Kata Kunci: minyak dan gas, reservoir miring, datum level, persamaan Darcy, kecepatan aliran fluida

ABSTRACT

Knowledge and calculation of the nature of fluid flow in sloping reservoirs is very important in oil and gas exploration activities, because on its journey from the source rock (source rock) to migrate to the reservoir, the fluid will pass through rocks which are often non-structural in the form of slopes. in the reservoir. Therefore, calculating oil and gas flows for sloping reservoirs is very important. Slope fault theory is a new idea in searching for non-structural reservoirs, because it is increasingly difficult to find large-scale structural reservoirs. Therefore, structural-lithological reservoirs in slope areas have gradually become the focus of exploration, and on slopes are favorable places for oil and gas accumulation. To calculate fluid flow in a sloping reservoir using the derivation of the Darcy equation, the datum level is a variable that can be selected from the bottom point to the top point of the reservoir height. The problem is whether the flow velocity calculation results are the same for any point. This is to make measurements easier in oil and gas fields. This research will prove that random selection of the datum level does not change the flow velocity value of the flowing fluid. Firstly, in this article, the fluid flow velocity will be calculated using the three datum level points used. Calculations use the usual/manual method with a calculator and it is proven that the calculation results are the same. Then all points from the bottom to the top of the reservoir height will be calculated. The method that will be used uses a lot of data to prove the results are the same. Because there are quite a lot of calculations, the calculations will be calculated numerically by coding using the Fortran program. It turns out from the programming results that the fluid flow rate in a sloping reservoir has the same value using datum level data calculated from the bottom to the height of the reservoir with an increase of every 1 ft. So it is concluded that calculations using datum levels can be done anywhere in the height range of oil and gas reservoirs.

Keywords: *oil and gas, sloping reservoir, level datum, Darcy equation, flow velocity fluids*

INTRODUCTION

This research is a continuation of the calculation of horizontal fluid flow in previous research, namely the derivation of the Darcy equation from the Navier Stokes equation for reservoirs with linear and radial flow which has been published in the journal *Petro Tri Jurnal lemlit* [Satiawati & Yulia, 2019], [Boas, 1983] & [Boas, 1984], numerical pressure calculation of unsteady state radial flow on slightly compressible fluids which has been published in AIP proceedings [Satiawati, 2020] and calculation of linear flow rate of compressible fluid (gas) in reservoirs presented at the Icemine seminar in 2023. The last one is about pressure calculations from radial flow of incompressible fluids in reservoir, in the *Petro Tri Journal Lemlit Journal* [Satiawati, 2023], this research is for sloping reservoirs, as it is known that the reservoir may be sloping in position. Knowledge and calculation of the nature of fluid flow in sloping reservoirs is very important in oil and gas exploration activities because on its journey from the source rock (source rock) to migrate to the reservoir, the fluid will pass through rocks which are often non-structural in the form of slopes. Reservoir [Green & Willhite 1998]. Therefore, calculating oil and gas flows for sloping reservoirs is very important. Because slope fault theory is a new idea in searching for non-structural reservoirs studied in Xinjiang Petroleum Geology [YOU Li-wei, et. al., 2005], it is increasingly difficult to find large-scale structural reservoirs. Therefore, structural-lithological reservoirs on slope areas have gradually become the focus of exploration discussed at the IOP Conference Series: Earth and Environmental Science [Junhui Li, 2021] & [Bourgoyne Jr, *et.al.*, 1991] and on slopes are favorable places for the accumulation of oil and gas as research conducted in Exploration and Development Research Institute [Qi'an Meng, et., al. 2020] & [Brown & Beggs, 1980]. To calculate fluid flow in a sloping reservoir using the derivation of the Darcy equation, the datum level is a variable that can be selected from the bottom point to the top point of the reservoir height. The problem is whether the flow velocity calculation results are the same for any datum level selection point. This research will prove that random selection of the datum level does not change the flow velocity value of the flowing fluid. Firstly, in this paper, the fluid flow velocity will be calculated using the three datum level points used, namely the lowest, middle and highest points. Calculations use the usual/manual method with a calculator and it is proven that the results of these three calculations are the same. In the final research report, all points from the bottom to the top of the reservoir height will be calculated. The method that will be used uses a lot of data to prove the results are the same. Because there are quite a lot of calculations, the calculations will be calculated numerically by coding using the Fortran program. The computer program, calculation results and interpretation in graphical form will be explained in the next section..

METHODS

In this chapter we study fluids, flow, geometry and flow rate in reservoirs and derive the formula for fluid flow rate in reservoirs, especially inclined reservoirs using the Darcy equation [Ahmed, 2011] and [Ahmed & Meehan, 2012]. Some of the characteristics of primary reservoirs are the types of reservoir fluids, namely incompressible fluids: namely fluids whose volume and density do not change due to changes in pressure, including ideal fluids [Rubiandini, R., 2012a] & [Rubiandini, R., 2012b]. Meanwhile, weakly compressible fluids are fluids whose volume and density change slightly due to changes in pressure (example: crude oil, water). And compressible fluid: is a fluid whose volume and density change a lot due to pressure (for example gas), while the type of reservoir fluid flow is steady state flow where the pressure at each reservoir location is always constant, non-steady state flow/transient flow is a fluid flowing condition where the pressure gradient at each position in the reservoir is constant (not zero). And pseudo-steady flow where the pressure at different reservoir locations is a linear function of time.

Meanwhile, reservoir geometry or reservoir shape influences flow properties. Some of the flow characteristics are radial where the direction of fluid flow in the reservoir is towards one center, namely towards the drilling well, see Figure 1, linear flow is fluid flow in the reservoir parallel to the horizontal, see Figure 2, while Figure 3 is fluid flow parallel and forming an angle with horizontal direction, this is what is called fluid flow in a sloping reservoir

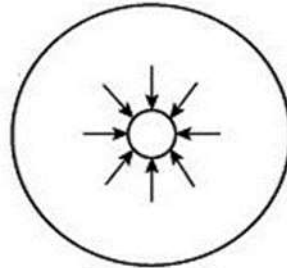


Figure 1 Radial flow

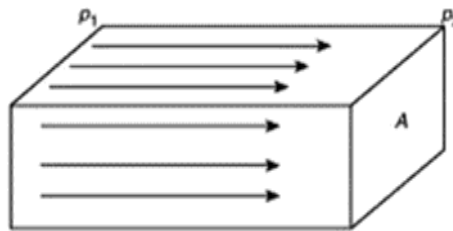


Figure 2 Linear flow

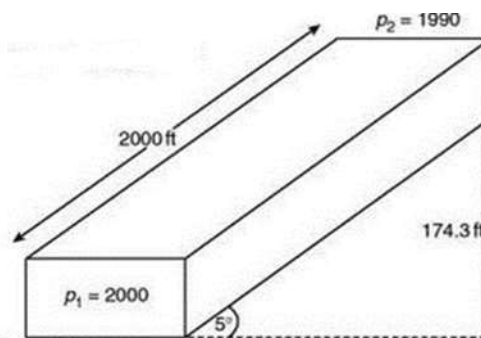


Figure 3 Sloping reservoir

Next, the Darcy equation will be used to calculate discharge and fluid flow rates in reservoirs, especially for linear flow and inclined reservoirs [Ahmed, 2011] & [Ahmed & Meehan, 2012]

For straight reservoir linear flow Darcy's formula is:

$$q = 0,001127 \frac{kA}{\mu L} (P_1 - P_2) \quad (1)$$

with,

q is the fluid flow rate (bbl/day), L is the length of the reservoir (ft), A is the area of the reservoir (ft²), where $A = h \times l$, h is the height of the reservoir (ft), l is the width of the reservoir (ft), k is permeability (mD), P_1 is upper pressure (psi), P_2 is lower pressure (psi) and μ is viscosity

(cP)

For linear fluid flow in a sloping reservoir, the pressure difference ($P_1 - P_2$) according to Darcy's law, is not the only force that influences fluid flow. In sloping reservoirs, fluid density and gravitational forces must also be considered to determine the direction and flow rate. Defined as Φ is the fluid potential and datum level, the datum level is the reference level taken/selected

For point (i) above the datum level

$$\Phi_i = P_i + \frac{\rho}{144} \Delta Z_i \quad (2)$$

For point (i) below the datum level

$$\Phi_i = P_i - \frac{\rho}{144} \Delta Z_i \quad (3)$$

By substituting Φ_i , by replacing P_i with Φ_i , Darcy's equation becomes:

$$q = 0,0011217 \frac{kA}{\mu L} (\Phi_1 - \Phi_2) \quad (4)$$

with

Φ_i is the fluid potential at point i (psi), P_i is the fluid pressure at point i (psi), ΔZ_i is the vertical distance from point i to datum level (ft) and ρ is the fluid density (lb/ft³). In the initial calculation, the fluid flow discharge will be calculated manually for 3 datum level points. In the final calculation a computer program will be created that calculates fluid flow for points along the reservoir height or various datum levels. The results obtained are expected to be the same so that it is proven that random selection of datum levels will produce the same values.

RESULTS

In this chapter, we will first manually calculate the fluid flow rate in a sloping reservoir for 3 datum level selection points, namely the lowest, middle and top points with the data:

An incompressible fluid flows in a linear porous medium, see Figure 3, with the following properties: L (reservoir length) 2000 ft, h (reservoir height) 20 ft, l (reservoir width) 300 ft, k (permeability) 100 mD, ϕ (porosity) 15%, P_1 (top pressure) 2000 psi, P_2 (bottom pressure) 1990 psi, and μ (viscosity) 2 cp

It is assumed that the porous media is tilted at an angle of 5 degrees. Incompressible fluid has a density of 42 lb/ft³. So it is calculated flow rate (bbl/day)

Calculation of reservoir slope height = $\sin 5^\circ$ multiplied by reservoir length

$$= \sin 5^\circ \times 2000 \text{ ft} = 174.3 \text{ ft}$$

It turns out that the three calculations above produce the same value, see table 4.1, namely the value of the fluid potential difference Φ is

$$\Phi_1 - \Phi_2 = -40,84 \text{ psi}$$

The calculation continues with the flow rate (bbl/day):

$$q = 0,0011217 \frac{kA}{\mu L} (\Phi_1 - \Phi_2) = 0,0011217 \frac{100 \times 6000}{2 \times 2000} (-40,84) = -6,9 \text{ bbl/day}$$

The minus sign states that the direction of fluid movement is opposite to the assumptions taken. It turns out that due to the influence of gravity and density the fluid flows from the direction of low pressure to high pressure.

Further calculations are numerical and the flow diagram for this calculation is in the Figure

4

Table 1 Manual calculation results

Bottom	Middle	Top
--------	--------	-----

ΔZ_1 (ft)	0	87,15	174,3
ΔZ_2 (ft)	174,3	87,15	0
$\Phi_1 - \Phi_2$ (psi)	- 40,84	- 40,84	- 40,84

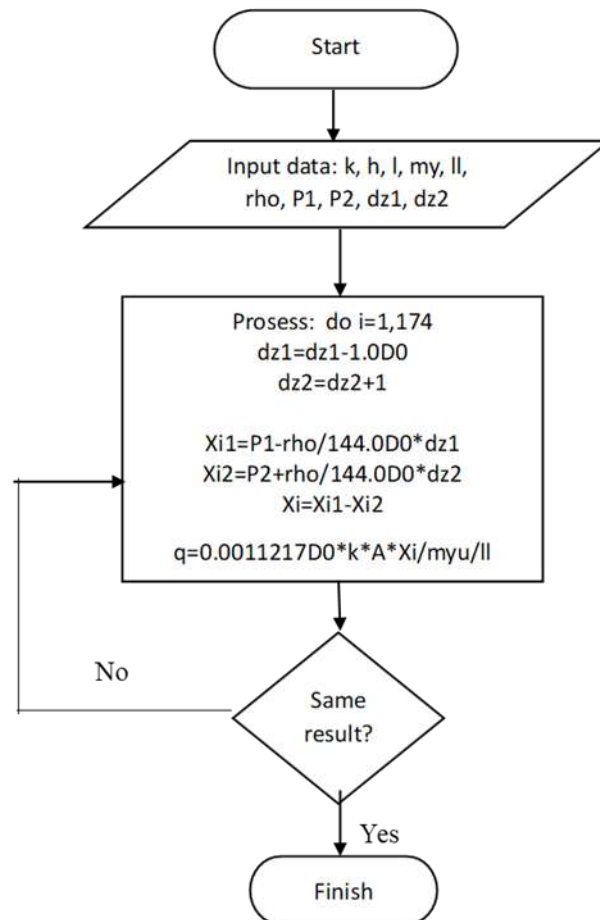


Figure 4 Flow chart of the computer program

For accuracy, count points along the vertical direction from 1 to 174 ft in 1 ft increments using the computer program below:

```

program reservoir
implicit none
real q,k,A,h,l,myu,P1,P2,Xi1,Xi2,Xi,dz1,dz2,rho,ll
integer i,j

k=100.0D0
  
```

```

h=20.0D0
l=300.0D0
A=h*l
myu=2.0D0
ll=2000.0D0
rho=42.0D0
P1=2000.0D0
P2=1990.0D0

dz1=174.0D0
dz2=0.0D0

do i=1,174

dz1=dz1-1.0D0
dz2=dz2+1

Xi1=P1-rho/144.0D0*dz1
Xi2=P2+rho/144.0D0*dz2
Xi=Xi1-Xi2

q=0.0011217D0*k*A*Xi/myu/ll
write(*,*)'dz1=',dz1,'dz2=',dz2,'q=',q
enddo

pause
end

```

Information:

Program name: reservoir program

k is permeability (mD)

h is the height of the reservoir (ft)

l is the width of the reservoir (ft)

A is the reservoir area (ft)

myu is viscosity (cp)

ll is the length of the reservoir (ft)

rho is fluid density (lb/ft³).

P1 and P2 are pressure (psi)

dz1 and dz2 are the upper and lower datum levels (ft)

dz = dz1 +dz2 is the datum level (ft)

Xi1 and Xi2 are fluid potential (psi)

q is the fluid flow rate (bbl/day)

DISCUSSION

The results of the computer calculations can be seen in the attachment. From this data, a graph can be obtained between the fluid flow rate and the datum level, see Figure 5

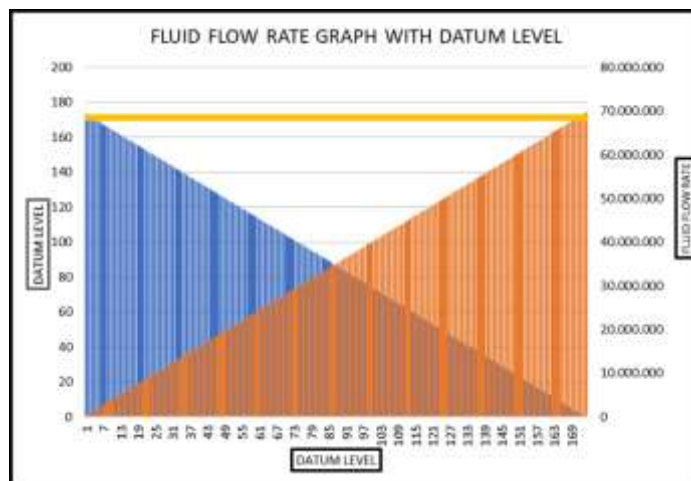


Figure 5 Graph between fluid flow rate and datum level

Knowledge and calculation of the nature of fluid flow in sloping reservoirs is very important in oil and gas exploration activities because on its journey from the source rock to migrate to the reservoir, the fluid will pass through rocks which are often non-structural in the form of slopes in the reservoir. Therefore, calculating oil and gas flows for sloping reservoirs is very important. Because the theory of slope breaks is a new idea in searching for non-structural reservoirs [YOU Li-wei, et. al., 2005], [Sumantri & Nugrahanti, 2011] & [Helander, 1989], It is increasingly difficult to find large-scale structural reservoirs. Therefore, structural-lithological reservoirs in slope areas have gradually become the focus of exploration. [Junhui Li, 2021] & [Hamid, A. 2016] and on the slopes it turns out to be a favorable place for the accumulation of oil and gas [Qi'an Meng, et., al. 2020]. To calculate fluid flow in a sloping reservoir using the derivation of the Darcy equation, apart from pressure differences, fluid density and forces due to the influence of gravity must also be considered to determine the direction and rate of flow. So it is defined that Φ is the fluid potential in units of pressure (psi) and the datum level (LD) in units of length (ft) is the reference level that will be taken/selected. The datum level is a variable selected from the lowest point to the highest point of the reservoir height. The problem is whether the results of calculating fluid flow velocity in units of discharge per time (bbl/day) are the same for any selected point.

In this article, the fluid flow velocity has been manually calculated to select the datum level at 3 points, namely top, middle and bottom, resulting in the same value. The next calculation is the selection of the datum level for each point along the height of the reservoir to prove that random selection of the datum level can be done, this is to facilitate calculations in the field. Calculations for an increase of 1 ft use a computer program to make calculations easier and so that the results can be known quickly. The coding of the computer program was created and the results of the computer calculations are in the Appendix section. There were 174 data generated consisting of upper and lower datum levels and fluid flow rates. From these data, a graph is drawn, which is in Figure 5. From the interpretation of the graph, it shows that for a decrease in the upper datum level and an increase in the lower datum level at an interval of 1 ft, the constant fluid flow rate value is - 6.8563914 bbl/day. The negative sign indicates that the fluid flow moves from right to left or from low pressure to high pressure, according to the equation derived from the Darcy equation above. This is likely due to the relatively large density value of the fluid, namely 42 lb/ft³, and also the influence of height or gravity.

So, in accordance with the topic of this research, it is proven that fluid flow velocity calculations can be done by selecting the desired datum level along the height of the reservoir.

CONCLUSION

1. From the manual calculations that have been carried out for the three selected points, namely the top point, middle point and bottom point, the same calculation results are obtained.
2. Numerical calculations by randomly selecting points in the interval between the top and bottom points produce the same calculation results. This is proven by the results of computer calculations from a height of 1 ft to 174 ft. The fluid flow rate calculation results are the same, namely - 6.8563914 bbl/day. A negative sign means that the fluid flow is flowing in the opposite direction than expected
3. From the calculation results, a straight lines graph is produced for fluid flow calculations which shows the same results for all datum level selections along the height of the reservoir

Acknowledgement

Thank you to the Research Institute and Faculty of Earth and Energy, Universitas Trisakti for providing the opportunity to carry out this research

REFERENCES

- Ahmed, T. (2011). *Reservoir Engineering Handbook*. Second Edition. Texas: Gulf Professional Publishing.
- Ahmed, T., & Meehan, D. N. (2012): *Advanced Reservoir Management and Engineering*. Second Edition. Oxford: Gulf Professional Publishing.
- Albert, K., S., Pauhesti, Samsol, Listiana S., Havidh P. (2023). Study Laboratorium Injeksi Surfaktan ABS dengan Konsentrasi Rendah pada Batuan Barea Sandstone. *PETRO: Jurnal Ilmiah Teknik Perminyakan* **12**(3), 183-190.
<https://e-journal.trisakti.ac.id/index.php/petro/article/view/17300>
- Ayres, F. J. (1967). *Schaum's Outline of Theory and Problems of Differential Equations*. USA: McGrawHill, Inc.
- Boas, L. M. (1983). *Mathematical Methods in The Physical Sciences*. Canada: JOHN WILEY & SONS, INC.
- Boas, L. M. (1984). *Solutions of Selected Problems for Mathematical Methods in The Physical Sciences*. Canada: JOHN WILEY & SONS, INC.
- Bourgoyne Jr., A.T., Millheim, K.K., Chenevert, M.E., & Young Jr, F.S. (1991). *Fundamentals of Formation Evaluation*. USA: Society of Petroleum Engineers.
- Brown, K.E. & Beggs, H.D. (1980). *The Technology of Artificial Lift Methods*. Tulsa; Penn Well Books
- Hamid, A. (2016). *Buku Penuntun Praktikum Peralatan Pemboran dan Produksi*. Jakarta: Laboratorium Konservasi Peralatan Jurusan Teknik Perminyakan Universitas Trisakti.
- Green, D.W. & Willhite, G.P. (1998). *Enhanced Oil Recovery*. Texas: Society of Petroleum Engineers.

- Helander, D. P. (1989). *Fundamental of Formation Evaluation*. Tulsa: OGCI Publications Oil & Gas Consultants International, Inc.
- Hugh D. Y., & Roger A. F. (2012): *University Physics*, 12th edition. San Francisco: Addison-Wesley Sansome Street.
- Junhui Li (2021). Classification of Slope Area Types and Hydrocarbon Accumulation Rules in Wuexun-Beier Depression, *IOP Conference Series: Earth and Environmental Science*. 836 012007. <https://iopscience.iop.org/article/10.1088/1755-1315/836/1/012007/pdf>
- Mourik, T. V. (2005). *Fortran Programming Manual*, <http://www.eio.upc.edu/lceio/manuals/Fortran95-manual.pdf>, 1–67
- Qi'an MENG, Xuefeng BAI, Wenjing ZHANG, Li FU, Tao XUE, Li BAO (2020). Accumulation and Exploration of Petroleum Reservoirs in West Slope of Northern Songliao Basin, China. *Exploration and Development Research Institute, PetroChina Daqing Oilfield Company*, Daqing 163712, China. [Volume 47, Issue 2](#), April 2020, Pages 254-265
- Rubiandini, R. (2012a). *Teknik Pemboran Modern*. Bandung: Penerbit ITB.
- Rubiandini, R. (2012b). *Teknik Operasi Pemboran*. Bandung: Penerbit ITB.
- Satiawati, L. (2020). Numerical solution of discharge calculations of the three reservoir problems. *AIP Conference Proceedings*, 2245(July). <https://doi.org/10.1063/5.0010096>
- Satiawati, L., dan Dalimunthe, Y. K. (2022). *Matematika Teknik*, Jakarta: Penerbit Universitas Trisakti Jakarta. http://www.karyailmiah.trisakti.ac.id/uploads/kilmiah/dosen/BUKU_AJAR_MATEMATIKA_TEKNIK_FINAL_4_JANUARI_2023.pdf
- Satiawati, L., Dalimunthe, Y. K., Abdurrosyid, S., dan Sugiarti, L. (2022a). Numerical Pressure Calculation of Unsteady-state Radial Flow on Slightly Compressibility Fluids. Jakarta: *Metrik Serial Teknologi dan Sains*, [https://publikasi.kocenin.com/index.php/teksi/issue/view/8_3\(1\)_7-15](https://publikasi.kocenin.com/index.php/teksi/issue/view/8_3(1)_7-15)
- Satiawati, L., Dalimunthe, Y. K., Widiyatni, H., dan Syabanissyiham, M. (2022b): Calculation of The Linear Flow Rate of a Compressible Fluid (Gas) in a reservoir. *The 5th International Conference Earth Science, Mineral, and Energy (ICEMINE) 2022* Yogyakarta.
- Satiawati, L., dan Yulia, P. S. (2019). Penurunan Persamaan Darcy Dari Persamaan Navier-Stokes Untuk Reservoir Aliran Linier Dan Radial. *PETRO:Jurnal Ilmiah Teknik Perminyakan*, 8(2), 65–69. <https://doi.org/10.25105/petro.v8i2.4778>
- Satiawati, L., Dalimunthe, Y. K., Widiyatni, H. (2023). Perhitungan Tekanan dari Aliran Radial Fluida Inkompressible pada Reservoir. *PETRO:Jurnal Ilmiah Teknik Perminyakan*, E-ISSN : 2614-7297, Volume 12, Nomor 4, Desember 2023, Halaman 221-232. <https://e-journal.trisakti.ac.id/index.php/petro/article/view/17949/10864>
- Sumantri, & Nugrahanti, A.(2011). *Penilaian Formasi I*. Bogor: Calakan Mediatama.

YOU Li-wei, PENG Jun, CHEN Guo, WANG (2005). Application of the Theory of Slope Break to Petroleum Exploration. [Xinjiang Petroleum Geology](#) >> 2005, Vol. 26 >> Issue (3): 322-325.

ATTACHMENT

The result of running a computer program:

dz1=	173.00000	dz2=	1.0000000	q=	-6.8563914
dz1=	172.00000	dz2=	2.0000000	q=	-6.8563914
dz1=	171.00000	dz2=	3.0000000	q=	-6.8563914
dz1=	170.00000	dz2=	4.0000000	q=	-6.8563914
dz1=	169.00000	dz2=	5.0000000	q=	-6.8563914
dz1=	168.00000	dz2=	6.0000000	q=	-6.8563914
dz1=	167.00000	dz2=	7.0000000	q=	-6.8563914
dz1=	166.00000	dz2=	8.0000000	q=	-6.8563914
dz1=	165.00000	dz2=	9.0000000	q=	-6.8563914
dz1=	164.00000	dz2=	10.000000	q=	-6.8563914
dz1=	163.00000	dz2=	11.000000	q=	-6.8563914
dz1=	162.00000	dz2=	12.000000	q=	-6.8563914
dz1=	161.00000	dz2=	13.000000	q=	-6.8563914
dz1=	160.00000	dz2=	14.000000	q=	-6.8563914
dz1=	159.00000	dz2=	15.000000	q=	-6.8563914
dz1=	158.00000	dz2=	16.000000	q=	-6.8563914
dz1=	157.00000	dz2=	17.000000	q=	-6.8563914
dz1=	156.00000	dz2=	18.000000	q=	-6.8563914
dz1=	155.00000	dz2=	19.000000	q=	-6.8563914
dz1=	154.00000	dz2=	20.000000	q=	-6.8563914
dz1=	153.00000	dz2=	21.000000	q=	-6.8563914
dz1=	152.00000	dz2=	22.000000	q=	-6.8563914
dz1=	151.00000	dz2=	23.000000	q=	-6.8563914
dz1=	150.00000	dz2=	24.000000	q=	-6.8563914
dz1=	149.00000	dz2=	25.000000	q=	-6.8563914
dz1=	148.00000	dz2=	26.000000	q=	-6.8563914
dz1=	147.00000	dz2=	27.000000	q=	-6.8563914
dz1=	146.00000	dz2=	28.000000	q=	-6.8563914
dz1=	145.00000	dz2=	29.000000	q=	-6.8563914
dz1=	144.00000	dz2=	30.000000	q=	-6.8563914
dz1=	143.00000	dz2=	31.000000	q=	-6.8563914
dz1=	142.00000	dz2=	32.000000	q=	-6.8563914
dz1=	141.00000	dz2=	33.000000	q=	-6.8563914
dz1=	140.00000	dz2=	34.000000	q=	-6.8563914
dz1=	139.00000	dz2=	35.000000	q=	-6.8563914
dz1=	138.00000	dz2=	36.000000	q=	-6.8563914
dz1=	137.00000	dz2=	37.000000	q=	-6.8563914
dz1=	136.00000	dz2=	38.000000	q=	-6.8563914
dz1=	135.00000	dz2=	39.000000	q=	-6.8563914
dz1=	134.00000	dz2=	40.000000	q=	-6.8563914
dz1=	133.00000	dz2=	41.000000	q=	-6.8563914
dz1=	132.00000	dz2=	42.000000	q=	-6.8563914
dz1=	131.00000	dz2=	43.000000	q=	-6.8563914
dz1=	130.00000	dz2=	44.000000	q=	-6.8563914
dz1=	129.00000	dz2=	45.000000	q=	-6.8563914
dz1=	128.00000	dz2=	46.000000	q=	-6.8563914

dz1=	127.00000	dz2=	47.000000	q=	-6.8563914
dz1=	126.00000	dz2=	48.000000	q=	-6.8563914
dz1=	125.00000	dz2=	49.000000	q=	-6.8563914
dz1=	124.00000	dz2=	50.000000	q=	-6.8563914
dz1=	123.00000	dz2=	51.000000	q=	-6.8563914
dz1=	122.00000	dz2=	52.000000	q=	-6.8563914
dz1=	121.00000	dz2=	53.000000	q=	-6.8563914
dz1=	120.00000	dz2=	54.000000	q=	-6.8563914
dz1=	119.00000	dz2=	55.000000	q=	-6.8563914
dz1=	118.00000	dz2=	56.000000	q=	-6.8563914
dz1=	117.00000	dz2=	57.000000	q=	-6.8563914
dz1=	116.00000	dz2=	58.000000	q=	-6.8563914
dz1=	115.00000	dz2=	59.000000	q=	-6.8563914
dz1=	114.00000	dz2=	60.000000	q=	-6.8563914
dz1=	113.00000	dz2=	61.000000	q=	-6.8563914
dz1=	112.00000	dz2=	62.000000	q=	-6.8563914
dz1=	111.00000	dz2=	63.000000	q=	-6.8563914
dz1=	110.00000	dz2=	64.000000	q=	-6.8563914
dz1=	109.00000	dz2=	65.000000	q=	-6.8563914
dz1=	108.00000	dz2=	66.000000	q=	-6.8563914
dz1=	107.00000	dz2=	67.000000	q=	-6.8563914
dz1=	106.00000	dz2=	68.000000	q=	-6.8563914
dz1=	105.00000	dz2=	69.000000	q=	-6.8563914
dz1=	104.00000	dz2=	70.000000	q=	-6.8563914
dz1=	103.00000	dz2=	71.000000	q=	-6.8563914
dz1=	102.00000	dz2=	72.000000	q=	-6.8563914
dz1=	101.00000	dz2=	73.000000	q=	-6.8563914
dz1=	100.00000	dz2=	74.000000	q=	-6.8563914
dz1=	99.000000	dz2=	75.000000	q=	-6.8563914
dz1=	98.000000	dz2=	76.000000	q=	-6.8563914
dz1=	97.000000	dz2=	77.000000	q=	-6.8563914
dz1=	96.000000	dz2=	78.000000	q=	-6.8563914
dz1=	95.000000	dz2=	79.000000	q=	-6.8563914
dz1=	94.000000	dz2=	80.000000	q=	-6.8563914
dz1=	93.000000	dz2=	81.000000	q=	-6.8563914
dz1=	92.000000	dz2=	82.000000	q=	-6.8563914
dz1=	91.000000	dz2=	83.000000	q=	-6.8563914
dz1=	90.000000	dz2=	84.000000	q=	-6.8563914
dz1=	89.000000	dz2=	85.000000	q=	-6.8563914
dz1=	88.000000	dz2=	86.000000	q=	-6.8563914
dz1=	87.000000	dz2=	87.000000	q=	-6.8563914
dz1=	86.000000	dz2=	88.000000	q=	-6.8563914
dz1=	85.000000	dz2=	89.000000	q=	-6.8563914
dz1=	84.000000	dz2=	90.000000	q=	-6.8563914
dz1=	83.000000	dz2=	91.000000	q=	-6.8563914
dz1=	82.000000	dz2=	92.000000	q=	-6.8563914
dz1=	81.000000	dz2=	93.000000	q=	-6.8563914
dz1=	80.000000	dz2=	94.000000	q=	-6.8563914
dz1=	79.000000	dz2=	95.000000	q=	-6.8563914
dz1=	78.000000	dz2=	96.000000	q=	-6.8563914
dz1=	77.000000	dz2=	97.000000	q=	-6.8563914
dz1=	76.000000	dz2=	98.000000	q=	-6.8563914
dz1=	75.000000	dz2=	99.000000	q=	-6.8563914
dz1=	74.000000	dz2=	100.00000	q=	-6.8563914
dz1=	73.000000	dz2=	101.00000	q=	-6.8563914

dz1=	72.000000	dz2=	102.00000	q=	-6.8563914
dz1=	71.000000	dz2=	103.00000	q=	-6.8563914
dz1=	70.000000	dz2=	104.00000	q=	-6.8563914
dz1=	69.000000	dz2=	105.00000	q=	-6.8563914
dz1=	68.000000	dz2=	106.00000	q=	-6.8563914
dz1=	67.000000	dz2=	107.00000	q=	-6.8563914
dz1=	66.000000	dz2=	108.00000	q=	-6.8563914
dz1=	65.000000	dz2=	109.00000	q=	-6.8563914
dz1=	64.000000	dz2=	110.00000	q=	-6.8563914
dz1=	63.000000	dz2=	111.00000	q=	-6.8563914
dz1=	62.000000	dz2=	112.00000	q=	-6.8563914
dz1=	61.000000	dz2=	113.00000	q=	-6.8563914
dz1=	60.000000	dz2=	114.00000	q=	-6.8563914
dz1=	59.000000	dz2=	115.00000	q=	-6.8563914
dz1=	58.000000	dz2=	116.00000	q=	-6.8563914
dz1=	57.000000	dz2=	117.00000	q=	-6.8563914
dz1=	56.000000	dz2=	118.00000	q=	-6.8563914
dz1=	55.000000	dz2=	119.00000	q=	-6.8563914
dz1=	54.000000	dz2=	120.00000	q=	-6.8563914
dz1=	53.000000	dz2=	121.00000	q=	-6.8563914
dz1=	52.000000	dz2=	122.00000	q=	-6.8563914
dz1=	51.000000	dz2=	123.00000	q=	-6.8563914
dz1=	50.000000	dz2=	124.00000	q=	-6.8563914
dz1=	49.000000	dz2=	125.00000	q=	-6.8563914
dz1=	48.000000	dz2=	126.00000	q=	-6.8563914
dz1=	47.000000	dz2=	127.00000	q=	-6.8563914
dz1=	46.000000	dz2=	128.00000	q=	-6.8563914
dz1=	45.000000	dz2=	129.00000	q=	-6.8563914
dz1=	44.000000	dz2=	130.00000	q=	-6.8563914
dz1=	43.000000	dz2=	131.00000	q=	-6.8563914
dz1=	42.000000	dz2=	132.00000	q=	-6.8563914
dz1=	41.000000	dz2=	133.00000	q=	-6.8563914
dz1=	40.000000	dz2=	134.00000	q=	-6.8563914
dz1=	39.000000	dz2=	135.00000	q=	-6.8563914
dz1=	38.000000	dz2=	136.00000	q=	-6.8563914
dz1=	37.000000	dz2=	137.00000	q=	-6.8563914
dz1=	36.000000	dz2=	138.00000	q=	-6.8563914
dz1=	35.000000	dz2=	139.00000	q=	-6.8563914
dz1=	34.000000	dz2=	140.00000	q=	-6.8563914
dz1=	33.000000	dz2=	141.00000	q=	-6.8563914
dz1=	32.000000	dz2=	142.00000	q=	-6.8563914
dz1=	31.000000	dz2=	143.00000	q=	-6.8563914
dz1=	30.000000	dz2=	144.00000	q=	-6.8563914
dz1=	29.000000	dz2=	145.00000	q=	-6.8563914
dz1=	28.000000	dz2=	146.00000	q=	-6.8563914
dz1=	27.000000	dz2=	147.00000	q=	-6.8563914
dz1=	26.000000	dz2=	148.00000	q=	-6.8563914
dz1=	25.000000	dz2=	149.00000	q=	-6.8563914
dz1=	24.000000	dz2=	150.00000	q=	-6.8563914
dz1=	23.000000	dz2=	151.00000	q=	-6.8563914
dz1=	22.000000	dz2=	152.00000	q=	-6.8563914
dz1=	21.000000	dz2=	153.00000	q=	-6.8563914
dz1=	20.000000	dz2=	154.00000	q=	-6.8563914
dz1=	19.000000	dz2=	155.00000	q=	-6.8563914
dz1=	18.000000	dz2=	156.00000	q=	-6.8563914

dz1=	17.000000	dz2=	157.00000	q=	-6.8563914
dz1=	16.000000	dz2=	158.00000	q=	-6.8563914
dz1=	15.000000	dz2=	159.00000	q=	-6.8563914
dz1=	14.000000	dz2=	160.00000	q=	-6.8563914
dz1=	13.000000	dz2=	161.00000	q=	-6.8563914
dz1=	12.000000	dz2=	162.00000	q=	-6.8563914
dz1=	11.000000	dz2=	163.00000	q=	-6.8563914
dz1=	10.000000	dz2=	164.00000	q=	-6.8563914
dz1=	9.0000000	dz2=	165.00000	q=	-6.8563914
dz1=	8.0000000	dz2=	166.00000	q=	-6.8563914
dz1=	7.0000000	dz2=	167.00000	q=	-6.8563914
dz1=	6.0000000	dz2=	168.00000	q=	-6.8563914
dz1=	5.0000000	dz2=	169.00000	q=	-6.8563914
dz1=	4.0000000	dz2=	170.00000	q=	-6.8563914
dz1=	3.0000000	dz2=	171.00000	q=	-6.8563914
dz1=	2.0000000	dz2=	172.00000	q=	-6.8563914
dz1=	1.0000000	dz2=	173.00000	q=	-6.8563914
dz1=	0.0000000	dz2=	174.00000	q=	-6.8563914
